User's Guide

Laser Controller Modules
LDC-3916370 Series
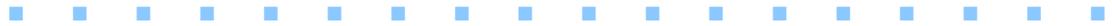
ILX Lightwave®

A Newport Corporation Brand

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SAFETY AND WARRANTY INFORMATION

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

Safety Information and the Manual

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

⚠ **CAUTION**

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

⚠ **WARNING**

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

☢ **WARNING**

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

General Safety Considerations

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

- Visible damage

- Severe transport stress

- Prolonged storage under adverse conditions

- Failure to perform intended measurements or functions

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

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

SAFETY SYMBOLS

This section describes the safety symbols and classifications.

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

- Indoor use only

- Ordinary Protection: This product is NOT protected against the harmful ingress of moisture.

- Class I Equipment (grounded type)

- Mains supply voltage fluctuations are not to exceed ±10% of the nominal supply voltage.

- Pollution Degree 2

- 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 ñ40 ×C to 70 ×C

- Maximum altitude: 3000 m (9843 ft)

- This equipment is suitable for continuous operation.

Safety Marking Symbols

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

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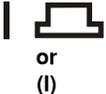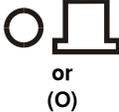
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WARRANTY

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

Limitations

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

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

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

Returning an Instrument

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

1   Obtain a Return Authorization number (RA) from ILX Customer Service.

2   Attach a tag to the instrument identifying the owner and indicating the required service or repair. Include the instrument serial number from the rear panel of the instrument.

3   Attach the anti-static protective caps that were shipped with the instrument and place the instrument in a protective anti-static bag.

4   Place the instrument in the original packing container with at least 3 inches (7.5 cm) of compressible packaging material. **Shipping damage is not covered by this warranty.**

5   Secure the packing box with fiber reinforced strapping tape or metal bands.

6   Send the instrument, transportation pre-paid, to ILX Lightwave. Clearly write the return authorization number on the outside of the box and on the shipping paperwork. ILX Lightwave recommends you insure the shipment.

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

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

Claims for Shipping Damage

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

Comments, Suggestions, and Problems

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

Phone . . . . (800) 459-9459 or (406) 556-2481

Fax . . . . (406) 586-9405

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

Or mail to:

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

When you contact us, please have the following information:

Model Number:	
Serial Number:	
End-user Name:	
Company:	
Phone:	
Fax:	
Description or sketch of what is connected to the ILX Lightwave instrument:	
Description of the problem:	

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

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

We look forward to serving you even better in the future!

ILX Lightwave

INTRODUCTION AND SPECIFICATIONS

This chapter is an introduction to the LDC-3916370 Series Laser Diode Controller Modules for the LDC-3916 LD Controller Mainframe containing unpacking information, instructions on how to install and apply power, and safety considerations and instructions. It also contains some maintenance information and specifications. It covers model numbers LDC-3916371 High Resolution Module, LDC-3916372 500 mA/9W Controller Module, LDC-3916374 1A/9W Controller Module, and LDC-3916376 1.5A/9W Controller Module.

WARNING

If any of the following symptoms exist, or are even suspected, remove the LDC-3916370 Series Controller Module from service. Do not use the module until safe operation can be verified by trained service personnel.

Visible damage

Severe transport stress

Prolonged storage under adverse conditions

Failure to perform intended measurements or functions

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

Safety Symbols and Terms

The following safety terms are used in this manual:

• The WARNING heading explains dangers that could result in personal injury or death.

• The CAUTION heading explains hazards that could damage your instrument.

• The NOTES heading gives information to the user that may be beneficial in the use of the instrument and to the devices being tested.

Product Overview

The LDC-3916370 Series Laser Diode Controller Modules are a combination current source/temperature controller for laser diodes. The current source provides high stability output of either 500 mA, 1 Amp, or 1.5 Amp with fully redundant current limits and multiple laser protection features such as contact bounce detection, compliance voltage limit adjust and 4-wire voltage measurement for precise laser diode forward voltage measurement. The built-in bi-polar temperature controller can work with thermistor type temperature sensors for precise laser temperature control over a wide range of temperatures. Other features of the TEC controller include TEC voltage measurement, digital selection of thermistor current range, and control loop gain adjustment from 1 to 127.

Initial Inspection

When you receive your Controller module, inspect it for any shipping damage. A shipping kit should be included which contains 9-pin and 15-pin D-connectors and hoods plus this instruction manual.

Installing the LDC-3916370 Series Laser Diode Controller Module

Installation into LDC-3916 Laser Diode Controller Mainframe

If you are receiving this new module for installation into a previously purchased LDC-3916 mainframe, follow the instructions below. If your mainframe system was configured at the factory with your desired modules, use this section for reference when moving modules.

Turn off the mainframe power switch before inserting or removing any modules. Damage from "hot swapping" the modules is not covered under the warranty.

⚠ CAUTION

Static discharge can damage your new Laser Diode Controller Module. Be certain you use proper grounding procedures before you unpack and install your controller module(s) into the LDC-3916 Mainframe.

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

Be sure that the LDC-3916 Mainframe power is off before inserting your new laser diode controller module. Damage from "hot swapping" is not included under the warranty.

Unwrap the module from the anti-static bag it was packaged in.

Insert the module into the desired slot from the rear of the LDC-3916 Mainframe. Each module is supported by two plastic card guides inside of the mainframe. Insert the module, 40 pin connector first, by lining up the edges of the module frame with the appropriate card guides (one on top and one on the bottom). Carefully slide the module into the mainframe slot until the connector is seated. Push firmly to fully seat the module until the rear panel of the module is flush with the mainframe. Fasten the module to the mainframe with two screws located at the top and bottom of the module rear panel.

General Shipping Instructions

If you need to ship your LDC-391637X Laser Diode Controller Module back to the factory for repair, be sure that the module is packaged in an anti-static bag and an enclosure with cushioning material to prevent damage to the module during shipment (use the original shipping containers and accessories if possible). Re-install the ESD protective caps on the rear panel over the connectors (9-pin and 15-pin D). Shipping damage is not covered under warranty.

Attach a tag to the module identifying the owner and indicating the service or repair needed. Include the model number, serial number, and return authorization number. We suggest that you insure the shipment. See your LDC-3916 Mainframe manual for instructions on where to ship the module.

Specifications

The following specifications are for when the modules are used in the LDC-3916 16-Channel Laser Diode Controller Mainframe or the LDC-3908 8-Channel Laser Diode Controller Mainframe. Please see the LDC-3926 16-Channel High Power Laser Diode Controller Mainframe brochure for specifications when the modules are used in the LDC-3926.

	3916371/372 **500mA/9W**	**3916374** **1A/9W**	**3916376** **1.5A/9W**
LASER CURRENT DRIVE OUTPUT[1]			
Output Current Range:	0 to 500 mA	0 to 1000 mA	0 to 1500 mA
Set-Point Resolution:	10 µA	20 µA	40 µA
Set-Point Accuracy:	± 0.1% of full scale	± 0.1% of full scale	± 0.1% of full scale
Compliance Voltage:	6 V (adjustable voltage limit)	6 V (adjustable voltage limit)	4.75 V (adjustable voltage limit)
Temperature Coefficient:	≤ 50 ppm/°C	≤ 50 ppm/°C	≤ 50 ppm/°C
Short-Term Stability (1 hr.): [2]	≤ 20 ppm	≤ 20 ppm	≤ 20 ppm
Long-Term Stability (24 hr.): [3]	≤ 50 ppm	≤ 50 ppm	≤ 50 ppm
Noise and Ripple: [4]			
High Bandwidth Mode:	< 10 µA rms	< 10 µA rms	< 12 µA rms
Low Bandwidth Mode:	< 5.0 µA rms	< 5.0 µA rms	< 8.0 µA rms
Transients:			
Operational: [5]	< 3 mA	< 3 mA	< 3 mA
1kV EFT / Surge: [6]	< 4 mA / < 8 mA	< 5 mA / < 10 mA	< 5 mA / < 10 mA
LASER DRIVE LIMIT SETTINGS			
Current Limit Range:	0 to 500 mA	0 to 1000 mA	0 to 1500 mA
Current Limit Resolution	0.2 mA	0.4 mA	0.6 mA
Current Limit Accuracy:	± 0.7 mA	± 1.4 mA	± 4.5 mA
Voltage Limit Range:	0 to 7.5 V	0 to 7.5 V	0 to 7.5 V
Voltage Limit Resolution:	0.1 V	0.1 V	0.1 V
Voltage Limit Accuracy:	± 0.2 V	± 0.2 V	± 0.2 V
PHOTODIODE FEEDBACK			
Type:	Differential 10Ω Input, Selectable Zero or 5V Reverse Bias	Differential 10Ω Input, Selectable Zero or 5V Reverse Bias	Differential 10Ω Input, Selectable Zero or 5V Reverse Bias
PD Current Range:	0 to 5,000 µA	0 to 5,000 µA	0 to 5,000 µA
Stability[7]:	± 0.01%	± 0.01%	± 0.01%
Accuracy, setpoint (% of FS):	± 0.1%	± 0.1%	± 0.1%
EXTERNAL ANALOG MODULATION			
Input : [8]	0 to 10V, 50 Ω	0 to 10V, 50 Ω	0 to 7.5V, 50 Ω
Transfer Function:	50 mA / V	100 mA / V	200 mA / V
High Bandwidth Mode, Small Signal Bandwidth: [9]	DC to 1.2 MHz	DC to 1.0 MHz	DC to 0.9 MHz
High Bandwidth Mode, Large Signal Bandwidth: [10]	DC to 1.0 MHz	DC to 1.0 MHz	DC to 0.9 MHz
Low Bandwidth Mode:	DC to 30 kHz	DC to 30 kHz	DC to 30 kHz
LASER CURRENT MEASUREMENT (DISPLAY*)*			
Output Current Range:	0 to 500.00 mA	0 to 1000.0 mA	0 to 1500.0 mA
Output Current Resolution:	0.01 mA	0.01 mA	0.01 mA
Output Current Accuracy (@25°C):	± 0.05% of full scale	± 0.05 % of full scale	± 0.07 % of full scale
Photodiode Current Range:	0 to 5,000 µA	0 to 5,000 µA	0 to 5,000 µA
PD Current Resolution:	0.1 µA	0.1 µA	0.1 µA
PD Current Accuracy (@25°C):	± 2 µA	± 2 µA	± 2 µA
PD Responsivity Range: [11]	0.00 to 1000.00 µA/ mW	0.00 to 1000.00 µA/ mW	0.00 to 1000.00 µA/ mW
PD Responsivity Resolution:	0.01 µA/ mW	0.01 µA/ mW	0.01 µA/ mW
Optical Power Range:	0.00 to 500.00 mW	0.00 to 500.00 mW	0.00 to 500.00 mW
Optical Power Resolution:	100 µW	100 µW	100 µW
Forward Voltage Range:	0.000 to 7.5 V	0.000 to 7.5 V	0.000 to 7.5 V
Forward Voltage Resolution:	10 mV (1 mV through GPIB)	10 mV (1 mV through GPIB)	10 mV (1 mV through GPIB)
Forward Voltage Accuracy: [12]	± 7 mV (± 2 mV through GPIB)	± 7 mV (± 2 mV through GPIB)	± 7 mV (± 2 mV through GPIB)

CURRENT SOURCE NOTES:
1. All values relate to a one-hour warm up period.
2. Over any one-hour period, half-scale output.
3. Over any 24-hour period, half-scale output.
4. Measured optically, evaluating noise intensity of a laser diode into a photodetector with 150 kHz bandwidth.
5. Maximum output current transient resulting from normal operational situations (e.g., power on-off, current on-off), as well as accidental situations (e.g., power line plug removal)
6. Maximum output current transient resulting from a 1000V power-line transient spike.
7. Maximum monitor photodiode current drift over any 30 minute period; assumes zero drift in responsivity of photodiode.
8. Modulation input is 50Ω terminated inside the mainframe.

9. 250 mA setpoint, 50 mA modulation current, 1Ω load.
10. 50% modulation at mid-scale output, 1Ω load.
11. Responsivity value is user-defined and is used to calculate the optical power.
12. Four wire voltage measurement; voltage measurement accuracy while driving calibration load; voltage accuracy specifications valid for values above 10mV.

Temperature Control[1]	**3916372, 3916374, and 3916376**	**3916371**
Temperature Control Range:[2]	-99 °C to +150 °C	-5 °C to +50 °C
Thermistor Setpoint		
Resolution and Accuracy:	Resolution Accuracy [3]	Resolution Accuracy [3]
-20 °C to 20 °C	0.1 °C ± 0.2 °C	0.01 °C ± 0.2 °C
20 °C to 50 °C	0.2 °C ± 0.2 °C	0.2 °C ± 0.2 °C
Short Term Stability (1 hr.): [4]	< ± 0.007 °C	< ± 0.007 °C
Long Term Stability (24 hrs.): [5]	< ± 0.01 °C	< ± 0.01 °C
Output Type:	Bipolar current source	Bipolar current source
Compliance Voltage:	> 7 V DC	> 7 V DC
Short Circuit Output Current:	1.5 Amps	1.5 Amps
Maximum Output Power:	9 Watts	9 Watts
Current Noise and Ripple: [6]	< 1 mA rms	< 1 mA rms
Current Limit Range:	0 to 1.5 Amps	0 to 1.5 Amps
Current Limit Set Accuracy:	± 0.05 Amps	± 0.05 Amps
Control Algorithm:	Smart Integrator, Hybrid PI	Smart Integrator, Hybrid PI
	Gain adjustable from 1 to 127	Gain adjustable from 1 to 127

TEMPERATURE SENSOR

Types:	Thermistor (2-wire NTC)	Thermistor (2-wire NTC)
Thermistor Sensing Current: [7]	10 µA / 100 µA	100 µA
Useable Thermistor Range:	25 to 450,000 Ω, typical	3,500 to 45,000 Ω, typical
User Calibration:	Steinhart-Hart, 3 constants	Steinhart-Hart, 3 constants

TEC MEASUREMENT (DISPLAY)

Temperature		
Range: [8]	-99.9 °C to +199.9 °C	-99.9 °C to +199.9 °C
Accuracy:	± 0.5 °C	± 0.5 °C
Thermistor Resistance		
10 µA Setting: [9]		
Range:	0.01 to 450.00 kΩ	35.0 to 450.0 kΩ
Accuracy:	± 0.05 kΩ	±50Ω
100 µA Setting: [10]		
Range:	0.001 to 45.000 kΩ	3.5 to 45 kΩ
Accuracy:	± 0.005 kΩ	±5Ω
TEC Current		
Range:	-1.500 to +1.500 Amps	-1.500 to +1.500 Amps
Accuracy:	± 0.04 Amps	± 0.04 Amps
Resolution:	± 0.01 Amps	± 0.01 Amps
Voltage		
Range:	-9.999 to +9.999 V	-9.999 to +9.999 V
Resolution:	100 mV (1 mV through GPIB)	100 mV (1 mV through GPIB)
Accuracy: [11]	± 70 mV (± 20 mV through GPIB)	± 70 mV (± 20 mV through GPIB)

TEMPERATURE CONTROL NOTES:
1. All values relate to a one-hour warm up period.
2. Software limits of range; actual range possible depends on the physical load, thermistor type, and TEC module used.
3. Accuracy figures are quoted for a typical 10kΩ thermistor and 100 µA current setting; accuracy figures are relative to the calibration standard; both resolution and accuracy are dependent upon the user-defined configuration of the instrument.
4. Over any one-hour period, half-scale output, controlling an LDM-4412 mount @ 25°C, which 10 kΩ thermistor, on 100 µA setting.
5. Over any 24-hour period, half-scale output, controlling an LDM-4412 mount @ 25°C, which 10 kΩ thermistor, on 100 µA setting.
6. Measured at 1 Amp output over a bandwidth of 10 Hz - 10 MHz.
7. Thermistor current range software selectable by front panel or GPIB.
8. Software limits of display range.
9. Using 100 kΩ thermistor, controlling an LDM-4412 mount over -30°C to +25°C
10. Using a 10kΩ thermistor, controlling an LDM-4412 mount over 0°C to +90°C
11. Voltage measurement accuracy while driving calibration load; accuracy is dependent upon load used.
12. -5°C to +50°C

In keeping with our commitment to continuing improvement, ILX Lightwave reserves the right to change specifications without notice or liability for such changes.

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OPERATIONS

■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■

This chapter introduces you to the operation of the LDC-3916370 Series LD Controllers' Laser and TEC control functions. It offers instructions for connecting your laser to the current source and temperature controller. This chapter also contains step by step procedures that teach you how to operate your controller module in Constant Current Mode, Constant Power Mode, and to operate the temperature controller in Constant Temperature Mode. We recommend that you review the contents of this chapter at a minimum before operating your LDC-3916 Laser Diode Controller.

Table 2.1 LDC-3916370 Series Controllers Default Settings

TEC CONTROLLER
  TEC output off
  TEC Mode = Constant Temperature (T)
  Temperature Set Point (T or Tset) = 22°C
  TEC current set point (ITE or Iset) = 1.0 Amp
  TEC current limit (LIM:ITE or Ilim) =1.0 Amp
  Temperature limit (LIM:THI or Tlim) = 80.0°C
  TEC resistance set point (R or Rset) = 10 kΩ
  TEC Tolerance values = 0.2°C, 5 seconds
  GAIN = 3
  TEC SENSOR current set to 100 μA range
  C1 = 1.125 (x 10^{-3})
  C2 = 2.347 (x 10^{-4})
  C3 = 0.855 (x 10^{-7})
LASER CONTROLLER
  LASER output off
  LAS current set point (LDI or Iset) = 50 mA
  LAS current limit (LIM:I or Ilim) = 150 mA
  LAS voltage limit (LIM:V or Vlim) = 5.0 V
  LAS Mode = Constant Current, low bandwidth mode (MODE:ILBW or Ilbw)
  Modulation off
  Optical power set point (MDP or Pset) = 3.0 mW
  Monitor responsivity (CALPD or CalPD) = 0.0 μA/mW
  Optical power limit (LIM:MDP or Plim) = 500 mW
  Monitor PD Bias off
  LASER STEP value = 0.1mA
  Monitor PD current set point (MDI or Ipdset) = 100 μA

Connecting to the Laser Controller

When connecting your laser diode or any other sensitive devices to the LDC-3916370 Series Laser Diode Controller Modules, we recommend that the instrument be powered up and the LASER output be off. In this condition, a low impedance shunt is active across the output terminals. When disconnecting devices, it is only necessary to turn the LASER Output off.

It is also recommended that the connections to the LDC-3916370 Series Laser Diode Controller module output be made using twisted wire pairs with an earth-grounded shield (see Figures 2.1 - 2.4). We recommend using our CC-305S or shorter CC-315S Shielded Laser Cable which are unique twisted-pair cables with braided outer shield designed to provide the best possible rejection of most transient noise signals.   The output terminals of the instrument are left floating relative to earth ground to suppress AC power-on/power-off transients that may occur through an earth-ground path. If the output circuit is earth-grounded at some point (such as through the laser package and mount), the user must 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:** Experience indicates that should an inadvertent open circuit occur during laser operation (while the LASER is ON), your laser may be damaged by a momentary circuit break-and-remake before the final circuit break. Your new LDC-3916370 Series Controller Module has circuitry designed to detect open circuits and will shut the output off under most conditions. However, we recommend that cable connections to the laser be secure enough that they won't open-circuit, should they be jostled or bumped.
>
> Use appropriately shielded cabling to reduce coupling of potentially laser damaging transients. Do not "bundle" the current source cables with other cables in your system or laboratory. See Application Note #3, "Laser Diode Protection Strategies" for more detailed discussions on connecting to your laser.

Figures 2.1 - 2.4 show the possible configurations of connecting laser diodes and photodiodes with the LDC-3916370 Series Laser Diode Controller Modules.
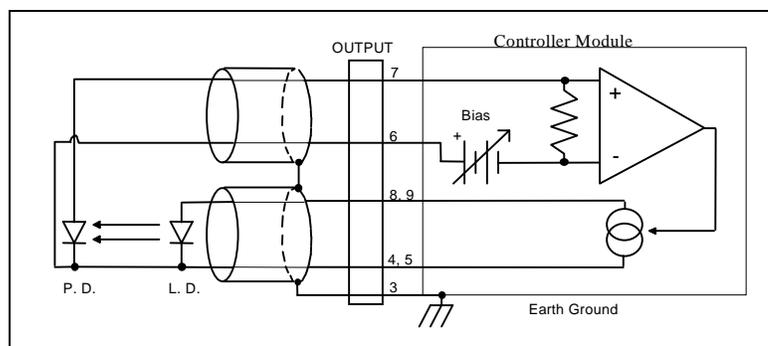
Figure 2.1 Common Laser Cathode - Photodiode Cathode

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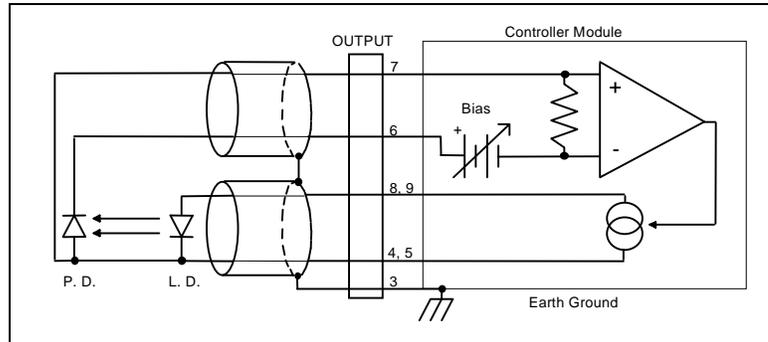
Figure 2.2 Common Laser Cathode - Photodiode Anode
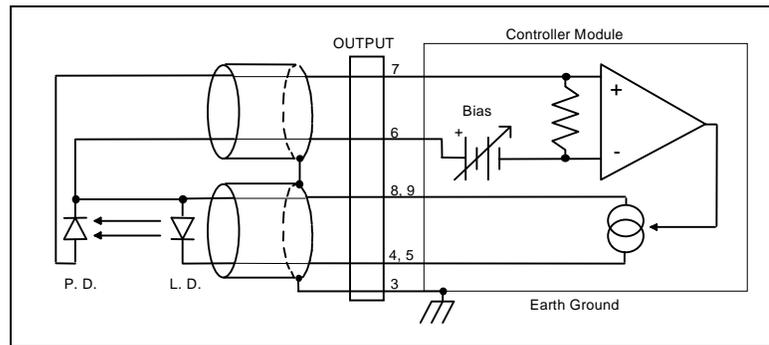
Figure 2.3 Common Laser Anode - Photodiode Cathode
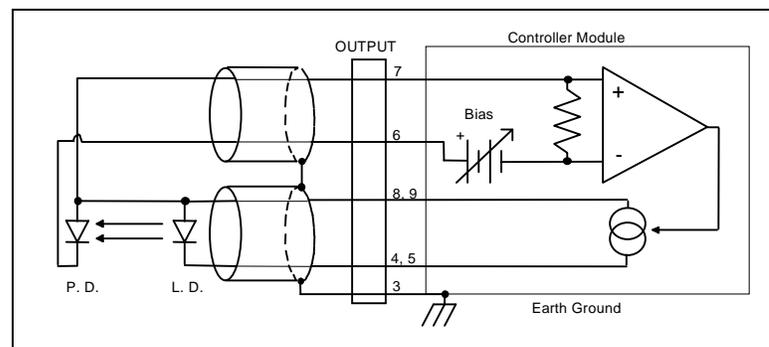
Figure 2.4 Common Laser Anode - Photodiode Anode

The 9-pin connector on the rear panel (bottom connector) of your Controller Module is used to connect your laser diode to the controller. There are connections provided for laser cathode and anode, photodiode cathode and

anode, chassis ground, interlock, and laser forward voltage. The pin-out diagram for this connector is shown in Figure 2.5.

```
1,2  Interlock
3    Chassis Ground
4    Cathode Voltage Sense
5    Laser Cathode
6    PD Cathode (+)
7    PD Anode (-)
8    Anode Voltage Sense
9    Laser Anode
```
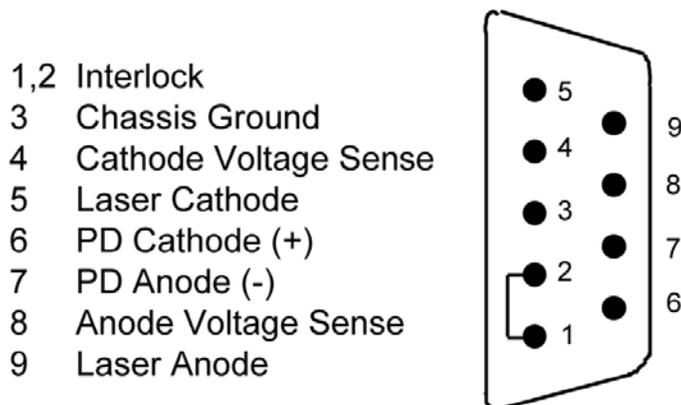
Figure 2.5 Back Panel LD Connector

Interlock Connections

In order for the laser output to be enabled, a short must exist between the Interlock pins (pins 1 and 2) of the connector. The short can be a direct short across the pins or a switch to prevent laser operation until the switch is closed. If a short does not exist between these two pins and you attempt to turn on the LAS output, an error (E501) will be indicated on the display for the respective channel, on any of the Laser set up pages, or on the status screen; furthermore, the output will be turned off.

⚠ CAUTION

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

Four-Wire Voltage Sense

The LDC-3916370 Series Modules have a 4-wire voltage sense feature. The laser voltage is sensed through a pair of connections (pins 4 and 8) that is separate from the laser current drive connections (pins 5 and 9). This allows a more accurate laser voltage reading for the voltage limit feature. All four of these pins (4,5,8,9) must be connected for the module to operate. See Tech Note #TN3916-2 for more information on 4-wire Voltage Sense.

Photodiode Connections

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

The photodiode and laser connections to the LDC-3916370 Series Laser Diode Controller Module are electrically isolated from ground and each other. So, 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.

Grounding Considerations

The LASER outputs of the LDC-3916370 Series Laser Diode Controller Module are isolated from chassis ground allowing either output terminal to be grounded at the user's option. Figure 2.1 shows the proper earth-ground shielding for laser diode/photodiode connections.

Connecting to the TEC Controller

The 15 pin connector on the rear panel of your Controller module (top connector) is used to make connections to the thermoelectric cooler (TEC) modules of your laser or laser mount, and the temperature sensor. There are connections provided for TEC module, temperature sensor, earth ground, and analog ground. The pin-out diagram for this connector is shown in Figure 2.6.

1,2	TEC Module (+)
3,4	TEC Module (-)
5,6	Earth Ground
7	Sensor (+)
8	Sensor (-)
9	Do not connect
10	Do not connect
11	Do not connect
12	Do not connect
13	Do not connect
14	Do not connect
15	Do not connect

See CAUTION statement below.
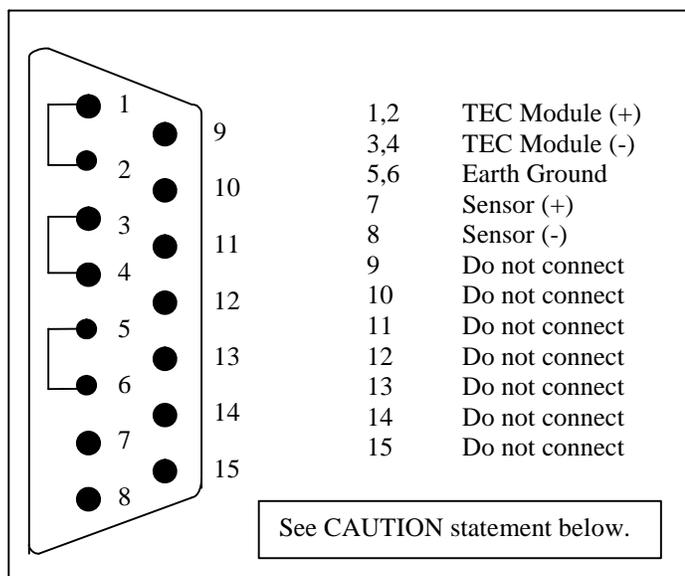
Figure 2.6 Rear Panel TEC Connector

Current will flow from pins 1 and 2 to pins 3 and 4 when the controller is trying to cool the load. This is referred to as "positive" current. Current will flow in the opposite direction when the controller is trying to heat the load. Pins 5 and 6 are connected to the 3916 chassis, which is connected to earth ground through the power cord. Thermistor sensor current (10 or 100 A) flows from pin 7 to pin 8, which develops a voltage for calculating thermistor resistance. Pins 9-15 are reserved by ILX Lightwave for diagnostics purposes and must not be connected to anything in your system.

TEC Grounding Considerations

The TEC outputs of your LDC-3916370 Series Laser Diode Controller Modules are isolated from chassis ground, allowing either output terminal to be grounded at the user's option if desired (see caution statement below).

⚠ CAUTION

For the TEC connector, if any one terminal pin is grounded, then no other terminal pin should be grounded. Do NOT connect Sensor (-) and TEC Module (-) to the same ground. Damage to the instrument and devices will occur.

If either pin of the TEC module is grounded (Pins 1-2 or 3-4) connect them only to earth ground. Grounding these pins to analog or digital ground will cause catastrophic failure of the TE controller.

Operating the Laser Current Source from the Front Panel

The various laser current source control parameters can be set the same for all of the channels via the All Chnl menu which is accessed through the MAIN menu. Alternatively, the laser source control parameters for each individual channel can be set independently via the LAS channel setup menu, which is accessed through the CHAN menu. You can move between multiple pages of any setup menu by pushing the up and down arrow soft keys (F3 and F4) while in the setup menu. Which parameter to adjust can be selected with the (DISPLAY) UP/DOWN ARROW keys. In general, the selected parameter value can be adjusted with the numeric keypad, the ADJUST knob, or the (ADJUST) UP/DOWN ARROW keys. The ENTER key must be pressed within three seconds after entering a numeric value with the keypad, or the value will revert to the previous value.

The DISPLAY is used to show both the set point and measured value of laser control parameters such as laser drive current (Iset and Io), laser current limit (Ilim), laser forward voltage (Vf), forward voltage limit (Vlim), mode of control (Mode), monitor photodiode current (Ipdset and Ipd), and laser optical power (Plim and Ppd). It will also display error codes, which relate to LASER operation. Error codes indicate control errors and are explained below in the section titled "LASER ERROR INDICATORS".

The following sections describe fundamentals of single channel operation for your LDC-3916370 Series Controller Module's Laser Diode Current Source in two operating modes, Constant Current (I) and Constant Power (P).

Operating a Laser in Constant Current (I) Mode

Suppose you have an LDC-3916370 Series Controller Module and you want to run the instrument in Constant Current low bandwidth mode (Ilbw), with a set point of 150 mA, a current limit of 175 mA, and a voltage limit of 6 volts. The Ilbw mode uses a low-pass filter on the laser drive current output to significantly reduce noise. In this mode a low bandwidth modulation input may be used via the back panel MODULATION connector. Follow the instructions below, in the sequence presented, to program the current source for a single channel.

