User's Guide

High Compliance Current Source
LDX-3232

Newport®

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70037802 February 2021

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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 the information about the Warranty including Customer Service contact information.

Safety Information and the Manual

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

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

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

Indicates 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
- Prolong 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 8).

All instruments returned to ILX Lightwave are required to have a Return Material Authorization (RMA) number assigned by an official representative of ILX Lightwave Corporation. See “Returning an Instrument” on page 7 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 of 3000m (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

Caution: Risk of Electric Shock

Earth Ground Terminal

Protective Conductor Terminal

Alternating Current

Caution: Hot Surface

Visible and/or invisible laser radiation

Frame or Chassis Terminal

On: In position of push control. The (I) denotes that the mains are on.

Of: Out position of push control. The (O) denotes that the mains are on.

Warranty

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

Limitations

This warranty does not apply to fuses, lamps, defects cause by abuse, modifications, or 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 shall not be liable for an incidental, special, or consequential damages.

If a problem occurs, please contact ILX Lightwave 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 Material Authorization number (RMA) from ILX Lightwave 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 (7.5cm) 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 Material Authorization number on the outside of the box and on the shipping paperwork. ILX Lightwave recommends the shipment be insured.

If the original shipping container is not available, place the instrument in a container with at least 3 inches (7.5cm) 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

Upon receiving 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 a quotation for estimated costs of repair. The customer is responsible for negotiation and settlement with the carrier for the amount of damage.

Comments, Suggestions, and Problems

To ensure getting the most out of ILX Lightwave products, direct any product operation, service related questions, or comments to ILX Lightwave Customer Support. Contact ILX Lightwave in whatever way is most convenient:

Phone (800) 459-9459 or (406) 586-1244
Fax (406) 586-9405
Email sales@ilxlightwave.com

Mailing Address:
ILX Lightwave
31950 Frontage Road
Bozeman, Montana, USA 59715

When contacting ILX Lightwave, please have the following information:

Model Number
Serial Number
End-User Name
Company
Phone Number
Email Address
Description of the problem

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

The customer or carrier is responsible for any shipping damage when returning an instrument to ILX Lightwave. ILX Lightwave recommends insuring the shipment. If the original shipping container is not available, place the instrument in a container with at least 3 inches (7.5cm) of compressible packaging material on all sides.

Chapter 1 :
Introduction and Specifications

This chapter is an introduction to the LDX-3232 High Compliance Current Source:

- ✓ Setup Information
- ✓ Safety Considerations
- ✓ Maintenance Information
- ✓ Instrument Specifications

WARNING

If any of the following symptoms exist, or are even suspected, remove the LDX-3232 from service. Do not use the LDX-3232 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 LDX-3232 to ILX Lightwave for service and repair to ensure that safety features are maintained.

Product Overview

The LDX-3232 instrument is a high compliance voltage laser diode current source. The LDX-3232 current source provides a high stability output with multiple laser protection features and a fully redundant current limit. The LDX-3232 offers the added benefits of dual laser interlocks and a GPIB interface to allow full automation of testing.

Initial Inspection

Upon receiving the LDX-3232 instrument, verify that the following items were shipped with the instrument:

- LDX-3232 High Compliance Current Source
- USB Flash Drive containing LDX-3232 User Manual
- Power Cord
- Shipping Kit

Installing the LDX-3232 High Compliance Current Source

Grounding Requirements

The LDX-3232 High Compliance Current Source comes with a three conductor AC power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact or two-contact adapter with the grounding wire connected to an electrical ground (safety ground). The LDX-3232's power jack and supplied power cable meet IEC safety standards.

AC Line Power Requirements

The LDX-3232 instrument can be operated from a single phase power source delivering nominal line voltages of 100, 120, or 220-240 VAC (all values RMS), at 50/60 Hz. The line power voltage can vary ±10% but cannot exceed 250 VAC. Maximum power consumption is 60 VA (Volt-Amps). Setting operating voltage can only be done at the factory. Before operating the instrument, verify that the voltage indicated on the back panel of the instrument matches the power-line voltage used in the operating environment.

WARNING

Before connecting the LDX-3232 High Compliance Current Source to a power source, verify that the AC power source matches the setting of the LDX-3232's voltage printed on the rear panel of the instrument.

To avoid electrical shock hazard, connect the instrument to properly earth-grounded, 3-prong receptacles only. Failure to observe this precaution can result in severe injury or death.

GPIB Connector

The IEEE 488 GPIB interface connector is located on the rear panel, directly above the power input module and fuse (See Figure 1.2). Attach the GPIB cable to the 24-pin connector located on the rear panel. The connector is tapered to ensure proper orientation. The two screws on the cable connector need only be finger tightened.

A total of 15 devices can be connected together on the same GPIB interface bus. The cables have single male/female connectors on each end so that several cables can be stacked. This allows more than one cable to be attached to any one device. However, the maximum length of the GPIB cables must not exceed 20 meters (65 feet) total or 2 meters (6.5 feet) per device.

The GPIB Address

The talk and listen addresses on the LDX-3232 High Compliance Current Source are identical. This GPIB address is read locally by pressing the (GPIB) LOCAL button with the address displayed on the LED display. The instrument comes from the factory configured with the GPIB address set to 1. The LDX-3232's GPIB address can be changed locally (via front panel). A procedure for changing the address can be found in the section Changing the GPIB Address in Chapter 3.

Tilt-Foot Adjustment

The LDX-3232 High Compliance Current Source comes standard with folding front legs and two rear feet for use as a bench top instrument. Extending the front feet so that the instrument front panel sits up makes it easier to view the LED displays. To use them, place the unit on a stable base and rotate the front legs downward until they lock into position.

Operating the LDX-3232 Precision Current Source

The following photos show the functional keypad groupings, back panel connectors, and so on. Use these figures to become familiar with the LDX-3232. After that, use Chapter 2 for fundamentals of instrument operation.

Figure 1.1 LDX-3232 Front View

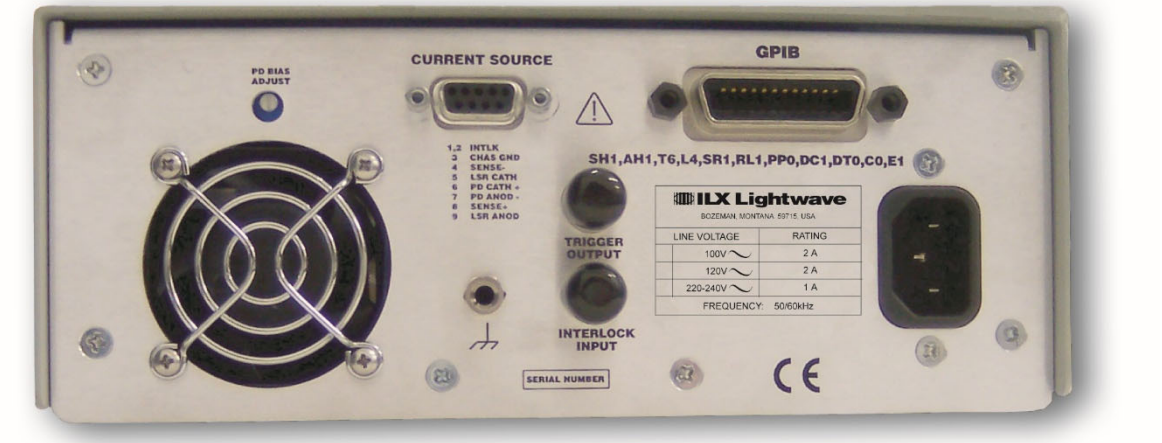


Figure 1.2 LDX-3232 Rear View

Specifications

Table 1.1 Specifications

	2000mA Range	4000mA Range
Drive Current Output[1]		
Output Current Range	0 to 2000 mA	0 to 4000 mA
Setpoint Resolution[2]	40 µA	80 µA
Setpoint Accuracy	±0.15% of SP ±2 mA	
Compliance Voltage	0 - 15 V, adjustable	
Temperature Coefficient	<100 ppm/°C	
Short Term Stability (1 hour)[3]	<20 ppm	
Long Term Stability (24 hours)[4]	<40 ppm	
Noise and Ripple (µA rms)[5] High Bandwidth Mode Low Bandwidth Mode	 <20 µA <20 µA	 <40 µA <20 µA
Transients Operational[6] 1 kV EFT/Surge[7]	 <4 mA <8 mA	
Compliance Voltage Adjust		
Range	0 - 15 V	
Resolution	60 mV	
Accuracy	±2.5%	
Drive Current Limit Settings		
Range	1 to 2020 mA	1 to 4040 mA
Resolution	10 mA	20 mA
Accuracy	±20 mA	±40 mA
Photodiode Feedback		
Type	Differential	
PD Reverse Bias	0 - 5V, adjustable	
PD Current Range	5 to 10,000 µA	
Output Stability[8]	±0.02%	
Accuracy, setpoint (% of FS)	±0.05%	
External Analog Modulation		
Input	0 - 10 V, 1 kΩ	
Transfer Function	200 mA / V	400 mA / V
Bandwidth (3 dB)[9] High Bandwidth Low Bandwidth	 DC to 250 kHz DC to 10 kHz	

Trigger Output		
Type	TTL	
Pulse Width	13 µs	
Delay	12 ms	
Measurement (Display)		
Output Current Range	0 to 2000.0 mA	0 to 4000.0 mA
Output Current Resolution[10]	0.1 mA	
Photodiode Current Range	0 to 10,000 µA	
Photodiode Current Resolution	1 µA	
Photodiode Current Accuracy	±4 µA	
PD Responsivity Range[11]	0.00 to 1000.00 µA/mW	
PD Responsivity Resolution	0.01 µA/mW	
Optical Power Range	0.00 to 5000.0 mW	
Optical Power Resolution	0.1 mW	
Forward Voltage Range	0.000 to 10.000 V	
Forward Voltage Resolution	1 mV	
Forward Voltage Accuracy[12]	±2 mV	
General		
Size (H x W x D)	4” x 8.5” x 13.4”; 102 mm x 216 mm x 340 mm	
Weight	~ 20 pounds (9 kg)	
Power	100/120/230-240 V~; 2/2/1A 50/60 Hz	
Temperature	0°C – 40°C operating; -40°C – 70°C storage	
Humidity	< 90% relative humidity, non-condensing	
Laser Safety Features	Key switch, interlock and output delay (meets CDRH US 21 CFR 1040.10)	
Display Type	5-digit, green LED	

Notes
1. All values relate to a one-hour warm-up period at room temperature, 25°C.
2. Based on resolution of digital-to-analog converters used in the design.
3. Over any 1-hour period, half-scale output.
4. Over any 24-hour period, half-scale output.
5. Measured electrically with a 1 ohm load at half-scale output; evaluating spectral noise density over a 150kHz bandwidth from 125kHz to 275 kHz.
6. Maximum output current transient from normal operational situations (e.g., power on-off, current on-off), as well as accidental situations (e.g., power line plug removal).
7. Maximum output current transient resulting from a 1000 V power-line transient spike. Tested to ILX Lightwave Technical Standard #LDX-00196.
8. Maximum monitor photodiode current drift over any 30 minute period. Assumes zero drift in responsivity of photodiode.
9. 50% modulation at mid-scale output. Higher bandwidth is possible with smaller magnitude modulation signal.
10. Similar resolution available over GPIB.
11. Responsivity value is user-defined and is used to calculate the optical power.
12. Four wire voltage measured at the load. Voltage measurement accuracy while driving calibration load. Accuracy is dependent upon load and cable used.

Available Options and Accessories

Options and accessories available for the LDX-3232 High Compliance Current Source include the following:

Table 1.2 Accessories List

DESCRIPTION	MODEL NUMBER
Low Noise CW Filter, 9-pin DSUB	LNF-320
Driver to Mount Cable, 5 Amp, DB9 Male to DB9 Male	CC-305S
Driver to Unterminated Cable, 5 Amp, DB9 Male to Bare Wire	CC-306S
Laser Diode Mount, 14-pin DIL	LDM-4982
Laser Diode Mount, 14-pin Butterfly	LDM-4894
Laser Diode Mount, TO-Can	LDM-4990
Single Rack Mount Kit, LDX-3200 Series & LDT-5900 Series	RM-139
Dual Rack Mount Kit, LDX-3200 Series & LDT-5900 Series	RM-140

Please contact ILX Lightwave or visit www.newport.com/ilxlightwave for information on additional options for applications.

Chapter 2 : Operation

This chapter introduces the operation of the LDX-3232 High Compliance Current Source. It offers instructions for connecting a laser diode to the current source and describes powering up the instrument. This chapter also includes:

- ✓ Operation Procedures
- ✓ Interlock Information

Applying Power to the LDX-3232

To turn on the LDX-3232, rotate the key in the POWER section of the front panel from O to I. This action will initiate the power on sequence. If the LDX-3232 does not appear to turn on, verify that it is connected to line power. If line power is not the problem, remove the power cord and check the voltage selection block in addition to the line power fuse.

The Power On Sequence

During the power-up sequence, the following takes place:

- For about three seconds all indicators are lit up; all of the 7-segment displays indicate 8.
- All indicator lights are turned off for three seconds.
- Firmware version will be displayed.
- Instrument performs a communications self-test between the hardware and processor.
- After this test, the instrument is ready to operate and is configured to the state it was in when the power was last shut off.

Connecting to the Laser

When connecting a laser to the LDX-3232, it is recommended that the instrument be powered up with the output off. In this condition, a low impedance shunt is active across the output terminals. When disconnecting devices, it is only necessary to turn the current source output off.

It is also recommended that the connections to the LDX-3232 output be made using twisted wire pairs with an earth-grounded shield (see Figures 2.1 - 2.4). 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 be careful to 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.

Note: Cable connections to the laser must be secure. Loose connections can cause momentary open circuits that can damage the laser.

Figures 2.1 – 2.4 show the possible configurations of connecting laser diodes and photodiodes with the LDX-3232 High Compliance Laser Current Source.

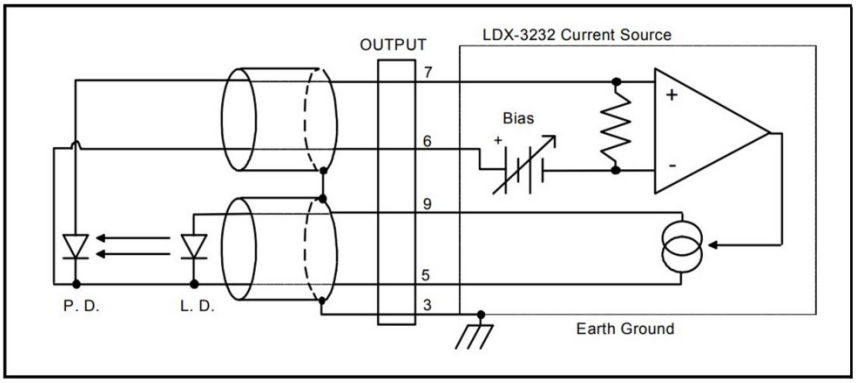


Figure 2.1 Common Laser Cathode & Photodiode Cathode

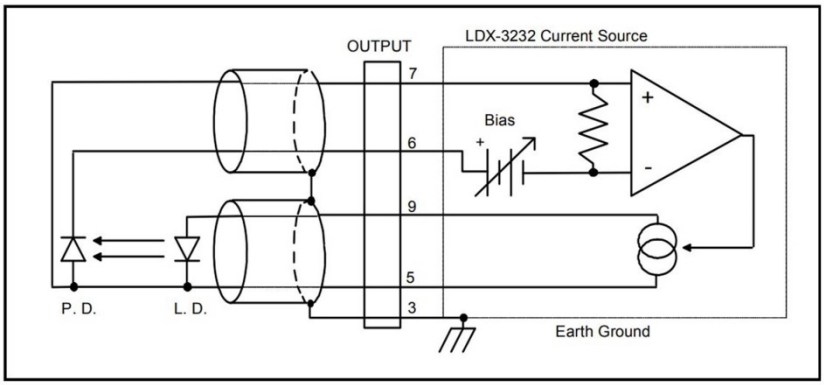


Figure 2.2 Common Laser Cathode & Photodiode Anode

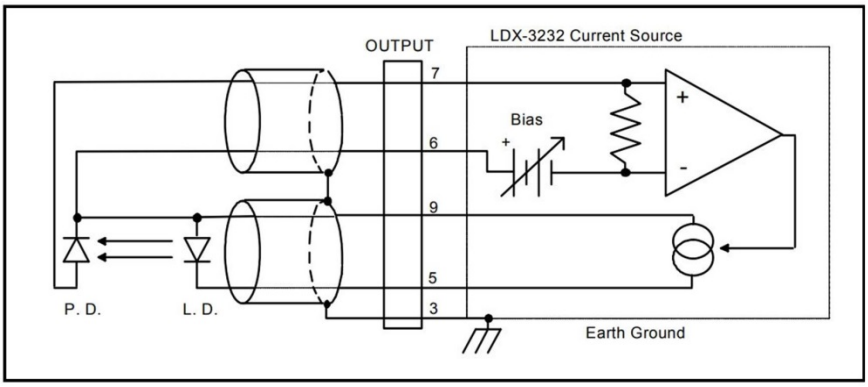


Figure 2.3 Common Laser Anode & Photodiode Cathode

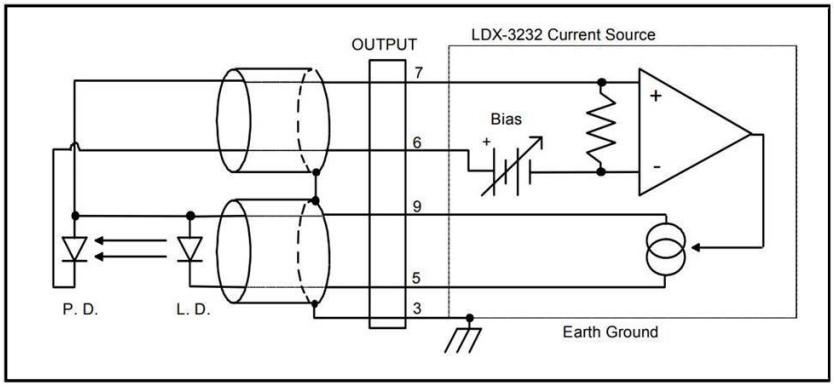


Figure 2.4 Common Laser Anode & Photodiode Anode

The 9-pin connector marked CURRENT SOURCE on the back panel is used to connect the laser diode to the LDX-3232. There are connections provided for laser cathode and anode, photodiode cathode and anode, chassis ground and interlock. The pinout diagram for this connector is shown in Figure 2.5.

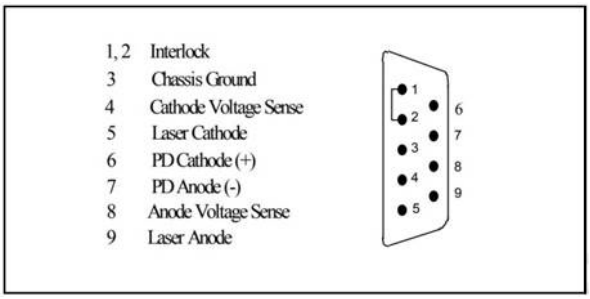


Figure 2.5 Back Panel LD Connector

Interlock Connections

In order for the laser output to be enabled a short circuit 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 INTERLOCK LED will illuminate on the front panel and the laser output will be disabled.

> **Note:** The BNC Interlock Connection from the BNC connector on the rear panel will also make the INTERLOCK LED illuminate. Please see the notes in chapter 5 on use of the BNC interlock connection to learn more about its operation.

CAUTION

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

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 LDX-3232 are electrically isolated from ground and each other. If a 4 pin connection is made (no common connections), no additional jumpers are required. Figures 2.1 - 2.4 show the recommended connections and shielding for 3-pin lasers (where the common connection is internal to the device). A 4-pin laser should be connected with the same shielding as shown in Figure 2.1, but the common connection (between the photodiode and the laser) is optional.

Setting the PD Bias

The LDX-3232 provides an adjustable reverse bias of 0-5 VDC for the photodiode. To set the photodiode bias to 5 V reverse bias, turn the back panel PD BIAS ADJUST fully clockwise. To set the photodiode bias to 0 V reverse bias, turn the back panel PD BIAS ADJUST fully counter-clockwise.

Grounding Considerations

The LASER outputs of the LDX-3232 High Compliance Current Source are isolated from chassis ground, allowing either output terminal to be grounded at the user's option. Figures 2.1 - 2.4 show the proper earth-ground shielding for laser diode/photodiode connections.

Front Panel Operation

Figure 2.6 LDX-3232 Front Panel

This section describes fundamentals of operation for the LDX-3232 in the two operating modes: Constant Current (I) and Constant Power (P).

The Display

The digital display is used to show control parameters such as laser drive current (mA), laser current limit (mA), laser forward voltage (V), voltage limit (V), monitor photodiode current (µA), and laser optical power (mW) in both set point and measurement modes. It will also display error codes that relate to LASER operation. Error indicators underneath the display indicate control errors and are explained in the section titled “ERROR INDICATORS”. All laser control parameters are displayed on this digital display with the appropriate annunciator illuminated.

Setting Up the LDX-3232 Precision Current Source

The following section describes the functionality of the front panel.

Mode Selection

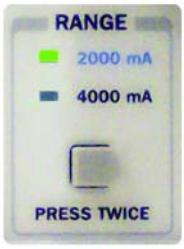
The LDX-3232 has three modes in which it can be driven:

- Constant Current – Low Bandwidth
- Constant Current – High Bandwidth
- Constant Power

Pressing the (MODE) SELECT button cycles between these three modes.

Pressing the (MODE) OUTPUT button will enable or disable the output of instrument in the mode which is selected.

Range Selection

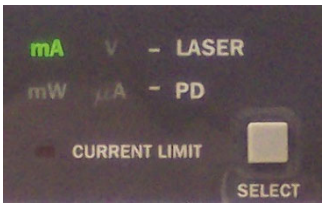


The LDX-3232 has two ranges in which it can be driven:

- 2000mA
- 4000mA

Pressing the button in the RANGE section twice will cycle between the modes. The button presses must be quick (less than 1 second) to switch between ranges. The LASER output must be OFF to change ranges.

Display Selection



The LDX-3232 can be configured to display the following properties:

- Laser Diode Current (mA)
- Laser Diode Power (mW)
- Laser Diode Voltage (V)
- Photodiode Current (µA)

Pressing the SELECT button in this section will cycle between the available display properties and the indicator will be lit.

When set point mode is active, the corresponding indicator which is being adjusted will flash to indicate that the unit is in set point mode rather than measurement display.

To only view the set point, press and hold down the display SELECT button for two or more sections. When the (DISPLAY) SELECT button is released, the previous measurement mode will be restored.

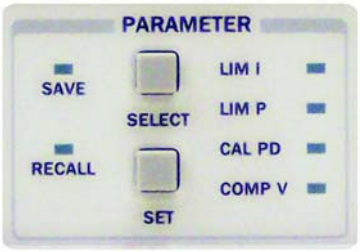
Adjust Knob

All set points are adjusted using the adjustment knob when operating from the front panel of the LDX-3232. When turning the adjustment knob, the instrument automatically changes to set point mode, as shown by the flashing indicator.

After an adjustment has been made, the set point mode will time out after three seconds and will return to the original measurement display mode.

The FINE button is used to make fine control adjustments. When the indicator is not lit, the instrument will make coarse control adjustments.

Parameter Selection



The LDX-3232 has multiple parameters which can be adjusted:

- Current Limit (LIM I)
- Power Limit (LIM P)
- Photodiode Responsivity in µA/mW (CAL PD)
- Compliance Voltage Limit (COMP V)
- Saving Parameter Setups to a Bin (SAVE)
- Recalling Parameter Setups from a Bin (RECALL)

To adjust these values, press the (PARAMETER) SELECT button until the indicator next to the parameter which is to be adjusted is lit, then press the (PARAMETER) SET button. Adjust the value using the ADJUST KNOB. After three seconds, the new parameter value is stored in non-volatile memory.

Using the LDX-3232 in Constant Power (P) Mode

Before using the LDX-3232 in Constant Power (P) Mode, the photodiode responsivity (CAL PD), which is used to convert between photodiode current and optical power of the laser diode, must be known.

A method to calculate the responsivity is suggested below.

1. Measure (with a calibrated detector) the output power of the device.
2. Measure the corresponding photodiode current.
3. Calculate the responsivity by dividing the photodiode current by the optical power noting the units required are µA/mW.
4. Input this value using the CAL PD Parameter Selection as described above.