Entering the Laser Channel Setup Menu

Push the CHAN key to display the single channel menu. From this menu you can see the measured parameters, enter the LAS or TEC channel setup menus, or turn the LAS current source and/or TEC on and off. Use the (ADJUST) UP/DOWN ARROW keys or the ADJUST knob to select the desired channel number highlighted at the top of the display. Push the DISPLAY LAS soft key (F2) to enter page 1 of the laser channel setup menu.

Setting the Mode of Control

Select the Mode parameter by pushing the (DISPLAY) UP/DOWN ARROW keys until the Mode parameter is highlighted. Repeatedly pushing the (ADJUST) UP/DOWN ARROW keys or turning the ADJUST knob will cycle through the

Constant Current low bandwidth (Ilbw), Constant Optical Power (P), Constant Current high bandwidth (Ihbw), and Photodiode Current (Ipd) control modes. Set the LDC-3916370 Series Controller Modules in Constant Current low bandwidth mode by selecting the Ilbw mode.

Setting the Current Limit

Now select the current limit (Ilim) parameter using the (DISPLAY) UP/DOWN ARROW keys. Adjust the value to 175mA. The current limit protects your laser by never allowing the laser drive current to exceed the Ilim value independent of the current set point and the controller mode (Constant Current or Constant Power).

⚠ **CAUTION**

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

Setting the Constant Current Value

Next, select the Iset parameter on the setup menu using the (DISPLAY) UP/DOWN ARROW keys. This parameter sets the laser current source drive value when in Ilbw or Ihbw modes. Enter 150 mA using the numeric keypad, the ADJUST knob, or the (ADJUST) UP/DOWN ARROW keys. Push the ENTER key to store the value in memory within three seconds after entering the value using the numeric keypad, or it will revert to the old value.

Setting the Voltage Limit
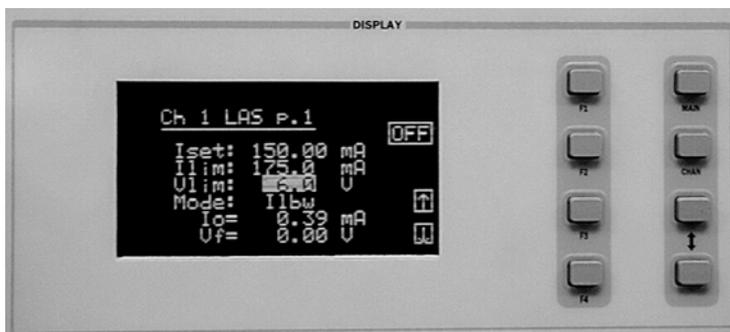
Select the voltage limit (Vlim) parameter and adjust it to 6 volts in the same manner as described above. The voltage limit also protects your laser by shutting off the source driver if the laser voltage exceeds the Vlim value. The Vlim value should be set slightly above the operating voltage of the laser diode to provide maximum protection.

Note: There is also a laser optical power limit (Plim) safety feature explained in this manual under the section titled "Operating a Laser in Constant Power (P) Mode". The laser optical power limit can be disabled by setting the CalPD value to zero on page 2 of the laser setup menu.

Enabling the Modulation Input

Change the display to LAS p.3 of the laser setup menu to set the next parameter. Do this by pushing the DOWN soft key (F4) twice. The Modulation parameter on this page controls whether the MODULATION connector input is active or not. Select the Modulation parameter by pressing the (DISPLAY) UP/DOWN ARROW keys until the Modulation parameter is highlighted. Adjust the value to ON or OFF as desired with the (ADJUST) UP/DOWN ARROW keys or the ADJUST knob. Refer to the LDC-3916370 Series Controller Module specifications for modulation input specifications and limitations.

Setting Photodiode Bias Voltage

The Bias parameter setting controls whether a 5 volt reverse voltage is supplied to the monitor photodiode or not. Set the Bias parameter to ON or OFF as desired.

Many laser diode modules are tested and characterized by the manufacturer with a 5 volt reverse bias on the photodiode. This bias can decrease the response time and increase the linearity and/or saturation level of the photodiode.

Turning the Laser Current Source On

Now you are ready to enable the current source output for your laser diode on this channel. You can enable this channel now or set all of the other channels first. The top soft key (F1) on any of the three pages of the LAS setup menu will toggle the laser current source on and off. You can also turn the current source on and off with the top soft key (F1) on the CHAN menu. The ON toggle has a two second delay before the current source is enabled in compliance with safety requirements.

Each single channel current source can be turned on or off independently as described above, or you can turn on all the channel sources at the same time from the All Chnl menu. See the LDC-3916 Mainframe Instruction Manual for more information on the all channel operation.

Operating a Laser in Constant Power (P) Mode

Suppose you want to operate a 3 mW laser in constant optical power at 1 mW. The LDC-3916370 Series Controller Modules allow you to operate the instrument current source drivers in Constant Optical Power (P) mode. In the "P" mode, the controller drives current to the laser to reach a set power value in mW. The control loop feedback parameter is monitor photodiode current, which the controller converts to optical power via a user defined photodiode responsivity number, CalPD. If laser power changes due to internal or environmental conditions, the controller will increase/decrease the current to the laser to maintain the power set point. The following paragraphs detail the instrument configuration in Constant Power Mode.

Calculating Photodiode Responsivity Values

The photodiode responsivity, CalPD, is used to convert between photodiode current and optical power of the laser diode. A method to calculate the responsivity is suggested below.

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

2   Measure the corresponding monitor photodiode current.

3   Calculate the responsivity (CalPD) by dividing the photodiode current by the optical power noting the units required are A/mW.

Entering the Laser Channel Setup Menu

To enter the setup menu, push the CHAN key, which displays the channel menu. Select the correct channel number at the top of the display by pushing the (ADJUST) UP/DOWN ARROW keys or turning the ADJUST knob. Then push the DISPLAY LAS soft key (F2) to enter page 1 of the laser setup menu.

Selecting the Mode of Control

Select the Mode parameter by pushing the (DISPLAY) UP/DOWN ARROW keys until the Mode parameter is highlighted. Repeatedly pushing the (ADJUST) UP/DOWN ARROW keys or turning the ADJUST knob will cycle through the Constant Current low bandwidth (Ilbw), Constant Optical Power (P), Constant Current high bandwidth (Ihbw), and Photodiode Current (Ipd) control modes. Set the LDC-3916370 Series Controller Module in Constant Optical Power mode by selecting the P mode.

Setting the Current Limit

Select the laser current limit (Ilim) parameter by pushing the (DISPLAY) UP/DOWN ARROW keys until the Ilim value is highlighted with the cursor. Adjust the current limit value with the numeric keypad, the ADJUST knob, or the (ADJUST) UP/DOWN ARROW keys. If you use the numeric keypad, you mush push the ENTER key to store the value in memory within three seconds after entering the value, or it will revert to the previous value. The current limit protects your laser by never allowing the laser drive current to exceed the Ilim value independent of the current set point and the controller mode (Constant Current or Constant Power).

⚠ **CAUTION**

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

Setting the Voltage Limit

Next, select the laser voltage limit (Vlim) parameter using the (DISPLAY) UP/DOWN ARROW keys. Adjust this value to your desired laser voltage limit. The voltage limit also protects your laser by shutting off the source driver if the laser voltage exceeds the Vlim value. The Vlim value should be set slightly above the operating voltage of the laser diode to provide maximum protection.

> **Note:** Be sure to push the ENTER key within three seconds after using the keypad to adjust any numeric values in the setup menus; otherwise, the value will revert to the previous setting.

Setting the Power Limit

Now push the DOWN soft key (F4) to advance to LAS p.2 of the laser setup menu. Before the laser is enabled, the power limit for the laser under test should be set. To do this, push the (DISPLAY) UP/DOWN ARROW keys to select the power limit (Plim) parameter. Adjust this value to your desired laser optical power limit. The responsivity value (CalPD) must be set to the correct value for the power limit feature to work properly. This is a software limit only. The LASER output is normally turned off if this limit is reached.

Adjusting the Constant Power Setting

Use the (DISPLAY) UP/DOWN ARROW keys to select the power (Pset) parameter, and adjust the value to 1 mW. The Controller Module will divide the measured photodiode current by the CalPD value to calculate the laser optical power. The current source will automatically adjust the laser drive current to keep the calculated laser power at the Pset value.

Setting the Responsivity Value (CalPD)

The correct responsivity value (CalPD) must be set for the constant power mode to operate properly. To do this, select the CalPD parameter, and adjust it to the correct value. The CalPD units are μA/mW.

A method to calculate the responsivity value (CalPD) is suggested here:

• Measure (with a calibrated detector) the output power of the laser.

• Measure the corresponding monitor photodiode current.

• Calculate the responsivity (CalPD) by dividing the photodiode current by the optical power noting the units required are μA/mW.

Setting the Photodiode Bias Voltage

Now push the DOWN soft key (F4) to display LAS p.3 of the laser setup menu. The Bias parameter setting controls whether or not a bias voltage is applied to the monitor photodiode. Select the Bias parameter and adjust it ON or OFF depending on whether you want a 5 volt reverse bias on your photodiode or not. (Many laser diode modules are tested and characterized by the manufacturer with a 5 volt reverse bias on the photodiode. This bias can decrease the response time and increase the linearity and/or saturation level of the photodiode.)

Enabling the Modulation Input

The Modulation parameter on the LAS p.3 setup menu controls whether the MODULATION connector input is active or not. Select the Modulation parameter by pressing the (DISPLAY) UP/DOWN ARROW keys until the Modulation parameter is highlighted. Adjust the value to ON or OFF as desired. Refer to the LDC-3916370 Series module specifications in Chapter 1 for modulation input specifications and limitations.

Constant Power Mode if CalPD is Unknown
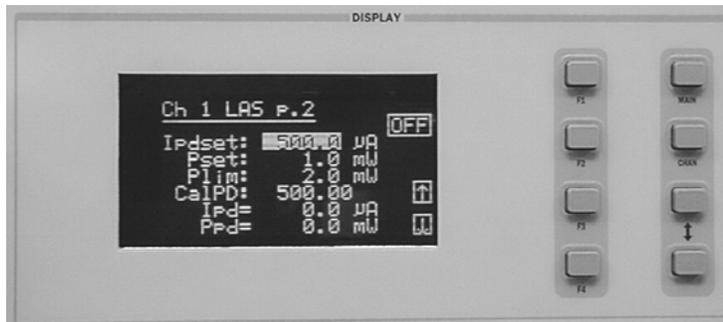
If you do not know the correct photodiode responsivity (CalPD) value, the LDC-3916370 Series Modules can still drive your laser at a constant light power. The Constant Photodiode Current (Ipd) mode will control the laser drive current so the monitor photodiode current remains at a constant set point. To do this, adjust the Mode to Ipd on LAS p.1 of the laser setup menu, and set the photodiode current (Ipdset) parameter on the LAS p.2 menu to your desired value. In this case, you may want to set the power limit (Plim) value high or set CalPD to zero which will disable the power limit feature. Be sure to set the Ilim and Vlim values on LAS p.1 of the laser setup menu to protect your laser.

Turning the Laser Current Source On

Now this channel is configured to operate in Constant Power Mode. The Controller's laser current source will drive the laser to the Constant Power set point and maintain closed loop control with the monitor photodiode current measurement. You can enable this channel now or set all of the other channels first. The top soft key (F1) on any of the three pages of the LAS setup menu will toggle the laser current source on and off. You can also turn the current source on and off with the top soft key (F1) on the channel menu. The ON toggle has a two second delay before the current source is enabled in compliance with safety requirements.

Each single channel current source can be turned on or off independently as described above, or you can turn on all the channel sources at the same time from the All Chnl menu. See the LDC-3916 Mainframe Instruction Manual for more information on all channel operation.

Conditions Which Will Automatically Shut Off the Laser Output

When the LASER output is off, an internal short is placed across the LASER output. The default condition for the current source output is OFF when the instrument is first powered up. With the laser output enabled, the channel or status displays should be indicating measured laser current. If the output won't function or an error code appears, check the conditions shown below or table 2.3 "LASER Error Indicators".

The following conditions will automatically force the laser current source to turn off:

1   LASER High Power Limit (Plim, E507)

2   LASER High Voltage Limit (Vlim, E503 or E505)

3   LASER ENABLE Interlock (E501)

4   LASER ENABLE Key Lock turned off on the front panel (E501)

5   LASER Open Circuit (E503)

6   TEC High Temperature Limit Condition (E509)

In addition, the LASER Current Limit setting (Ilim) will clip the laser drive current at the Ilim set point when the signal is being modulated. When the LASER current limit (Ilim) is reached, an ILIM warning will appear on the CHAN menu display. The current limit setting is independent of the voltage drop of the device connected to the LASER output. Furthermore, since the current limit circuitry is fully independent of the main current control, the current limit can be adjusted safely, even while the LASER output is active.

The LDC-3916370 Series Controller Modules' response to sensing the various limits can be controlled via the GPIB interface. Most high limit responses can be set to either turn off the source or just give a limit warning through the GPIB interface. See the "LAS:ENAB:OUTOFF" command in Chapter 4 of this manual for more information.

Laser Error Indicators

The LDC-3916370 Series Laser Diode Current Source Controllers indicate general LASER operational error conditions. When an error occurs, the Error Indicator Code will appear on the Status page, the Chan page, or the LAS Setup pages for the respective channel. The Error Indicator Code will clear if you exit any page that it appears on. The output drive will shut off when any laser error occurs. Laser Error Indicator codes are summarized in Table 2.2. Some of these errors can be disabled using GPIB: see Chapter 4 for more information. See Table 2.3 for TEC Error Code Indicators, and Chapter 3 in the LDC-3916 mainframe manual for mainframe error codes.

Table 2.2 LASER Error Indicators

Error Condition	Probable Cause
E501 Interlock	Interlock pins not connected properly or LASER ENABLE key lock turned off on front panel.
E503 Voltage limit or Open circuit	The laser current source or voltage measurement pins are open, or some condition caused the laser voltage to reach the limit value (Vlim).
E504 Current limit	The current limit (Ilim) was reached. This condition will cause Error Indicator Code E504 and shut down the source only when enabled through the GPIB interface; otherwise, a current limit will only clip the drive current at the Ilim value and indicate ILIM on the display.
E505 Voltage limit warning	The voltage on the laser current source is approaching the Vlim value. This condition will cause Error Indicator Code E505 and shut down the source only when enabled through the GPIB interface.
E507 Output Power Limit	Software calculated optical output power limit (Plim) was detected.
E508 TEC is off	TEC source has turned off for some reason. This condition will cause Error Indicator Code E508 and shut down the laser source only when enabled through the GPIB interface.
E509 TEC temperature limit	Software calculated TEC temperature limit (TLim) was detected.
E510 Tolerance event	Out of tolerance status forces LAS output off.
E511 Hardware error	Hardware has detected an error.
E529 Output off when controller thinks it is on	Laser source is off without hardware or software indicating a reason.
E535 Mode changed while output on	Operating mode was changed while the laser current source was on.

Operating the TEC Controller from the Front Panel

This section describes how to operate your LDC-3916370 Series Controller Module's Temperature Controller in Constant Temperature Mode, T. There are three modes in which you can operate the temperature controller: Constant Temperature (T), Constant Thermistor Resistance (R), and Constant TEC Current (I). Operating in Constant Temperature Mode is presented in the following sections, however the same operating principles apply to the other operating modes.

The various temperature control parameters can be set the same for all channels via the ALL CHAN menu, which is accessed through the MAIN menu. Alternatively, the temperature control parameters for each individual channel can be set independently via the TEC channel setup menu, which is accessed through the CHAN menu. You can move between multiple pages of any setup menu by depressing the up and down arrow soft keys, F3 and F4, while in the setup menu. Which parameter to adjust can be selected with the (DISPLAY) UP/DOWN ARROW keys. In general, the selected parameter value can be adjusted with the numeric keypad, the (ADJUST) knob, or the (ADJUST) UP/DOWN ARROW keys. If you use the numeric keypad, the ENTER key must be pressed within three seconds after entering any numeric value, or the value will revert to the previous value.

The display is used to show both the set point and measured value of TEC control parameters such as temperature (Tset and T), thermoelectric module current (Iset and I), temperature limit (TLim), thermoelectric module current limit (Ilim), controller mode, thermoelectric module forward voltage (Vt), sensor resistance (R), temperature control loop gain (Gain), sensor current range (10 A or 100 A), and sensor constants (C1, C2, and C3).

Selecting the TEC Control Setup Menu

To access any of the TEC Control setup menus, you must start with the channel menu. This can be accomplished in several ways; the most direct way is to depress the CHAN hard key right below the MAIN key. Here you can select the desired channel by turning the (ADJUST) knob or pushing the (ADJUST)

ILX Lightwave

UP/DOWN ARROW keys.   Press soft key F4 (TEC) to access the first page of the three TEC setup menu pages.

Operating the Controller in Constant Temperature (T) Mode

Suppose you need to operate and temperature control a laser with an internal TEC module. The maximum TEC module operating current for this device is 1.5 Amps. A typical operating mode would be to control the laser diode temperature to 25 ^{o}C with the temperature sensor type being a 10 KΩ thermistor. In this experiment, the maximum operating temperature will be 40 ^{o}C. To configure the LDC-3916370 Series Temperature Controller, you will need to select the sensor current range, enter the correct thermistor constants, select the Temperature Control mode, set the control loop gain, and set appropriate temperature and TEC module current limits.

Setting the TEC Control Mode

Set the LDC-3916370 Series Temperature Controller to Temperature Control mode by selecting T in the MODE section of the display on TEC p.1. Use the (DISPLAY) UP/DOWN arrow hard keys until the MODE parameter is highlighted. Repeatedly pushing the (ADJUST) UP/DOWN ARROW hard keys or turning the ADJUST knob will cycle through the available instrument modes T (constant temperature), I (constant TEC current), and R (constant thermistor resistance). Set the temperature controller in Constant Temperature Mode by selecting the T mode.

Setting the Temperature Limit

Now, let's set the temperature limit to 40°C. The temperature limit function (TLim) sets the maximum temperature the controller will allow before generating an error condition and disabling the TEC and laser outputs. During controller operation, if this limit is reached, the error indicator E407 will be shown on the display and the LASER and TEC outputs will be shut off to protect the laser.

To set the temperature limit to 40°C, use the (DISPLAY) UP/DOWN ARROW keys to highlight the TLim value. Next, use the (ADJUST) UP/DOWN ARROW keys, knob, or the keypad to enter the desired value of 40°C.

> **Note:** When using the keypad to enter a numeric value, be sure to push the ENTER key within three seconds, otherwise the value will revert to the previous setting.

Adjusting the Temperature Set Point

Now adjust the set point operating temperature of the controller to 25°C. The temperature controller will monitor actual temperature and adjust TEC current to maintain the thermal load at the set point temperature.

To adjust the Temperature Set Point to 25°C, use the (DISPLAY) UP/DOWN ARROW key to highlight the Tset value. Next, use the (ADJUST) UP/DOWN ARROW keys, knob, or the keypad to enter the desired value of 25°C.

Setting TEC Current Limit

The TEC Current Limit protects your TEC by limiting the controller's output current so that the instrument does not provide more current than your TEC module can safely handle. During controller operation, if the TEC current limit is reached, the warning, ILim will be shown on the display. The TEC current limit is set in Amps.

> **Note:** The thermoelectric module current limit condition is a normal operating condition of the temperature controller module. This limit condition will cause error indication E404 and shut down the source current only when enabled through GPIB; otherwise the current limit will clip the source current at the limit value.

To set the TEC current limit to 1.5 Amps, first select TEC p. 2 by pushing the down soft key (F4) on the TEC p. 1 menu. Use the (DISPLAY) UP/DOWN ARROW keys to highlight the ILim value. Next, use the (ADJUST) UP/DOWN ARROW keys, knob, or the keypad to enter the desired value of 1.5 amps (A).

The Rset and Iset parameters on TEC p.2 are used in the Constant Thermistor Resistance and Constant TEC Current Modes.

Setting TEC Control Loop Gain

For best temperature control loop performance, the control loop gain needs to be set. The GAIN function sets the analog feedback gain which, in part, determines how fast the actual temperature reaches and settles to the set point temperature. If the gain is set too low, the TE cooler will take longer to reach the temperature set point. If it is set too high, the actual temperature may overshoot and may oscillate around the set temperature resulting in long temperature settling times. The allowed GAIN values in the LDC-3916370 Series Temperature Controller are from 1 to 127 in steps of 1. These values define the proportional loop gain of the hybrid PI temperature control loop.

The gain setting depends on the type of TEC module and thermal load that you are using, but we can suggest guidelines for selecting the proper gain. Set the gain to 30 and increase it until the actual temperature oscillates around the set temperature. Then reduce the gain to the next lower value.

To adjust the GAIN value, first select TEC p.3 by pushing the down soft key (F4) on TEC p.2. Then use the (DISPLAY) UP/DOWN ARROW keys to highlight the GAIN number. To change the value, use the (ADJUST) UP/DOWN ARROW keys, knob, or the keypad to enter the desired value. The quickest way would be to use the keypad for large changes in gain values. Set the temperature control loop GAIN value to 30.

Temperature Controller Sensor Selection

Because we have selected a 10 k thermistor as our temperature sensing element and we have chosen 25°C as our set point temperature, we need to set the SENSOR range to 100 μA.

Your LDC-3916370 Series Temperature Controller operates in a closed loop fashion with a temperature sensor being the feedback element. The only temperature sensor allowed for these controller modules is the thermistor type. Thermistor resistances are rated at room temperature. In this case, we are using a 10 kΩ thermistor, which means that at 25°C the resistance value of the thermistor is 10,000 ohms (10 kΩ). For the controller to operate accurately, the correct range of sensor needs to be selected.

> **Note:** The LDC-3916371 module thermistor sensor current is set to 100 μA and is not adjustable.

Thermistor resistance changes with temperature. A constant current source integrated into the controller supplies current through the thermistor, in this case 100 μA, so that a temperature change results in a voltage change across the thermistor (V=IR). This voltage change is sensed by the controller and fed back to the control loop. The 10 μA and 100 μA designations are current levels supplied by the controller. The selected supply current depends on the thermistor operating temperature range and the required temperature resolution. A general rule of thumb for a 10 kΩ thermistor is to use the 10 μA range for temperatures between -30 and +30 ^{o}C, and the 100 μA range for temperatures between +10 ^{o}C to +70 ^{o}C. For a more complete description of thermistor selection see our Application Note #2 titled, "Selecting and Using Thermistors for Temperature Control".

To set the temperature controller's Sensor range, use the (DISPLAY) UP/DOWN ARROW keys until the SENSOR parameter is highlighted. Repeatedly pushing the (ADJUST) UP/DOWN ARROW hard keys or turning the ADJUST knob will cycle through the available thermistor current modes of 100 µA and 10 µA. Set the temperature controller in 100 µA sensor range.

Setting Temperature Sensor Constants

For accurate temperature control, it will be necessary to enter the sensor calibration constants into the controller for accurate conversion of sensor resistance to actual temperature. These constants are used in a temperature conversion equation to calibrate the TEC, and are usually supplied with your thermistor's data sheet. The Steinhart-Hart equation is used to derive temperature from the non-linear resistance of an NTC (Negative Temperature Coefficient) thermistor. The constants are displayed on TEC p.3.

To adjust the value of a C1, C2, or C3 constant, use the (DISPLAY) UP/DOWN ARROW keys to highlight the desired constant name (C1, C2, or C3). To change the value, use the (ADJUST) UP/DOWN ARROW keys, knob, or the keypad to enter the desired value. The range of values for C1, C2, and C3 are -99.9999 to +99.9999. The quickest way would be to use the keypad for large changes in constant values.

Understanding DAC Mode (LDC-3916371 Modules Only)

What's a DAC and what is DAC mode?

"DAC" is an acronym for "digital to analog converter" and the temperature control module uses a DAC to control the temperature of the TE device. The microprocessor in the module sets the temperature setpoint by placing a 16-bit word in the DAC, and the DAC produces a DC voltage proportional to the value of the 16-bit word.

The 16-bit word can have any value between 0 and 65535 counts. An increment of one bit or count, for example, is equivalent to an increase of the DAC output voltage from about 200 mV to 200.0625 mV, or an increase of 62.5 μV.

**How is the temperature related to DAC counts?**

The 3916371 temperature controller measures the temperature by measuring the voltage across the thermistor, which is an indication of the thermistor resistance and temperature. During the thermistor calibration a mathematical relationship is developed that relates the DAC counts to the thermistor voltage. The exact relationship between DAC counts, thermistor voltage, and temperature depends on the thermistor and the Steinhart-Hart constants C1, C2 and C3 that are used.

When is DAC mode useful?

DAC mode is useful any time constant temperature mode or constant resistance mode does not provide the required tuning resolution. For example, the 3916371 controller is being used to tune the wavelength of a certain type of laser. The desired laser temperature is in the range of 20.00 $^\text{o}$C, but 20.00 $^\text{o}$C is not exact enough and the settings of 20.01 $^\text{o}$C or 199.99 $^\text{o}$C are too coarse and cause the wavelength to be tuned out of range. DAC mode in this case could provide the required resolution by allowing the temperature to be adjusted in smaller steps. For a typical 10kΩ thermistor at 20 $^\text{o}$C, each DAC step is equivalent to about 0.0013 $^\text{o}$C.

How do I know if I'm using DAC mode the right way?

The DAC menu (page 4 of the TEC menu) displays an equivalent temperature and an equivalent resistance for every DAC setting so one can see immediately if the selected DAC value is in the desired temperature range. The measured resistance and temperature are also displayed so one can easily compare the equivalent value to the measured values. The DAC values can be adjusted to any value between 10 and 65535 (values less than 10 result in extremely high temperatures). It is important to remember that as the DAC counts go down, the equivalent temperature goes up.
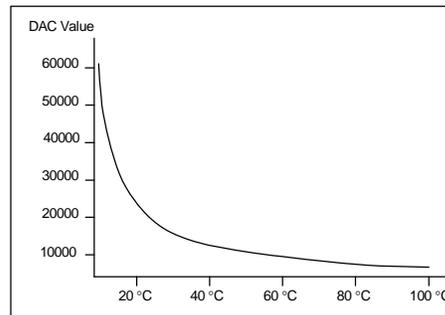
Figure 2.7 DAC Response Curve

Recall that a typical thermistor resistance vs. temperature response curve is not linear. The response curve for DAC value vs. temperature is similar as depicted in Figure 2.7. It is important to remember that for every incremental change in the DAC value, the resulting incremental change in temperature (ΔT) will be different depending on the desired operating temperature. At high DAC values the resulting ΔT will be much smaller than the ΔT at low DAC values.

The GPIB command set includes commands for converting temperature to resistance or DAC counts, resistance to temperature or DAC counts, and for converting DAC counts to equivalent temperature or resistance. Use these commands to find an appropriate starting DAC value if the desired temperature or resistance is known. For example, to convert 31.22 ^oC to DAC counts use the command TEC:CONV:T_DAC? 31.22. This command will return the DAC value associated with this temperature. If you want to know what resistance is equivalent to a DAC value of 16293, you can use the following command: TEC:CONV:DAC_R?16293. The DAC setpoint can also be adjusted or queried via GPIB using the TEC:DAC command.

Operating in DAC Mode
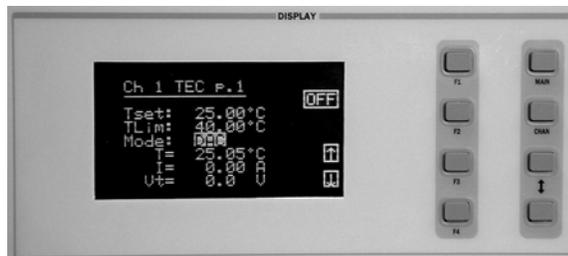
To operate the controller in DAC mode, go to page 1 of the TEC menu and change the mode to DAC by using the (DISPLAY) UP/DOWN ARROW keys to highlight the MODE parameter. Select DAC mode by repeatedly pushing the (ADJUST)

UP/DOWN ARROW hard keys or by turning the ADJUST knob until "DAC" is displayed.

Set the TEC menu to page 4. The DAC value may be adjusted by using the (ADJUST) UP/DOWN ARROW hard keys, knob, or by entering in the value on the keypad. As the DAC value changes, the equivalent temperature and resistance are calculated and displayed beneath the DAC value.

When all the TEC parameters are set to the desired values, the output of the temperature controller can be enabled. With the output enabled the temperature controller will drive current to the TEC modules to cool or heat the load depending on the difference between the set point and the actual temperature. Press the soft key F1 once to enable the TEC output, and again to disable the output. The display soft key enunciator will toggle from off to on to off by repeatedly depressing the soft key. The default condition for the TEC output is off when the instrument is first powered up. Other conditions which will disable the TEC output are listed in the next section.

Conditions Which Will Automatically Shut Off the TEC Output

The following conditions will automatically cause the instrument to turn off the TEC output when the default settings are used. Some responses to limit and error conditions can be changed through GPIB control. See Chapters 3 and 4 for more information.

1   High Temperature Limit reached (E407)

2   Sensor Open (while output is enabled, E402)

3   TEC Module Open (while output is enabled, E403)

4   Sensor Range Changed (while output is on, E409)

5   Sensor Shorted (while output is on, E415)

6   TEC Mode Changed (while output is on, E435)

TEC Error Indicators

The LDC-3916370 Series Controllers indicate general TEC operational error conditions. When an error occurs, the Error Indicator Code will appear on the Status page, the Chan page, or the respective channel's setup pages. The Error Indicator Code will clear if you exit any page that it appears on. TEC Error Indicator Codes are summarized in Table 2.3. Some of these errors can be disabled using GPIB. See Chapter 4 for more information. See Chapter 3 in the LDC-3916 mainframe manual for mainframe error codes.

Table 2.3 TEC Error Indicators

Error Number	Error Condition	Probable Cause
E402	Open Sensor	An open circuit has been detected in the thermistor connections. Check the connections to the thermistor and to pins 7 and 8 on the 15-pin connector.
E403	TEC Module Open	An open circuit has been detected in the TEC module connections. Check the wires and connections to the TEC module, and to pins 1,2 and 3,4 on the controller's 15-pin connector.
E404	TEC Current Limit	The controller reached the current limit, and the "current limit" bit of the Output Off Enable register has been set using GPIB.
E405	Voltage Limit	The output driver has reached its voltage limit and the "voltage limit" bit of the Output Off Enable register has been set using GPIB.
E407	Temperature Limit	The measured temperature has reached the high-temperature limit setting.
E409	Sensor Changed (with output enabled)	The sensor current source range was changed during operation of the temperature controller while the output was enabled. The TEC output only is disabled and the error condition is displayed.
E410	Tolerance error	The output dropped out of tolerance, and the "Tolerance" bit in the Output Off Enable register has been set.
E415	Sensor Shorted	The measured thermistor resistance is less than 25 Ω, and the "Sensor Shorted" bit in the Output Off Enable register has been set.
E435	Mode Changed	The TEC mode was changed while the TEC output was on.

The errors that are enabled in the "Output Off Enable" register by default at power-up are Open Sensor, TEC Module Open, Temperature Limit, and Sensor Shorted. The Output Off Enable register is not saved at power-down.

REMOTE OPERATIONS

Everything you can do from the front panel can also be done remotely and in some cases with more flexibility. For example, in remote mode, you can enable or disable conditions that will cause the laser current source or the TEC controller to automatically shut off.   The following sections show you the fundamentals of operating your LDC-3916370 Series module remotely through the GPIB and RS-232 interfaces.

Remote Configuration

Refer to the LDC-3916 Instruction Manual Chapter 3, "Operating in Remote Control" for information concerning setup of GPIB or RS-232 remote communications. That section also describes the use of IEEE 488.2 common commands, LDC-3916 mainframe commands, and syntax.

LDC-3916370 Series Laser Diode Controller Command Set

The LDC-3916370 Series module utilizes its own module-specific commands, as well as the commands for the LDC-3916 mainframe (see LDC-3916 User's Manual Chapter 3 "Operating in Remote Control"). Figure 3.1 shows all of the commands which are usable by the LDC-3916 in conjunction with the LDC-3916370 Series modules.
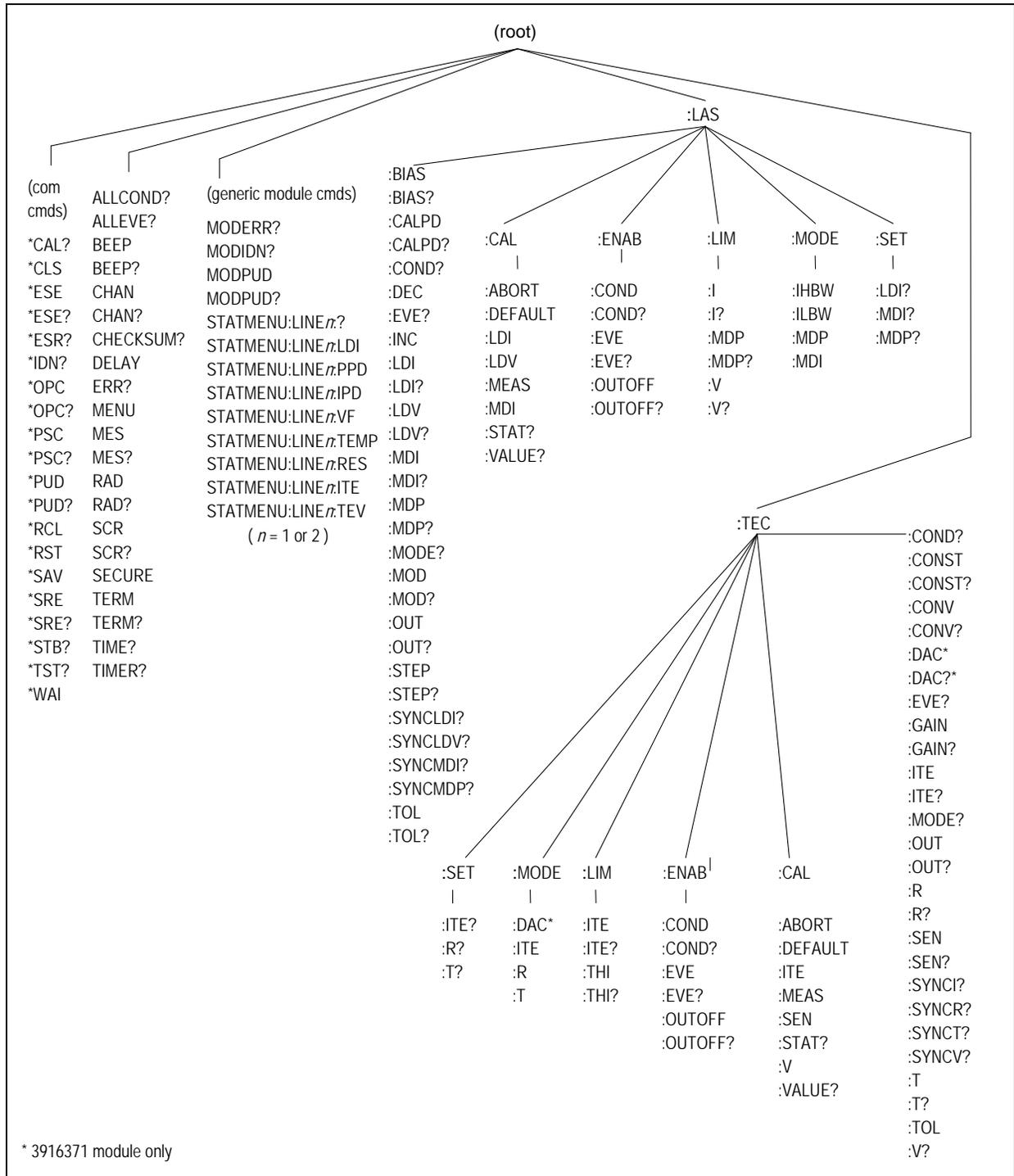
(root)

(com cmds)

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

ALLCOND?
ALLEVE?
BEEP
BEEP?
CHAN
CHAN?
CHECKSUM?
DELAY
ERR?
MENU
MES
MES?
RAD
RAD?
SCR
SCR?
SECURE
TERM
TERM?
TIME?
TIMER?

(generic module cmds)

MODERR?
MODIDN?
MODPUD
MODPUD?
STATMENU:LINE*n*.?
STATMENU:LINE*n*.LDI
STATMENU:LINE*n*.PPD
STATMENU:LINE*n*.IPD
STATMENU:LINE*n*.VF
STATMENU:LINE*n*.TEMP
STATMENU:LINE*n*.RES
STATMENU:LINE*n*.ITE
STATMENU:LINE*n*.TEV
(*n* = 1 or 2)

:LAS

:BIAS
:BIAS?
:CALPD
:CALPD?
:COND?
:DEC
:EVE?
:INC
:LDI
:LDI?
:LDV
:LDV?
:MDI
:MDI?
:MDP
:MDP?
:MODE?
:MOD
:MOD?
:OUT
:OUT?
:STEP
:STEP?
:SYNCLDI?
:SYNCLDV?
:SYNCMDI?
:SYNCMDP?
:TOL
:TOL?

:CAL
|
:ABORT
:DEFAULT
:LDI
:LDV
:MEAS
:MDI
:STAT?
:VALUE?

:ENAB
|
:COND
:COND?
:EVE
:EVE?
:OUTOFF
:OUTOFF?

:LIM
|
:I
:I?
:MDP
:MDP?
:V
:V?

:MODE
|
:IHBW
:ILBW
:MDP
:MDI

:SET
|
:LDI?
:MDI?
:MDP?

:TEC

:SET
|
:ITE?
:R?
:T?

:MODE
|
:DAC*
:ITE
:R
:T

:LIM
|
:ITE
:ITE?
:THI
:THI?

:ENAB
|
:COND
:COND?
:EVE
:EVE?
:OUTOFF
:OUTOFF?

:CAL
|
:ABORT
:DEFAULT
:ITE
:MEAS
:SEN
:STAT?
:V
:VALUE?

:COND?
:CONST
:CONST?
:CONV
:CONV?
:DAC*
:DAC?*
:EVE?
:GAIN
:GAIN?
:ITE
:ITE?
:MODE?
:OUT
:OUT?
:R
:R?
:SEN
:SEN?
:SYNCI?
:SYNCR?
:SYNCT?
:SYNCV?
:T
:T?
:TOL
:V?

* 3916371 module only

Figure 3.1 LDC-3916 and LDC-3916370 Series Command Path Structure

LDC-3916370 Series Laser Diode Controller Often Used Commands

Table 3.1 LDC-3916370 Series Often Used Commands

NAME	PARAMETER	FUNCTION
CHAN	1	Sets the channel (or ALL channels) for further commands
ERR?	NONE	Returns "mainframe" errors generated since the last query, followed by a binary representation of existing module errors
MODERR?	NONE	Returns module errors generated since the last error query (to that module)
STATMENU:LINE*n*	NONE	Returns the name of the measurement that is displayed on line *n* of the status menu; *n* can be either 1 or 2
STATMENU:LINE*n*:LDI	NONE	Sets line *n* of the status menu to display laser current
STATMENU:LINE*n*:VF	NONE	Sets line *n* of the status menu to display laser forward voltage
STATMENU:LINE*n*:IPD	NONE	Sets line *n* of the status menu to display photodiode current
STATMENU:LINE*n*:PPD	NONE	Sets line *n* of the status menu to display optical power
STATMENU:LINE*n*:TEMP	NONE	Sets line *n* of the status menu to display tec temperature
STATMENU:LINE*n*:ITE	NONE	Sets line *n* of the status menu to display tec current
STATMENU:LINE*n*:RES	NONE	Sets line *n* of the status menu to display thermistor resistance
STATMENU:LINE*n*:TEV	NONE	Sets line *n* of the status menu to display tec forward voltage
LASER		
LAS:CALPD	1	Sets the monitor photodiode responsivity for power mode use
LAS:LDI	1	Sets the LAS constant current source set point value
LAS:LDI?	NONE	Returns the constant current source measured value
LAS:LDV?	NONE	Returns the measured laser voltage value
LAS:LIM:I	1	Sets the LAS current source limit
LAS:LIM:MDP	1	Sets the constant optical power (from monitor PD) limit value

LAS:LIM:V	1	Sets the LAS current compliance voltage limit
LAS:MDP	1	Sets the constant optical power set point
LAS:MDP?	NONE	Returns the actual monitor PD power value
LAS:MODE:IHBW	NONE	Sets the mode to constant current, high bandwidth mode
LAS:MODE:ILBW	NONE	Sets the mode to constant current, low bandwidth mode
LAS:MODE:MDP	NONE	Sets the mode to constant optical power mode
LAS:OUT	1	Used to enable/disable the current source output
LAS:OUT	NONE	Returns the current source output status
TEC CONTROLLER		
TEC:CONST	3	Used to enter temperature sensor constants, C1, C2, C3
TEC:GAIN	1	Sets the TEC control loop gain parameter
TEC:LIM:ITE	1	Sets the TEC current limit value
TEC:LIM:THI	1	Sets the TEC upper temperature limit value
TEC:MODE:R	NONE	Sets the instrument to constant (sensor) reference mode
TEC:MODE:T	NONE	Sets the instrument to constant temperature mode
TEC:OUT	1	Used to enable/disable the TEC output
TEC:OUT?	NONE	Returns the TEC output status
TEC:SEN	1	Sets the SENSOR type for TEC feedback
TEC:T	1	Sets the TEC (temperature) set point
TEC:T?	NONE	Returns the TEC measured temperature value
TEC:V?	NONE	Returns the TEC measured voltage value

Command Timing and Completion

All commands for the LDC-3916370 Series modules are sequential, except for the "LAS:OUT ON", "LAS:INC", and "LAS:DEC" commands. The "LAS:OUT ON" command is overlapped to allow the user to abort it with the "LAS:OUT OFF" command during a two second interval after the output is told to be on. The "LAS:INC" and "LAS:DEC" commands are overlapped to allow the user to monitor the other functions while in an automatic ramping mode.

For more information on the use of operation complete commands, such as *WAI and *OPC, refer to the LDC-3916 User's Manual, Chapter 3.

Status Reporting

Refer to the LDC-3916 Laser Diode Controller Instruction Manual, Chapter 3 "Operating in Remote Control" for information on standard status structures, mainframe-related commands, and for understanding the Operation Complete definition.

The following sections discuss the LDC-3916370 Series module-dependent aspects of the status reporting, including the "OUTOFF" commands and queries. The Output Off Register section also contains information on specifying some of the conditions that will force the laser current source and/or TEC output off.

Status Registers

The LDC-3916370 Series modules provide status registers which are summarized in the LDC-3916 mainframe. These summaries are accessed by the "ALLCOND?" and "ALLEVE?" remote queries. Refer to the LDC-3916 Instruction Manual for details on remote status reporting.

Each channel of the LDC-3916 may contribute to the "ALLCOND" and "ALLEVE" registers. For the LDC-3916370 Series modules, the enabled conditions of both the LAS and TEC functions are logically ORed, and the summary is passed to the appropriate bit of the ALLCOND register (see Figure 3.2). Likewise, the enabled events of both the LAS and TEC functions are logically ORed, and the summary is passed to the appropriate bit of the ALLEVE register (see Figure 3.3).

For example, you may wish to have the LDC-3916 create an interrupt to the host PC in the event of the TEC output shutting off. To do this you would first enable the event with the "TEC:ENAB:EVE 1024" command. This would allow the event to be passed to the ALLEVE register on the 3916 mainframe. The ALLEVE status can be read by the "ALLEVE?" query and the summary can be monitored with the "*STB?" query. To generate the SRQ (interrupt) for our example, you must also set the Service Request Enable Register, e.g. "*SRE 1", to allow the ALLEVE summary to generate the interrupt. See the LDC-3916 Instruction Manual, Chapter 3, for details on status structures.

Note: When the laser voltage reaches the voltage limit setting (LAS:LIM:V), the hardware will always shut the laser off. The "Laser Voltage Limit" referred to in the Event, Condition, and Output Off Registers occurs when the voltage is about 0.25 volts less than the voltage limit setting. This feature can be used for a warning before the actual voltage limit is reached.

LASER Condition Status Register
LASer:COND?

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |

bit-wise
LOGICAL AND

LOGICAL OR

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |

LASER Condition Status Enable Register
LASer:ENABle:COND <nrf>
LASer:ENABle:COND?

LOGICAL OR

To ALLCOND Register

TEC Condition Status Register
TEC:COND?

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |

bit-wise
LOGICAL AND

LOGICAL OR

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |

TEC Condition Status Enable Register
TEC:ENABle:COND <nrf>
TEC:ENABle:COND?

LAS Condition Bit Reference

0 - LAS Current Limit	8 - Output Shorted
1 - LAS Voltage Limit	9 – In Tolerance
2 - N/A	10 - Output On
3 - Power Limit	11 - N/A
4 - Interlock Error	12 - N/A
5 - N/A	13 - N/A
6 - N/A	14 - N/A
7 - Open Circuit	15 - N/A

TEC Condition Bit Reference

0 - TEC Current Limit	8 - N/A
1 - TEC Voltage Limit	9 - In Tolerance
2 - N/A	10 - Output On
3 - Temperature Limit	11 - N/A
4 - N/A	12 - N/A
5 - N/A	13 - N/A
6 - Sensor Open	14 - N/A
7 - TE Module Open	15 - N/A

Figure 3.2 LDC-3916370 Series Condition Registers
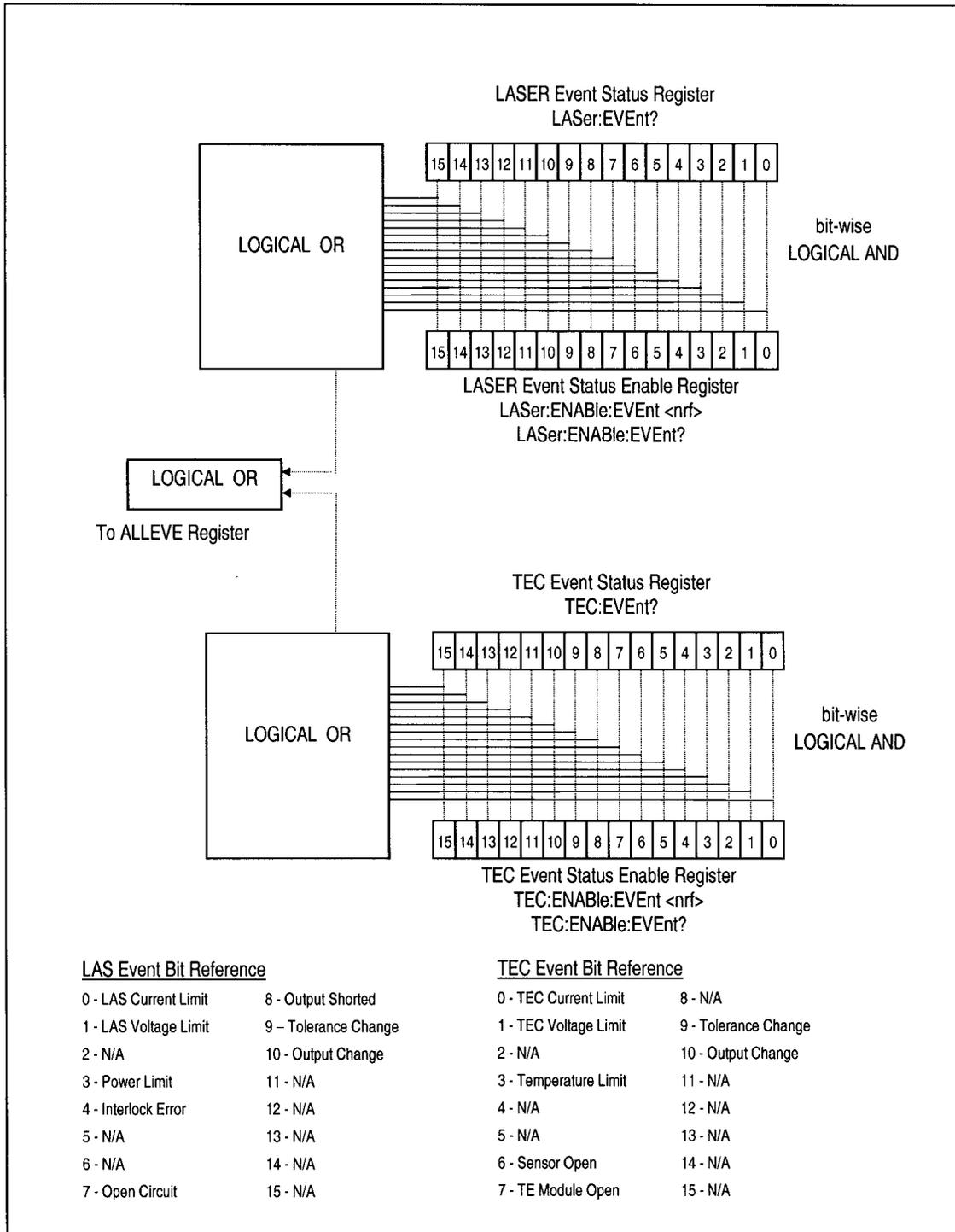
Figure 3.3 LDC-3916370 Series Event Registers

Output Off Registers

The Output Off Enable Registers allow you to determine which conditions and events in the TEC and LASER controllers can cause their outputs to be turned off. These registers are configured in a manner which is similar to the status reporting registers. However, their values are not reported in the Status Byte Register. These registers are used by the firmware to control the output enable for that function (LASER or TEC). The events and conditions which may be set to cause the TEC and LASER outputs to be turned off are shown in Figures 3.4 and 3.5.

The default settings for these registers for an LDC-3916370 Series module are shown in Table 3.2. The registers take on these values at power-up, as the result of a *RST command, or when you choose "Default" from the Save/Recall menu. These settings are not affected by the *PSC (Power-On Status Clear) command.

Table 3.2 LDC-3916370 Series Default Settings for Output Off Registers

	LASER Output Off Register			TEC Output Off Register	
Bit	Name	State	Bit	Name	State
0	Current Limit	Disabled	0	Current Limit	Disabled
1	Voltage Limit	Disabled	1	Voltage Limit	Disabled
2	N/A		2	N/A	
3	Power Limit	Enabled	3	High Temperature Limit	Enabled
4	N/A		4	N/A	
5	N/A		5	N/A	
6	N/A		6	Sensor Open	Enabled
7	N/A (see Note 1 below)		7	TE Module Open Circuit	Enabled
8	N/A		8	Sensor Type changed	Enabled
9	Out of Tolerance	Disabled	9	Out of Tolerance	Disabled
10	TEC Output Off	Disabled	10	Sensor Shorted	Enabled
11	TEC High Temp Limit	Enabled	11	N/A	
12	N/A		12	N/A	
13	N/A		13	N/A	
14	N/A		14	N/A	
15	N/A		15	N/A	

Note: Bit 7 is Laser Open Circuit in the Laser Condition and Event registers. It is not available to disable in the Output Off Enable register because it is always active in the hardware.
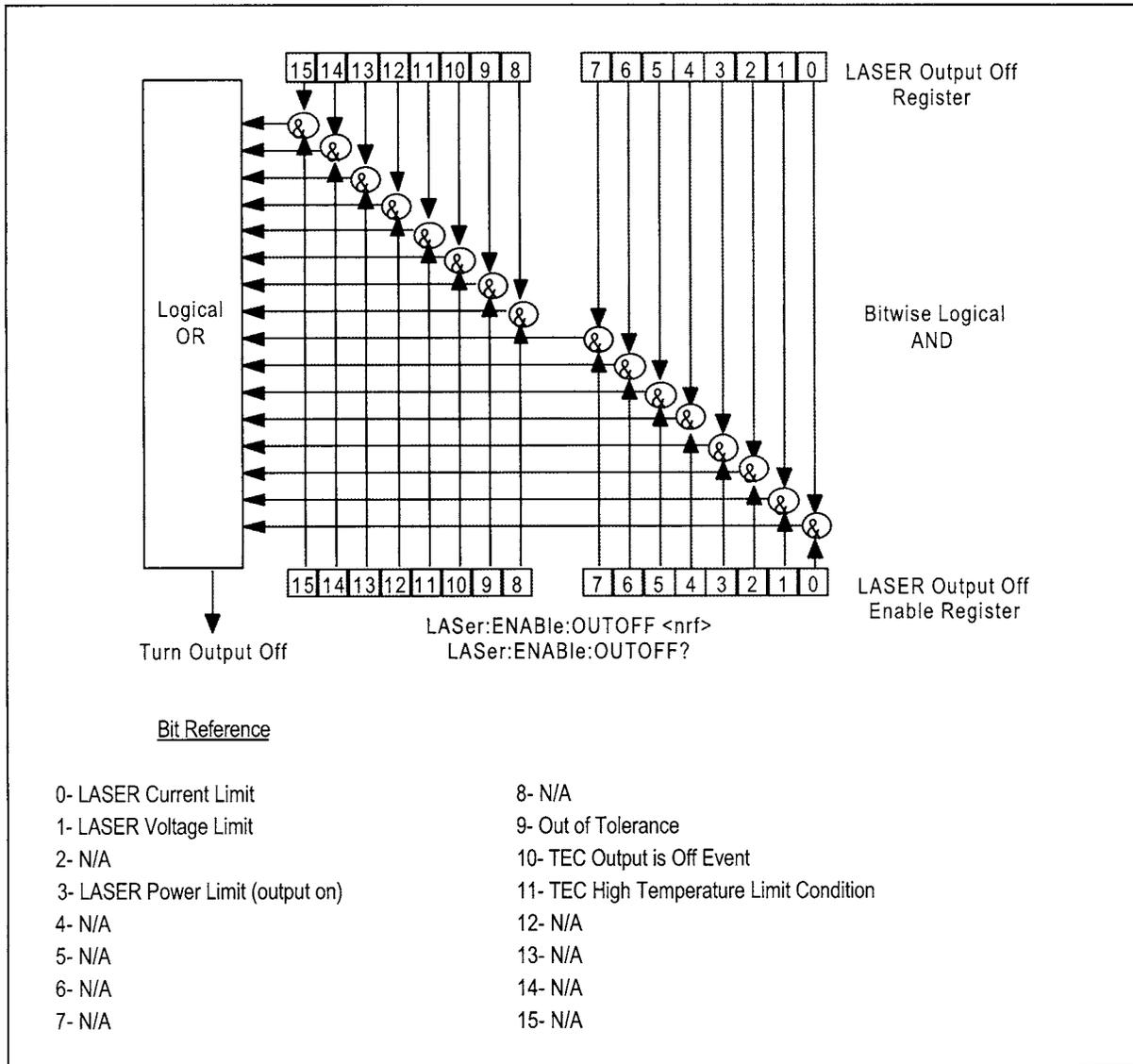
Figure 3.4 LDC-3916370 Series Laser Diode Controller LASER Output Off Register
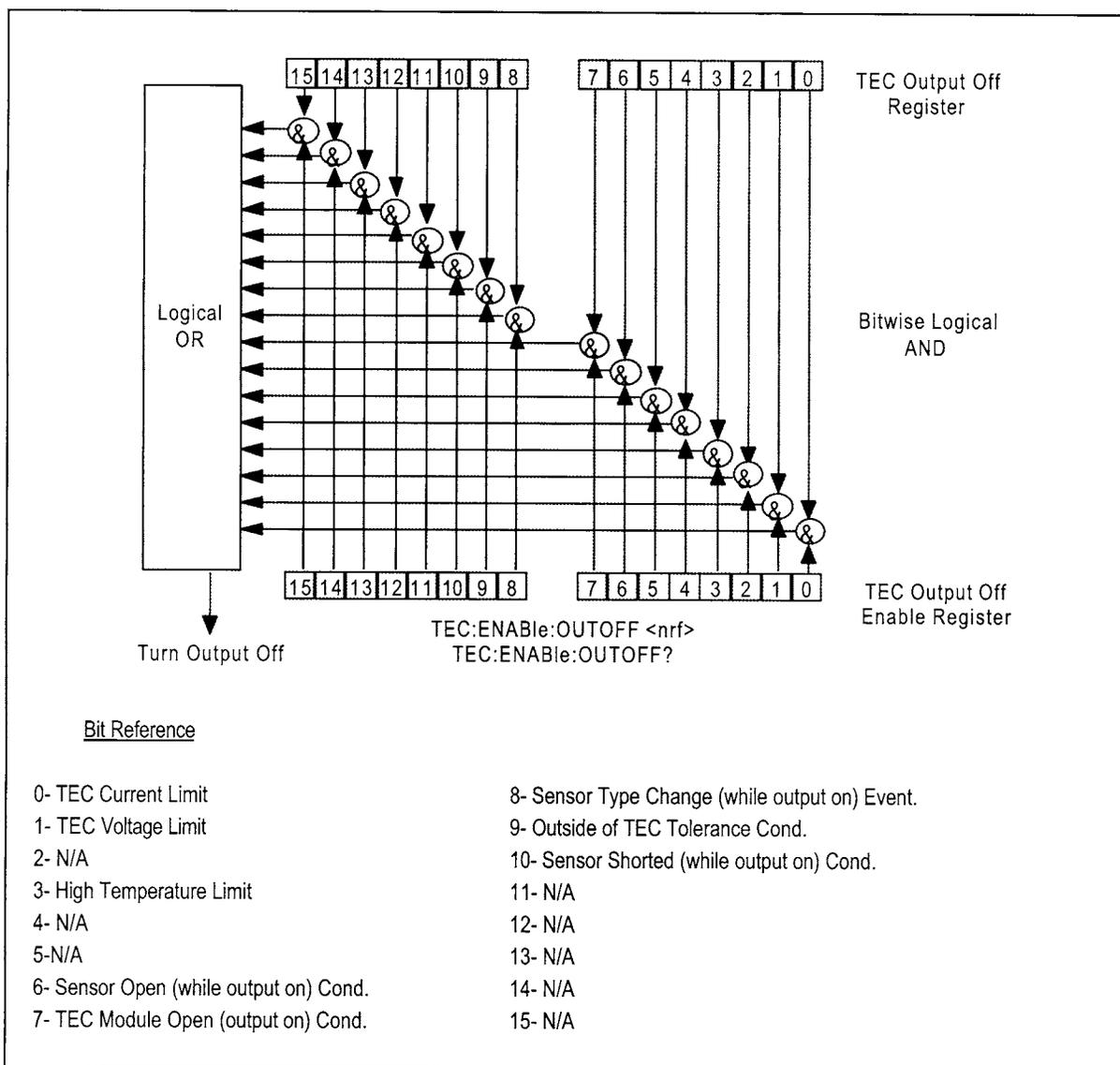
Figure 3.5 LDC-3916370 Series Laser Diode Controller TEC Output Off Register

Error Messages

This section contains descriptions of the errors which are specific to the LDC-3916370 Series modules. These are the error codes that are returned from the "MODERR?" query. Refer to the LDC-3916 Laser Diode Controller Instruction Manual, Chapter 3, for a list of LDC-3916 mainframe error codes and descriptions (the codes returned from the "ERR?" query).

During remote operation, the recommended method for error testing is as follows. First read the system errors and module error summary with the "ERR?" query. This allows you to error check the LDC-3916 as a whole. If any module errors are present, the corresponding bit of the error summary will be set. For example, if the "ERR?" query returns "0,0001000000100000" there are errors on channels 13 and 6. Then read the module errors using the "MODERR?" query. For example, "Chan 13;Moderr?" and "Chan 6;Moderr?" queries could be sent. For more information on LDC-3916 mainframe errors, refer to Chapter 3 of the LDC-3916 Instruction Manual.

Table 3.3 LDC-3916370 Series Error Message Codes

Error Code	Explanation
E-103	Length of arbitrary block is different from expected length.
E-104	Parameter is an undefined numeric type.
E-105	Parameter has an invalid exponent.
E-106	A digit was expected in the parameter but was not found.
E-114	Specified arbitrary block length is invalid.
E-123	Command is not found.
E-126	Wrong number of parameters for command.
E-201	Parameter value out of range.
E-202	Error in conversion of parameter type.
E-203	Command is a "secure" command, but secure commands are disabled.
E-205	Expected Boolean parameter is invalid.
E-206	Error in conversion to signed 16-bit integer.
E-207	Error in conversion to unsigned 16-bit integer.
E-209	Error in conversion to unsigned 32-bit integer.
E-210	Error in conversion to floating-point number.
E-214	Response is too long to output.
E-220	Programmable User Data specification invalid.
E-221	Internal error: message undeliverable.
E-222	Set value is over range.
E-223	Set value is under range.

Error Code	Explanation
E-402	Sensor open forces TEC output off.
E-403	Module Open forces TEC output off.
E-404	TE Current Limit forces TEC output off.
E-405	TE Voltage Limit forces TEC output off.
E-407	High Temperature Limit forces TEC output off.
E-409	Sensor Changed while output enabled; TEC output forced off.
E-410	Out of Tolerance status forces TEC output off.
E-415	Sensor Shorted forces TEC output off.
E-435	TEC Operating Mode changed while output on; TEC output forced off.
E-501	Interlock Open forces LAS output off.
E-503	LAS forward voltage exceeds Voltage Limit setting; LAS output forced off. (Open Circuit error)
E-504	LAS Current Limit forces LAS output off.
E-505	LAS forward voltage approaching Voltage Limit setting; LAS output forced off.
E-507	LAS Power Limit forces LAS output off.
E-508	TEC Output Off Status forces LAS output off.
E-509	TEC Temperature Limit forces LAS output off.
E-510	Out of Tolerance Status forces LAS output off.
E-511	LAS Hardware Error forces LAS output off.
E-512	A TEC source, such as a 3916558 or 3916545, which has been programmed to control this laser module has turned off for some reason. This condition will shut down the laser source when enabled.
E-513	A TEC source, such as a 3916558 or 3916545, which has been programmed to control this laser module has turned off because it reached the temperature limit. This condition will shut down the laser source when enabled.
E-529	LAS Output is off, but LAS status thought it was on.
E-535	LAS Operating Mode changed while output on; LAS output forced off.
E-601	Internal error: recalled setting has incorrect checksum (settings do not match bin).
E-710	Internal error: AC power low detected.
E-711	Internal error: AC power low detected.
E-712	Internal error: over-temperature error found on internal sensor.
E-713	Internal error: power brown-out error detected.
E-714	Internal error: writing to display
E-802	Calibration Measurement Entered Before Calibration was Ready.
E-803	Attempted to Enter Invalid Calibration Mode.