   Note: The LDX-3232 High Compliance Current Source can be put into a special mode with the CAL PD parameter set to zero. When the CAL PD value is zero, the LASER output will be controlled to the IPD set point value. Therefore, the instrument is in Constant IPD mode. The display will indicate -.- for the power measurement.

Error Indicators

The LDX-3232 High Compliance Current Sources indicate general operational error conditions. Each error condition results in an action as shown in the table below.

Table 2.1 LDX-3232 Error Indicators

Error Condition	Action
Interlock	Output off; INTERLOCK light flashes at 1 Hz
Open Circuit	Output off; OPEN CIRCUIT light flashes at 1 Hz; if this condition was caused by an excessively high compliance voltage, the VOLTAGE LIMIT light will also be turned on.
Current Limit	CURRENT LIMIT light flashes at 1 Hz
Voltage Limit	VOLTAGE LIMIT light flashes at 1 Hz; this indicator warns that the output is within 0.25 V of LIM V setting; if the voltage limit (LIM V) is reached, the LASER output will shut off.
Optical Output Power Limit	Output off; POWER LIMIT light flashes at 1 Hz

Automatic Laser Output Shut Off Conditions

These conditions will automatically cause the instrument to disable the current source output:

- LASER High Power Limit
- LASER Interlock / Key Lock Turned Off
- LASER Open Circuit or Voltage Limit

Chapter 3 :
Remote Operation

This chapter details the fundamentals of operating the LDX-3232 High Compliance Current Source remotely through the GPIB interface.

- ✓ Current Source Command Set
- ✓ Command Paths

Reading the GPIB Address

Before operating the LDX-3232 instrument from a remote location, its GPIB address must be known. Simply press the LOCAL button in the section labeled GPIB on the front panel. The instrument will display the address. The default address from the factory is address 01.

Changing the GPIB Address

Every device on the GPIB bus must have a unique address. If it is necessary to change the address, press and hold in the (PARAMETER) SET button while displaying the GPIB address. Turn the ADJUST KNOB until the desired address value is displayed, then release the SET button. The new GPIB address will then be stored in non-volatile memory. The allowable address range is 0-30 for primary GPIB addressing. Extended GPIB addressing is not implemented on the LDX-3232 at this time.

Changing Operation from Local to Remote

Sending a command over the GPIB automatically puts the instrument in REMOTE mode. The REMOTE indicator will identify when the Current Source is in remote operation mode. When the instrument is in REMOTE mode, pressing the LOCAL button returns the instrument to LOCAL control mode.

The TALK/LISTEN indicator is illuminated when the instrument is communicating over the GPIB bus.

LDX-3232 Current Source Command Set

This section contains information regarding GPIB-IEEE488 Command Commands, most used device specific commands, and command syntax. Error and status registers are also introduced in this chapter.

Command Syntax

Any command or command query must contain all of the letters that are shown in the LDX-3232 Command Path Structure, Figure 3.1. However, the Current Source's command parser is NOT case sensitive, so upper or lower case may be used in any combination. The lower case letters shown with the Device Dependent commands in Chapter 4 are optional letters and may be used for clarity. For example, the following commands are equal:

- LAS:DIS 1
- LAS:Dis 1
- LAS:DISPLAY 1

In this example, only the first three letters “DIS” are required, while the other letters, “play” are optional. These optional letters must be used in the proper sequence as shown.

The syntax of the LDX-3232 High Compliance Current Source commands follows the rules laid out in the GPIB-IEEE488 standard. Colons (:) indicate the start of a new command path, while semicolons (;) indicate a separation of commands within a command string. A leading colon on a command may be used to return the LDX-3232 High Compliance Current Source command parser to the command path root (see Figure 3.1).

Spaces or white space may be used to separate commands and/or data (after the command header or query question mark). Spaces or white space must be used to separate the command (header) from the first parameter (or program data). The following examples show valid syntax for commands with the LDX-3232 High Compliance Current Source:

- LAS:display:ldi
- Laser:limit:ldi 400
- LAS:DIS 1; las:set:ldi?
- Las:MODE:Mdp; LAS:OUT 1

The following are examples of invalid syntax for the LDX-3232 High Compliance Current Source. These command strings would produce an erroneous result, as explained:

LAS:MODE MDP	Missing colon, MODE? expected
LAS:MODE:ILBW 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

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 should be separated with commas:

LAS:INC 100,50

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

LAS:LDI?

The LDX-3232 High Compliance Current Source uses a terminator of <NL><^END> (new line with 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 command in Chapter 4). For more information, refer to the GPIB driver's configuration manual.

The command structure is illustrated in Figure 3.1. Table 4.1 lists all of the LDX-3232 High Compliance Current Source's device-dependent commands, with the full path shown for each command and a brief explanation of its usage.

Command Paths

The LDX-3232 High Compliance Current Source device-dependent commands are structured into a tree format (see Figure 3.1). Each of the legal paths is listed below, followed by its list of path options, each of that is followed by the commands themselves. It is recommended that the first-time user begin learning the commands by using the full path notation. Once familiar with the commands, taking advantage of the shortcuts allowed for command paths may be useful.

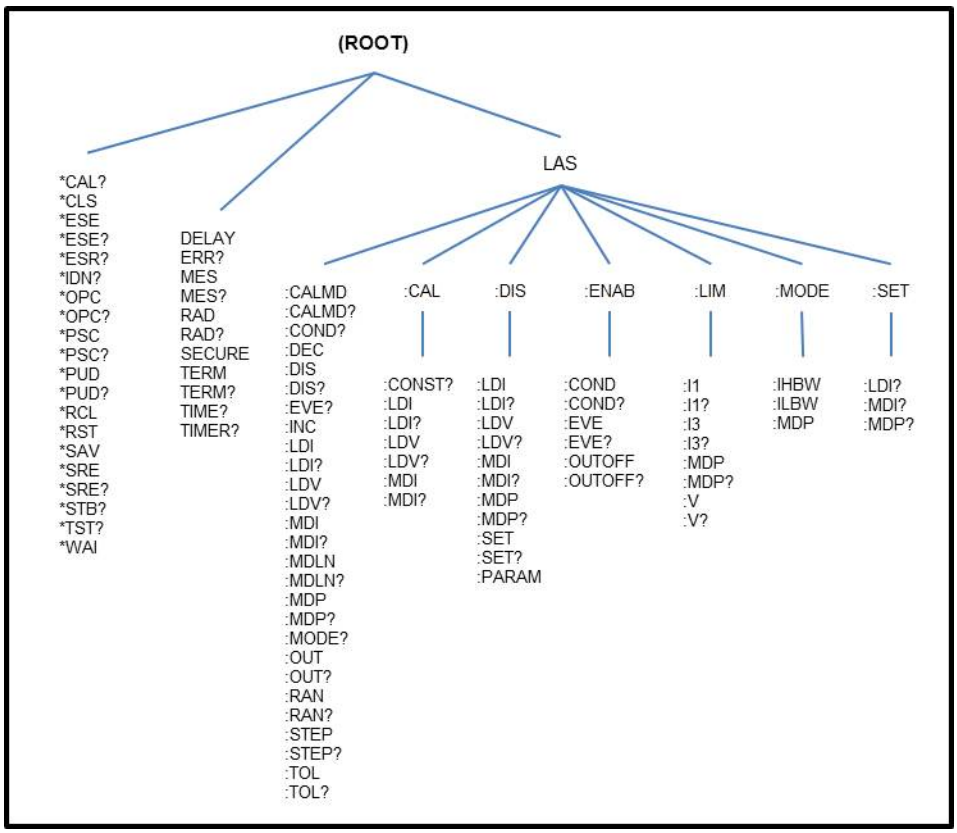


Figure 3.1 LDX-3232 Command Path Structure

IEEE488.2 Command Commands

The IEEE488.2 Common Commands and Queries are distinguished by the * that begins each mnemonic. The diagrams below show the syntax structure for common commands, common commands with numeric data required, and command queries.

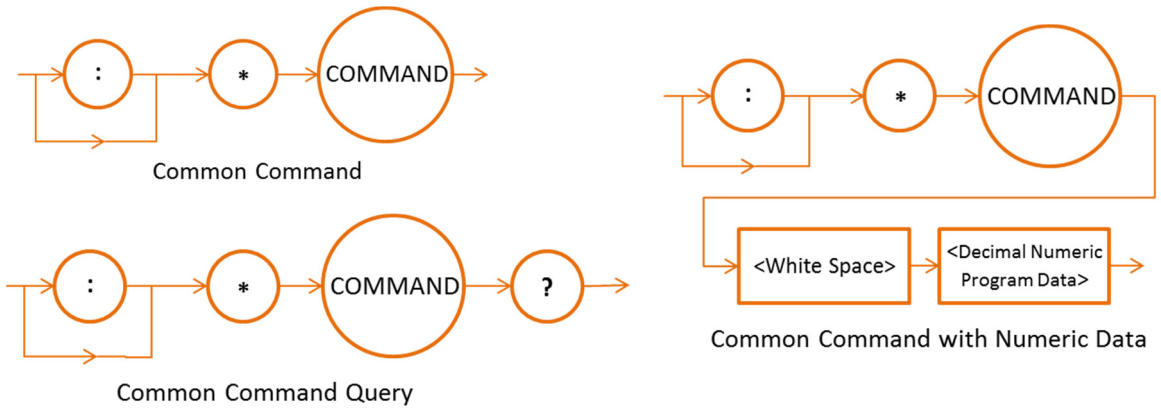


Figure 3.2 Common Command Structure

Numeric data is required with:

*PSC (1=on, 0=off)
*RCL (0 to 10, see front panel RECALL function)
*SAV (1 to 10, see front panel SAVE function)
*ESE (0 to 255, see Figure 3.3)
*SRE (0 to 255, see Figure 3.3)
*PUD (used at factory only)

A list of all of the GPIB-IEEE488 Common Commands supported by the LDX-3232 follows:

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

For more information on these commands, refer to an ANSI/IEEE 488-1987 standards reference.

> **Note:** Care should be taken to set the GPIB time-out appropriately for use with the *WAI, DELAY, or *OPC? commands. If the time for a response after one of these commands exceed the GPIB time-out period, a bus (timeout) error will occur. Usually, after this timeout error, the LDX-3232 will generate a query error (E302). This error code is reported via the ERR? query.

Status Reporting

This section contains information that is relevant for understanding instrument error and status reporting. It also contains information regarding the use of the instrument status for generating interrupts for interrupt driven programs or subroutines. Understanding the Operation Complete definition for the instrument is useful for programming synchronization. The Output Off Register section also contains information on setting some of the conditions that will force the laser current source output off.

The following sections describe the Event and Condition registers, Operation Complete Flag, Output Off registers, and Error Messages.

Event and Condition Registers

In addition to the required GPIB-IEEE488 status reporting structures, the LDX-3232 High Compliance Current Source remote interface provides Event and Condition Registers for LASER operations. The Event Registers are used to report events that occur during the operation of the LDX-3232 High Compliance Current Source. Events differ from conditions in that events signal an occurrence once, and are not reset until the Event Register is queried, the status cleared by the *CLS command, or the instrument is powered off. Conditions reflect the current state of the device and therefore may change many times during operation. Querying a Condition Register does not change its contents.

Figure 3.3 shows the status reporting scheme of the LDX-3232 High Compliance Current Source. Each of the registers that may be accessed by a command or query has the appropriate command or query written above or below the register representation. For example, the LASER Condition Register may be queried via the LASer:COND? query.

The condition or event registers are logically ANDed with their respective enable registers. These bits are then logically ORed to form a summary message in the status byte for that particular register.

Operation Complete Definition

Note that Bit 0 of the Standard Event Status Register contains the status of the Operation Complete flag. Enabling this bit via the *ESE command allows the user to update bit 5 of the status byte. Then, if the SRE mask has bit 5 set, and the user issues an *OPC command, the SRQ (bus) signal will be generated upon completion of the currently processed commands. This bus signal (SRQ) may be used to initiate service request routines, which depend on the completion of all previous commands.

For example, the user may turn the current source on (LAS:OUT 1), enable an SRQ on Operation Complete (set *ESE 1 and *SRE 5), and have an SRQ handling routine in the user's software, that reads a new measurement after the output on state has been reached. This allows the use of the operation complete features of the LDX-3232, without the need for program looping or polling that can tie up the GPIB.