COMMAND REFERENCE

This chapter is a guide to all of the device-dependent commands for the LDC-3916370 Series Laser Diode Controller module. This chapter is divided into two parts. The first part contains an overview of the remote commands used by the LDC-3916370 Series. The second part contains all of the LDC-3916370 Series commands in alphabetical order. Figure 4.1 shows the format for the device command descriptions in this chapter. The commands which 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.

GPIB Command Reference Summary

ILX Lightwave

Command Reference

Table 4.1 GPIB Command Summary Reference List

Name	Parameters	Function
LAS:BIAS	1	Enables or disables the -5 volt photodiode bias
LAS:BIAS?	NONE	Returns the status of the photodiode bias control
LAS:CALPD	1	Used to set the CAL PD (monitor responsivity) constant
LAS:CALPD?	NONE	Returns the CAL PD (monitor responsivity) constant
LAS:CAL:ABORT	NONE	Aborts a LAS calibration
LAS:CAL:DEFAULT	NONE	Restores all LAS calibration values to their defaults
LAS:CAL:LDI	NONE	Enters the laser current calibration mode
LAS:CAL:LDV	NONE	Enters the laser voltage calibration mode
LAS:CAL:MDI	NONE	Enters the monitor photodiode current calibration mode
LAS:CAL:MEAS	1	Enters a calibration value
LAS:CAL:STAT?	NONE	Returns a value which represents the calibration status
LAS:CAL:VALUE?	1	Used for factory calibration testing only
LAS:COND?	NONE	Returns the value of the LASER condition register
LAS:DEC	2	Decreases the laser set point value by one or more steps with user-programmable delay between steps
LAS:ENAB:COND	1	Sets the enable register for LASER conditions
LAS:ENAB:COND?	NONE	Returns the value of the LAS conditions enable register
LAS:ENAB:EVE	1	Sets the enable register for LAS events
LAS:ENAB:EVE?	NONE	Returns the value of the LAS event enable register
LAS:ENAB:OUTOFF	1	Sets the enable register for LAS conditions which turn the LAS output off
LAS:ENAB:OUTOFF?	NONE	Returns the value of the LAS outoff enable register
LAS:EVE?	NONE	Returns the value of the LAS event register
LAS:LDI	1	Sets the LASER constant current source set point value
LAS:LDI?	NONE	Returns the constant current source measured value
LAS:INC	2	Increases the laser set point value by one or more steps with user-programmable delay between steps
LAS:LDV?	NONE	Returns the measured laser voltage value
LAS:LIM:I	1	Sets the LASER current source limit
LAS:LIM:I?	NONE	Returns the LASER current source limit
LAS:LIM:MDP	1	Sets the constant optical power (from monitor PD) limit value
LAS:LIM:MDP?	NONE	Returns the optical power (from monitor PD) limit value
LAS:LIM:V	1	Sets the LASER compliance voltage limit value
LAS:LIM:V?	NONE	Returns the LASER compliance voltage limit value
LAS:MDI	1	Sets the monitor current set point
LAS:MDI?	NONE	Returns the monitor PD current measured value
LAS:MDP	1	Sets the constant optical power set point
LAS:MDP?	NONE	Returns the actual monitor PD power value

Table 4.1 GPIB Command Summary Reference List

Name	Parameters	Function
LAS:MODE?	NONE	Returns the mode, I (current), IHBW (high bandwidth), P (optical power) or MDI (constant monitor current)
LAS:MODE:IHBW	NONE	Sets the mode to constant current, high bandwidth.
LAS:MODE:ILBW	NONE	Sets the mode to constant current low bandwidth mode
LAS:MODE:MDP	NONE	Sets the mode to constant optical power mode.
LAS:MOD	1	Enables or disables the channel's modulation output
LAS:MOD?	NONE	Returns the status of the channel's modulation output
LAS:OUT	1	Enables/disables the current source output
LAS:OUT?	NONE	Returns the current source output status
LAS:SET:LDI?	NONE	Returns the laser constant I (current) set point
LAS:SET:MDI?	NONE	Returns the laser constant optical power set point
LAS:SET:MDP?	NONE	Returns the constant P (optical power) set point
LAS:STEP	1	Sets the LASER set point step value
LAS:STEP?	NONE	Returns the LASER set point step value
LAS:SYNCLDI?	NONE	Synchronized measurement; returns the laser current in mA
LAS:SYNCLDV?	NONE	Synchronized measurement; returns the laser voltage in volts
LAS:SYNCMDI?	NONE	Synchronized measurement; returns the monitor photodiode current in μA
LAS:SYNCMDP?	NONE	Synchronized measurement; returns the optical power
LAS:TOL	2	Sets the LASER set point tolerance value and time period value
LAS:TOL?	NONE	Returns the LASER set point tolerance value and time period value
MODERR?	NONE	Returns the error codes (up to 10) from the module
MODIDN?	NONE	Returns identification data from the module
MODPUD	1	Used at factory to set calibration information
MODPUD?	NONE	Returns factory set calibration information
STATMENU:LINE*n*?	NONE	Returns the name of the measurement that is displayed on line *n* of the status menu (*n* can be either 1 or 2)
STATMENU:LINE*n*:LDI	NONE	Sets line *n* of the status menu to display laser current
STATMENU:LINE*n*:VF	NONE	Sets line *n* of the status menu to display laser forward voltage
STATMENU:LINE*n*:IPD	NONE	Sets line *n* of the status menu to display photodiode current
STATMENU:LINE*n*:PPD	NONE	Sets line *n* of the status menu to display optical power
STATMENU:LINE*n*:TEMP	NONE	Sets line *n* of the status menu to display tec temperature
STATMENU:LINE*n*:ITE	NONE	Sets line *n* of the status menu to display tec current
STATMENU:LINE*n*:RES	NONE	Sets line *n* of the status menu to display thermistor resistance
STATMENU:LINE*n*:TEV	NONE	Sets line *n* of the status menu to display tec forward voltage
TEC:CAL:ABORT	NONE	Aborts a TEC calibration
TEC:CAL:DEFAULT	NONE	Sets all of the TEC calibration values to defaults
TEC:CAL:ITE	1	Enters the TEC current source calibration mode
TEC:CAL:MEAS	1	Enters a calibration value
TEC:CAL:SEN	1	Enters the sensor calibration mode

Table 4.1 GPIB Command Summary Reference List

Name	Parameters	Function
TEC:CAL:STAT?	NONE	Returns the status of the TEC calibration
TEC:CAL:V	1	Enters the TEC voltage calibration mode
TEC:CAL:VALUE?	1	Used for factory calibration testing only
TEC:COND?	NONE	Returns the value of the TEC condition register
TEC:CONST	3	Sets temperature sensor constants (C1, C2 and C3)
TEC:CONST?	NONE	Returns the temperature sensor constant values
TEC:CONV:R	1	Converts a resistance (KΩ) to temperature (^{o}C)
TEC:CONV:R?	0 or 1	Returns the equivalent temperature (^{o}C) of the last conversion
TEC:CONV:T	1	Converts a temperature (^{o}C) to resistance (KΩ)
TEC:CONV:T?	0 or 1	Returns the equivalent resistance (KΩ) of the last conversion
TEC:ENAB:COND	1	Sets the enable register for TEC conditions
TEC:ENAB:COND?	NONE	Returns the value of the TEC conditions enable register
TEC:ENAB:EVE	1	Sets the enable register for TEC events
TEC:ENAB:EVE?	NONE	Returns the value of the TEC event enable register
TEC:ENAB:OUTOFF	1	Sets the enable register for TEC conditions which turn the TEC output off
TEC:ENAB:OUTOFF?	NONE	Returns the value of the TEC outoff enable register
TEC:EVENT?	NONE	Returns the value of the TEC event register
TEC:GAIN	1	Sets TEC control loop gain parameter
TEC:GAIN?	NONE	Returns the TEC control loop gain parameter
TEC:ITE	1	Sets the TEC current (ITE) set point
TEC:ITE?	NONE	Returns the measured TEC current (ITE) value
TEC:LIM:ITE	1	Sets the TEC constant current source limit value
TEC:LIM:ITE?	NONE	Returns the TEC constant current source limit value
TEC:LIM:THI	1	Sets the TEC upper temperature limit value
TEC:LIM:THI?	NONE	Returns the TEC upper temperature limit value
TEC:MODE?	NONE	Returns the mode, ITE (TEC current), R (sensor), T (temperature) or DAC (DAC Count - 3916371 module only).
TEC:MODE:DAC	NONE	Sets the mode to DAC mode (3916371 module only)
TEC:MODE:ITE	NONE	Sets the mode to constant TEC current mode
TEC:MODE:R	NONE	Sets the mode to constant thermistor resistance/linear sensor reference mode
TEC:MODE:T	NONE	Sets the TEC mode to constant temperature mode
TEC:OUT	1	Enables/disables the TEC current output
TEC:OUT?	NONE	Returns the TEC OUTPUT status
TEC:R	1	Sets the constant sensor resistance set point
TEC:R?	NONE	Returns the measured thermistor resistance value
TEC:SEN	1	Sets the SENSOR type
TEC:SEN?	NONE	Returns the SENSOR type (value)
TEC:SET:ITE?	NONE	Returns the constant ITE (TEC current) set point
TEC:SET:R?	NONE	Returns the constant R (thermistor resistance) set point

Table 4.1 GPIB Command Summary Reference List

Name	Parameters	Function
TEC:SET:T?	NONE	Returns the constant T (temperature) set point
TEC:SYNCI?	NONE	Synchronized measurement; returns the TE current in amps
TEC:SYNCR?	NONE	Synchronized measurement; returns the thermistor resistance in kΩ.
TEC:SYNCT?	NONE	Synchronized measurement; returns the thermistor temperature in ^{o}C
TEC:SYNCV?	NONE	Synchronized measurement; returns the measured TE voltage in volts
TEC:T	1	Sets the TEC constant T (temperature) set point
TEC:T?	NONE	Returns the TEC measured temperature value
TEC:TOL	2	Sets the TEC set point tolerance value and time period value
TEC:TOL?	NONE	Returns the TEC set point tolerance value and time period value
TEC:V?	NONE	Returns the TEC voltage measurement

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LDC-3916370 Series Device-Dependent Command Reference

This section contains all of the device dependent commands for the LDC-3916370 Series Laser Diode Controller, listed in alphabetical order. Sub-sections for each path are presented, listing the commands which are legal for that path. The following pages also contain a reference for the device dependent commands. This reference contains useful information for both local and remote operation of the laser diode controller.

LASer:

COMMON
DEVICE DEPENDENT
FRONT PANEL

The LASer: command path is used to get to the LDC-3916370 Series Laser Diode Controller's laser current source commands. The following command paths may be reached from the LASer: command path.

LASer:CAL:	LASer:MODE:
LASer:ENABle:	LASer:SET:
LASer:LIMit:	

The following commands may be reach directly from the LASer: command path.

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

LASer:BIAS

COMMON

DEVICE DEPENDENT

FRONT PANEL

The LASer:BIAS command turns the selected channel's laser photodiode bias on or off.
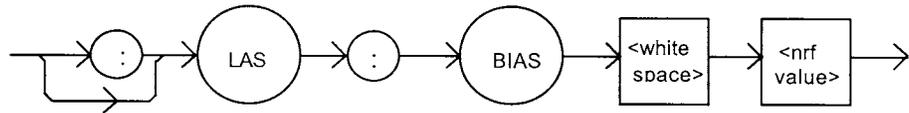
Parameters	An <nrf value>; 1 = on, 0 = off
Notes	When the BIAS is on, a bias of -5 volts is placed across the photodiode terminals.
Examples	"LAS:BIAS ON" - action: sets the selected channel's laser photodiode bias output on.
	"Las:Bias 0" - action: turns the selected channel's laser photodiode bias off.

LASer:BIAS?

COMMON

DEVICE DEPENDENT

FRONT PANEL

The LASer:BIAS? query returns the status of the selected laser channel's photodiode bias selection.
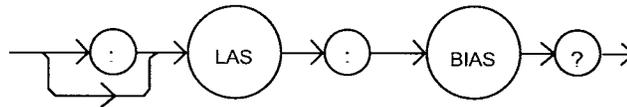
Parameters	None. The response is an <nrf value>.
Notes	Photodiode bias is turned off when a *RST command is issued.
Examples	"Las:BIAS?" - response: 0, means that the selected channel's photodiode bias is off.
	"LAS:Bias?" - response: 1, means that the selected channel's photodiode bias is enabled.

ILX Lightwave

`LASer:CALPD`

The LASer:CALPD command sets the laser's photodiode feedback responsivity (the CAL PD parameter) on the selected channel.
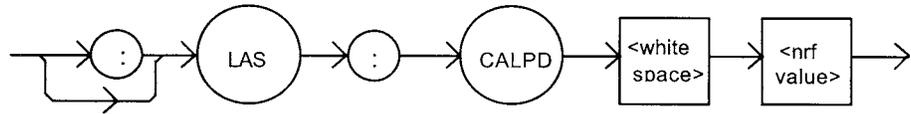
Parameters   An <nrf value>, in microamps/milliwatt.

Notes   Optical power (PPD) is calculated as the monitor photodiode current divided by this value.

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

"Laser:Calpd 1" - action: sets the CAL PD parameter to 1.00 microamp/milliwatt: a photodiode feedback current of 1 microamp will cause the P display to read 1 milliwatt.

`LASer:CALPD?`

The LASer:CALPD? query returns the value of the laser's photodiode feedback responsivity (CAL PD parameter) setting for the selected channel.
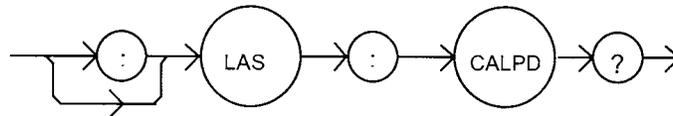
Parameters   None. The response is an <nrf value>.

Notes   If this value is 0, the selected channel's monitor current/power conversion will not be done. If the mode is set to MDP, the actual set point will be forced to be (near) 0, regardless of the LAS:MDP value.

If this value is 0, the front panel P will display "----", and no P value can be calculated.

Examples   "LASER:CALPD?" - response: 0, means the selected channel's monitor current/power conversion will not be done. If the mode is set to P, the actual set point will be forced to be (near) 0, regardless of the LAS:MDP value.

"Las:CALPD?" - response: 1.1, means the selected channel is set for operation in constant P mode (if MDP mode is also selected) and the responsivity is set to 1.10 μA/mW. 1.1 μA of photodiode feedback current represents 1 mW of optical power.

LASer:CAL:

The LASer:CAL: command path is used to get to the selected channel's laser calibration commands.

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

LASer:CAL:ABORT	LASer:CAL:DEFAULT	LASer:CAL:LDI
LASer:CAL:LDV	LASer:CAL:MDI	LASer:CAL:MEAS
LASer:CAL:VALUE?		

LASer:CAL:ABORT

The LASer:CAL:ABORT command is used to exit a laser calibration without changing the calibration values.
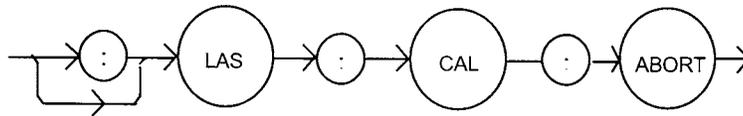
Parameters	None.
Notes	After this command is issued it is safe to run the LDC-3916370 Series Laser Diode Controller with the same calibration values used as before the LAS calibration mode was started.
	This command is intended for use after a false or invalid calibration value is entered, or to exit calibration mode before any values have been entered.
Examples	"Las:CAL:ABORT" - action: the LDC-3916370 Series Laser Diode Controller exits calibration mode.

LAS:CAL:DEFAULT

The LASer:CAL:DEFAULT command is used to restore all of the module's LAS calibration default values.
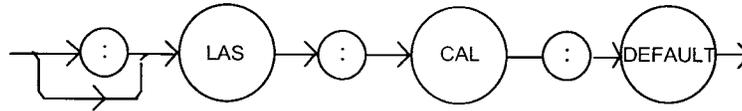
Parameters   None.

Notes   This command should not be used except when normal calibration procedures and/or normal operation of the LAS functions is not possible.

After this command is issued, the LAS module will not be calibrated. Each of the prescribed calibration procedures must be redone. The default values are the starting point values which exist before factory calibration is done.

Examples   "Las:CAL:Default" - action: the LDC-3916370 Series Laser Diode Controller sets all of the LAS calibration values to defaults on the selected module.

LASer:CAL:LDI

COMMON

DEVICE DEPENDENT

FRONT PANEL

The LASer:CAL:LDI command is used to enter the LASER current set point, measurement, and limit calibration mode for the selected channel.
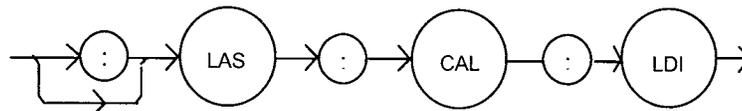
Parameters   None.

Notes   Since the limit circuit is the same for both high and low bandwidth modes, it is only calibrated when low bandwidth mode is selected. Both low and high bandwidth are calibrated during this procedure.

After this command is issued, the LDC-3916370 Laser Diode Controller will allow calibration of the current set point, measurement, and limit. This procedure is outlined in the calibration section of the laser module instruction manual.

Examples   "Las:CAL:LdI" -action: the LDC-3916370 Series Laser Diode Controller enters calibration mode for LASER current.

"Las:Cal:LDI" -action: the LDC-3916370 Series Laser Diode Controller enters calibration mode for laser current.

LASer:CAL:LDV

The LASer:CAL:LDV command is used to enter the LASER voltage measurement calibration mode for the selected channel.
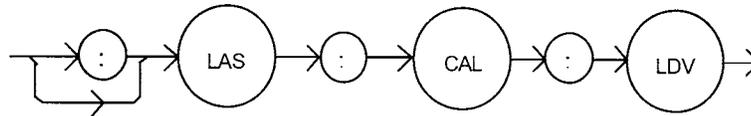
Parameters None.

Notes After this command is issued, the LDC-3916370 Series Laser Diode Controller will allow calibration of the laser voltage measurement. This procedure is outlined in the calibration section of the laser module instruction manual.

The LASer:CAL:STAT? query may be used to determine when the unit is ready for a calibration value to be entered.

Examples "Las:CAL:Ldv" -action: the LDC-3916370 Series Laser Diode Controller enters calibration mode for LASER voltage.

"Las:Cal:LDV" -action: the LDC-3916370 Series Laser Diode Controller enters calibration mode for LASER voltage.

LASer:CAL:MDI

The LASer:CAL:MDI command is used to enter the LASER photodiode current calibration mode.
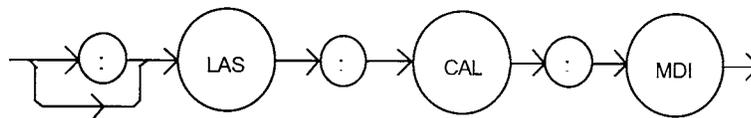
Parameters None.

Notes After this command is issued, the LDC-3916370 Series Laser Diode Controller will automatically enter the LASER photodiode current calibration mode for the current LASER range. When the LDC-3916370 Series Laser Diode Controller is ready, the user should enter the true measured value. This procedure is outlined in the calibration section of the laser module instruction manual.

In remote operation, the LASer:CAL:STAT? query may be used to determine if the LDC-3916370 Series Laser Diode Controller is ready for the user to enter a value via the LASer:CAL:MEAS command.

Examples "Las:CAL:MDI" -action: the LDC-3916370 Series Laser Diode Controller enters the LASER photodiode current calibration mode.

"Chan 1; LAS:Cal:MDI" -action: the LDC-3916370 Series Laser Diode Controller enters the LASER photodiode current calibration mode for channel 1.

LASer:CAL:MEAS

COMMON
DEVICE DEPENDENT
FRONT PANEL

The LASer:CAL:MEAS command is used to enter the laser calibration values for the selected channel.
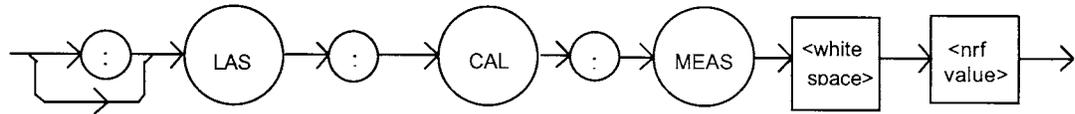
Parameters An <nrf value> which represents the calibration value expected for the present LAS calibration state.

Notes In remote operation, the LAS:CAL:STAT? query may be used to determine if the LDC-3916370 Series Laser Diode Controller is ready for the user to enter a value via the LAS:CAL:MEAS command.

Examples "Las:CAL:MEAS 4.95" - action: the LDC-3916370 Series Laser Diode Controller enters the value 4.95 for calibration value of the present calibration mode.

LASer:CAL:STATus?

COMMON
DEVICE DEPENDENT
FRONT PANEL

The LASer:CAL:STATus? query is to determine whether the unit is ready for a calibration value and whether it is in calibration mode.
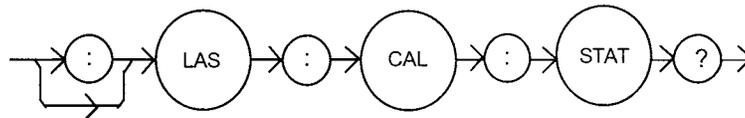
Parameters None. The response will be an <nrf value>; 0 = not ready for measurement; 1 = ready for measurement; 2 = calibration completed; 3 = calibration aborted

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

Examples "LAS:CAL:STAT?" = response: 1, means the LDC-3916370 Series Laser Diode Controller is ready for a calibration measurement to be entered via the "LAS:CAL:MEAS" command.

"LAS:CAL:STAT?" = response: 2; means the calibration has been completed.

"LAs:Cal:Stat?" = response: 0, means the unit is not yet ready for the LAS calibration measurement value to be entered.

LASer:CAL:VALUE?

COMMON
DEVICE DEPENDENT
FRONT PANEL

The LASer:CAL:MEAS command is used to enter the laser calibration values for the selected channel.

LASer:COND?

The LASer:COND? query returns the value of the selected channel's laser condition status register.
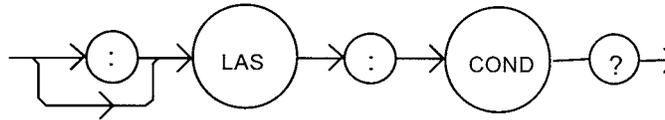
Parameters	None. The response is the sum of the following:

1 - LASER Current Limit	256 - Output is off
2 - LASER Voltage Limit	512 - Output in tolerance
4 - N/A	1024 - Output is on
8 - Power limit	2048 - N/A
16 - Interlock disabled	4096 - N/A
32 - N/A	8192 - N/A
64 - N/A	16384 - N/A
128 - Open circuit	32768 - N/A

Notes   The LASER conditions which are reported to the status byte and ALLCOND register are set via the LASer:ENABle:COND command (for each channel).

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

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

NOTE: The voltage limit condition occurs as a warning when the voltage is about 0.25 volts below the VLIM setting.

Examples   "LAS:COND?" - response: 1027, means that the output is on, and the current limit and voltage limit conditions currently exist.

`LASer:DEC`

The LASer:DEC command decrements the selected channel's laser constant current set point by one or more steps. Parameters allow multiple steps to be decremented and the time (in milliseconds) between decrements to be set, respectively.
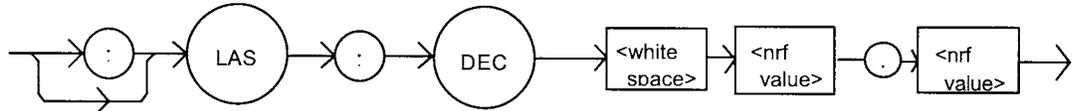
Parameters Two <nrf values> are required. The first one represents the number of steps, and the second is the number of milliseconds between steps.

Notes The step size can be edited via the LAS:STEP command. Its default value is 1.0 mA.

The first parameter (number of steps) must be an integer between 1 and 50000.

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

Only the LAS:LDI set point is decremented via this command regardless of LAS:MODE setting or LAS:OUTPUT status.

Examples "LAS:STEP 0.3; LAS:DEC 1,10" - action: the laser source current set point is decremented by 0.3 mA.

"LAS:STEP 0.3; LAS:DEC 3,10" - action: the laser source current set point is decremented by 0.9 mA (0.3 mA * 3).

"LAS:STEP 0.3; LAS:DEC 3, 5000" - action: the laser source current set point is decremented by 0.3 mA, three times, with 5 seconds between decremental steps. So the laser output is decremented a total of 0.9 mA after 10 seconds.

`LASer:ENABle`

The LASer:ENABle: command path is used to get to the selected channel's laser status enable commands and queries.

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

LASer:ENABle:COND	LASer:ENABle:EVEnt?
LASer:ENABle:COND?	LASer:ENABle:OUTOFF
LASer:ENABle:EVEnt	LASer:ENABle:OUTOFF?

LASer:ENABle:COND

The LASer:ENABle:COND command sets the selected channel's laser condition status enable register. The bits in this register determine which bits in the condition status register are summarized in the 3916 status byte.
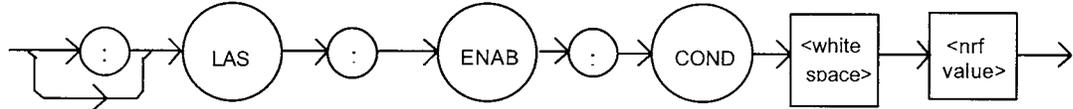
Parameters   An <nrf value> whose sum represents the enabled bits:

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

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

Examples   "LAS:ENAB:COND 129" -action: only the open circuit and current limit conditions will be summarized in the status byte.

LASer:ENABle:COND?

The LASer:ENABle:COND? query returns the value of the status condition enable register of the LASER operations.
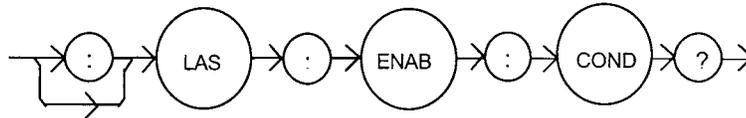
Parameters   The response is the sum of the following:

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

Notes   The selected channel's enabled laser conditions can be set by using the LASer:ENABle:COND command.

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

Examples   "LAS:ENAB:COND?" -response: 17, means that the current limit and interlock disabled laser conditions will be summarized in the status byte.

`LASer:ENABle:EVEnt`

The LASer:ENABle:EVEnt command sets the selected channel's laser event status enable register. The bits in this register determine which bits in the event status register are summarized in the 3916 status byte.
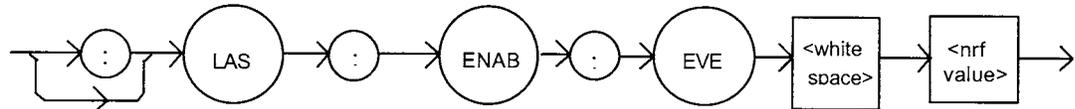
Parameters An <nrf value> whose sum represents the bits which are enabled:

1 - LASER Current Limit Changed State	256 - Output is Off Changed State
2 - Laser Voltage Limit Changed State	512 - Output Changed Tolerance State
4 - N/A	1024 - Output is On Changed State
8 - Power Limit Changed State	2048 - N/A
16 - Interlock Changed State	4096 - N/A
32 - N/A	8192 - N/A
64 - N/A	16384 - N/A
128 - Open Circuit Changed State	32768 - N/A

Notes The enabled LASER events for the selected channel can be read by using the LASer:ENABle:EVEnt? query. The selected channel's LASER event status can be monitored by the LASer:EVEnt? query.

Examples "LAS:ENAB:EVENT 136" -action: only the open circuit and power limit events will be summarized in the status byte.

`LASer:ENABle:EVEnt?`

The LASer:ENABle:EVEnt? query returns the value of the selected channel's laser event status event enable register of the LASER operations.

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

1 - LASER Current Limit Changed State	256 - Output is Off Changed State
2 - Laser Voltage Limit Changed State	512 - Output Changed Tolerance State
4 - N/A	1024 - Output is On Changed State
8 - Power Limit Changed State	2048 - N/A
16 - Interlock Changed State	4096 - N/A
32 - N/A	8192 - N/A
64 - N/A	16384 - N/A
128 - Open Circuit Changed State	32768 - N/A

Notes   The enabled LASER events for the selected channel can be set by using the LASer:ENABle:EVEnt command. The selected LASER event status can be monitored by the LASer:EVEnt? query.

Examples   "LAS:ENAB:EVE?" -response: 1040, means that the output on changed state and interlock changed state laser events for the selected channel will be reported (in summarized form) to the status byte.

LASer:ENABle:OUTOFF

The LASer:ENABle:OUTOFF command sets the status outoff enable register of the LASER operations (things which will turn the LASER output off).
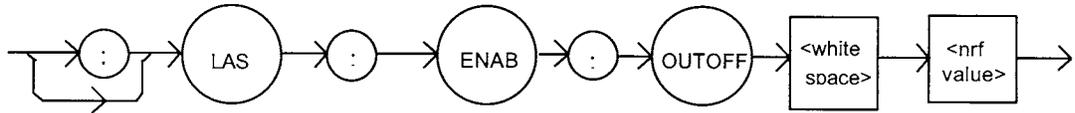
Parameters   An <nrf value> whose sum represents the enabled bits:

1 - LASER Current Limit	256 - N/A
2 - Laser Voltage Limit	512 - Output Out of Tolerance
4 - N/A	1024 - TEC Output is Off
8 - Power Limit (with output on)	2048 - TEC High Temperature Limit
16 - N/A	4096 - N/A
32 - N/A	8192 - N/A
64 - N/A	16384 - N/A
128 - N/A	32768 - N/A

Notes   The enabled LASER outoff bits for the selected channel can be read by using the LASer:ENABle:OUTOFF? query.

The default value for this register is 2056: TEC Temperature Limit, and Power Limit.

Enabling voltage limit will cause the laser output to shut off when the voltage limit is detected, otherwise this voltage limit is a warning. The hardware will shut off (regardless of how the laser voltage limit bit is set here) when the VLIM voltage is reached.

Examples   "LAS:ENAB:OUTOFF 2049" -action: the TEC temperature limit and laser current limit conditions will cause the laser output to be turned off.

LASer:ENABle:OUTOFF?

The LASer:ENABle:OUTOFF? query returns the contents of the selected channel's laser output off enable register.
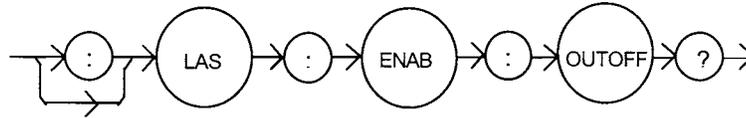
Parameters   None. The response is the sum of the following:

1 - LASER Current Limit	256 - N/A
2 - Laser Voltage Limit	512 - Output Out of Tolerance
4 - N/A	1024 - TEC Output is Off Event
8 - Power Limit (with output on)	2048 - TEC High Temperature Limit Condition
16 - N/A	4096 - N/A
32 - N/A	8192 - N/A
64 - N/A	16384 - N/A
128 - N/A	32768 - N/A

Notes   The selected channel's enabled laser events can be set by using the LASer:ENABLE:OUTOFF command. The selected channel's laser output status can be monitored by the LASer:EVEnt? query.

Examples   "LAS:ENAB:OUTOFF?" -response: 1025, means that the selected channel's current limit condition and a TEC output off condition will cause the selected channel's laser output to be turned off.

`LASer:EVEnt?`

The LASer:EVEnt? query returns the value of the selected channel's event status register.

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

1 - LASER Current Limit Changed State	256 - Output is Off Changed State
2 - Laser Voltage Limit Changed State	512 - Output Changed Tolerance State
4 - N/A	1024 - Output is On Changed State
8 - Power Limit Changed State	2048 - N/A
16 - Interlock Changed State	4096 - N/A
32 - N/A	8192 - N/A
64 - N/A	16384 - N/A
128 - Open Circuit Changed State	32768 - N/A

Notes   The events that are reported in the status byte can be set by using the LASer:ENABle:EVEnt command.

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

Examples   "LAS:EVE?" -response: 9, the power limit and current limit conditions have changed state since the event register was last read.

`LASer:INC`

The LASer:INC command increments the selected channel's laser constant current set point by one or more steps. Parameters allow multiple steps to be incremented and the time (in milliseconds) between increments to be set, respectively.
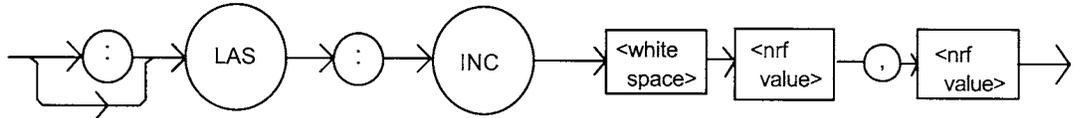
Parameters   Two <nrf values> are required. The first represents the number of steps, and the second is the time in milliseconds between steps.

Notes   The step size can be edited via the LAS:STEP command. Its default value is 1.0 mA.

The first parameter (number of steps) must be an integer between 1 and 50000.

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

Examples   "LAS:STEP 0.3; LAS:INC 1,10" - action: the selected channel's laser source current set point is incremented by 0.3 mA.

"LASOUTon; LAS:STEP 0.3; LAS:INC 3,5000" - action: the set point is incremented by 0.3 mA, three times, with 5 seconds between incremental steps (with the output on); the selected channel's laser output is incremented a total of 0.9 mA after 10 seconds.

`LASer:LDI`

The LASer:LDI command sets the laser current setpoint for the selected channel.
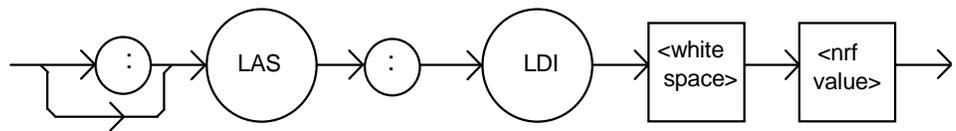
Parameters   An <nrf value> which represents the (laser) output current, in mA.

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

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

LASer:LDI?

The LASer:LDI? query returns the value of the measured laser current for the selected channel.
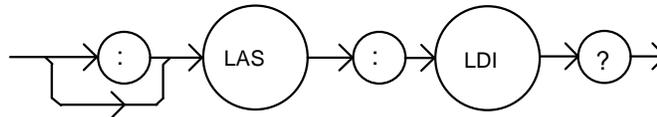
Parameters	None. The response is an <nrf value>.
Notes	Response is the selected channel's measured laser output current, regardless of LAS control mode. This measurement is updated approximately once every 600 msec.
Examples	"LAS:ldi?" -response: 30.0, means the selected channel's measured laser output current is 30.0 mA.
	"Laser:LDI?" -response: 149.6, means the selected channel's measured laser output current is 149.6 mA.

LASer:LDV?

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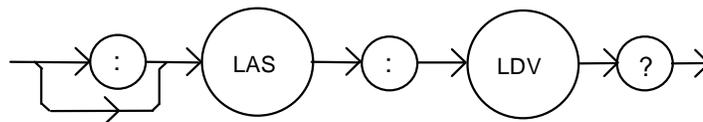
Parameters	None. The response is an <nrf value>.
Notes	Response is the selected channel's measured laser output voltage, regardless of LAS control mode. This measurement is updated approximately once every 600 msec.
Examples	"LAS:ldv?" -response: 3.03, means the measured laser output voltage is 3.03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

LASer:LIMIT:

The LASer:LIMit: command path is used to get to the selected channel's laser limit commands.

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

LASer:LIMit:I	LASer:LIMit:MDP	LASer:LIMit:V
LASer:LIMit:I?	LASer:LIMit:MDP?	LASer:LIMit:V?

LASer:LIMit:I

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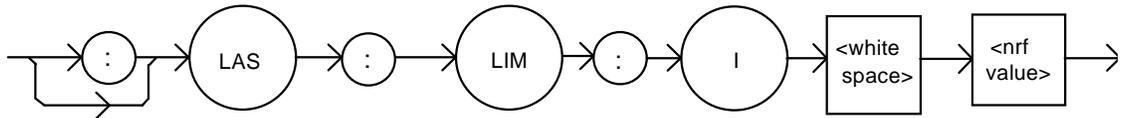
Parameters	An <nrf value> which represents the selected channel's LASER limit current, in mA.
Notes	The current limit is in effect in all modes of operation of the selected channel's laser output.
Examples	"LAS:LIM:I 80" -action: the selected channel's LASER current limit is set to 80 mA.
	":Laser:Limit:I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

LASer:LIMit:I?

The LASer:LIMit:I? query returns the value of the selected channel's laser current limit.
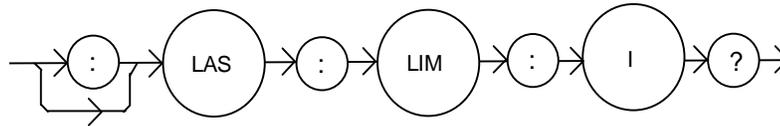
Parameters	None. The response in an <nrf value>.
Notes	The selected channel's current limit is valid for all modes of laser operation.
Examples	"LAS:LIM:I?" -response: 40, means the selected channel's laser current limit is 40 mA.
	"Laser:LIM:I?" -response: 300, means the selected channel's laser current limit is 300 mA.

LASer:LIMit:V

The LASer:LIMit:V commands sets the selected channel's LASER compliance voltage limit value.
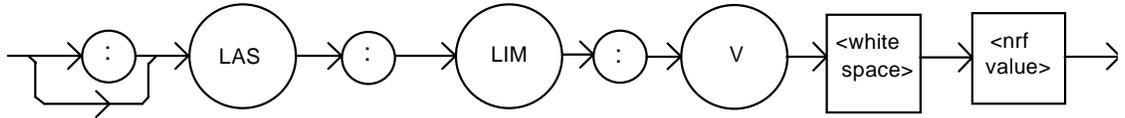
Parameters   An <nrf value> which represents the selected channel's LASER limit voltage, in volts.

Notes   The compliance voltage limit is in effect in all modes of operation of the selected channel's laser output. The range for the compliance voltage limit is 0.1 to 10.0 volts.

Examples   "LAS:LIM:V 4.6" -action: the selected channel's LASER compliance voltage limit is set to 4.6 volts.

":Laser:Limit:v 6.1" -action: the selected channels' LASER compliance voltage limit is set to 6.1 volts.

LASer:LIMit:V?

The LASer:LIMit:V? query returns the value of the selected channel's LASER compliance voltage limit setting.
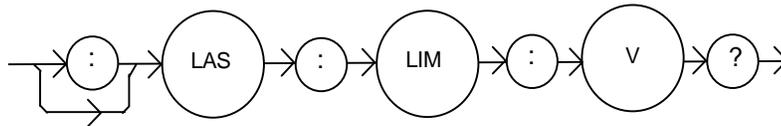
Parameters   None. The response is an <nrf value>.

Notes   The selected channel's compliance voltage limit is valid for all modes of laser operation.

Examples   "LAS:LIM:V?" -response: 4.0, means the selected channel's laser current limit is 4.0 volts.

"Laser:LIM:V?" -response: 3.3, means the selected channel's laser current limit is set to 3.3 volts.

LASer:LIMit:MDP

The LASer:LIMit:MDP command sets the laser monitor photodiode power limit value.
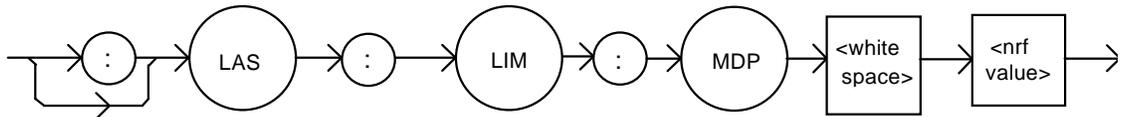
Parameters   An <nrf value> which represents the selected channel's laser monitor photodiode power limit, in mW.

Notes   When constant MDP mode is used, the selected channel's output is limited (in hardware) only by the LIM I value.

The LIM MDP condition normally shuts the selected channel's laser output off, but this can be disabled via the LASer:ENABle:OUTOFF command, bit 3.

Examples   "LAS:LIM:MDP 10" - action: sets the selected channel's laser output power limit to a value which corresponds to producing 10.00 mW of PD feedback (optical power).

"Las:Limit:MDp 5" - action: sets the selected channel's laser output power limit to a value which corresponds to producing 5.00 mW of PD feedback (optical) power.

LASer:LIMit:MDP?

The LASer:LIMit:MDP? query returns the value of the selected channel's laser monitor PD power limit.
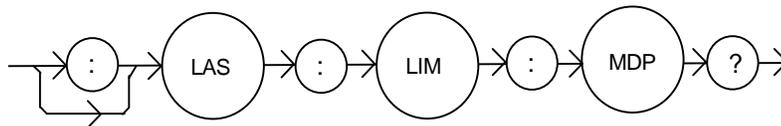
Parameters   None. The response is an <nrf value>.

Notes   The LAS:LIM:MDP is in effect for all LAS operating modes.

Examples   "LAS:LIM:MDP?" - response: 3.0, means the selected channel's monitor PD power limit is set to 3.0 mW.

":LAS:Limit:MDP?" - response: 10.0, means the selected channel's monitor PD power limit is set to 10.0 mW.

LASer:MDI

COMMON
DEVICE DEPENDENT
FRONT PANEL

The LASer:MDI commands sets the value of the photodiode feedback current set point, in μA.
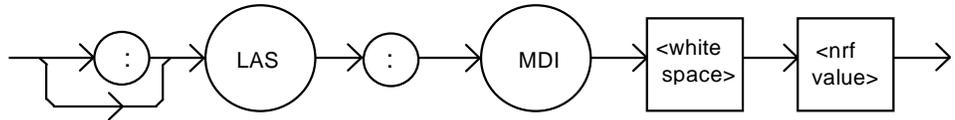
Parameters   An <nrf value> which represents the selected channel's photodiode feedback current in μA.

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

Examples   "Las:Mdi 40" - action: the selected channel's laser output is controlled so that the photodiode feedback current remains constant at 40 μA.

"Laser:MDI 200" - action: the selected channel's laser output is controlled so that the photodiode feedback current remains constant at 200 μA.

LASer:MDI?

COMMON
DEVICE DEPENDENT
FRONT PANEL

The LASer:MDI? query returns the value of the selected channel's laser photodetector current measurement, in μA.
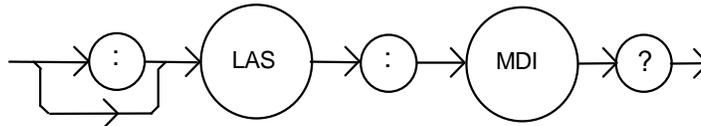
Parameters   None. The response is an <nrf value>.

Notes   The response is in μA. The response is valid, even when the unit is not in MDI mode. This measurement is updated approximately once every 600 msec.

Examples   "Las:MDi?" - response: 100.0, means 100 μA of photodetector current (from the selected channel) was measured.

LASer:MDP

The LASer:MDP command sets the value of the optical power set point, in mW.
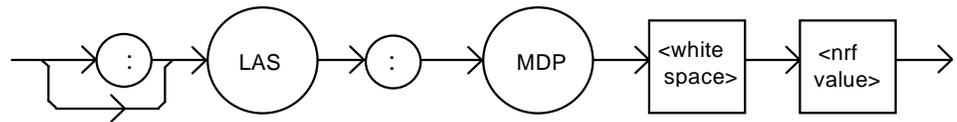
Parameters   An <nrf value> which represents the selected channel's photodiode feedback power, in mW.

Notes   If the selected channel's mode is not MDP, the LAS:MDP value will not be used. If CALPD is 0, the measured MDP will be invalid, and the actual MDP set point would be (near) 0.

On the front panel, the monitor diode photodetector power is referred to as P.

Examples   "Las:Mdp 40" - action: the selected channel's laser output is controlled so that the photodiode feedback power remains constant at 40 mW.

LASer:MDP?

The LASer:MDP? query returns the value of the selected channel's laser photodetector power measurement, in mW.
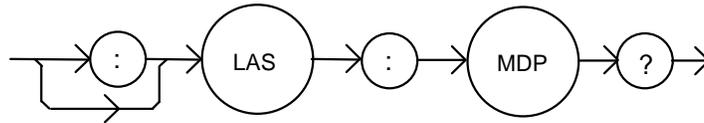
Parameters   None. The response is an <nrf value>.

Notes   The response is in mW. The response is valid, even when the unit is not in constant P mode. This measurement is updated approximately once every 600 msec.

Examples   "Las:MDp?" - response: 100.0: 100 mW of photodetector power was measured on the selected channel.

LASer:MODE?

The LASer:MODE? query returns the present channel's selected laser control mode.

Parameters	None. The response is character data (which represents the LAS operating mode).
Notes	IHBW mode is the same as ILBW mode (low bandwidth), except that the output low bandpass filter is disabled in IHBW mode.
Examples	"LAS:MODE?" -response: ILBW, means that constant I (low bandwidth current) mode is in effect for the selected channel's laser output.
	":Las:Mode?" -response: MDP, means that constant P (power) mode is in effect for the selected channel's laser output.
	"Las:Mode?" -response: MDI, means that constant monitor current mode is in effect for the selected channel's laser output.
	"Laser:MODE?" -response: IHBW, means that IHBW (constant current, high bandwidth) mode is in effect for the selected channel's laser output.

LASer:MODE:

The LASer:MODE: command path is used to get to the selected channel's laser mode selection commands.

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

LASer:MODE:IHBW   LASer:MODE:ILBW
LASer:MODE:MDI   LASer:MODE:MDP

`LASer:MODE:IHBW`

The LASer:MODE:IHBW command selects laser high bandwidth constant current mode for the selected channel.
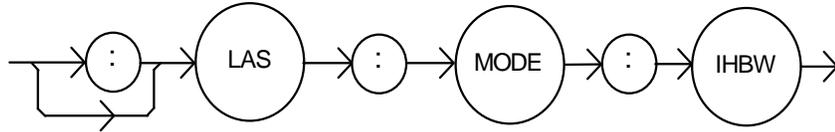
Parameters	None.
Notes	In high bandwidth mode the modulation bandwidth is increased.
Examples	":las:mode:ihbw" - action: enables the laser high bandwidth constant current mode for the selected channel.
	"LAS:Mode:Ihbw" - action: enables the laser high bandwidth constant current mode for the selected channel.

`LASer:MODE:ILBW`

The LASer:MODE:ILBW command selects laser constant current mode.
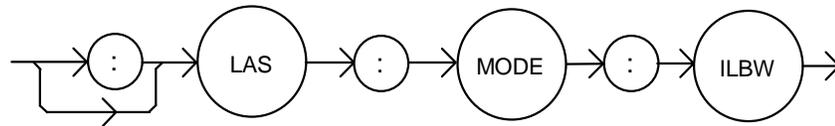
Parameters	None.
Notes	Constant ILBW mode (low bandwidth) enables the selected channel's output low bandpass filter.
Examples	"LAS:MODE:ILBW" -action: sets the selected channel's laser output for constant I mode (low bandwidth).

LASer:MODE:MDI

The LASer:MODE:MDI command selects laser constant monitor diode current mode for the present channel.
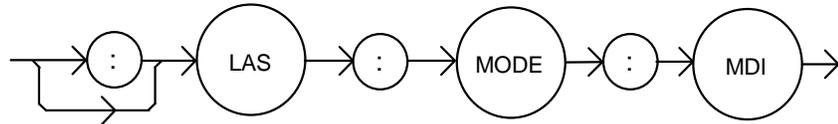
: → LAS → : → MODE → : → MDI

Parameters   None.

Notes   On the front panel, monitor diode current mode is referred to as IPD mode. In this mode, the control set point is entered via the LAS:MDI command.

Examples   "Laser:Mode:MDi" - action: sets the selected channel's laser output mode of operation to constant monitor diode current mode.

LASer:MODE:MDP

The LASer:MODE:MDP command selects laser constant power mode for the present channel.

: → LAS → : → MODE → : → MDP
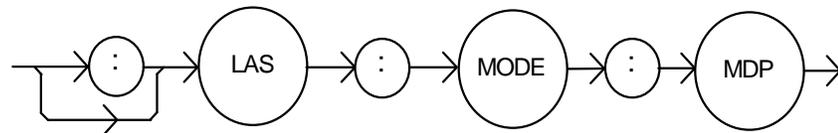
Parameters   None.

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

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

Examples   "LAS:MODE:MDP" -action: sets the selected channel's laser output mode of operation to constant optical power mode.

LASer:MODulation

The LASer:MODulation command turns the selected channel's laser modulation switch on or off.
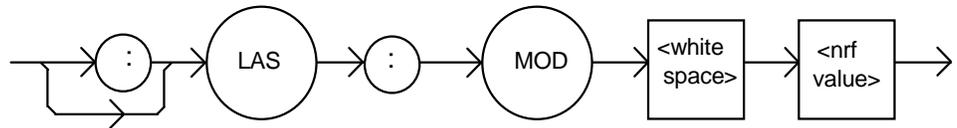
Parameters	An <nrf value>; 1 = on; 0 = off.
Notes	When the modulation switch is enabled for a channel, the laser current may be modulated by connecting a modulation signal onto the 3916's back panel "MODULATION" connector.
	The modulation bandwidth depends on the LAS operating mode and module used. Refer to Chapter 1, Laser Specifications, for more information on bandwidth specifications.
Examples	"LAS:LDI 20; LAS:MODULA ON" - action: sets the selected channel's laser output current to 20 mA and then turns the selected channel's modulation switch on.
	"Las:Mod 0" - action: turns the selected channel's modulation switch off.

LASer:MODulation?

The LASer:MODulation? query returns the status of the selected laser channel's modulation switch.
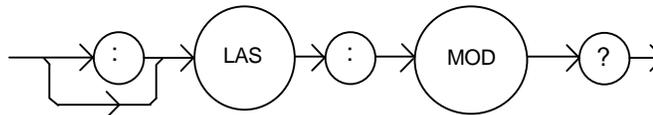
Parameters	None. The response is an <nrf value>, 1 = on; 0 = off.
Notes	More than one channel at a time may be modulated via the modulation signal, if desired.
Examples	"Las:MODULATION?" - response: 0, means that the selected channel's modulation switch is disabled.
	"LAS:MOD?" - response: 1, means that the selected channel's modulation switch is enabled. A modulation signal applied to the back panel connector will be present at the selected channel.

`LASer:OUTput`

The LASer:OUTput command turns the laser output on or off.
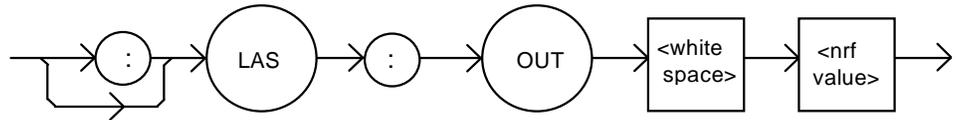
Parameters   An <nrf value>; 1 = on, 0 = off.

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

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

Examples   "LAS:I 20; LAS:OUT ON" -action: sets the selected channel's laser output current to 20 mA and then turns the output on.

"Las:Out 0" - action: turns the selected channel's laser output off.

`LASer:OUTput?`

The LASer:OUTput? query returns the status of the selected channel's laser OUTPUT switch.
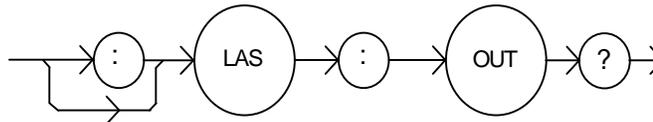
Parameters   None. The response is an <nrf value>.

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

Examples   "Las:OUT?" -response: 0, means that the selected channel's output switch is disabled; devices may be safely disconnected or connected at the selected channel's output terminals.

"LAS:OUT?" -response: 1, means that the selected channel's output switch is enabled; LASER output current is present for the selected channel.

`LASer:SET:`

The LASer:SET: command path is used to get to the selected channel's laser set point queries.

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

LASer:SET:LDI?　　　LASer:SET:MDI?　　　LASer:SET:MDP?

`LASer:SET:LDI?`

The LASer:SET:LDI? query returns the constant current setpoint which is used for both bandwidth modes.
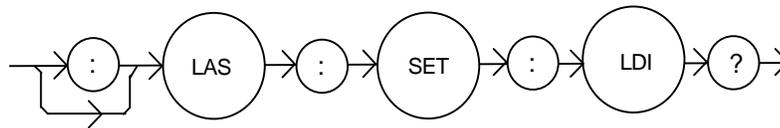
Parameters　None. The response is an <nrf value> which represents the selected channel's constant I set point value, in mA.

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

Examples　"LAS:SET:LDI?" -response: 50.0, means the selected channel's laser output current set point value is 50.0 mA.

`LASer:SET:MDI?`

The LASer:SET:MDI? query returns the selected channel's laser monitor photodiode current set point value, in μA.
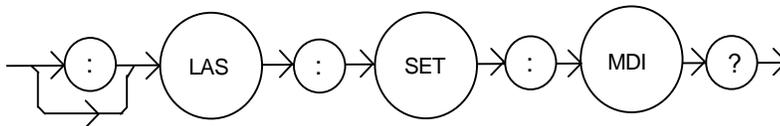
Parameters　None. The response is an <nrf value> which represents the selected channel's constant IPD set point, in μA.

Notes　The monitor photodiode current is directly proportional to the laser optical output power. Therefore, the IPD setpoint may be used to control optical output of the laser.

Examples　"las:set:mdi?" -response: 30.0, means the selected channel's laser monitor PD current is set point is 30 μA, for use in constant P mode.

LASer:SET:MDP?

The LASer:SET:MDP? query returns the selected channel's laser optical power set point value, in mW.
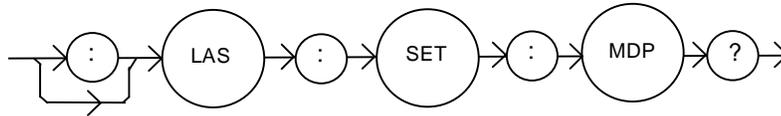
Parameters   None. The response is an <nrf value> which represents the selected channel's constant P set point, in mW.

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

Examples   "LAS:Set:MDP?" -response: 10.0, means the selected channel's laser monitor PD feedback set point is 10.0 mW (CALPD > 0).

LASer:STEP

The LASer:STEP command specifies the amount the current setpoint will change in response to the LASer:INC or LASer:DEC command.
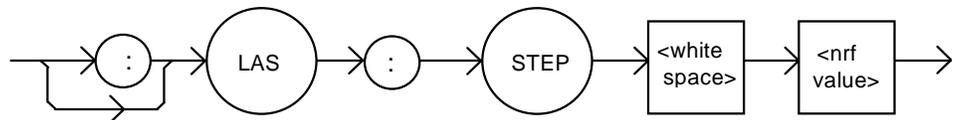
Parameters   An <nrf value> of the step amount, in the range 1.0 to 100.0. The resolution is 0.1.

Notes   The step of 0.1 corresponds to 0.1 mA.

Examples   "Las:ldi 20; Las:Step 10.0; Las:Inc 1,1; Las:set:i?" - action: sets the selected channel's step to 10.0 mA, so the Las:set:i? query will return a value of 30.0 mA.

"LAS:STEP 10" - action: sets the selected channel's step size to 10.00 mA.

LASer:STEP?

The LASer:STEP? query is used to read back the selected channel's STEP value. This value, in mA, is used by the Las:Inc and Las:Dec commands to increment or decrement the laser current setpoint.
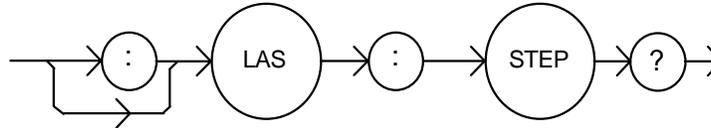
Parameters   None. The response is an <nrf value> of the selected channel's step amount.

Notes   The step of 1 corresponds to 1.0 mA.

Examples   "Las:Step?" - response: 1.0, means the selected channel's step size is 1.0 mA.

LASer:SYNCLDI?

The LASer:SYNCLDI? query returns the value of the selected channel's measured laser current, in mA.
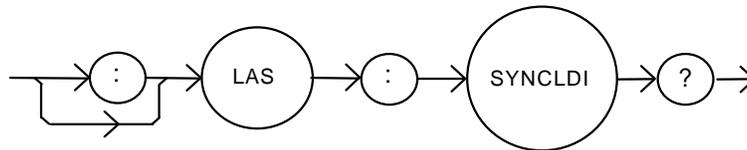
Parameters   None. The response is an <nrf value> representing current in mA.

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

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

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

LASer:SYNCLDV?

The LASer:SYNCLDV? query returns the value of the selected channel's measured laser voltage, in volts.
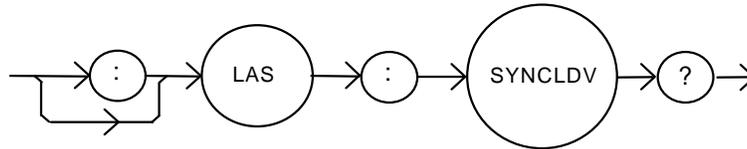
Parameters   None. The response is an <nrf value> representing voltage in volts.

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

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

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

LASer:SYNCMDI?

The LASer:SYNCMDI? query returns the value of the selected channel's measured monitor photodiode current in μA.
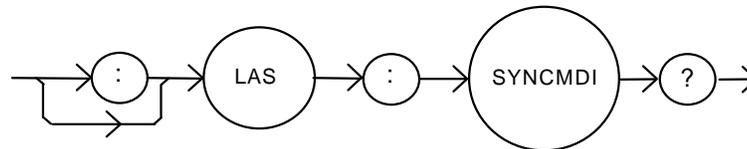
Parameters   None. The response is an <nrf value> representing current in μA.

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

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

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

LASer:SYNCMDP?

The LASer:SYNCMDP? query returns the value of the selected channel's measured optical power, in mW.
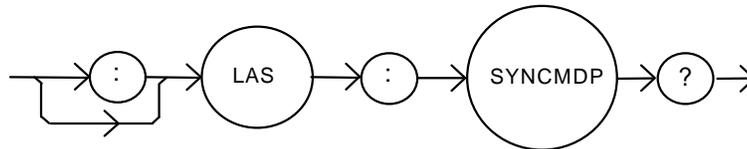
Parameters	None. The response is an <nrf value> representing optical power in mW.
Notes	Optical power is derived from photodiode current. Optical power is defined as photodiode current divided by CalPD, the photodiode responsivity.
	This is a "synchronized" measurement: the measurement system is connected to the monitor current measure signal when this query is received. The photodiode current measurement is made, optical power is calculated, and the result is returned as the response. After the measurement is made, the measurement system returns to its normal function, switching between the various signals and measuring them.
	The response time to this query is from 200 msec to 250 msec, but the measurement is made as soon as the query is received. In contrast, the laser:mdp? query returns immediately, but the measurement can be up to 600 msec old.
Examples	"LAS:syncmdp?" - response: 5.5, means the calculated optical power is 5.5 mW.

LASer:TOLerance

The LASer:TOLerance command sets the selected module's laser control tolerance parameters.
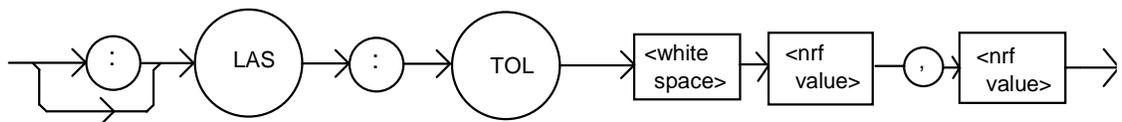
Parameters	Two <nrf values>; the first represents the measurement window, in mA, μA, or mW, depending on the laser control mode. The second parameter represents the time window, in seconds.
Notes	The range of the first parameter, the tolerance window, is 0.01 to 500.0. The units of this parameter depend on the control mode. In current mode, the units are mA, in IPD mode the units are μA. If the mode is constant power (P), the first parameter is in mW. The range of the second parameter, the time window, is 0.1 to 50.0.
	The LDC-3916370 Series Laser Diode Controller defaults to a tolerance of 100 mA, μA, or mW, for 5 seconds, unless changed by the LAS:TOLerance command.
	WARNING: If the tolerance is set too tight, the output may never reach tolerance.
Examples	"LAS:LDI 750; LAS:TOL 0.5,1;LAS:OUT ON" - action: the laser current will be in tolerance when it is within 0.5 mA of 750.00 mA for a period of 1.0 second, at which point the in tolerance bit in the laser condition status register will be set.

LASer:TOLerance?

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

```
: → LAS → : → TOL → ?
```

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

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

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

"LAS:TOL?" - response: "1.0,5.0", means the selected module has a laser tolerance window of 1.0 mA, 1.0 µA, or 1.0 mW (depending on the mode) with a duration of 5.0 seconds.

STATMENU:LINE*n*:

The STATMENU:LINE*n*: command path is used to get to the selected channel's status menu display selection commands. (*n* can be either 1 or 2).

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

STATMENU:LINE*n*:IPD	STATMENU:LINE*n*:LDI
STATMENU:LINE*n*:PPD	STATMENU:LINE*n*:VF
STATMENU:LINE*n*:TEMP	STATMENU:LINE*n*:ITE
STATMENU:LINE*n*:RES	STATMENU:LINE*n*:TEV

STATMENU:LINE*n*?

COMMON

DEVICE DEPENDENT

FRONT PANEL

The STATMENU:LINE*n*? query returns the name of the measurement that is currently being displayed on line *n* of the status menu. (*n* can be either 1 or 2).
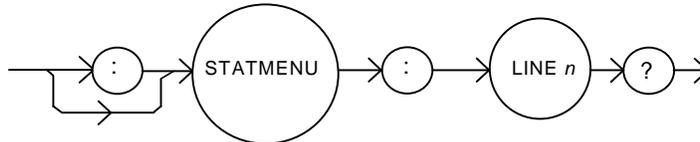
Parameters   None. The response is character data which represents the measurement that is currently being displayed on line 1 of the selected channel's portion of the status menu.