Operation Complete on the LDX-3232 is defined as:

1. No operations to the LASER current source hardware are pending.
2. No EEPROM (non-volatile) memory write cycles are in progress.

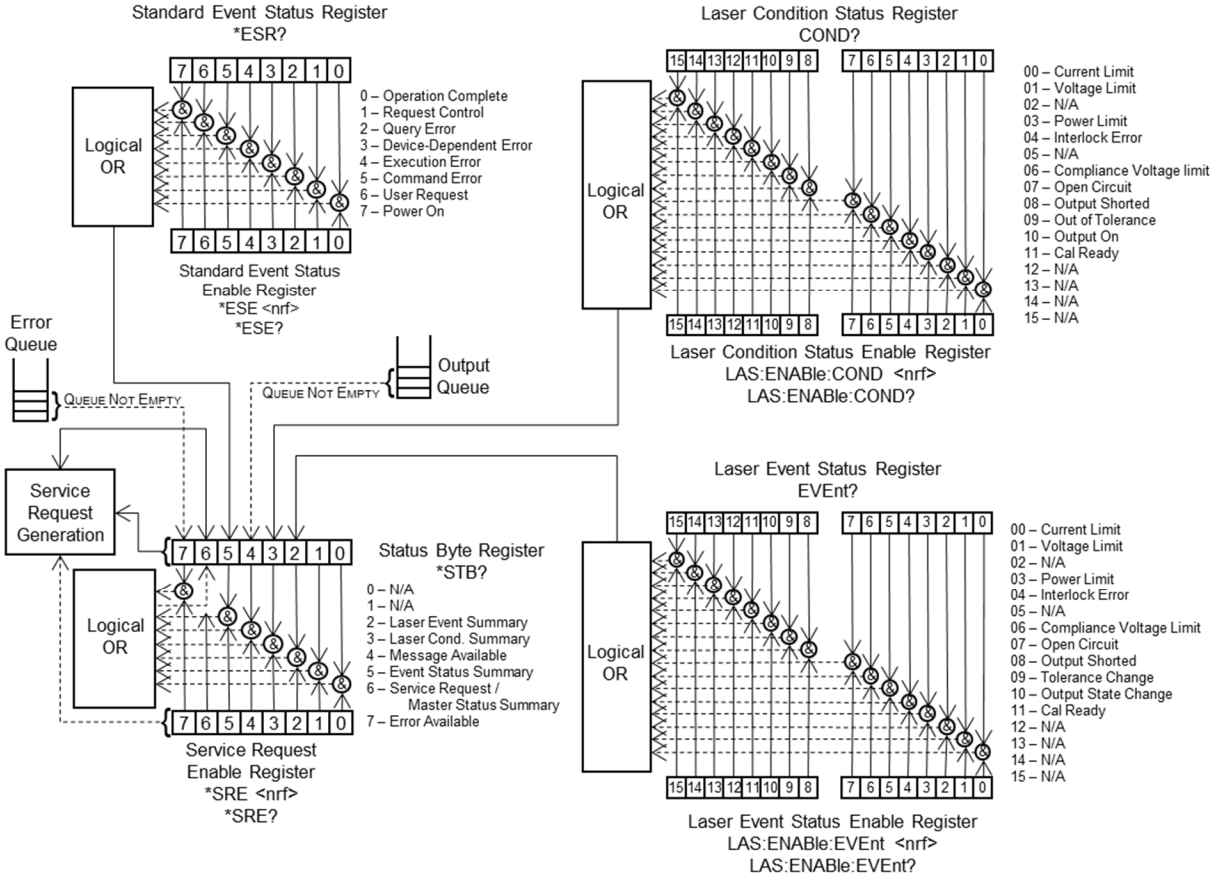


Figure 3.3 LDX-3232 Status Reporting Schematic Diagram

Note: If the GPIB times out while waiting for a response, either set the GPIB time-our longer or use SRQ generated interrupts in the program. See the GPIB manual for time-out configuration or SRQ programming setup.
The *OPC, *OPC? and *WAI commands should not be used inside a calibration routine.

Output Off Register

The Output Off Enable Register allows determination of conditions and events in the LDX-3232 High Compliance Current Source can cause the current source output to be turned off. This reigster is configured in a manner similar to the status reporting registers. However, the register output is not reported in the Status Byte Register. Rather, it sets the hardware that controls the output switching. The events and conditions that may be set to cause the current source output to be turned off are shown in Figure 3.4.

The default (factory) settings for this register are shown in the table below. These settings are not affected by the *PSC (Power-On Status Clear) command.

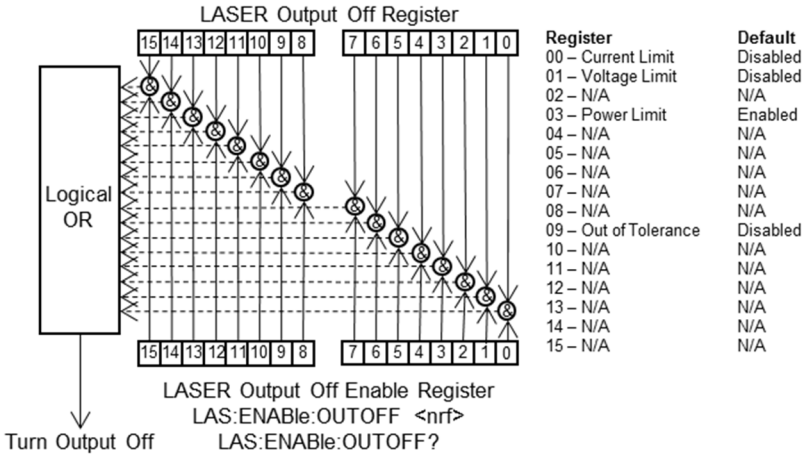


Figure 3.4 LDX-3232 Output Off Register & Defaults

Command Timing and Completion

This section describes whether a command is performed in an overlapped or sequential manner. In other words, it states whether the next command may begin while the current command is being executed, or if the next command must wait until the current command is completed before its execution begins. The conditions for setting the operation complete flag are given in the Chapter 3 section titled Operation Complete Definition.

All LDX-3232 device-dependent commands are executed in an overlapped manner, except the DELAY command that is sequential. The operation complete flag is set after the conditions outlined in the Operation Complete Definition have been satisfied.

The *WAI command (common command) is an example of a sequential command that 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 will not have their OPC flag set until all present writing to non-volatile memory has been completed. This is done to ensure that the OPC flag is never set prematurely.

Whenever there is any output (response) data in the Output Queue, bit 4 is set in the Status Byte Register. Whenever there is any error message in the Error Queue, bit 7 is set in the Status Byte Register.

Error Messages

In the event of a hardware error condition, error messages will be displayed on the display. In most cases, the error message will appear for three seconds. In some cases the error code display will remain until the user changes display modes. In the case of multiple error messages, the display may sequentially show each message for three seconds. In addition to the hardware errors, GPIB errors may be read via the ERR? query. Table 3.2 lists the numerical error ranges by function. Table 3.3 contains all of the error messages that may be generated. Not all of these messages may appear on the front panel displays. Some refer to GPIB activities only.

In remote operation, the errors can be read by issuing the ERR? query. When this is done, all of the error messages that are resident in the error queue are returned (up to 10 may be stored). Reading the error queue via GPIB clears the error queue.

Table 3.2 Error Code Classifications

Error Code Range	Area of Operation
E-001 to E-099	Internal Program Errors
E-100 to E-199	Parser Errors
E-200 to E-299	Execution Control Errors
E-300 to E-399	GPIB Errors
E-500 to E-599	LASER Control Errors

Table 3.3 LDX-3232 Error Codes

Error Code	Explanation
E-001	Memory allocation failure
E-103	<DEFINITE LENGTH ARBITRARY BLOCK PROGRAM DATA> length too long
E-104	<NON-DECIMAL NUMERIC PROGRAM DATA> type not defined
E-105	<DECIMAL PROGRAM DATA> exponent not valid
E-106	<DECIMAL PROGRAM DATA> digit expected
E-123	Command not found
E-124	<program mnemonic> Lookup, failed because query/command type match failed
E-126	Too few or too many program data elements
E-201	<PROGRAM DATA> value out of range
E-202	<PROGRAM DATA> will not convert to valid type
E-203	Security violation, command is not available without clearance
E-205	<PROGRAM DATA> is not a Boolean value or word
E-207	<PROGRAM DATA> will not convert to an unsigned 16-bit value
E-209	<PROGRAM DATA> will not convert to an unsigned 32-bit value

E-210	<PROGRAM DATA> will not convert to a floating point value
E-211	<PROGRAM DATA> will not convert to a character value
E-213	<PROGRAM DATA> is incorrect block data length
E-214	<PROGRAM DATA> length exceeds maximum

E-302	Query error; device was addressed to talk, but GPIB controller failed to read all of the <RESPONSE MESSAGE>

Error Code	Explanation
E-501	LASER interlock disabled output
E-503	LASER open circuit disabled output
E-504	LASER current limit disabled output
E-505	LASER voltage limit disabled output
E-507	LASER power limit disabled output
E-510	LASER out of tolerance disabled output
E-511	LASER control error disabled output
E-512	Analog section status is all 1’s or all 0’s (power down)
E-513	Serial EEPROM checksum error
E-515	Laser output must be off to change ranges
E-516	Incorrect configuration for calibration sequence to start
E-519	Setting a measurement is only valid during the calibration phase for that measurement; user has tried to calibrate a measurement without first entering the required calibration mode.

Chapter 4 : Command Reference

This chapter is a guide to all the device dependent commands for the LDX-3232 High Compliance Current Source.

- ✓ Overview of Remote Commands
- ✓ List of Commands in Alphabetical Order

Figure 4.1 shows the format for the device command descriptions in this chapter. The commands that emulate local (front panel) operation are denoted by the solid box next to the Local label in the upper left corner of the command description.

Table 4.1 Remote Command Summary Reference List

Name	Parameters	Function
DELAY	1	Sets a single command execution delay.
ERR?	NONE	Returns a list of errors that have occurred since the last query.
LAS:CALMD	1	Sets photodiode feedback responsivity.
LAS:CALMD?	NONE	Returns photodiode feedback responsivity.
LAS:CAL:LDI	NONE	Initiates laser current calibration.
LAS:CAL:LDI?	NONE	Queries if the instrument is ready for a current calibration value to be written.
LAS:CAL:LDV	NONE	Initiates laser voltage calibration.
LAS:CAL:LDV?	NONE	Queries if the instrument is ready for a voltage calibration value to be written.
LAS:CAL:MDI	NONE	Initiates laser photodiode calibration.
LAS:CAL:MDI?	NONE	Queries if the instrument is ready for a photodiode calibration value to be written.
LAS:COND?	NONE	Returns the value of the status condition register.
LAS:DEC	NONE	Decrements the selected laser control mode set point by one step.
LAS:DIS	1	Enables or disables the display and some LEDS.
LAS:DIS?	NONE	Returns the value shown on the display.
LAS:DIS:LDI	NONE	Sets the status of the laser display for constant current measurement.
LAS:DIS:LDI?	NONE	Returns the status of the laser display for constant current measurement.
LAS:DIS:LDV	NONE	Sets the status of the laser display for forward voltage measurement.
LAS:DIS:LDV?	NONE	Returns the status of the laser display for forward voltage measurement.
LAS:DIS:MDI	NONE	Sets the status of the laser display for monitor photodiode current measurement.
LAS:DIS:MDI?	NONE	Returns the status of the laser display for monitor photodiode current measurement.
LAS:DIS:MDP	NONE	Sets the status of the laser display for monitor photodiode power measurement.

LAS:DIS:MDP?	NONE	Returns the status of the laser display for monitor photodiode power measurement.
LAS:DIS:PARAM	NONE	Sets the status of the laser display to display parameters.
LAS:DIS:SET	NONE	Sets the display to show the setpoint for the presently selected display mode.
LAS:DIS:SET?	NONE	Returns the status of the setpoint mode display.
LAS:ENAB:COND	1	Sets the value of the condition status enable register.
LAS:ENAB:COND?	NONE	Returns the value of the condition status enable register.
LAS:ENAB:EVE	1	Sets the value of the status event enable register.
LAS:ENAB:EVE?	NONE	Returns the value of the status event enable register.
LAS:ENAB:OUTOFF	1	Sets the value of the status outoff enable register.
LAS:ENAB:OUTOFF?	NONE	Returns the value of the status outoff enable register.
LAS:EVENT?	NONE	Returns the value of the status event register.
LAS:LDI	1	Sets the output current.
LAS:LDI?	NONE	Returns the output current.
LAS:INC	0, 1, or 2	Increments the selected laser control mode set point by a number of steps.
LAS:LDV	1	Inputs a voltage value for voltage calibration.
LAS:LDV?	NONE	Returns the value of the measured voltage.
LAS:LIM:I2	1	Sets the current limit value for the 2000mA range.
LAS:LIM:I2?	NONE	Returns the current limit value for the 2000mA range.
LAS:LIM:I4	1	Sets the current limit value for 4000mA range.
LAS:LIM:I4?	NONE	Returns the current limit value for 4000mA range.
LAS:LIM:MDP	1	Sets the monitor photodiode power limit value.
LAS:LIM:MDP?	NONE	Returns the monitor photodiode power limit value.
LAS:LIM:V	1	Sets the compliance voltage limit value.
LAS:LIM:V?	NONE	Returns the compliance voltage limit value.
LAS:MDI	1	Sets the value of the photodiode current measurement when CALPD = 0.
LAS:MDI?	NONE	Returns the value of the photodiode current measurement when CALPD = 0.
LAS:MDP	1	Sets the value of the photodiode power measurement when CALPD > 0.
LAS:MDP?	NONE	Returns the value of the photodiode power measurement when CALPD > 0.
LAS:MODE?	NONE	Returns the instrument output mode.
LAS:MODE:IHBW	NONE	Sets the instrument to high bandwidth constant current output mode.
LAS:MODE:ILBW	NONE	Sets the instrument to low bandwidth constant current output mode.
LAS:MODE:MDP	NONE	Sets the instrument to constant power output mode.
LAS:OUT	1	Sets the status of the laser output.
LAS:OUT?	NONE	Returns the status of the laser output.
LAS:RAN	1	Sets the output current range.
LAS:RAN?	NONE	Returns the output current range.
LAS:SET:LDI?	NONE	Returns the output current setpoint value.
LAS:SET:MDI?	NONE	Returns the monitor photodiode current setpoint.

LAS:SET:MDP?	NONE	Returns the monitor photodiode power setpoint.
LAS:STEP	1	Sets the step size value.
LAS:STEP?	NONE	Returns the step size value.
LAS:TOL	2	Sets the current tolerance and time window.
LAS:TOL?	NONE	Returns the current tolerance and time window.
MES	1	Sets a stored string.
MES?	NONE	Returns a stored string.
RAD	1	Sets the radix type for status, condition, and event query response data.
RAD?	NONE	Returns the radix type for status, condition, and event query response data.
TERM	1	Sets the default terminator to include a carriage return.
TERM?	NONE	Returns the default terminator to include a carriage return.
TIME?	NONE	Returns the duration of time since the instrument was powered up.
TIMER?	NONE	Returns the duration of time since the last TIMER? query was issued.

LDX-3232 Device Dependent Command Reference

The following pages contain a reference for the device-dependent commands of the LDX-3232 High Compliance Current Source. This reference contains useful information for both local and remote operation of the LDX-3232.

In some reference, parentheses are used to signify the labeled are for a particular button or LED indicator on the front panel. For example, (PARAMETER) SET refers to the button labeled "SET" in the PARAMETER area of the front panel.

DELAY <nrf> FRONT PANEL **REMOTE**

The DELAY command causes the execution of commands to be delayed by a user-defined time. This command is similar to the *WAI common command, except that execution resumes after the specified number of milliseconds instead of waiting for the Operation-Complete flag to be set.

Description	Sets a single command execution delay.	
Parameters	An <nrf value> that represents the delay time in milliseconds.	
Notes	The Operation-Complete flag is held false until the delay period elapses, but the *OPC? Query will not execute until the delay period has elapsed. This command is useful for creating delays that don't require a lot of program code and don't tie up the GPIB during execution. Care should be taken to set the GPIB time-out appropriately for use with this command. The delay time is approximate, with an error of about ±10%.	
Examples	Write:	DELAY 500
	Action:	The next command or query is not executed until ~0.5 seconds have elapsed from the time this command is executed.

ERRors? FRONT PANEL **REMOTE**

The ERRors? query returns a list of command and device errors that have occurred since the last query. These errors are notated by a number that corresponds to the type of error that occurred. See Chapter 3 for information regarding error handling.

Description	Returns a list of errors that have occurred since the last query.	
Parameters	None.	
Examples	Query:	ERR?
	Response:	0 No errors reported.
	Query:	ERR?
	Response:	201 Out of range error was reported.

LASer:CALMD <nrf> FRONT PANEL REMOTE
LASer:CALMD?

Description	Sets/returns photodiode feedback responsivity.	
Parameters	An <nrf> value between 0 and 1000 in µA/mW.	
Notes	If the parameter is set to 0, the LDX-3232 will operate in a constant IPD mode, when Constant P (MDP) mode is selected.	
Examples	Write:	LAS:CALMD 1
	Action:	Sets the CAL PD parameter to 1 µA/mW.
	Query:	LAS:CALMD?
	Response:	2.5 Photodiode feedback responsivity is 2.5µA/mW.

LASer:CAL:LDI FRONT PANEL REMOTE
LASer:CAL:LDI?

Description	Initiates laser current calibration. Queries if the instrument is ready for a current calibration value to be written.	
Parameters	None	
Examples	Write:	LAS:CAL:LDI
	Action:	Enters calibration mode for LASER current.
	Query:	LAS:CAL:LDI?
	Response:	1 Instrument is ready for user to enter calibration value.

LASer:CAL:LDV FRONT PANEL REMOTE
LASer:CAL:LDV?

Description	Initiates laser voltage calibration. Queries if the instrument is ready for a voltage calibration value to be written.	
Parameters	None.	
Examples	Write:	LAS:CAL:LDV
	Action:	Enters calibration mode for LASER voltage.
	Query:	LAS:CAL:LDV?
	Response:	0 Instrument is not ready for user to enter calibration value.

LASer:CAL:MDI
LASer:CAL:MDI?

FRONT PANEL REMOTE

Description	Initiates laser photodiode calibration. Queries if the instrument is ready for a photodiode calibration value to be written.	
Parameters	None.	
Examples	Write:	LAS:CAL:MDI
	Action:	Enters the LASER photodiode current calibration mode.
	Query:	LAS:CAL:MDI?
	Response:	1 Instrument is ready for user to enter calibration value.

LASer:COND?

FRONT PANEL REMOTE

Description: Returns the value of the status condition register.

Notes: Response is the sum of the following:

1	LASER Current Limit	256	Output is shorted
2	LASER Voltage Limit	512	Output is outside tolerance limit
4	N/A	1024	Output on/off state
8	Power limit	2048	Ready for calibration data state
16	Interlock disabled	4096	N/A
32	N/A	8192	N/A
64	Compliance Voltage Limit	16384	N/A
128	Open circuit	32768	N/A

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

Examples	Query:	LAS:COND?
	Response:	513 LASER limit current and out of tolerance LASER conditions currently exist.

LASer:DEC

FRONT PANEL REMOTE

Description	Decrements the selected laser control mode set point by one step.	
Parameters	None.	
Notes	The minimum time to complete one decrement is about 20 ms.	
Examples	Write:	LAS:DEC
	Action:	The laser source current set point is decremented.

LASer:DISplay <bool>

FRONT PANEL REMOTE

Description	Enables or disables the display and some LEDS.	
Parameters	A <bool value>; - where 1 = on, 0 = off.	
Examples	Write:	LAS:DIS 1
	Action:	Turns the LASER display on.

LASer:DISplay? FRONT PANEL **REMOTE**

Description	Returns the value shown on the display.	
Parameters	None.	
Notes	Returns the actual (6-character) string from the output buffer to the display. If the display is disabled, it returns …	
Examples	Query:	LAS:DIS?
	Response:	-99.9
		LASER display shows -99.9

LASer:DISplay:LDI **FRONT PANEL** **REMOTE**
LASer:DISplay:LDI?

Description	Sets/returns the status of the laser display for constant current measurement.	
Parameters	None.	
Notes	The LDI measurement display mode is turned off automatically when another display selection is enabled.	
Examples	Write:	LAS:DIS:LDI
	Action:	Enables the display for current measurement.
	Query:	LAS:DIS:LDI?
	Response:	0
		LDI measurement is not displayed.

LASer:DISplay:LDV **FRONT PANEL** **REMOTE**
LASer:DISplay:LDV?

Description	Sets/returns the status of the laser display for forward voltage measurement.	
Parameters	None.	
Notes	The LDV measurement mode is turned off automatically when another display selection is enabled.	
Examples	Write:	LAS:DIS:LDV
	Action:	Enables the display for LDV measurement.
	Query:	LAS:DIS:LDV?
	Response:	1
		LDV measurement is displayed.

LASer:DISplay:MDI FRONT PANEL REMOTE
LASer:DISplay:MDI?
LASer:DISplay:MDP
LASer:DISplay:MDP?

Description	Sets/returns the status of the laser display for monitor photodiode current/power measurement.	
Parameters	None.	
Notes	The MDI/MDP measurement display is turned off automatically when another display selection is enabled.	
Examples	Write:	LAS:DIS:MDI
	Action:	Enables the display for photodiode current measurement.
	Query:	LAS:DIS:MDP?
	Response:	1
		Monitor photodiode power measurement is displayed.

LASer:DISplay:PARAM FRONT PANEL REMOTE

Description	Sets the status of the laser display to display parameters.	
Parameters	None.	
Notes	This command has the same effect as pressing the (PARAMETER) SELECT button while in LASER mode.	
	Each time the command is issued, the next LASER parameter will be selected and displayed.	
Examples	Write:	LAS:DIS:PARAM
	Action:	Displays the next parameter value.

LASer:DISplay:SET FRONT PANEL REMOTE

Description	Sets the display to show the setpoint for the presently selected display mode.	
Parameters	None.	
Notes	Using this command has the same effect as physically holding the (DISPLAY) button down continuously.	
Examples	Write:	LAS:DIS:SET
	Action:	Enables the display for the set point of the selected mode.

LASer:DISplay:SET? FRONT PANEL REMOTE

Description	Returns the status of the setpoint mode display.	
Parameters	None.	
Notes	The set point display will not time out when REMOTE operation is used. (It will be continuously displayed.)	
Examples	Query:	LAS:DISPLAY:SET?
	Response:	0
		The set point is not shown on the display.

LASer:ENABle:COND <nrf> FRONT PANEL **REMOTE**
LASer:ENABle:COND?

Description: Sets/returns the value of the condition status enable register.

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

1	LASER Current Limit	256	Output is shorted
2	LASER Voltage Limit	512	Output is outside tolerance limit
4	N/A	1024	Output on/off state
8	Power limit	2048	Ready for calibration data state
16	Interlock disabled	4096	N/A
32	N/A	8192	N/A
64	Compliance Voltage Limit	16384	N/A
128	Open circuit	32768	N/A

Examples

Write: LAS:ENAB:COND 129
Action: Enables the open circuit and current limit conditions.
Query: LAS:ENAB:COND?
Response: 17
Current limit and interlock disable conditions are enabled.

LASer:ENABle:EVEnt <nrf> FRONT PANEL **REMOTE**
LASer:ENABle:EVEnt?

Description: Sets/returns the value of the status event enable register.

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

1	LASER Current Limit	256	Output is shorted
2	LASER Voltage Limit	512	Output changed to be in/out of tolerance
4	N/A	1024	Output on/off state changed
8	Power limit	2048	New measurements taken
16	Interlock changed state	4096	N/A
32	N/A	8192	N/A
64	Compliance Voltage Limit	16384	N/A
128	Open circuit	32768	N/A

Examples

Write: LAS:ENAB:EVENT 136
Action: Enables the open circuit and power limit events to be reported.
Query: LAS:ENAB:EVE?
Response: 1040
Output on/off state and interlock state changed events were reported.

LASer:ENABle:OUTOFF <nrf>
LASer:ENABle:OUTOFF?

FRONT PANEL **REMOTE**

Description: Sets/returns the value of the status outoff enable register.

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

1	LASER Current Limit	256	N/A
2	LASER Voltage Limit	512	Output is out of tolerance*
4	N/A	1024	N/A
8	Power limit (with output on)	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

Examples

Write: LAS:ENAB:OUTOFF 9

Action: Enables the power limit and current limit conditions to turn off output if the conditions occur.