Notes   The possible responses are:

1: "LDI" laser diode current	2: "IPD" photodiode current
3: "PPD" optical power	4: "VF" laser diode forward voltage
5: "TEMP" tec temperature	6: "ITE" tec current
7: "RES" thermistor resistance	8: "TEV" tec forward voltage

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

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

STATMENU:LINE*n*:IPD

COMMON

DEVICE DEPENDENT

FRONT PANEL

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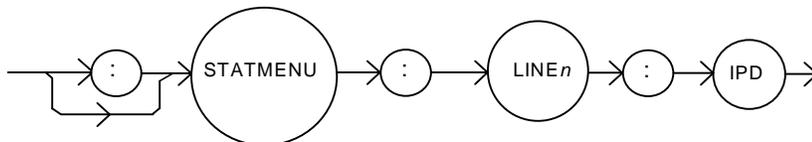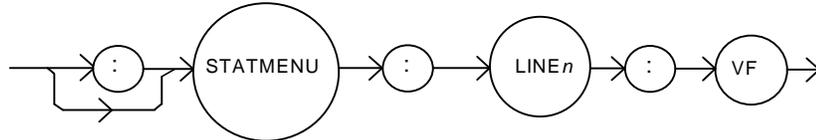

Parameters   None.

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

Examples   "STATMENU:LINE1:IPD" - response: photodiode current is displayed on line 1 of the status menu.

STATMENU:LINE*n*:LDI

The STATMENU:LINE*n*:LDI command sets the measurement that is to be displayed on line *n* of the status menu to laser diode current (LDI).
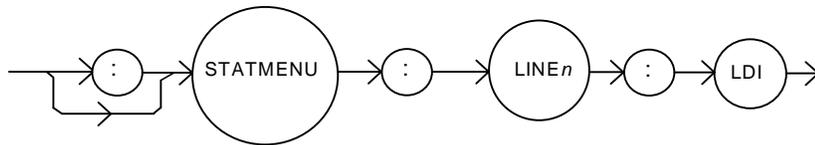
Parameters　None.

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

Examples　"STATMENU:LINE2:LDI" - response: laser diode current is displayed on line 2 of the status menu.
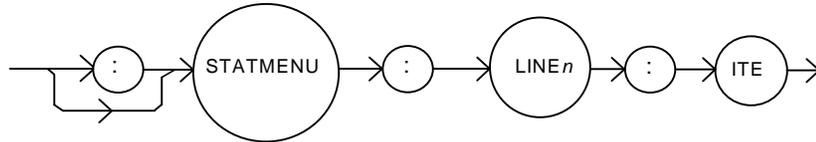
STATMENU:LINE*n*:PPD

The STATMENU:LINE*n*:PPD command sets the measurement that is to be displayed on line *n* of the status menu to optical power (PPD).
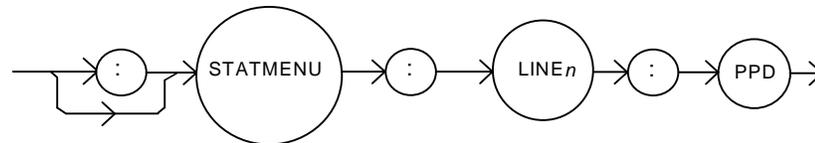
Parameters　None.

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

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

STATMENU:LINE*n*:VF

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

```
 : ──▶ STATMENU ──▶ : ──▶ LINEn ──▶ : ──▶ VF ──▶
```

Parameters   None.

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

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

STATMENU:LINE*n*:TEMP

The STATMENU:LINE*n*:TEMP command sets the measurement that is to be displayed on line *n* of the status menu to tec temperature (TEMP).
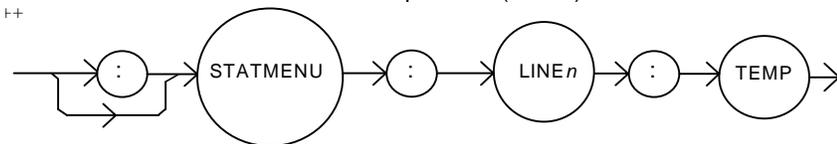
```
 : ──▶ STATMENU ──▶ : ──▶ LINEn ──▶ : ──▶ TEMP ──▶
```

Parameters   None.

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

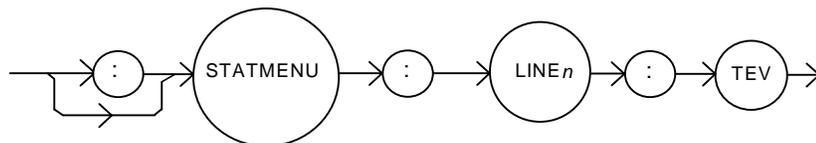Examples   "STATMENU:LINE1:TEMP" - response: tec temperature is displayed on line 1 of the status menu.

STATMENU:LINE*n*:ITE

COMMON

DEVICE DEPENDENT

FRONT PANEL

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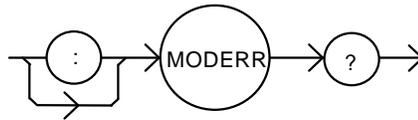

Parameters   None.

Examples   "STATMENU:LINE1:ITE" - response: tec current is displayed on line 1 of the status menu.

STATMENU:LINE*n*:RES

COMMON

DEVICE DEPENDENT

FRONT PANEL

The STATMENU:LINE*n*:RES command sets the measurement that is to be displayed on line *n* of the status menu to thermistor resistance (RES).
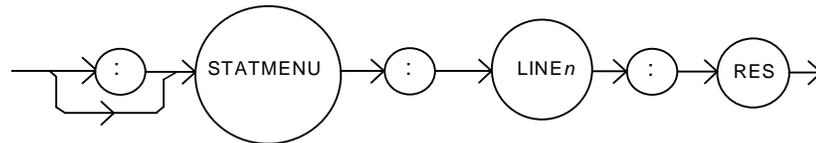
Parameters   None.

Examples   "STATMENU:LINE1:RES" - response: thermistor resistance is displayed on line 1 of the status menu.

STATMENU:LINE*n*:TEV

COMMON

DEVICE DEPENDENT

FRONT PANEL

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

Parameters   None.

Examples   "STATMENU:LINE1:TEV" - response: tec forward voltage is displayed on line 1 of the status menu.

`MODERR?`

The MODERR? query returns a list of the "module" device and command errors. The "module" errors are those which have occurred since the last "MODERR?" query. The errors are notated by a number (code) which corresponds to the type of error which occurred. See the appropriate module instruction manual for information regarding error handling for each specific module.
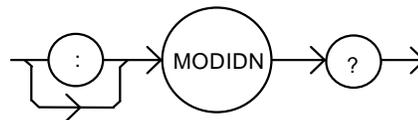

Parameters	None. The response consists of one or more "module" error code values, separated by commas.
Notes	A response of "0" indicates that no errors were reported. The response data is sent as character data.
Examples	"MODERR?" - response: 0, means no "module" errors reported.
	"Moderr?' - response: 501, means that the module has a LASER interlock error which prevented the LAS output from being turned on.

`MODIDN?`

The MODIDN? query returns the module's model name and serial number.

Parameters	None. The response consists of the module's model number, serial number, and version number, separated by commas.
Notes	The serial number may also be found by removing the module from the mainframe and viewing the serial number information on the side of the module.
Examples	"MODIDN?" - response: "3916374,03740001,v1.00", for example.
	NOTE: MODERR, MODIDN and MODPUD commands are also described in Chapter 4 of the mainframe instruction manual.

`MODPUD`

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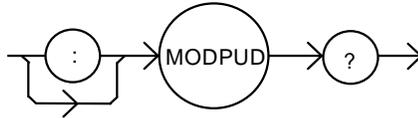
MODPUD?

The MODPUD? query returns protected user data from a module. This data is entered by factory personnel when the module is calibrated.

Parameters   None. The response consists of serial number, hardware version, option information, calibration date, and initials of the calibrating technician. The response is in the form of <arbitrary block data> with the header, #221, indicating twenty-one characters.

Notes   The serial number may also be found by removing the module from the mainframe and viewing the serial number information on the side of the module.

Examples   "MODPUD?" - response: #221037200020011120498grb.

NOTE: MODERR, MODIDN and MODPUB commands are also described in Chapter 4 of the mainframe instruction manual.

TEC:

The TEC: command path is used to get to the LDC-3916370 Series thermoelectric cooler (TEC) source commands.

The following command paths may be reached from the TEC: command path.

TEC:CAL:	TEC:CONV:R
TEC:ENABle:	TEC:CONV:R?
TEC:LIMit:	TEC:CONV:T
TEC:MODE:	TEC:CONV:T?
TEC:SET:	

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

TEC:COND?	TEC:MODE?	TEC:T?
TEC:CONST	TEC:OUTput	TEC:TOL
TEC:CONST?	TEC:OUTput?	TEC:TOL?
TEC:EVEnt?	TEC:R	TEC:V?
TEC:GAIN	TEC:R?	TEC:SYNCI?
TEC:GAIN?	TEC:SENsor	TEC:SYNCR?
TEC:ITE	TEC:SENsor?	TEC:SYNCT?
TEC:ITE?	TEC:T	TEC:SYNCV?

`TEC:CAL:`

COMMON

DEVICE DEPENDENT

FRONT PANEL

The TEC:CAL: command path is used to get to the selected channel's TEC calibration commands.

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

TEC:CAL:ABORT	TEC:CAL:DEFAULT	TEC:CAL:MEAS
TEC:CAL:ITE	TEC:CAL:SENsor	TEC:CAL:STAT?
TEC:CAL:V	TEC:CAL:VALUE?	

CAUTION: It should be noted that if at anytime during the calibration procedure, the user exits the calibration menu by pressing the UP arrow softkey, the MAIN key or the CHAN key, the calibration procedure will be aborted.

`TEC:CAL:ABORT`

COMMON

DEVICE DEPENDENT

FRONT PANEL

The TEC:CAL:ABORT command is used to exit a TEC calibration without changing the calibration values.
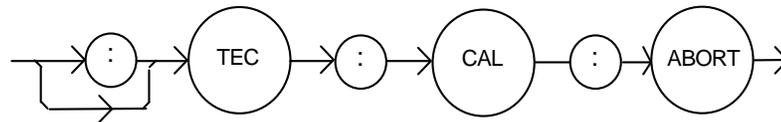
```
: → TEC → : → CAL → : → ABORT →
```

Parameters   None.

Notes   After this command is issued it is safe to run the LDC-3916370 Series Laser Diode Controller with the same calibration values used as before the TEC calibration mode was started.

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

Examples   "TEC:CAL:ABORT" - action: the LDC-3916370 Series Laser Diode Controller exits calibration mode.
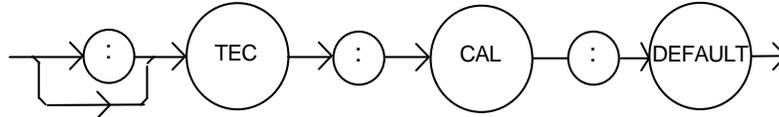
TEC:CAL:DEFAULT

The TEC:CAL:DEFAULT command is used to restore all of the module's TEC calibration default values. This command should be used with caution, as the accuracy of the module will not be guaranteed after it is issued.

Parameters   None.

Notes   This command should not be used except when normal calibration procedures and/or normal operation of the TEC functions are not possible.

After this command is issued, the TEC module will not be calibrated. Each of the prescribed calibration procedures must be redone. The default values are the starting point values which exist before factory calibration is done.

Examples   "Tec:CAL:Default" - action: the LDC-3916370 Series Laser Diode Controller sets all of the TEC calibration values to defaults on the selected module.

TEC:CAL:ITE

The TEC:CAL:ITE command initiates the selected channel's calibration procedure for TEC current setpoint, current limit, and current measurement.
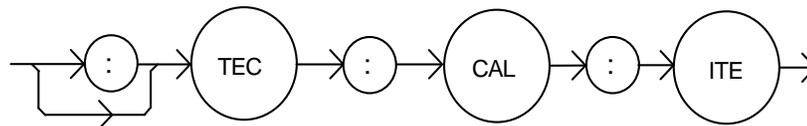
Parameters   None.

Notes   This command puts the module into an automatic calibration mode. It requires the user to enter certain measurements at specified times. This procedure is outlined in Chapter 5.

Examples   "Tec:CAL:ITE" -action: the selected channel enters TEC calibration mode for current.

TEC:CAL:MEAS

COMMON

DEVICE DEPENDENT

FRONT PANEL

The TEC:CAL:MEAS command is used to enter the TEC calibration values for the selected channel.

```
:  →  TEC  →  :  →  CAL  →  :  →  MEAS  →  <white space>  →  <nrf value>  →
```
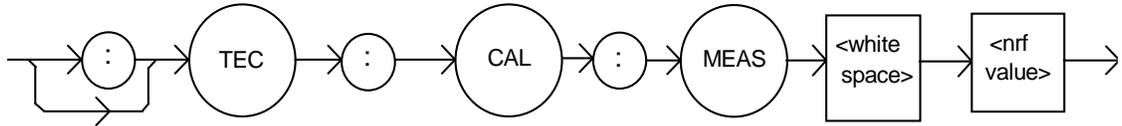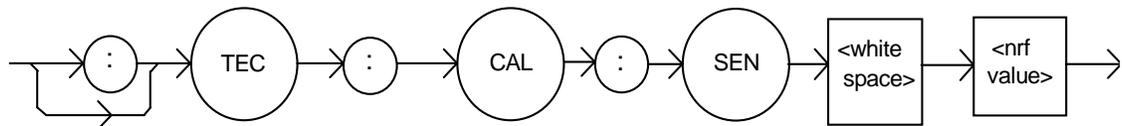
Parameters An <nrf value> which represents the calibration value expected for the present TEC calibration state.

Notes The TEC:CAL:STAT? query may be used to determine if the module is ready for the user to enter a value via the TEC:CAL:MEAS command.

Examples "TEC:CAL:MEAS 4.95" - action: the LDC-3916370 Series Laser Diode Controller enters the value 4.95 for calibration value of the present calibration mode.

TEC:CAL:SENsor

COMMON

DEVICE DEPENDENT

FRONT PANEL

The TEC:CAL:SENsor command initiates the selected channel's thermistor resistance calibration procedure.

```
:  →  TEC  →  :  →  CAL  →  :  →  SEN  →  <white space>  →  <nrf value>  →
```

Parameters An <nrf value> which represents the thermistor sense current range, 1 = 100 μA, 2 = 10 μA.

Notes After this command is issued, the LDC-3916 will automatically enter the sensor calibration mode for the selected channel. This calibration procedure is outline in Chapter 5.

Examples "Tec:CAL:SEN 1" - action: the selected channel enters thermistor calibration mode for the 100 μA thermistor mode.

"Tec:Cal:Sensor 2" - action: the selected channel enters calibration mode for the 10 μA thermistor mode.

TEC:CAL:STATus?

COMMON
DEVICE DEPENDENT
FRONT PANEL

The TEC:CAL:STATus? query is used to determine whether the selected channel is in calibration mode and whether it is ready for a calibration value.
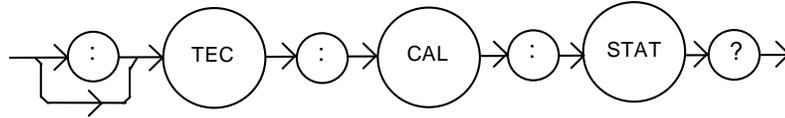
**Parameters**   None. The response will be an <nrf value>; 0 = not ready for measurement; 1 = ready for measurement; 2 = calibration completed; 3 = calibration aborted.

Notes   If the calibration is aborted, the status value will remain "3" until the calibration is started again. The calibration procedure may terminate prematurely if, for example, a value entered using the TEC:CAL:MEAS command is invalid. The user can also abort calibration using the TEC:CAL:ABORT command.

Examples   "Tec:Cal:Stat?" - response: 0, means the LDC-3916370 Series Laser Diode Controller module is not yet ready for the TEC calibration measurement value to be entered.

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

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

TEC:CAL:V

COMMON
DEVICE DEPENDENT
FRONT PANEL

The TEC:CAL:V command initiates the selected channel's TE voltage measurement calibration procedure.
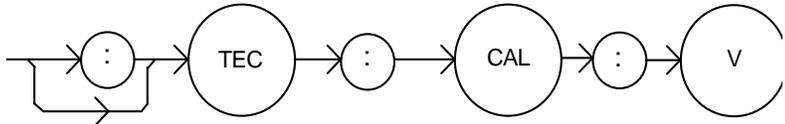
Parameters   None.

Notes   This command places the module in an automated calibration mode. It requires the user to enter certain measurements at specified times. The required procedure is described in Chapter 5 of this manual.

Examples   "Tec:CAL:V" -action: the LDC-391637X module enters TEC voltage calibration mode.
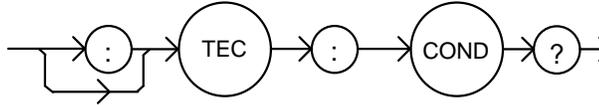

TEC:CAL:VALUE?

COMMON
DEVICE DEPENDENT
FRONT PANEL

The TEC:CAL:VALUE? query is used at the factory only.

ILX Lightwave

TEC:COND?

The TEC:COND? query returns the value of the selected channel's TEC condition status register.

```
: → TEC → : → COND → ?
```

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

1 - TE Current Limit	256 - N/A
2 - TE Voltage Limit	512 - Output in Tolerance
4 - N/A	1024 - Output On
8 - High Temperature Limit	2048 - N/A
16 - N/A	4096 - N/A
32 - N/A	8192 - N/A
64 - Sensor Open	16384 - N/A
128 - TE Module Open	32768 - N/A

Notes   The TEC conditions that are reported to the 3916 status byte can be set using the TEC:ENABle:COND command. See Chapter 3 of this manual and the status reporting section of the 3916 manual for more information.

The conditions that are reflected in the condition status register are, in general, transitory. To ensure that a control program does not miss the occurrence of a condition, use the TEC:EVEnt? query.

Examples   "TEC:COND?" - response: 513, means that the TE output in tolerance and TE current limit conditions currently exist.

`TEC:CONST`

COMMON
DEVICE DEPENDENT
FRONT PANEL

The TEC:CONST command sets the TEC's Steinhart-Hart equation constants.
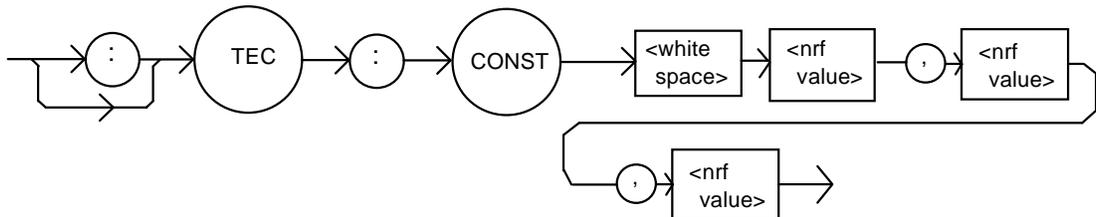
Parameters   Three <nrf value>s, for the three Steinhart-Hart equation constants. The range of values is -99.999 to +99.999 for all three constants. These values are scaled by the appropriate exponential value for the Steinhart-Hart equation.

Notes   The LDC-3916370 Series Laser Diode Controller module uses these constants to convert the thermistor resistance measurement into a temperature.

Examples   "Tec:CONST 1, 2.33, 0.5 " -action: sets C1 to 1.000, C2 to 2.330, and C3 to 0.500.

`TEC:CONST?`

COMMON
DEVICE DEPENDENT
FRONT PANEL

The TEC:CONST? query returns the values of the selected channel's Steinhart-Hart constants.
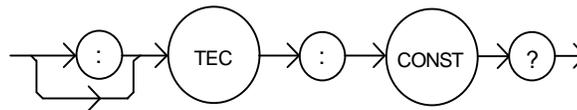
Parameters   None. The response data represent the values of C1, C2, and C3 respectively.

Notes   These values are pre-scaled so that the exponential value is not given. The actual value of C1 is scaled by 10E-3, C2 by 10E-4, and C3 by 10E-7.

Examples   "TEC:CONST?" -response: 1.111,2.03,0.85 means C1 = 1.111, C2 = 2.030, and C3 = 0.850.

`TEC:CONV:R`

The TEC:CONV:R command converts thermistor resistance (KΩ) to temperature ($^{\mathrm{o}}$C).
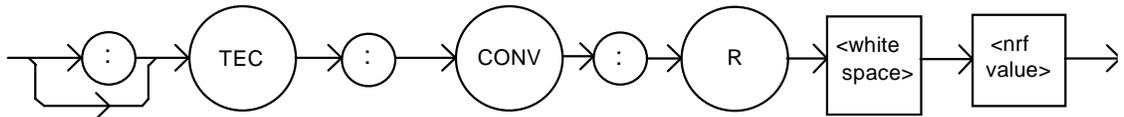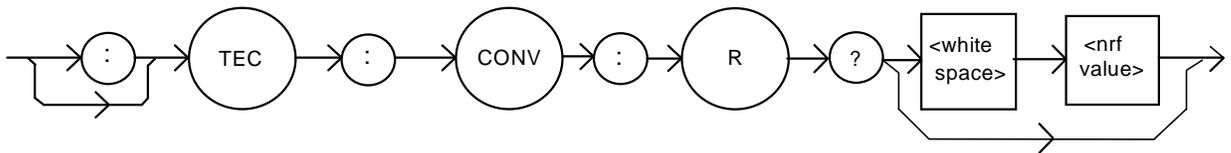

Parameters An <nrf value> that corresponds to a resistance in KΩ.

Notes The selected channel's Steinhart-Hart constants C1, C2 and C3 are used to convert resistance (KΩ) to temperature ($^{\mathrm{o}}$C).

Examples "TEC:CONV:R 12.456" - 12.456 KΩ is converted to temperature and saved in memory.

`TEC:CONV:R?`

The TEC:CONV:R? query converts thermistor resistance (KΩ) to temperature ($^{\mathrm{o}}$C) and returns the value of the most recent conversion.
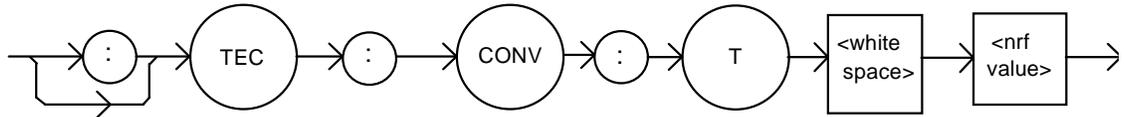

Parameters Either no parameter or an <nrf value> that corresponds to a resistance in KΩ.

Notes The calibration constants C1, C2 and C3 are used to convert resistance to temperature.

Examples "TEC:CONV:R?" - returns a value that corresponds to the temperature of the most recent conversion.

"TEC:CONV:R? 12.789" - converts 12.789 KΩ to temperature and returns a number that corresponds to temperature in $^{\mathrm{o}}$C.

TEC:CONV:T

COMMON

DEVICE DEPENDENT

FRONT PANEL

The TEC:CONV:T command converts temperature (^{o}C) to thermistor resistance (KΩ).
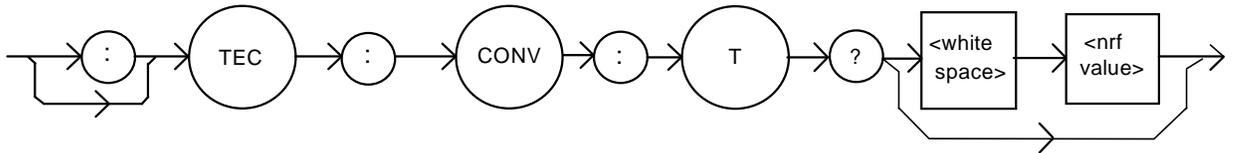

Parameters	An <nrf value> that corresponds to a temperature in ^{o}C.
Notes	The selected channel's Steinhart-Hart constants C1, C2 and C3 are used to convert temperature (^{o}C) to resistance (KΩ).
Examples	"TEC:CONV:T 25.6" - 25.6 ^{o}C is converted to resistance and saved in memory.

TEC:CONV:T?

COMMON

DEVICE DEPENDENT

FRONT PANEL

The TEC:CONV:T? query converts temperature (^{o}C) to thermistor resistance (KΩ) and returns the value of the most recent conversion.

|	
Parameters	Either no parameters or an <nrf value> that corresponds to a temperature in ^{o}C.
Notes	The calibration constants C1, C2 and C3 are used to convert temperature to resistance.
Examples	"TEC:CONV:T?" - returns a number the corresponds to the resistance value of the most recent conversion.
	"TEC:CONV:T? 35.5" - converts 35.5 ^{o}C to resistance and returns a number that corresponds to resistance in KΩ.

▌▙▌ ILX Lightwave

TEC:CONV:DAC_R?

`3916371 Module only`

The TEC:CONV:DAC_R? query converts the DAC count into its equivalent resistance (KΩ) and returns the value of the most recent conversion.
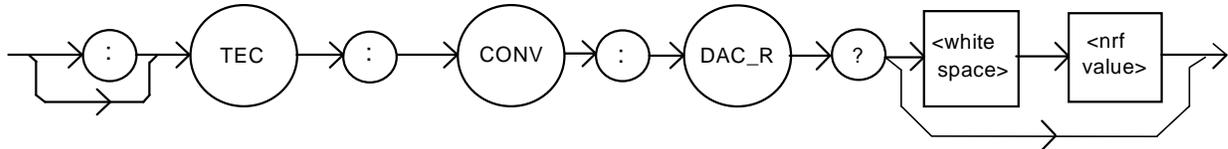
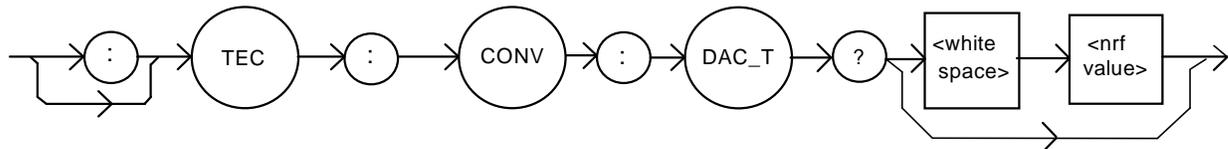| Parameters | Either no parameters or an <nrf value> that corresponds to a resistance in KΩ. |
| Notes | The selected channel's DAC count is converted into its equivalent resistance (KΩ). |
| Examples | "TEC:CONV:DAC_R?" - returns a value that corresponds to the resistance of the most recent conversion.
"TEC:CONV:DAC_R? 8527" - converts 8527 counts to resistance (KΩ) and returns a number. |

TEC:CONV:DAC_T?

`3916371 Module only`

The TEC:CONV:DAC_T? query converts the DAC count into its equivalent temperature (^{o}C) and returns the value of the most recent conversion.

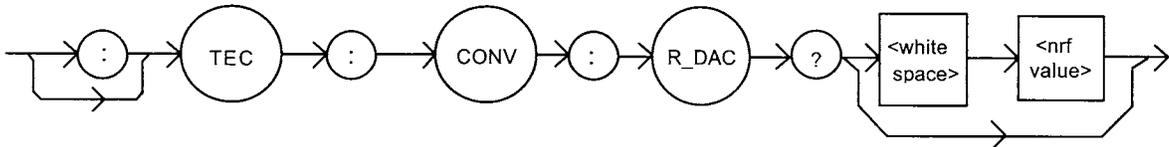| Parameters | Either no parameters or an <nrf value> that corresponds to a resistance in ^{o}C. |
| Examples | "TEC:CONV:DAC_T?" - returns a value that corresponds to the temperature of the most recent conversion.
"TEC:CONV:DAC_T? 8527" - converts 8527 counts to temperature (^{o}C) and returns a number. |

TEC:CONV:R_DAC?

`3916371 Module only`

The TEC:CONV:R_DAC? query converts the resistance (KΩ) to DAC counts and returns the value of the most recent conversion.

Parameters Either no parameters or an <nrf value> that corresponds to a temperature in KΩ.

Examples "TEC:CONV:R_DAC?" - returns a number that corresponds to the DAC count of the most recent conversion.

"TEC:CONV:R_DAC? 10.345" - converts 10.345KΩ is converted to DAC counts and returned.

TEC:CONV:T_DAC?

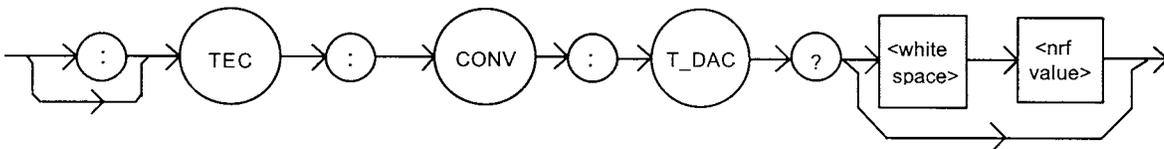`3916371 Module only`

The TEC:CONV:DAC_T? query converts temperature (^{o}C) to DAC counts and returns the value of the most recent conversion.

Parameters Either no parameters or an <nrf value> that corresponds to a temperature in ^{o}C.

Examples "TEC:CONV:T_DAC?" - returns a value that corresponds to the temperature of the most recent conversion.

"TEC:CONV:T_DAC? 35.5" - converts 35.5 ^{o}C to DAC counts and returns the value.

TEC:DAC

`3916371 Module only`

The TEC:DAC command adjusts the controller set point in DAC counts. See Chapter 2, Understanding DAC Mode for more information about DAC counts.

Parameters An <nrf value> that corresponds to an equivalent temperature or resistance. The DAC values can be adjusted to any value between 10 and 65535.

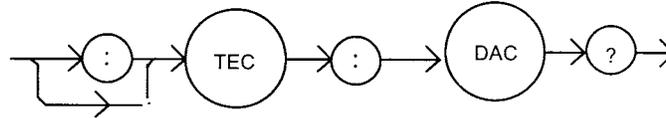**Notes** For a typical 10 kΩ thermistor at 20 ^{o}C, each DAC step is equivalent to about 0.0013 ^{o}C.

Examples "TEC:DAC 12876" - sets the temperature setpoint to 25 ^{o}C.

TEC:DAC?

`3916371 Module only`

The TEC:DAC? query returns the DAC count set point used in DAC mode. See Chapter 2, Understanding DAC Mode for more information about DAC counts.

Notes   For a typical 10kΩ thermistor at 20 ^{o}C, each DAC step is equivalent to about 0.0013 ^{o}C.

Examples "TEC:DAC:" - returns a number that corresponds to the DAC count setting of the selected channel. For instance, if the set point is 25 ^{o}C, then "TEC:DAC?" returns "12876".

TEC:ENABle:

The TEC:ENABle: command path is used to get to the selected channel's TEC status enable commands and queries.

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

TEC:ENABle:COND	TEC:ENABle:COND?
TEC:ENABle:EVEnt	TEC:ENABle:EVEnt?
TEC:ENABle:OUTOFF	TEC:ENABle:OUTOFF?