Query: LAS:ENAB:OUTOFF?

Response: 1

Current limit condition will turn off the output if it occurs.

LASer:EVENT?

FRONT PANEL **REMOTE**

Description: Returns the value of the status event register.

Parameters: None.

Notes: An <nrf value> whose sum represents the following:

1	LASER Current Limit	256	Output is shorted
2	LASER Voltage Limit	512	Output changed to be in / out of tolerance
4	N/A	1024	Output on / off state changed
8	Power limit	2048	Measurement ready
16	Interlock disabled	4096	N/A
32	N/A	8192	N/A
64	Compliance Voltage Limit	16384	N/A
128	Open Circuit	32768	N/A

Examples

Query: LAS:EVE?

Response: 513

Output tolerance changed and current limit events have occurred.

LASer:INC <nrf,nrf>

FRONT PANEL **REMOTE**

Description	Increments the selected laser control mode set point by a number of steps.	
Parameters	None, 1, or 2. First optional parameter is the number of steps. Second optional parameter is the time in milliseconds between steps. The minimum time to complete one decrement is about 20 ms.	
Examples	Write:	LAS:INC
	Action:	The laser source current set point is incremented one step.
	Write:	LAS:INC 0
	Action:	Does nothing.
	Write:	LAS:INC 3,5000
	Action:	The laser source current set point is incremented by 0.3 mA with 5 seconds between steps.

LASer:LDI <nrf>

FRONT PANEL **REMOTE**

Description	Sets/returns the output current.	
Parameters	An <nrf value> in mA.	
Examples	Write:	LAS:LDI 400
	Action:	Sets the laser output current to 400mA.
	Query:	LAS:LDI?
	Response:	100 Laser output current is 100mA.

LASer:LDV <nrf>

FRONT PANEL **REMOTE**

Description	Inputs a voltage value for voltage calibration.	
Parameters	An <nrf value> in volts.	
Examples	Write:	LAS:LDV 4
	Action:	Enters a value of 4.000 V.

LASer:LDV?

FRONT PANEL **REMOTE**

Description	Returns the value of the measured voltage.	
Parameters	None.	
Notes	This measurement is updated approximately once every 600ms.	
Examples	Query:	LAS:LDV?
	Response:	3.03 Measured output voltage is 3.03 V.

LASer:LIMit:I2 <nrf> FRONT PANEL REMOTE
LASer:LIMit:I2?

Description	Sets/returns the current limit value for the 2000mA range.	
Parameters	An <nrf value> in mA.	
Notes	The current limit is in effect in all modes of operation (ILBW, IHBW, or P). The current limit in use depends on the LASER output range selection.	
Examples	Write:	LAS:LIM:I2 180
	Action:	Current limit is set to 180mA.
	Query:	LAS:LIM:I2?
	Response:	50
		Current limit is set to 50mA.

LASer:LIMit:I4 <nrf> FRONT PANEL REMOTE
LASer:LIMit:I4?

Description	Sets/returns the current limit value for the 4000mA range.	
Parameters	An <nrf value> in mA.	
Notes	The current limit is in effect in all modes of operation (ILBW, IHBW, or P). The current limit in use depends on the LASER output range selection.	
Examples	Write:	LAS:LIM:I4 1800
	Action:	Current limit is set to 1800mA.
	Query:	LAS:LIM:I4?
	Response:	1500
		Current limit is set to 1500mA.

LASer:LIMit:MDP <nrf> FRONT PANEL REMOTE
LASer:LIMit:MDP?

Description	Sets/returns the monitor photodiode power limit value.	
Parameters	An <nrf value> in mW.	
Notes	When constant MDP mode is used, the output level is limited only by the LIM Ix value. Exceeding the power limit will either cause the output to shut off (default) or generate a warning.	
Examples	Write:	LAS:LIM:MDP 10
	Action:	Monitor photodiode power limit is set to 10mW.
	Query:	LAS:LIM:MDP?
	Response:	5
		Monitor photodiode power limit is set to 5mW.

LASer:LIMit:V <nrf> FRONT PANEL REMOTE
LASer:LIMit:V?

Description:	Sets/returns the compliance voltage limit value.	
Parameters	An <nrf value> in volts.	
Examples	Write:	LAS:LIM:V 5.0
	Action:	Compliance voltage limit is set to 5.0V.
	Query:	LAS:LIM:V?
	Response:	4.5
		Compliance voltage limit is set to 4.5V.

LASer:MDI <nrf> FRONT PANEL REMOTE
LASer:MDI?

Description	Sets/returns the value of the photodiode current measurement when CALPD = 0.	
Parameters	An <nrf value> in µA.	
Notes	If the CALMD (CAL PD) parameter is not set to 0, the LAS:MDI value will not be used. In this case, the measured MDI would be converted to MDP (PPD, by the CAL PD factor), and the MDP (PPD) set point would be used.	
Examples	Write:	LAS:MDI 40
	Action:	Output is controlled to provide a constant 40µA photodiode feedback current.
	Query:	LAS:MDI?
	Response:	200
		Photodiode feedback current measurement is 200µA.

LASer:MDP <nrf> FRONT PANEL REMOTE
LASer:MDP?

Description	Sets/returns the value of the photodiode power measurement when CALPD > 0.	
Parameters	An <nrf value> in mW.	
Notes	If the CALMD (CAL PD) parameter is set to 0, the LAS:MDP value will not be used. In this case, the measured MDP would be invalid, and the MDI (IPD) set point would be used.	
Examples	Write:	LAS:MDP 40
	Action:	Output is controlled to provide a constant 40mW photodiode feedback power.
	Query:	LAS:MDP?
	Response:	200
		Photodiode feedback power measurement is 200mW.

LASer:MODE? FRONT PANEL REMOTE

Description	Returns the instrument output mode.
Parameters	None.

Examples	Query:	LAS:MODE?
	Response:	ILBW
		Instrument is in Low Bandwidth constant current mode.

LASer:MODE:<string> FRONT PANEL REMOTE

Description	Sets the instrument output mode.	
Parameters	String representing output mode.	
	ILBW	Low bandwidth constant current mode.
	IHBW	High bandwidth constant current mode.
	MDP	Constant power mode.
Examples	Write:	LAS:MODE:IHBW
	Action:	Sets output mode to high bandwidth constant current mode.

LASer:OUTput <bool> FRONT PANEL REMOTE
LASer:OUTput?

Description	Sets/returns the status of the laser output.	
Parameters	A <bool value>; 1=on, 0=off.	
Examples	Write:	LAS:OUT ON
	Action:	Turns on the laser output.
	Query:	LAS:OUT?
	Response:	0
		Laser output is off.

LASer:RANge <nrf> FRONT PANEL REMOTE
LASer:RANge?

Description	Sets/returns the output current range.	
Parameters	An <nrf value> that represents the output current range.	
	2 = 2000 mA	
	4= 4000 mA range	
Notes	This range setting effects the Laser Drive Current output current range only. The Laser Drive Current output should be “off” when this command is issued. If the Laser Diode Current output is “on” when this command is issued, the LDX-3232 will generate error E515, and the range will not be changed.	
Examples	Write:	LAS:RAN 4
	Action:	Sets the current range to 4000mA.
	Query:	LAS:RAN?
	Response:	2
		Current range is 2000mA.

LASer:SET:LDI? FRONT PANEL REMOTE

Description	Returns the output current setpoint value.
Parameters	None.

Examples	Query:	LAS:SET:LDI?
	Response:	50.0

LASer:SET:MDI? FRONT PANEL REMOTE

Description	Returns the monitor photodiode current setpoint.	
Parameters	None.	
Examples	Query:	LAS:SET:MDI?
	Response:	30.0, Monitor photodiode feedback current is set point is 30µA.

LASer:SET:MDP? FRONT PANEL REMOTE

Description	Returns the monitor photodiode power setpoint.	
Parameters	None.	
Examples	Query:	LAS:SET:MDP?
	Response:	10.0 Monitor photodiode feedback power set point is 10.0mW

LASer:STEP <nrf> FRONT PANEL REMOTE
LASer:STEP?

Description	Sets/returns the step size value.	
Parameters	An <nrf value> value between 1 to 9999 in 0.1mA.	
Notes	The step of one corresponds to the smallest display resolution for the mode. For example, a step of one means 0.1mA, 0.1mW, or 1µA (if CALPD=0).	
Examples	Write:	LAS:STEP 100
	Action:	Sets the step size to 10mA, 10mW, or 100µA. Dependent on instrument setup.
	Query:	LAS:STEP?
	Response:	3 Step size is 0.3mA, 0.3mW, or 3µA. Dependent on instrument setup.

LASer:TOLerance <nrf,nrf> FRONT PANEL REMOTE
LASer:TOLerance?

Description	Sets/returns the current tolerance and time window.
Parameters	Two <nrf values> The first is current tolerance in mA with a range of 0.1 to 100.0mA. The second is the time window in seconds with a range of 0.001 to 50.000 seconds.
Notes	Operation complete flag will bet set when the conditions are met. The LDX-3232 defaults to a tolerance of 1.0 mA for three seconds, unless changed by the LASer:TOLerance command. If the LDX-3232 is operated in P mode, the current tolerance parameter is not used. Instead a fixed value of 50µA is used for the IPD current. A fixed value of 1mW is used for PPD power, and only the time window parameter may be adjusted.

If the tolerance is set too tight it may never be achieved. This is due to the calibration of the setpoint and measurement values.

Examples
Write: LAS:TOL 0.5,10
Action: Current source will be in tolerance when the current is within 0.5 mA for 10.000 seconds.
Query: LAS:TOL?
Response: 1.0,20.0
Tolerance setting of 1mA with a time window of 20 seconds.

MESsage <string> FRONT PANEL **REMOTE**
MESsage?

Description: Sets/returns a stored string.
Parameters: An ASCII string that is 1 - 16 bytes in length.
Examples
Write: MESSAGE "This is a test."
Action: "This is a test." will be stored in non-volatile memory.
Query: MESSAGE?
Response: Test 3
"Test 3" is stored in non-volatile memory.

RADix <string> FRONT PANEL **REMOTE**
RADix?

Description: Sets/returns the radix type for status, condition, and event query response data.
Parameters
BIN Binary
OCT Octal
DEC Decimal
HEX Hexadecimal
Notes: DECimal is the default type.
Examples
Write: RAD DEC
Action: Decimal radix is selected.
Query: RAD?
Response: HEX
Hexadecimal radix is selected.

TERM <bool> FRONT PANEL **REMOTE**
TERM?

Description	Sets/returns the default terminator to include a carriage return.	
Parameters	A <bool value>, 0=FALSE, non-zero=TRUE	
Notes	An altered terminator will be in the form <CR><NL><^END>. This technically takes the LDX-3232 out of GPIB/IEEE488 specification, but may be done for convenience when using nonstandard GPIB controllers. This termination will be sent with all output until the TERM 0 command is sent or the LDX-3232 is powered off.	
Examples	Write:	TERM 1
	Action:	Sets <CR><NL><^END> as the output terminator.
	Query:	TERM?
	Response:	0 <NL><^END> is set as the output terminator.

TIME? FRONT PANEL **REMOTE**

Description	Returns the duration of time since the instrument was powered up.	
Parameters	None.	
Examples	Query:	TIME?
	Response:	1:02.36 Instrument has been powered up for one minute and 2.36 seconds.

TIMER? FRONT PANEL **REMOTE**

Description:	Returns the duration of time since the last TIMER? query was issued.	
Parameters	None.	
Notes	Each time the TIMER? query is issued, the timer is reset to 0 and the elapsed time since the last TIMER? query is returned.	
Examples	Query:	TIMER?
	Response:	00:02:00.31 Two minutes and 0.31 seconds have elapsed since the last TIMER? query was issued.

Chapter 5 :
Functions and Features

This chapter introduces LDX-3232 High Compliance Current Source functions and operating features such as event triggering, analog modulation of laser injection current, and save and recall.

- ✓ Saving and Recalling
- ✓ Modulating the Current Source

Saving and Recalling from the Front Panel

For applications where alternation between particular instrument configurations is needed, the LDX-3232 Current Source offers a SAVE and RECALL feature. The SAVE feature allows easy storage of all front panel settings for any given instrument configuration. These settings, that are stored in one of ten memory bins, can be retrieved at any time with the RECALL function. This saves setup time and it reduces the chance of setup error for tests that are periodically repeated.

To enter the SAVE/RECALL mode, press the SELECT button in the PARAMETER section until the SAVE indicator LED becomes lit and the unit displays the SAVE bin on the display. If another bin number is desired, press and hold the SET button and rotate the adjust knob until the desired bin number is displayed. Releasing the SET button completes the SAVE operation and all of the instrument parameters are saved to the indicated bin number as they appear on the front panel.

To recall a previously saved instrument setup, press the SELECT button until the RECALL indicator led becomes lit. The instrument will display a RECALL bin number on the display. If another bin number is desired, press and hold the SET button and rotate the adjust knob until the desired bin number is displayed. Releasing the SET button completes the RECALL operation. The instrument is restarted and the front panel parameters are reconfigured to the new parameters saved under that bin number.

Table 5.1 LDX-3232 Default Settings (Bin 0)

GPIB mode in LOCAL via front panel REMOTE via GPIB	Output off
PARAMETERS not selected	DISPLAY enabled, in I mode
CAL PD = 0 µA / mW	Constant I, low bandwidth mode selected
LIM I (high range) = 1000 mA	I setpoint = 0 mA
LIM I (low range) = 500 mA	I_{PD} setpoint = 0 µA
LIM V = 15 volts	P_{PD} setpoint = 0 mW
LIM P = 5000 mW	RECALL BIN number = 0

The factory default values for front panel parameters may be restored by recalling bin zero (0).

Saving and Recalling Under Remote Operation

For saving under remote operation, use the command *SAV x, where x is the desired bin number (1-10). For a recall under remote operation, use the command *RCL x, where x is the desired bin number (0 - 10).

Using the Laser Compliance Voltage Adjustment

For applications where critical protection of the laser is required, ILX Lightwave recommends the following. Using a 1 Ω resistor or other non-critical load, set the LASER voltage limit as described in Chapter 2.

Then with the LASER output on, slowly increase the LASER current and watch the LASER voltage measurement. Press the (DISPLAY) SELECT push button to see the voltage. At about 0.25 V below the LASER voltage limit value, the VOLTAGE LIMIT warning indicator will become lit on the display. Continue to adjust the current upwards until the voltage limit is reached and the output is shut off. Record the voltage at that the LASER output shuts off. It should be within the specification of the LASER voltage limit accuracy. However, there is typically some offset error. For example, if the LASER voltage limit is set to 5.0 V, the actual voltage where it shuts off may be 4.9 V. This error term of 0.1 V should be considered when setting the LASER compliance voltage limit.

The closer the LASER voltage limit shut off point is to the operating voltage of the laser, the faster the circuit will work in the event of an open circuit. Some experimentation may be necessary for optimum results.

Using the LDX-3232 Current Source's Trigger Function

For applications where synchronous initiation of measurement tasks is required from a remote instrument with the LDX-3232 Current Source, the Current Source offers a trigger output signal. The TTL pulse is initiated with any remote change in set point of the laser current source.

The trigger output is available via a standard BNC connector on the rear panel of the LDX-3232 Current Source. See Figure 1.2. The TTL pulse is approximately 13µs wide and has a delay time of about 10-12ms after the current set point is changed via GPIB. This delay does not include the GPIB transmission time. The time for any command to be sent via GPIB depends on the interface hardware and software control. The current set point may be changed by the LAS:LDI, LAS:INC, or LAS:DEC commands.

> **Note:** The minimum step change time required for a corresponding trigger pulse is 20ms. Care should be used with respect to the timing of any set point commands in relation to the actual hardware function. The INC and DEC commands have a minimum step time of about 20ms that allows for the hardware initiation of a set point change and the settling of the output. The LAS:LDI command does not have any fixed delay for settling. With this command, some trigger pulses may be missed if the program step time is less than the 20ms minimum.
>
> A one shot trigger pulse will occur on power up of the instrument due to the states of the processor I/O.

Using the LDX-3232's BNC Interlock Connection

The LDX-3232 BNC interlock connection is designed to allow an external emergency input signal to turn the current output off. The BNC interlock is TTL compatible and configured to be normally closed (as opposed to the DB-9 interlock connection that is normally open). The BNC interlock connection, when left unconnected, is pulled to a logic high with a 100kΩ resistor. High values (+5 V) will keep the current source in the operational state, while low values (0 V) will force the output off. Once the BNC interlock forces the output off, the output will stay off until the interlock is closed again, and the output is re-enabled.

BNC Interlock Usage Example

When using the LDX-3232 Current Source to drive a temperature controlled laser diode, the BNC interlock can be used to accept an error signal from the laser diode temperature controller unit. Linking the LDX-3232 Current Source to a temperature controller* with the ability to signal when its temperature control has gone outside of some tolerance window will allow the LDX-3232 to safely shutoff its output before thermal damage occurs to the laser diode.

> *The ILX Lightwave LDT-5900 series of temperature controllers include an output BNC connector that is compatible with the BNC interlock feature of the LDX-3232. The output BNC connector of the LDT-5900 has a TTL compatible output signal that will signal when the temperature control has gone outside of a programmable temperature window.

Entering Photodiode Responsivity Values

The photodiode responsivity (CAL PD) is used to convert between photodiode current and optical power of the laser diode.

To enter the CAL PD parameter, use the following steps:

1. Calculate photodiode responsivity:
    a. Measure (with a calibrated detector) the output power of the device.
    b. Measure the corresponding photodiode current (I_{PD}).
    c. Calculate the responsivity by dividing photodiode current by the optical power.
2. Select CAL PD with the (PARAMETER) SELECT button.
3. Enter the calculated photodiode responsivity from step 1.
    a. If the CAL PD value is 0, the instrument will be put into a special mode where the current output will be controlled by the I_{PD} value.

This value will determine the output power of the instrument while in constant power mode.

Modulating the Laser Current Source

The LDX-3232 Current Source allows a modulated signal to be superimposed on the source output current. The allowable bandwidth of the modulated analog signal, defined as the 3dB roll off point, is dependent on the output current range and the mode (constant current low/high bandwidth). See Chapter 1 for external analog modulation bandwidth specifications.

To set up the current source for modulated laser injection current, use the following steps:

1. Connect the modulation source signal to the instrument via the (MOD) EXTERNAL BNC connector on the front panel.
2. Set the LDX-3232 to the appropriate bandwidth constant current mode by pressing the (MODE) SELECT button on the front panel.
    a. Low bandwidth mode uses a low pass filter to reduce noise. This results is slower rise/fall times.
    b. High bandwidth mode does not use a low pass filter. Use this mode to get faster rise/fall times.
3. Select the appropriate current source range. The output must be off in order to change ranges.
4. Turn on the LDX-3232 output.
5. Turn on the modulation source output.
    a. If the modulation source output is turned on before the LDX-3232 output, it can trigger limit errors

Notes: The limit clamp function for DC output current also applies to the modulated current, protecting the laser in any mode.

The current limit setting is independent of the voltage drop of the device connected to the laser output, and therefore, no dummy load is required for precise adjustment of the current limit. Furthermore, since the current limit circuitry is fully independent of the main current control, the current limit can be adjusted safely, even while the current source output is active.

When the LDX-3232 current output is off, an internal short is placed across the output. This short will prevent the modulation signal from reaching the device under test. Thus, it is safe to disconnect the device when the LDX-3232's output is off, regardless of the presence of the modulation signal.

Chapter 6 :
Calibration and Troubleshooting

This chapter described the calibration of the LDX-3232 Series Current Source. Descriptions of the required test instruments, calibration conditions, and the detailed procedures for calibration are included. A troubleshooting guide is offered for some of the more common failure symptoms.

- ✓ Local Calibration
- ✓ Remote Calibration
- ✓ Troubleshooting Guide

WARNING

Potentially lethal voltages exist within the LDX-3232 High Compliance Current Source. To avoid electric shock, the user should not perform any of the maintenance on the instrument unless qualified to do so. Qualified service personnel are required to wear protective eyeglasses and anti-static wristbands while working on the LDX-3232 High Compliance Current Source circuit boards. High voltages are present on and around the instrument's printed circuit boards.

CAUTION

High voltages are present on and around the printed circuit boards of the LDX-3232 High Compliance Current Source.

Calibration Overview

There are several calibrations to be performed to completely calibrate the LDX-3232 Current Source. The Laser Diode Current Source calibration consists of calibrating the current source in both ranges and both modes (low and high bandwidth), calibrating the photodiode monitor feedback and finally the forward voltage measurement. The current limits are calibrated internally by the instrument as part of the calibration process.

The LDX-3232 Current Source can be calibrated with the case closed. It should be calibrated every 12 months or whenever performance verification indicates that calibration is necessary, such as differences between set point and measurement display values that exceed the accuracy specification. Calibrate the instrument under laboratory conditions. Recommended calibration temperature is at 23°C ± 1.0°C. When necessary, however, the LDX-3232 Current Source may be calibrated at its intended use temperature if this is within the specified operating temperature range of 0 to 40°C.

Finally, the LDX-3232 Current Source should be allowed to warm up for at least one hour before beginning calibration.

Recommended Equipment

Recommended test equipment for calibrating the LDX-3232 Current Source is listed in Table 6.1. Equipment other than that shown in the table may be used if the specifications meet or exceed those listed.

Table 6.1 Recommended Test Equipment

DESCRIPTION	MFG / MODEL	SPECIFICATION
DMM	HP 3457A	DC Amps (@ 1.0A): ±0.02% Resistance (@ 10Ω): 0.02% 0.1 μA or 0.1 mW resolution

It will be necessary to connect various loads and circuits to the outputs of each current source for the calibration procedure. A schematic is shown in Figure 6.1 for the photodiode calibration circuit with the required components listed in the table below. Devices required for other calibration loads are also listed in the table below.

Table 6.2 Calibration Circuit Components

Laser Current Source Calibration	
Current Source Calibration, all models	10Ω, 20W resistor, low TCR
Voltage Measurement Calibration	15Ω, 5W resistor, low TCR
PD Monitor Calibration (See Schematic in Figure 6.1)	
PD Calibration Circuit	
R1	49Ω resistor, 1%, 1/4W
R2	100Ω resistor, 1%, 1/4W
R4	1.0MΩ resistor, 1%, 1/4W
R3	5Ω, 1%, 10W
U1	TIL 117 opto-isolator

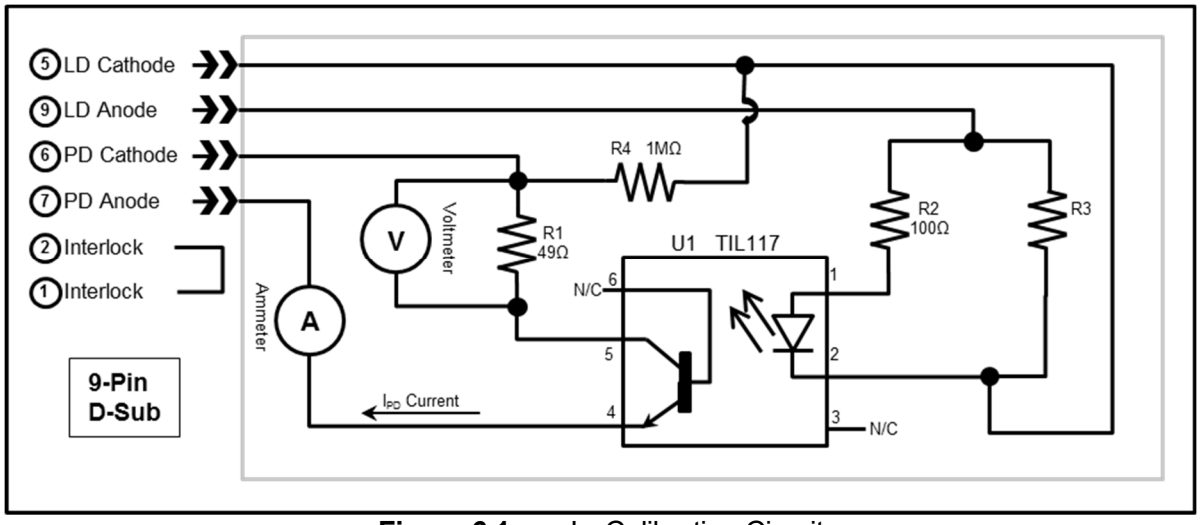


Figure 6.1 I_{pn} Calibration Circuit

Calibration of the LDX-3232 Current Source

There are three calibration adjustments required for the LASER current source of the LDX-3232 Current Source. They are:

- Calibration of the constant current source for both bandwidths and ranges.
- Calibration of the laser voltage measurement.
- Calibration of the constant light power (I_{PD}) feedback circuits.