`TEC:ENABle:COND`

The TEC:ENABle:COND command sets the selected channel's TEC condition status enable register. The bits in this register determine which TEC conditions are summarized in the 3916 status byte.
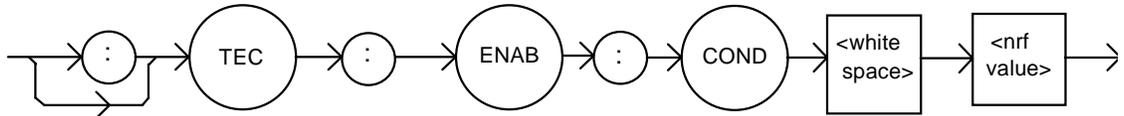
Parameters   An <nrf value> whose sum represents the enabled bits:

1 - TE Current Limit	256 - N/A
2 - TE Voltage LImit	512 - Output inTolerance
4 - N/A	1024 - Output On
8 - High Temperature Limit	2048 - N/A
16 - N/A	4096 - N/A
32 - N/A	8192 - N/A
64 - Sensor Open	16384 - N/A
128 - TE Module Open	32768 - N/A

Notes   The contents of this register determine which of the conditions in the TEC condition status register are reported to the 3916 status byte. See Chapter 3 of this manual for more information on status reporting.

The existing TEC conditions can be monitored using the TEC:COND? query.

Examples   "TEC:ENAB:COND 513" -action: sets the TEC condition status enable register so that the Output Out of Tolerance and Current Limit conditions will be reported in the status byte register.

TEC:ENABle:COND?

The TEC:ENABle:COND? query returns the value of the status condition enable register of the TEC operations.
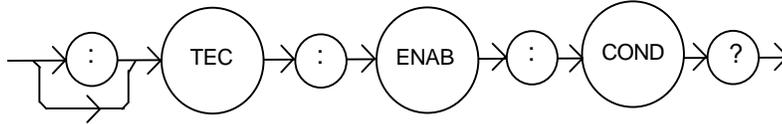
Parameters   None. The response is the sum of the following:

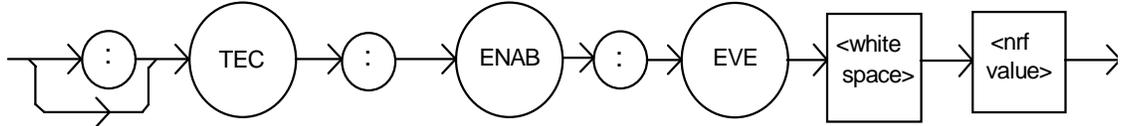|	
1 - TE Current Limit	256 - N/A
2 - TE Voltage Limit	512 - Output inTolerance
4 - N/A	1024 - Output On
8 - High Temperature Limit	2048 - N/A
16 - N/A	4096 - N/A
32 - N/A	8192 - N/A
64 - Sensor Open	16384 - N/A
128 - TE Module Open	32768 - N/A

Notes   The enabled TEC conditions for the selected channel can be set by using the TEC:ENABle:COND command.

Examples   "TEC:ENAB:COND?" -response: 129, means that only the TE Module Open and TE Current Limit conditions for the selected channel may be reported in the 3916 status byte register.

TEC:ENABle:EVEnt

The TEC:ENABle:EVEnt command sets the contents of the selected channel's TEC event status enable register. The bits in this register determine which events are summarized in the 3916 status byte.

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

1 - TE Current Limit Changed State	256 - N/A
2 - TE Voltage Limit Changed State	512 - Output Changed Tolerance State
4 - N/A	1024 - Output On/Off Changed
8 - High Temperature Limit	2048 - N/A
16 - N/A	4096 - N/A
32 - N/A	8192 - N/A
64 - Sensor Open Changed State	16384 - N/A
128 - TE Module Open Changed State	32768 - N/A

Notes   Chapter 3 of this manual contains more information on status reporting.
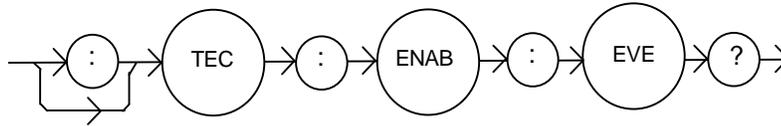
The selected channel's TEC events can be monitored by the TEC:EVEnt? query.

Examples   "Tec:Enab:EVENT 1536" - action: the only events that will be reported to the 3916 status byte will be the output on/off changed state and the output changed tolerance state events.

`TEC:ENABle:EVEnt?`

The TEC:ENABle:EVEnt? query returns the value of the selected channel's TEC event status enable register.

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

1 - TE Current Limit Changed State	256 - N/A
2 - TE Voltage Limit Changed State	512 - Output Changed Tolerance State
4 - N/A	1024 - Output On/Off Changed
8 - High Temperature Limit	2048 - N/A
16 - N/A	4096 - N/A
32 - N/A	8192 - N/A
64 - Sensor Open Changed State	16384 - N/A
128 - TE Module Open Changed State	32768 - N/A

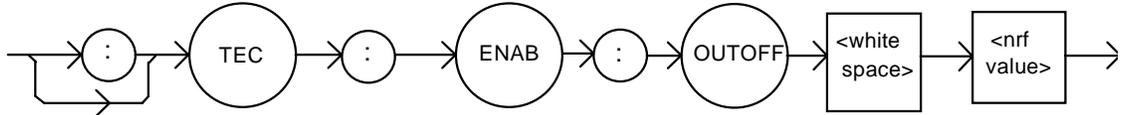Notes   The bits in this register determine which of the selected channel's events are summarized in the 3916 status byte; they can be set by using the TEC:ENABle:EVEnt command.

The selected channel's TEC events can be monitored by the TEC:EVEnt? query.

Examples   "TEC:ENAB:EVE?" - response: 520, only the high temperature limit changed state and output changed tolerance state events will be reported to the 3916 status byte.

`TEC:ENABle:OUTOFF`

The TEC:ENABle:OUTOFF command sets the contents of the selected channel's TEC output off enable register. The bits in this register determine which conditions will cause the TEC to automatically shut off.

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

1 - TE Current Limit Condition	256 - Sensor Type Changed
2 - TE Voltage Limit Condition	512 - Output Out of Tolerance
4 - N/A	1024 - Sensor Shorted Condition
8 - High Temperature Limit Condition	2048 - N/A
16 - N/A	4096 - N/A
32 - N/A	8192 - N/A
64 - Sensor Open Condition	16384 - N/A
128 - Module Open Circuit Condition	32768 - N/A

Notes   The enabled TEC output off bits can be read by using the TEC:ENABle:OUTOFF? query.

The default value for this register is 1480: the default conditions that will turn off the output are temperature limit, sensor open, module open circuit, sensor change and sensor shorted. The default value is placed in the register at power up and as the result of a *RST command.

Examples   "TEC:ENAB:OUTOFF 72" - action: the only conditions that will cause the TEC to automatically turn off are sensor open and high temperature limit.

`TEC:ENABle:OUTOFF?`

The TEC:ENABle:OUTOFF? query returns the contents of the selected channel's TEC output off enable register.

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

1 - TE Current Limit Condition	256 - Sensor Type Changed
2 - TE Voltage Limit Condition	512 - Output Out of Tolerance
4 - N/A	1024 - Sensor Shorted Condition
8 - High Temperature Limit Condition	2048 - N/A
16 - N/A	4096 - N/A
32 - N/A	8192 - N/A
64 - Sensor Open Condition	16384 - N/A
128 - Module Open Circuit Condition	32768 - N/A

Notes | Use the TEC:ENABle:OUTOFF command to set the conditions or events that will cause the output to automatically shut off.

Examples | "TEC:ENAB:OUTOFF?" - response: 258, means that a sensor type change condition or a voltage limit condition will cause the TEC output to be turned off.

TEC:EVEnt?

The TEC:EVEnt? query returns the contents of the selected channel's TEC event status register. Changes that occur in the condition status register are latched in this register.

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

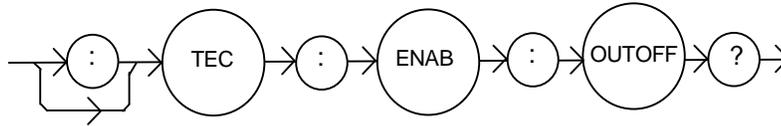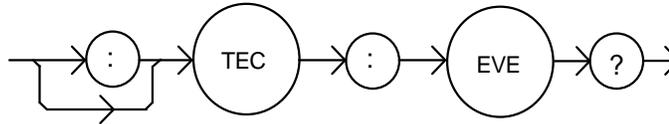|	
1 - TE Current Limit Changed State	256 - N/A
2 - TE Voltage Limit Changed State	512 - Output Changed Tolerance State
4 - N/A	1024 - Output On/Off Changed
8 - High Temperature Limit Changed State	2048 - N/A
16 - N/A	4096 - N/A
32 - N/A	8192 - N/A
64 - Sensor Open Changed State	16384 - N/A
128 - Module Open Circuit Changed State	32768 - N/A

Notes   The TEC event status register is only cleared after it is read using this command, or when a *CLS command is issued. This is a better method of ensuring that an event is captured by a controller than by monitoring the conditions using the TEC:COND? query.

You can specify which of these events are reported to the 3916 status byte by using the TEC:ENABle:EVEnt command.

Examples   "TEC:EVE?" -response: 513, means the since the last TEC:EVEnt? query, the output went into or out of tolerance, and the TEC current limit condition has changed.

TEC:GAIN

The TEC:GAIN command sets the selected channel's TEC control loop proportional gain.
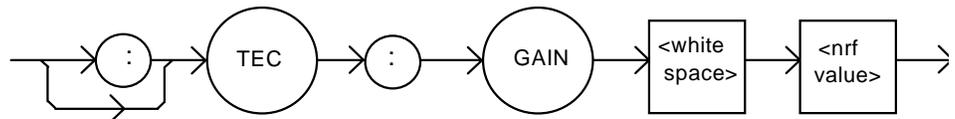
Parameters   An <nrf value> between 1 - 127.

Notes   A higher value may make the controller settle to the desired temperature setpoint quicker. A lower value may have less overshoot. The optimal value is highly dependent upon the user's system.

Examples   "TEC:GAIN 100" -action: the TEC control loop gain is set to 100.

TEC:GAIN?

The TEC:GAIN? query returns the value of the selected channel's TEC control loop gain.

```
: → TEC → : → GAIN → ? →
```
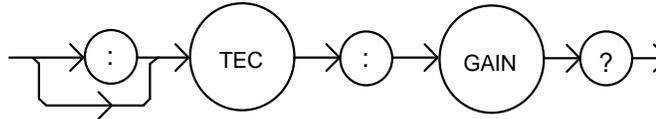
Parameters   None. The response is an integer value between 1 and 127.

Notes   The proportional gain is only used in constant temperature or constant-resistance modes.

Examples   "TEC:Gain?" -response: 30.0, means the control loop gain is set to 30.

TEC:ITE

The TEC:ITE command sets the selected channel's constant TEC current setpoint.

```
: → TEC → : → ITE → <white space> → <nrf value> →
```
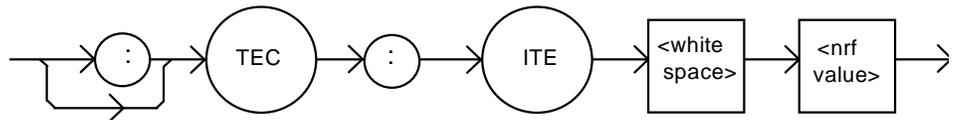
Parameters   An <nrf value> which represents the ITE setpoint current, in Amps.

Notes   This set point is only used when the control mode is "ITE".

Examples   "TEC:ITE 1" -action: sets the selected channel's TEC output current set point to 1.0 Amps.

"TEC:MODE:ITE; Tec:Ite 1.5; tec:out on" - action: selects constant TEC current mode, sets the TEC output current setpoint to 1.5 A, and turn on the output. The output will drive a constant 1.5 A.

`TEC:ITE?`

COMMON

DEVICE DEPENDENT

FRONT PANEL

The TEC:ITE? query returns the selected channel's measured TEC current.
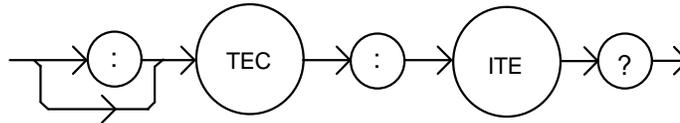
Parameters   None. The response value represents the measured ITE current, in Amps.

Notes   The TEC load current is constantly measured and updated, regardless of the TEC control mode. This measurement is updated approximately once every 600 mSec.

Examples   "TEC:ITE?" -response: 1.43, means the measured TEC current is 1.43 Amps.

"Tec:Ite?" -response: -1.27, means the measured TEC current is -1.27 Amps.

`TEC:LIMit:`

COMMON

DEVICE DEPENDENT

FRONT PANEL

The TEC:LIMit: command path is used to get to the selected channel's TEC limit commands.

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

TEC:LIMit:ITE   TEC:LIMit:ITE?

TEC:LIMit:THI   TEC:LIMit:THI?

`TEC:LIMit:ITE`

COMMON

DEVICE DEPENDENT

FRONT PANEL

The TEC:LIMit:ITE command sets the selected channel's TEC current limit.
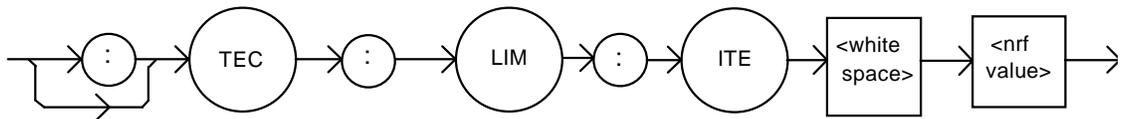
Parameters   An <nrf value> representing the limit value of the TE current, in Amps.

Notes   Although the TEC:LIM:ITE value is positive, it limits both polarities of the TE current.

Examples   "TEC:LIM:ITE 1.5" -action: the TEC current limit is set to 1.5 Amps for the selected channel.

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`TEC:LIMit:ITE?`

The TEC:LIMit:ITE? query returns the value of the selected channel's TEC's current limit.
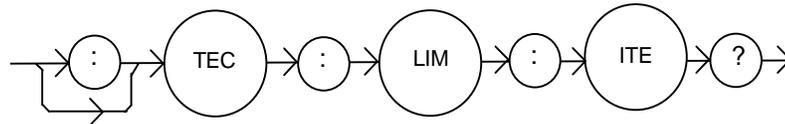
Parameters	None. The response is an <nrf value>.
Notes	The response value is in amps.
Examples	"TEC:LIM:ITE?" - response: 1.5, means the TEC output current limit is 1.5 amps for the selected channel.

`TEC:LIMit:THI`

The TEC:LIMit:THI command sets the selected channel's TEC high temperature limit.
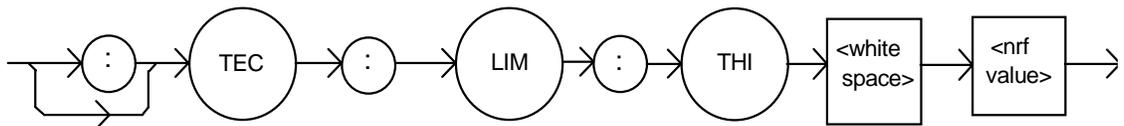
Parameters	An <nrf value> which represents the upper limit of the TEC load temperature, in °C.
Notes	By default, the TEC controller automatically shuts off if the measured temperature ever gets above this value. This behavior can be disabled using the TEC:ENABle:OUTOFF command.
	The THI limit value must be in the range 0 - 199.9 °C.
Examples	"TEC:LIM:THI 100" -action: sets the selected channel's TEC load temperature limit to 100.0 °C.

TEC:LIMit:THI?

The TEC:LIMit:THI? query returns the value of the selected channel's TEC's high temperature limit.
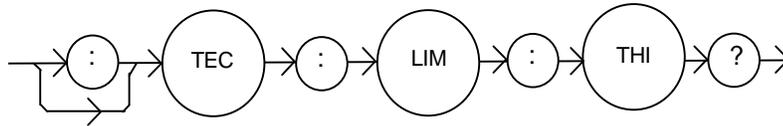
Parameters	None. The response is an <nrf value>.
Notes	If the high temperature limit is set too low, the TEC output may not be able to be turned on, if the high temperature condition is enabled to turn the TEC output off (see TEC:ENABle:OUTOFF).
Examples	"TEC:LIM:Thi?" -response: 30.5, means the TEC high temperature limit is 30.5 ^{o}C.

TEC:MODE?

The TEC:MODE? query returns the selected channel's present TEC control mode.
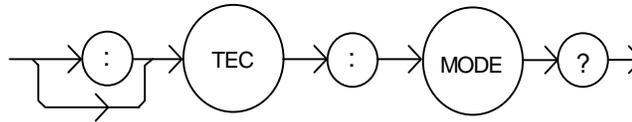
Parameters	None. The response is a character response.
Notes	The TEC output is controlled so that the chosen quantity (temperature, thermistor resistance, or TEC current) is kept constant.
Examples	"Tec:MODE?" - response: ITE, means constant ITE (current) mode is in effect.
	":TEC:Mode?" - response: R, means constant R (thermistor resistance) mode is in effect.
	"Tec:Mode?" - response: T, means constant T (temperature, as measured by the thermistor) mode is in effect.

TEC:MODE:

The TEC:MODE: command path is used to get to the selected channel's TEC mode selection commands.

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

TEC:MODE:DAC (3916371 module only)
TEC:MODE:ITE
TEC:MODE:R
TEC:MODE:T

`TEC:MODE:DAC`

The TEC:MODE:DAC command selects the DAC mode for the selected channel's TEC controller.
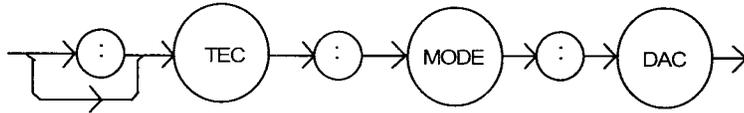
Parameters   None.

Notes   This mode keeps the DAC count constant, regardless of the load conditions.

Changing modes causes the output to be forced off.

Examples   "TEC:MODE:DAC" - action: sets the TEC controller for DAC mode operation.

`TEC:MODE:ITE`

The TEC:MODE:ITE command selects constant TE current mode for the selected channel's TEC controller.
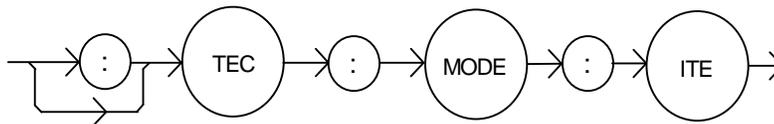
Parameters   None.

Notes   This mode keeps the TEC current constant, regardless of load temperature variations.

Changing modes causes the output to be forced off.

Examples   "TEC:MODE:ITE" - action: sets the TEC controller for constant TEC current operation.

`TEC:MODE:R`

The TEC:MODE:R command selects constant thermistor resistance mode for the selected channel's TEC controller.
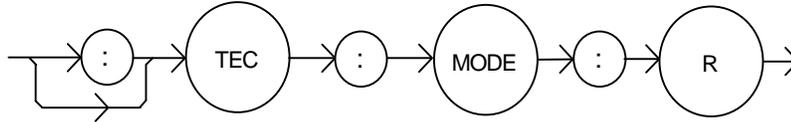
Parameters   None.

Notes   Since sensor resistance is a function of temperature, this mode also controls the TEC output load temperature, but it bypasses the use of the use of the conversion constants for set point calculation. This allows finer control of temperature in cases where the sensor's temperature model (and therefore the constants) is not known.

Changing modes causes the selected TEC's output to be forced off.

Examples   "TEC:MODE:R" -action: sets the TEC controller for constant thermistor resistance control mode.

`TEC:MODE:T`

COMMON
DEVICE DEPENDENT
FRONT PANEL

The TEC:MODE:T command selects constant temperature mode for the selected channel's TEC controller.
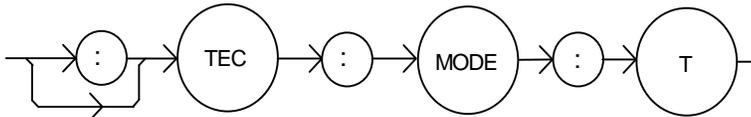
Parameters   None.

Notes   Since TEC load temperature is derived from sensor resistance, constant R and T modes are related. In T mode the set point is converted to resistance using the appropriate constants (see the TEC:CONSTant command) and thermistor type (see TEC:SENsor command).

Examples   "TEC:MODE:T" - action: sets the TEC controller for constant temperature control mode.

`TEC:OUTput`

The TEC:OUTput command turns the selected channel's TEC output on or off.
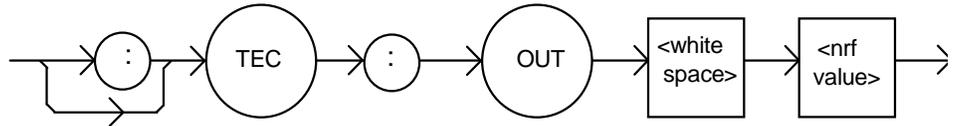
Parameters   An <nrf value>; 1 = on, 0 = off.

Notes   After the selected TEC output is turned on, it may be useful to wait until the output is stable (within tolerance) before performing further operations on the selected channel, but it is not necessary.

Examples   "TEC:OUTPUT 1" - action: turns the TEC output on.

"Tec:Out 0" - action: turns the TEC output off.

"Tec:Out OFF" - action: turns the TEC output off.

`TEC:OUTput?`

The TEC:OUTput? query returns the selected channel's TEC controller output switch status.
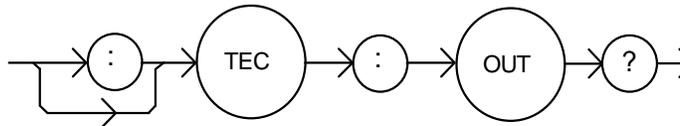
Parameters   None. The response is an <nrf value>.

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

Examples   "Tec:Out?" - response: 0, means the TEC output is off.

"TEC:OUT?" - response: 1, means the TEC output is on.

TEC:R

The TEC:R command sets the selected channel's constant-resistance setpoint.

```
: → TEC → : → R → <white space> → <nrf value> →
```
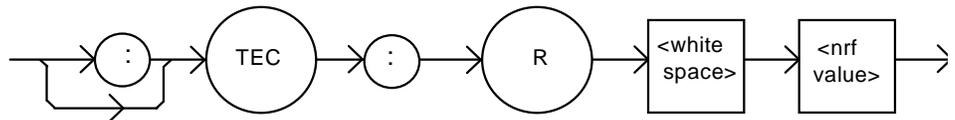
Parameters   An <nrf value> which represents the thermistor resistance set point value, in Ω.

Note   The R set point is used to control the TEC output in R mode only. The range for the R set point parameter is 0.001 to 500.0 kΩ.

Examples   "TEC:R 20.5" - action: sets the set point thermistor to 20.5 kΩ.

"TEC:Mode:R; TEC:R 10" - action: sets the set point thermistor to 10.0 kΩ. The module controls the output current to maintain a constant thermistor resistance of 10.0 kΩ, if the output is on.

TEC:R?

The TEC:R? query returns the selected channel's measured thermistor resistance.

```
: → TEC → : → R → ? →
```
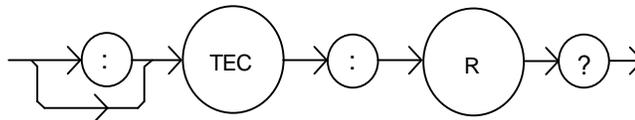
Parameters   None. The response value is the measured thermistor resistance, in kΩ.

Notes   Measured temperature is derived from the thermistor resistance measurement. This measurement is updated approximately once every 600 mSec.

Examples   "TEC:R?" - response: 10.543, means the measured thermistor resistance is 10.543 kΩ.

"Tec:R?" - response: 0.128, means the measured resistance is 128 Ω.

`TEC:SENsor`

The TEC:SENsor command sets the selected channel's thermistor sense current.
This command is not available in the 3916371 module.
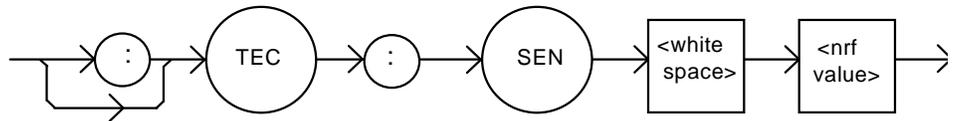
Parameters — An <nrf value> which represents the thermistor sense current. 1 = 100 μA; 2 = 10 μA.

Notes — The thermistor sense current effects the measurement range of the thermistor. Since the 3916370 Series Laser Diode Controller has a useful measurement range of 5 volts, having two separate sense current ranges allows for a greater range of resistance measurement.

When the sense current is 10 μA, the maximum resistance range is about 500 kΩ. When the sense current is 100 μA, the maximum is about 50 kΩ. The optimum sense current setting depends on the expected thermistor resistance for the temperature set point.

Examples — "TEC:Sen 1" - action: sets the thermistor sense current to 100 μA.

`TEC:SENsor?`

The TEC:SENsor? query is used to read back the selected channel's thermistor sense current setting. This value is a coded representation of the thermistor sense current.
This command is not available in the 3916371 module.
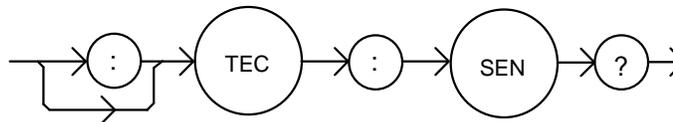
Parameters — None. The response value of 1 = 100 μA; 2 = 10 μA.

Notes — The sense current used affects the optimal measurement range of the thermistor. The internal measurement is actually a voltage in the range of 0 to 5.0 volts, approximately. The two sense current ranges allow two measurement ranges for the thermistor. The 10 μA range may be more appropriate for lower temperatures, or for thermistors that have a higher resistance.

Examples — "TEC:Sensor?" - response: 1, means the thermistor sense current setting is 100 μA.

TEC:SET:

The TEC:SET: command path is used to get to the selected channel's TEC set point queries.

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

TEC:SET:ITE?   TEC:SET:R?   TEC:SET:T?

TEC:SET:ITE?

The TEC:SET:ITE? query returns the selected channel's constant TE current (ITE) set point value.
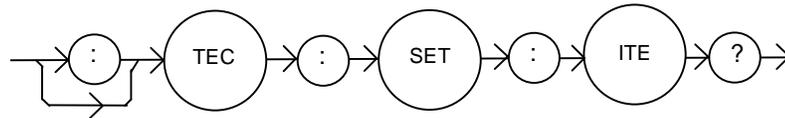
Parameters	None. The response represents the ITE set point for the selected channel, in Amps.
Notes	The TEC output is controlled to this set point value only when constant ITE mode is in effect.
Examples	"TEC:SET:ITE?" - response: 1.0, means the ITE set point is 1.0 Amps.
	"Tec:Set:Ite?" - response: 0.5, means the ITE set point is -0.5 Amps.

TEC:SET:R?

The TEC:SET:R? query returns the selected channel's constant thermistor resistance set point value.
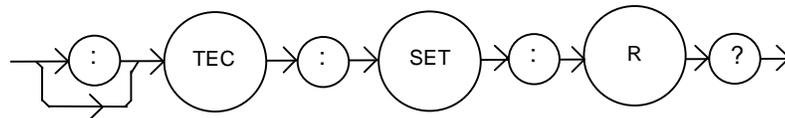
Parameters	None. The response represents the set point thermistor resistance value, in kΩ.
Notes	The TEC output is controlled to this set point value only when constant R mode is in effect.
Examples	"TEC:SET:R?" - response: 3.4, means the constant resistance set point is 3.4 kΩ.
	"Tec:Set:R?" - response: 14.0, means the R set point is 14.0 kΩ.

TEC:SET:T?

The TEC:SET:T? query returns the selected channel's constant temperature set point value.
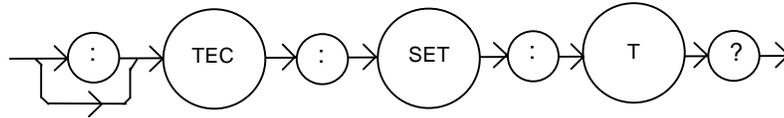
Parameters	None. The response represents the set point temperature, in ^{o}C.
Notes	The TEC output is controlled to this set point value only when constant T mode is in effect.
Examples	"TEC:SET:T?" - response: 33.4, means the constant temperature set point is 33.4 ^{o}C.
	"Tec:Set:t?" - response: -4.0, means the constant T set point is -4.0 ^{o}C.

TEC:SYNCI?

The TEC:SYNCI? query returns the selected channel's measured TE current, in Amps.
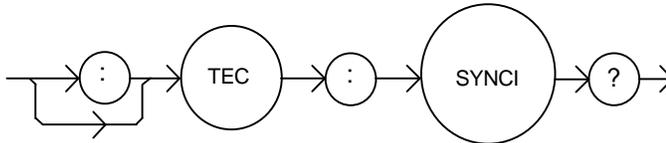
Parameters	None. The response is an <nrf value> representing current in Amps.
Notes	This is a "synchronized" measurement: the TEC measurement system is connected to the current measure signal when this query is received. A current measurement is made, and the result is returned as the response. After the measurement is made, the measurement system returns to its normal functions, switching between the various signals and measuring them.
	The response time to this query is from 200 msec to 250 msec, but the measurement is made as soon as the query is received. In contrast, the tec:ite? query returns immediately, but the measurement can be up to 600 msec old.
Examples	"TEC:SYNCI?" - response: 1.3, means the measured TE current is 1.3 A.

TEC:SYNCR?

The TEC:SYNCR? query returns the selected channel's measured thermistor resistance in kΩ.
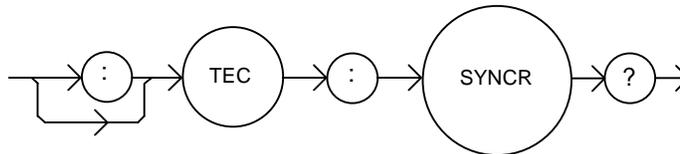
Parameters	None. The response is an <nrf value> representing resistance in kΩ.
Notes	This is a "synchronized" measurement: the TEC measurement system is connected to the thermistor resistance measure signal when this query is received. A resistance measurement is made, and the result is returned as the response. After the measurement is made, the measurement system returns to its normal functions, switching between the various signals and measuring them.
	The response time to this query is from 200 msec to 250 msec, but the measurement is made as soon as the query is received. In contrast, the tec:r? query returns immediately, but the measurement can be up to 600 msec old.
Examples	"TEC:SYNCR?" - response: 10.543, means the measured thermistor resistance is 10.543 kΩ.

TEC:SYNCT?

The TEC:SYNCT? query returns the selected channel's measured thermistor temperature in ^{o}C.
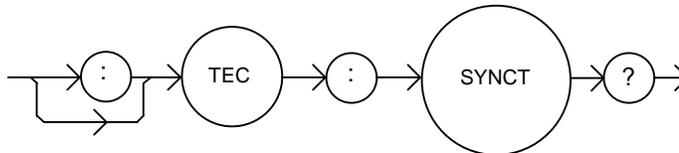
Parameters	None. The response is an <nrf value> representing temperature in ^{o}C.
Notes	This is a "synchronized" measurement: the TEC measurement system is connected to the thermistor resistance measure signal when this query is received. A resistance measurement is made, the temperature is calculated, and the result is returned as the response. After the measurement is made, the measurement system returns to its normal functions, switching between the various signals and measuring them.
	The response time to this query is from 200 msec to 250 msec, but the measurement is made as soon as the query is received. In contrast, the tec:t? query returns immediately, but the measurement can be up to 600 msec old.
Examples	"TEC:SYNCT?" - response: 17.9, means the measured thermistor temperature is 17.9 ^{o}C.