The LDX-3232 Current Source implements a two-point calibration for the Laser current source. Two currents (approximately 80% and 20% of FS) are applied to a test load, and the resulting actual currents are fed back (by the user) to the Current Source. The Laser Current Source calibration program uses the two sets of data to calculate new calibration constants. These calibration constants are used to set the actual current output of the current source.

Calibration can be done either locally via the front panel of the instrument or remotely through GPIB commands.

> **Note:** The operation complete flag (bit 0 of the ESR) may be used to trigger a service request. This type of interrupt is enabled by setting bit 0 of the SRE register (via the *ESE command) and bit 5 of the SRE register (via the *SRE command). Service request (SRQ) handling depends on the GPIB hardware in use. Refer to the GPIB hardware user's manual for details on how service requests are handled.
>
> After a calibration value is entered, the *OPC? query may be used to determine when the calibration sequence is done. However, the *OPC, *WAI commands, or *OPC? query should not be issued until after the expected calibration value is entered, or the system will hang. This happens because the LDX-3232 Current Source will wait indefinitely for an input, yet not allow any input until the calibration is finished.

Current Source Calibration

The following procedure is for calibrating each range of the current source. Calibration must be performed on both bandwidth modes. A total of four calibrations will be performed on the current source. Start with the low range, low bandwidth mode. Configure the Laser Current Source in the following state:

Table 6.3 Current Calibration Configuration Setup

Function	State	GPIB Command
LASER MODE	I (constant current low bandwidth) I (constant current high bandwidth)	LAS:MODE:ILBW LAS:MODE:IHBW
RANGE	low (lowest per instrument model)	LAS:RAN <nrf>
CURRENT LIMIT	90% of FS (full scale of range)	LAS:LIM:Ix <nrf>
SETPOINT	80% of FS	LAS:LDI <nrf>

a. Measure and record the resistance of a 1Ω, 20 W resistor (A 4-wire resistance measurement is recommended.) Connect the load resistor across the LASER output terminals (Laser Anode and Laser Cathode) on the 9 pin connector of the rear panel.
b. Connect the calibrated DMM across the load resistor. Configure the multimeter to measure voltage in volts. The actual Laser current will be calculated in the following manner using Ohm's Law.

$$I = \frac{V}{R}$$

where V is the accurately measured voltage across the resistor, and R is the accurately measured load resistance in Ohms. I is the actual Laser current in Amps.

Note: Check the current measuring range of the multimeter. Laser Output current may be measured in mA by connecting the meter directly to the outputs of the Laser Current Source.

c. The laser output must be turned on to begin laser current calibration mode:
   i. Local: Press the (MODE) ON button.
   ii. Remote: Write the LAS:OUTPUT ON command.
d. Enter LASER current calibration mode:
   i. Local: Press (GPIB) LOCAL and (DISPLAY) SELECT buttons at the same time.
   ii. Remote: Write the LAS:CAL:LDI command.

   The display will blank and the Current Source will drive the current output to the set point and the Display will indicate output current in mA.
e. Calculate the actual current through the load as described in step ***b***.
   i. Local: Press and hold in the (PARAMETER) SET button and turn the adjust knob until the display indicates the calculated actual current.
   ii. Remote: Write the LAS:LDI <nrf> command, where <nrf> is the actual measured output current.

   Note: Querying the LAS:CAL:LDI? query and receiving a response of 1 means that the instrument is ready to receive a calibration value.

f. The current source will drive the current output to approximately 25% of the first calibration set point when the following actions occur:
   i. Local: Releasing the (PARAMETER) SET button to store the first calibration value.
   ii. Remote: Writing the LAS:LDI <nrf> command to store the first calibration value.

g. Repeat step ***e***.
h. Once the second actual value is entered, the new calibration constants will be calculated and stored into non-volatile memory. In low bandwidth mode calibration mode, the LDX-3232 Current Source will also perform current limit calibration as indicated by the CURRENT LIMIT LED flashing.
   i. If performing a remote calibration, the *OPC? query may be used after the LAS:LDI <nrf> command is sent to determine when the calibration is completed.
i. Turn the current source output off:
   i. Local: Press the (MODE) ON button.
   ii. Remote: Write the LAS:OUTPUT OFF command.
j. Change the Mode to IHBW (high bandwidth constant current mode):
   i. Local: Press the (MODE) SELECT button until the I_{HBW} LED is lit.
   ii. Remote: Write the LAS:MODE:IHBW command.
k. Repeat the calibration procedure as described above.
l. Change the output range to high range and repeat the calibration procedure as described above.

I_{PD} Current Calibration

The following procedure is for calibrating the LASER I_{PD} (PD monitor) set point and measurement. This procedure calibrates the feedback circuits for constant I_{PD} and constant P_{PD} modes. When these values are reached and are stable, the user enters the actual value of the monitor current, measured with a DMM. The LDX-3232 Series Current Source then automatically calibrates the LASER feedback circuits.

Configure the Current Source in the following manner for the Laser Current Source calibration:

Table 6.4 Power Calibration Configuration Setup

Function	State	GPIB COMMAND
MODE	P (constant power)	LAS:MODE:MDP
CAL PD	set equal to zero	LAS:CALMD 0
CURRENT LIMIT	90% of FS (full scale of range)	LAS:LIM:Ix
I_{PD} SETPOINT	80% of FS	LAS:MDI <nrf>

a. With the LASER output off, connect a calibrated ammeter to the PD Anode output of the Laser Current Source output connector (9 pin on rear panel), and connect the circuit of Figure 6.1 to the LASER and PD outputs with the correct load resistor for the Current Source model under calibration (See Table 6.2).

> **Note:** If a precision ammeter is not available, use a zero-Ohm jumper in place of the ammeter. Then, place a calibrated DMM (with 0.1 mV resolution) to measure the voltage across the resistor, R1, as shown in Figure 6.1. Calculate the current in the following steps by using Ohm's Law:
>
> $$I = \frac{V}{R}$$
>
> where V is the accurately measured voltage across the resistor, and R is the accurately measured load resistance in Ohms. I is the actual Laser current in Amps.

b. The laser output must be turned on to begin the power calibration mode:
   i. Local: Press the (MODE) ON button.
   ii. Remote: Write the LAS:OUTPUT ON command.

   After the output is on, verify proper operation. The I_{PD} measurement (via the DMM) and set point should be close, and the unit should not be in current limit.

c. Enter I_{PD} Current Calibration Mode:
   i. Local: Press the (GPIB) LOCAL and FINE buttons at the same.
   ii. Remote: Write the LAS:CAL:MDI command.

   After a few seconds the display will show the I_{PD} set point value.

d. Wait for the value on the display to stabilize (has not changed by more than one digit for several seconds). When this has occurred, the LDX-3232 Current Source is ready for the actual I_{PD} value to be entered.
   i. Local: Press and hold in the (PARAMETER) SET button and turn the adjust knob until the display shows the actual monitor current, as shown on the calibrated ammeter (or the calculated I_{PD} value from Step ***a***).

ii. Remote: Write the LAS:MDI <nrf> command, where <nrf> is the actual monitor current, as shown on the calibrated ammeter (or the calculated I_{PD} value from Step ***a***.)

e. The current source will drive the current output to approximately 25% of the first calibration set point when the following actions occur:
   i. Local: Releasing the (PARAMETER) SET button to store the first calibration value.
   ii. Remote: Writing the LAS:MDI <nrf> command to store the first calibration value.
f. Repeat Step ***d***.
g. The current source will calculate the calibration constants and store them to non-volatile memory when the following actions occur:
   i. Local: Releasing the (PARAMETER) SET button to store the second calibration value.
   ii. Remote: Writing the LAS:MDI <nrf> command to store the second calibration value.

Laser Forward Voltage Measurement Calibration

The following procedure is for calibrating the LASER voltage measurement. Configure the Current Source in the following manner for the Laser Current Source Voltage calibration:

Table 6.5 Voltage Calibration Configuration Setup

Function	State	GPIB Command
LASER MODE	I (constant current low bandwidth)	LAS:MODE:ILBW
RANGE	2000 mA	LAS:RAN 2
CURRENT LIMIT	Set to FS (full scale of range)	LAS:LIM:I2 2000
I SETPOINT	800 mA	LAS:LDI 800

a. With the current source output off, connect a calibrated voltmeter, in parallel with a resistor (15Ω, 5W), to the LASER output (Laser Anode and Laser Cathode) on the rear panel of the Current Source.
b. The laser output must be turned on to beg laser voltage calibration mode:
   i. Local: Press the (MODE) ON button.
   ii. Remote: Write the LAS:OUTPUT ON command.
c. Enter LASER voltage calibration mode:
   i. Local: Press the (GPIB) LOCAL and RANGE buttons at the same time.
   ii. Remote: Write the LAS:CAL:LDV command.

   The display will blank and the Current Source will drive the LASER current output to the respective set point and the display will indicate forward voltage in Volts.
d. Enter the measured voltage (in volts):
   i. Local: Press and hold in the (PARAMETER) SET button and turn the adjust knob until the display indicates the measured voltage.
   ii. Remote: Write the LAS:LDV <nrf> command, where <nrf> is the actual voltage, as shown on the calibrated ammeter.
e. The current source will drive the current output to approximately 25% of the first calibration set point when the following actions occur:
   i. Local: Releasing the (PARAMETER) SET button to store the first calibration value.
   ii. Remote: Writing the LAS:LDV <nrf> command to store the first calibration value.
f. Repeat Step ***d*** to enter the second measured voltage.
g. The Current Source will store the calibration constants and store them to non-volatile memory when the following actions occur:
   i. Local: Releasing the (PARAMETER) SET button to store the second calibration value.
   ii. Remote: Writing the LAS:LDV <nrf> command to store the second calibration value.

This ends the section on calibration of the LDX-3232 Current Source.

Troubleshooting Guide

This section is a guide to troubleshooting the LDX-3232 Current Sources. More common symptoms are listed here, and appropriate troubleshooting actions are given. The user is recommended to start at the beginning of this guide. Read the symptom descriptions, and follow the steps for the corrective actions that apply. If a problem encountered is beyond the scope of this guide, contact an ILX Lightwave customer service representative.

Table 6.6 Troubleshooting Guide

Symptom	Corrective Actions
GENERAL	
LDX-3232 unit will not power up	Check AC power line voltage and power cord connection.
Power on, but display is frozen and buttons don't operate	Instrument may have lost power (AC line) briefly. Cycle power to restart.
• Displays E514 on power up on display • Instrument resets at power up or any LASER mode change	Hold (GPIB) LOCAL button, RANGE button and FINE button as the instrument powers up. This clears the laser board EEPROM, LLLLL will be displayed on the display; **the laser current source must be recalibrated.**
LASER CURRENT SOURCE	
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. If OPEN CIRCUIT indicator is lit, check the load connections and then try again. Check the OUTPUT ON button, the corresponding LED should be lit.
Output current at limit; can't be lowered	If POWER mode is used, check the monitor diode (feedback) connections; try reversing the polarity of the monitor photodiode; check the photodiode bias adjustment on the rear panel. If in I or I_{HBW} mode, check the current setpoint and I LIMIT setting; setting the output below the limit may require several turns of the adjust knob if the setpoint is much greater than the desired limit setting.
Output goes off intermittently	Check the interlock circuit; an intermittent interlock will turn the output off. Check that 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.
Unable to adjust output	Check the I LIMIT parameter for the output range in use; see that it is set above 0 mA.
Power mode operation has high output current, but little or no power measured	Check back panel PD BIAS; if set too low, may act as an open feedback loop; if in doubt, set the PD BIAS to mid-range (2.5 V)
Output exceeds power limit	The "power limit" is not a hardware limit. It only serves as a warning that the power measurement has exceeded the limit setpoint. Normally this limit will cause the output to shut off. This feature can be disabled via the LAS:ENABLE:OUTOFF command.
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.
VOLTAGE LIMIT indicator blinks	This indicates a voltage limit error; check laser connections. High impedance may cause this condition.
Open circuit error E503 or voltage limit error E505 prevents output from reaching desired value	The LDX-3232 instrument has an adjustable laser compliance voltage. Check to see if the LASER voltage limit setting is too low (Chapter 2); check laser connections.