TEC:SYNCV?

COMMON

DEVICE DEPENDENT

FRONT PANEL

The TEC:SYNCV? query returns the selected channel's measured TE forward voltage in Volts.
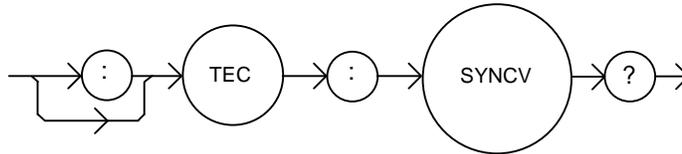
Parameters   None. The response is an <nrf value> representing voltage in Volts.

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

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

Examples   "TEC:SYNCV?" - response: 1.9, means the measured forward voltage is 1.9V.

TEC:T

COMMON

DEVICE DEPENDENT

FRONT PANEL

The TEC:T command sets the selected channel's constant temperature set point value.
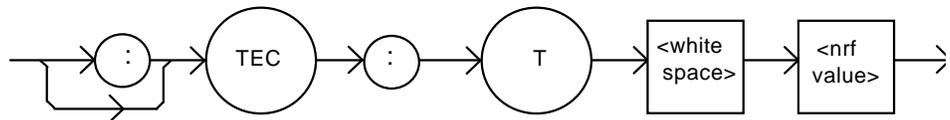
Parameters   An <nrf value> which represents the constant temperature set point value, in ^{o}C.

Notes   The temperature will be controlled to this set point only when the TEC is operated in T mode. The valid range for temperature setpoints is -99.9 ^{o}C to 199.9 ^{o}C.

Examples   "Tec:T 20" - action: sets the selected TEC's temperature set point to 20.0 ^{o}C.

"TEC:MODE:T; TEC:T 25.3" - action: selects constant temperature control mode, sets the temperature set point to 25.3 ^{o}C. The output is controlled to this value, if the output is on.

`TEC:T?`

The TEC:T? query returns the selected channel's temperature measurement value.
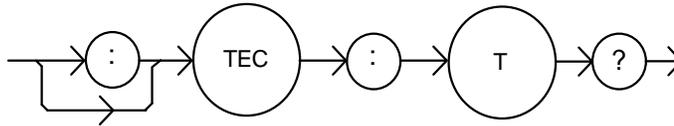
Parameters	None. The response is an <nrf value>.
Notes	The measured temperature is valid for all modes of TEC operation. Temperature is continually updated, approximately once every 600 mSec.
	The temperature is calculated from the thermistor resistance using the Steinhart-Hart constants entered using the TEC:CONST command.
Examples	"TEC:T?" - response: 10.42, means the measured temperature is 10.42 $^\circ$C.

TEC:TOLerance

The TEC:TOLerance command sets the selected channel's TE control tolerance parameters. These parameters consist of a window and a duration. When the controlled load's control variable is within the specified window about the setpoint for the specified duration, the load is said to be "in tolerance".
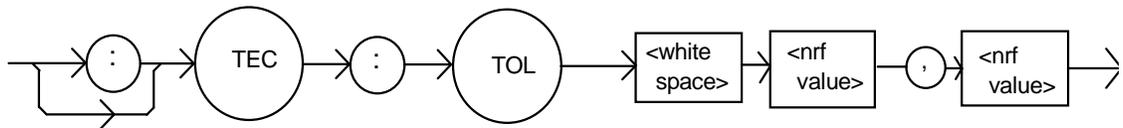
Parameters   Two <nrf values>; the first represents the window, in ^{o}C, kΩ, or Amps, depending on the TE control mode, with a range of 0.1 to 10.0. The second parameter represents the duration, in seconds, with a range of 0.001 to 50.0 seconds.

Notes   You can determine when the load goes into tolerance by using the TEC:COND? query. Alternatively, you can check for operation complete. The OPC flag will be set after the TEC is turned on, when the load is finally in tolerance.

For example, assume the control mode is constant temperature, the set point is 10 ^{o}C, and the tolerance parameters are 0.2 ^{o}C and 5 seconds. After the TEC output is turned on, the load's temperature will be "out of tolerance" until it is between 9.8 ^{o}C and 10.2 ^{o}C for 5 seconds, at which point the In Tolerance bit in the TEC Condition Status register will be set, and the OPC flag will be set.

If the mode is constant thermistor resistance (R), the first parameter is a resistance window is kΩ. There are not separate tolerance values for each mode.

The LDC-3916370 Series Laser Diode Controller defaults to a tolerance of 0.2 ^{o}C for 5 seconds, unless changed by the TEC:TOLerance command.

WARNING: If the tolerance is set too tight, the output may never reach tolerance.

Examples   "TEC:T 44;TEC:Tol 0.5,10;tec:out on" - action: the controlled load will be in tolerance when the temperature is within 0.5 ^{o}C of 44 ^{o}C for a period of 10.0 seconds.

`TEC:TOLerance?`

The TEC:TOLerance? query returns the selected channel's TE control tolerance parameters.

Parameters   None. The response consists of two data units, the first represents the tolerance window, in ⁰C, kΩ, or Amps (depending on the mode). The second represents the tolerance duration, in seconds.

Notes   The TEC tolerance specification is also used in the TEC status event and condition registers, so entering or exiting TEC temperature tolerance may be tested by polling via the TEC:COND? query. It may also be used to generate service requests.

Examples   "Tec:Tol?" - response: "0.2,5", means the selected channel has a TEC tolerance window of 0.2 ⁰C or 0.2 kΩ or 0.2A (depending on the mode) with a duration of 5.0 seconds.

"TEC:TOL?" - response: "1.0,20", means the selected channel has a TEC tolerance window of 1.0 ⁰C or 1.0 kΩ, or 1.0A (depending on the mode) with a duration of 20.0 seconds.

`TEC:V?`

The TEC:V? query returns the selected channel's voltage measurement value.
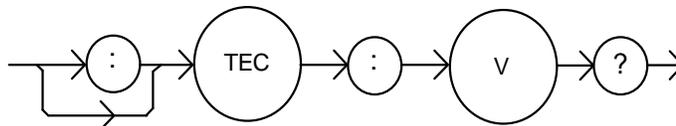
Parameters   None. The response is an <nrf value>, the units are Volts.

Notes   The voltage measurement is updated approximately every 600 msec.

Examples   "TEC:V?" - response: 1.3, means the TEC voltage is 1.3 Volts.

TROUBLESHOOTING

■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■

This chapter describes calibration of your LDC-3916370 Series Laser Diode Controller Module. Descriptions of the required test instruments, calibration conditions, and the detailed procedures for calibration of the instrument's Temperature Controller and the Laser Diode Current Source are included. A troubleshooting guide is also offered for some of the more common failure symptoms. This chapter is divided into three major sections: Local (front panel) calibration, remote (through the GPIB Interface) calibration, and a troubleshooting guide.

ILX Lightwave offers calibration services either in our factory or on site at your location.

Calibration Overview

There are several calibrations to be performed for a completely calibrated 3916370 Laser Diode Controller. The Temperature Controller calibration consists of calibrating the temperature sensors, the TE bipolar current source, and the TE load voltage measurement. The Laser Diode Current Source calibration consists of calibrating the current source, the photodiode monitor feedback ammeter, and the forward voltage measurement. The current limits are calibrated internally by the instrument, using measurements supplied by the user, as part of the calibration process.

Your 3916370 Series Controller Module can be calibrated while installed in a 3916 mainframe 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 which exceed the accuracy specification. Calibrate the instrument under laboratory conditions. We recommend calibration at $23^{o}C \pm 1.0^{o}C$. When necessary, however, the 3916370 Series Laser Diode Controller may be calibrated at its intended use temperature if this is within the specified operating temperature range of 0 to 40 ^{o}C.

The 3916370 Series Laser Diode Controller module should be allowed to warm up for at least 1 hour before calibration.

Recommended Equipment

Recommended test equipment for calibrating the 3916370 Series Laser Diode Controller module is listed in Table 5.1. Equipment other than that shown in the table may be used if the specifications meet or exceed those listed.

Table 5.1 Recommended Test Equipment

Description	Mfg./Model	Specification
DMM	HP 3457A	DC Amps (@ 1.0A): $\pm$0.02%
		Resistance (@10Ω): 0.02%
		0.1 μA or 0.1 mV resolution

It will be necessary to connect various loads and circuits to the outputs of the module for the calibration procedure. The devices required for most of the calibration loads are listed in Table 5.2. A schematic is shown in Figure 5.1 for the photodiode calibration circuit, with the required components listed in Table 5.3.

Table 5.2 Required Calibration Components

TEMPERATURE CONTROLLER CALIBRATION	
Temperature Sensor (Thermistor) Calibration	
10 μA setting	50 kΩ resistor, 1% 1/4W 400 kΩ resistor, 1% 1/4W
100 μA setting	4 kΩ resistor, 1% 1/4W 40 kΩ resistor, 1% 1/4W
100 μA setting (3916371)	5 kΩ resistor, 1% 1/4W 12kΩ resistor, 1% 1/4W
Current Source Calibration	1 Ω 20W resistor, low TCR
Voltage Measurement Calibration	2 Ω 20W resistor, low TCR
LASER CURRENT SOURCE CALIBRATION	
Current Source Calibration	1 Ω 20W resistor, low TCR
Voltage Measurement Calibration	15 Ω 20W resistor, low TCR
PHOTODIODE MONITOR CALIBRATION	
See schematic in Figure 5.1	
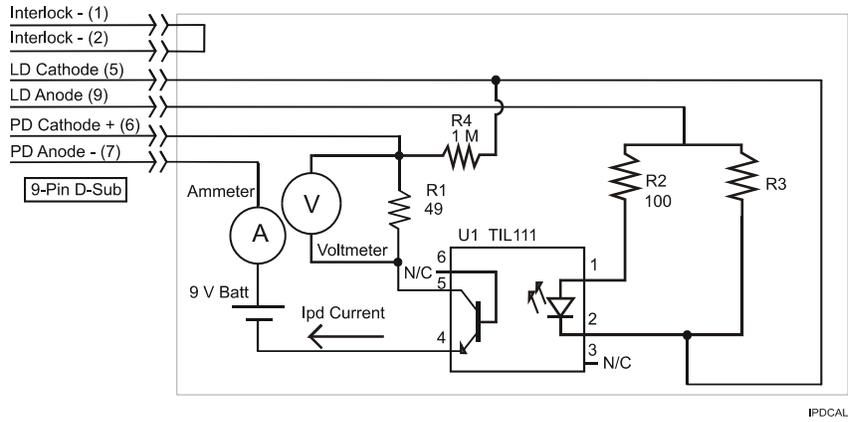
Figure 5.1 I_{PD} Calibration Circuit

Table 5.3 Components for I_{PD} Calibration Circuit

COMPONENTS FOR PHOTODIODE CURRENT (I_{PD}) CALIBRATION CIRCUIT	
R1	49Ω resistor, 1% 1/4W
R2	100Ω resistor, 1% 1/4W
R4	1.0 MΩ resistor, 1% 1/4W
R3	5Ω resistor, 1% 10W
U1	TIL 117 opto isolator
Battery	9V battery
Connector	9-pin D-sub, male

Local Calibration of the Temperature Controller

Thermistor Calibration

The following procedure is for calibrating the 100 μA and 10 μA thermistor current sources so that the thermistor resistance measurement for these ranges will meet the stated accuracy specifications.

1   Install the module into a 3916 mainframe. Turn on the mainframe and allow it to warm up for at least one hour.

2   Using the multimeter, measure and record the exact resistance of your metal film resistors. You should know the exact resistance of the resistors to at least 1Ω.

   Note: For best accuracy in your calibration, a four-point probe resistance measurement is recommended.   After connecting the probe to the calibration resistor, wait at least a half a second before recording the resistance value. Heat from your fingers can change the value of the resistance.

3   Enter the 10 μA sensor calibration mode by pushing the (DISPLAY) MAIN front panel button, then the Sys. Config soft key, then the Cal. soft key, then the Cal TEC soft key, then the Therm10 Cal soft key. The module's 10 μA calibration screen will appear. (All except 3916371 module)

4   Press the Start soft key. The internal calibration procedure will begin, and the screen will prompt you to connect a 50 kΩ resistor.

5   Connect a resistor of approximately 50 kΩ (you should know the exact resistance value to at least 1Ω) to the TE connector's sensor pins (pins 7 and 8). Allow the measurement to settle for at least 10 seconds.

6   Enter the exact resistance value in kΩ into the "RReal" adjust field, and press Enter. Be sure not to enter more than 7 characters, including the decimal point. The screen will now prompt you to attach a 400 kΩ resistor.

7   Connect a resistor of approximately 400 kΩ (again you should know the exact value to within 1Ω), and allow the measurement to settle for at least 30 seconds.

8   Enter the exact resistance value into the "RReal" adjust field, and press Enter. The internal calibration procedure will make its calculations, and when it has finished it will indicate so on the screen.

   Follow a similar procedure for the 100 μA sensor calibration, except use the Therm100 Cal soft key, and use a 4 kΩ and a 40 kΩ resistor for all modules.

ITE Current Calibration

The following procedure is for calibrating the TE current source. The internal calibration procedure sets the current to two negative values and two positive values. You must enter the exact current that you measure at each of these points. The internal procedure will then use this information to calibrate the current source setpoint, measurement, and limit circuits.

1 With the output off, connect a 1 Ω, 20 W resistor across the TEC output terminals (TE Module (+), pins 1 & 2; and TE Module (-), pins 3 & 4). Positive current flows from the module (+) pins to the module (-) pins.

2 Connect a calibrated DMM across the load resistor. You will be calculating TE current (ITE) in the following manner using Ohm's Law:

   $I = E / R$; where E is the accurately measured voltage across the resistor, and R is the accurately measured load resistance. I is the calculated current in Amps. A 4-point probe resistance measurement is recommended.

   Note: We recommended that the load resistor be temperature-controlled during the calibration.

   The current may be measured directly using an ammeter with a range of at least 2 A, and accurate to within 0.01 A. Connect the ammeter in series with a load resistor of value no more than 1Ω.

3 Enter the ITE calibration mode by pushing the (DISPLAY) MAIN front panel button, then the Sys. Config soft key, then the Cal. soft key, then the Cal TEC soft key, then the ITE Cal soft key. The module's ITE calibration screen will appear.

4 Press the Start soft key. The internal calibration procedure will turn on the output and drive the TE current to approximately 75% of its negative output range. Allow the current to settle for at least 10 seconds.

5 Calculate or measure the actual current to within 0.01 A and enter the value (in Amps) into the "IReal" adjust area, press (ADJUST) ENTER. Be sure to include the minus sign, and do not enter more than five characters, including the minus sign and decimal point. If you do enter more than five characters, and as a result the minus sign is chopped off the left side of the display, press the (ADJUST) CLEAR button and re-enter the value. Otherwise the internal calibration procedure will either abort, or produce an incorrect calibration.

Repeat this process for the next three values of current that the internal procedure sets. The next three current settings are approximately 25% of negative output range, then 25% of positive output range, and finally 75% of positive output range. Allow the current to settle for at least 10 seconds at each step.

After you have entered the last actual current, the internal calibration procedure will perform the calibration for the current setpoint, measurement, and limit circuits. The screen will then display a message indicating that the calibration has finished.

TE Voltage Calibration

The following procedure is for calibrating the TE voltage measurement. The internal calibration procedure sets the current to a negative value and a positive value. You must enter the exact voltage that you measure at both of these points. The internal procedure will then use this information to calibrate the voltage measurement circuit.

1   With the output off, connect a 2 Ω, 20 W resistor across the TEC output terminals (TE Module (+), pins 1 & 2; and TE Module (-), pins 3 & 4).

2   Connect a calibrated voltmeter across the load resistor.

3   Enter the TE voltage calibration mode by pushing the (DISPLAY) MAIN front panel button, then the Sys. Config soft key, then the Cal. soft key, then the Cal TEC soft key, then the TE Volts Cal soft key. The module's TE Volts calibration screen will appear.

4   Press the Start soft key. The internal calibration procedure will turn on the output and drive the TE current to approximately 75% of its negative output range. Allow the current to settle for at least 10 seconds.

5   Measure the voltage across the load resistor to within 0.01 V and enter the value in Volts into the "VReal" adjust area. Press (ADJUST) ENTER. Be sure to include the minus sign, and do not enter more than five characters, including the minus sign and decimal point. If you do enter more than five characters, and as a result the minus sign is chopped off the left side of the display, press the (ADJUST) CLEAR button and re-enter the value. Otherwise the internal calibration procedure will either abort, or produce an incorrect calibration.

After you have entered the first voltage, the internal cal procedure will set the output current to approximately 75% of positive output range. Measure the voltage across the load resistor, enter this measurement in the "VReal" adjust area, and press (ADJUST) ENTER. The internal cal procedure will calibrate the TE voltage measurement circuit, and the screen will display a "Completed" message.

Local Calibration of the Laser Current Source

There are three calibration adjustments for the LASER current source of the 3916370 Series Laser Diode Controller Module. They are: calibration of the constant current (LDI) source, calibration of the constant light power (IPD) feedback circuit, and calibration of the laser forward voltage (LDV) measurement.

Current Source Calibration

The following procedure is for calibrating the laser current source. The internal calibration procedure sets the current to two values. You must enter the exact Laser Diode current that you measure at both of these points. The internal procedure will then use this information to calibrate the current source.

1   With the output off, connect a 1Ω, 20 W resistor across the LASER output terminals (Laser Anode, pin 9, and Laser Cathode, pin 5).   Current will flow from the anode to the cathode.

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

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

Note: We recommend that the load resistor be temperature-controlled during the calibration.

Alternatively, the current may be measured directly using an ammeter with a range of at least 2 A, and accurate to ±0.001 mA. If you use the ammeter approach, you should connect the ammeter in series with a load resistor with a nominal value of 1Ω.

3   Enter the LDI calibration mode by pushing the (DISPLAY) MAIN front panel button, then the Sys. Config soft key, then the Cal. soft key, then the Cal LAS soft key, then the LDI Cal soft key. The module's LDI calibration screen will appear.

4   Press the Start soft key. The internal calibration procedure will turn on the output and drive the LD current to approximately 25% of full range. Allow the current to settle for at least 10 seconds.

5   Calculate or measure the actual current through the load resistor, enter that value (in mA) into the highlighted "IReal" adjust field on the screen, and press (ADJUST) ENTER. Do not enter more than eight characters, including the decimal point.

6   The internal cal procedure will then set the LD current to approximately 75% of full range. Allow the current to settle for at least 10 seconds.

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

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

IPD Current Calibration

The following procedure is for calibrating the LASER IPD (photodiode monitor) measurement circuit. The internal calibration procedure sets the current to two values. You must enter the resulting IPD (photodiode monitor) current that you measure at both of these points. The internal procedure will then use this information to calibrate the IPD measurement circuit.

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

2   Connect an ammeter with at least 5000 μA range and at least $\pm$0.1 μA accuracy as shown in the figure. This ammeter is in series with the Photodiode Anode input to the module, and directly measures the photodiode current.

3   Enter the IPD calibration mode by pushing the (DISPLAY) MAIN front panel button, then the Sys. Config soft key, then the Cal. soft key, then the Cal LAS soft key, then the IPD Cal soft key. The module's IPD calibration screen will appear.

4   Press the Start soft key. The internal calibration procedure will turn on the output and drive the LD current to approximately 25% of full range. Allow the current to settle for at least 10 seconds.

5   Use the ammeter and measure the actual photodiode current, enter that value (in A) into the highlighted "IPDReal" adjust field on the screen, and press (ADJUST) ENTER. Do not enter more than seven characters, including the decimal point.

6   The internal calibration procedure will then drive the LD current to approximately 75% of full range. Allow the current to settle for at least 10 seconds.

7   Measure the actual photodiode current, enter that value (in μA) into the highlighted "IPDReal" adjust field on the screen, and press (ADJUST) ENTER.

After you have entered the second value, the internal cal procedure calibrates the IPD current measurement circuit and displays a "Completed" message on the screen.

Laser Forward Voltage Measurement Calibration

The following procedure is for calibrating the LASER forward voltage (LDV) measurement circuit. The internal calibration procedure sets the current to two values. You must enter the resulting forward voltage that you measure at both of these points. The internal procedure will then use this information to calibrate the LDV measurement circuit.

1 With the output off, connect a 15Ω 20W load resistor across the Laser Anode sense/drive terminals (pins 8 and 9) and Laser Cathode sense/drive terminals (pins 4 and 5).

2 Connect a voltmeter with at least 10V range and accuracy of at least ±0.01V across the load resistor.

3 Enter the LDV calibration mode by pushing the (DISPLAY) MAIN front panel button, then the Sys. Config soft key, then the Cal. soft key, then the Cal LAS soft key, then the LDV Cal soft key. The module's LDV calibration screen will appear.

4 Press the START soft key. The internal calibration procedure will turn on the output and drive the LD current to approximately 4% of full range. Allow the current to settle for at least 10 seconds.

5 Then measure the voltage across the load resistor, enter that value (in Volts) into the highlighted "VReal" adjust field on the screen, and press (ADJUST) ENTER. Do not enter more than seven characters, including the decimal point.

6 The internal calibration procedure will then drive the LD current to approximately 18% of full range. Allow the current to settle for at least 10 seconds.

7 Measure the actual voltage across the load resistor, enter that value (in Volts) into the highlighted "VReal" adjust field on the screen, and press (ADJUST) ENTER.

After you have entered the second value, the internal cal procedure calibrates the laser forward voltage measurement circuit and displays a "Completed" message on the screen.

This ends the section on front panel (local) calibration of your controller. The next section discusses calibration through the IEEE488.2 GPIB interface.

Remote Calibration of the LDC-3916370 Controller

The 3916370 Controller Modules can be calibrated remotely via the GPIB Interface. All of the required calibration commands are listed in Table 4.1 in Chapter 4. The procedures below are general guidelines for writing a program to calibrate your instrument.

⚠ CAUTION

It should be noted that if at anytime during the calibration procedure the user exits the calibration menu by pressing the Up-Arrow softkey, the MAIN key or the CHAN key, the calibration procedure will be aborted.

Thermistor Calibration

The following procedure is for remotely calibrating the 100 μA and 10 μA thermistor current sources so that the thermistor resistance measurements for these ranges will meet the stated accuracy specifications.

1   Install the module into a 3916 mainframe. Turn on the mainframe and allow it to warm up for at least one hour.

2   Using the multimeter, measure and record the exact resistance of your metal film resistors. You should know the exact resistance of the resistors to at least 1Ω.

   Note: For best accuracy in your calibration, a four-point probe resistance measurement is recommended. After connecting the probe to the calibration resistor, wait at least a half a second before recording the resistance value. Heat from your fingers can change the value of the resistance.

3   Connect a resistor of approximately 50 kΩ to the TEC connector's sensor pins (pins 7 and 8).

4   Enter the 10 μA sensor calibration mode by sending the following command over GPIB:

   TEC:CAL:SEN 2. (all modules except the 3916371 module)

   This starts the internal 10 μA sensor calibration procedure. Allow the measurement to settle for at least 10 seconds. If this calibration value is to be measured and entered remotely via a GPIB controlled DMM, for example, the actual value of the resistance should not be entered until the LDC-3916 controller is ready to receive it.

5   Check to see if the internal cal procedure is ready for a measurement, send the following query to the module:

   TEC:CAL:STATUS?

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

6   Enter the exact resistance value (that you previously measured) in kΩ of the first resistor by sending the following command:

TEC:CAL:MEAS (value in kΩ) e.g. TEC:CAL:MEAS 45.678

Note: The internal cal procedure will store this value and briefly change its measurement status to "0" to indicate that it is not yet ready for another measurement.

7   Connect the 400 kΩ resistor and allow the measurement to settle for at least 10 seconds.

8   Check to see if the internal cal procedure is ready for a measurement, send the following query to the module:

TEC:CAL:STATUS?

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

When the status query returns "1", enter the value of the second resistor:

9   Enter the exact resistance value (that you previously measured) in kΩ of the second resistor by sending the following command:

TEC:CAL:MEAS (value in kΩ) e.g. TEC:CAL:MEAS 398.877

The internal cal procedure will now complete the calibration of the 10 μA sensor measurement circuit. It indicates that it is finished by responding to the status query with the value "2".

Follow a similar procedure for the 100 μA sensor calibration, except use the following command to start the cal:

TEC:CAL:SEN 1.

For the 100 μA sensor calibration, use 4 kΩ for the first resistor and 40 kΩ for the second for all modules except the 3916371. For the 3916371, use a 5 kΩ and 12 kΩ resistor.

ITE Current Calibration

The following procedure is for remotely calibrating the TE current source. The internal calibration procedure sets the current to two negative values and two positive values. You must measure the current at each of these points and send the measurements to the module over GPIB. The internal procedure will then use this information to calibrate the current source setpoint, measurement, and limit circuits.

1   With the output off, connect a 1Ω, 20 W resistor across the TEC output terminals (TE Module (+), pins 1 & 2, and TE Module (-), pins 3 & 4).

2   Connect a calibrated DMM across the load resistor. You will be calculating TE current (ITE) in the following manner using Ohm's Law:

I = E / R; where E is the accurately measured voltage across the resistor, and R is the accurately measured load resistance. I is the calculated current in Amps. A 4-point probe resistance measurement is recommended.

We recommended that the load resistor be temperature-controlled during the calibration. The current may be measured directly using an ammeter with a range of at least 2 A and accurate to within ±0.01 A. If you use the ammeter approach, you should connect the ammeter in series with a load resistor with a nominal value of 1Ω.

3   Enter the ITE calibration mode by sending the following command over GPIB:

TEC:CAL:ITE

The internal cal procedure will begin by setting the TE output current to approximately 75% of its negative full range. Allow the current to settle for at least 10 seconds. If this calibration value is to be measured and entered remotely via a GPIB controlled DMM, for example, the actual value of the current should not be entered until the LDC-3916 controller is ready to receive it.

4   Check to see if the internal cal procedure is ready for a measurement by sending the following query to the module:

TEC:CAL:STATUS?

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

5   Enter the measured current in Amps by sending the following command:

TEC:CAL:MEAS (current in Amps) e.g. TEC:CAL:MEAS -1.45

Note: The internal cal procedure will store this value and briefly change its measurement status to "0" to indicate that it is not yet ready for another measurement. This will occur after each time a new measurement is entered.

6   The controller will set the output current to approximately 25% of its negative output range. Allow the current to settle for at least 10 seconds.

7   Check to see if the internal cal procedure is ready for the second measurement. Send the following query to the module:

TEC:CAL:STATUS?

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

8 Enter the second actual measured TE current:

TEC:CAL:MEAS (current in Amps) e.g. TEC:CAL:MEAS -0.43

9 The controller will set the output current to approximately 25% of its positive output range. Allow the current to settle for at least 10 seconds.

10 Check to see if the internal cal procedure is ready for the third measurement. Send the following query to the module:

TEC:CAL:STATUS?

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

11 Enter the third actual measured TE current:

TEC:CAL:MEAS (current in Amps) e.g. TEC:CAL:MEAS 0.45

12 The controller will set the output current to approximately 75% of its positive output range. Allow the current to settle for at least 10 seconds.

13 Check to see if the internal cal procedure is ready for the fourth measurement. Send the following query to the module:

TEC:CAL:STATUS?

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

14 Enter the fourth actual measured TE current:

TEC:CAL:MEAS (current in Amps) e.g. TEC:CAL:MEAS 1.47

After you have entered the last measured current, the internal calibration procedure will perform the calibration for the current setpoint, measurement, and limit circuits. The cal procedure will set the status to the value "2" to indicate that it has finished.

TE Voltage Calibration

The following procedure is for remotely calibrating the TE voltage measurement circuit. The internal calibration procedure sets the current to two values. You must measure the voltage at each of these points and send the measurements to the module over GPIB. The internal procedure will then use this information to calibrate the TE voltage measurement circuit.

1   With the output off, connect a 2 Ω, 20 W load resistor across the TEC output terminals (TE Module (+), pins 1 & 2; and TE Module (-), pins 3 & 4).

2   Connect a calibrated voltmeter across the load resistor.

3   Enter the TE voltage calibration mode by sending the following command over GPIB:

TEC:CAL:V

The internal cal procedure will begin by setting the TE output current to approximately 75% of its negative full range. Allow the current to settle for at least 10 seconds. If this calibration value is to be measured and entered remotely via a GPIB controlled DMM, for example, the actual value of the resistance should not be entered until the LDC-3916 controller is ready to receive it.

4   Check to see if the internal cal procedure is ready for the measurement. Send the following query to the module:

TEC:CAL:STATUS?

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

5   Enter the actual measured TE voltage:

TEC:CAL:MEAS (voltage in Volts) e.g. TEC:CAL:MEAS -2.91

Note: The internal cal procedure will store this value and briefly change its measurement status to "0" to indicate that it is not yet ready for another measurement. This will occur after each time a new measurement is entered.

6   The controller will set the output current to approximately 75% of its positive output range. Allow the current to settle for at least 10 seconds.

7   Check to see if the internal cal procedure is ready for the measurement. Send the query to the module:

TEC:CAL:STATUS?

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

8   Enter the actual measured TE voltage:

TEC:CAL:MEAS (voltage in Volts) e.g. TEC:CAL:MEAS 2.94

After you have entered the second measured voltage, the internal calibration procedure will perform the calibration for the voltage measurement circuit. The cal procedure will then set the status to the value "2" to indicate that it has finished.

Laser Current Source Calibration

There are three calibration adjustments for the laser current source of the 3916370 Series Laser Diode Controller Module. They are: calibration of the constant current (LDI) source, calibration of the laser forward voltage (LDV) measurement, and calibration of the constant light power (I_{PD}) feedback circuit.

LDI Calibration

The following procedure is for remotely calibrating the laser current source. The module's internal calibration procedure sets the current to two values. You must measure and enter the exact Laser Diode current at both of these points. The module's internal cal procedure will then use this information to calibrate the current source.

1 With the output off, connect a 1Ω, 20 W resistor across the LASER output terminals (Laser Anode, pin 9, and Laser Cathode, pin 5).

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

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

Note: We recommend that the load resistor be temperature-controlled during the calibration. Alternatively, the current may be measured directly using an ammeter with a range of at least 2 A, and accurate to $\pm$0.001 mA. If you use the ammeter approach, you should connect the ammeter in series with a load resistor with a nominal value of 1Ω.

3 Enter the Laser Current Source calibration mode by sending the following command over GPIB:

LAS:CAL:LDI

4 The internal cal procedure will begin by setting the Laser output current to approximately 25% of its full range. Allow the current to settle for at least 10 seconds.

If this calibration value is to be measured and entered remotely via a GPIB controlled DMM, for example, the actual value of the current should not be entered until the LDC-3916 controller is ready to receive it.

5 Check to see if the internal cal procedure is ready for the measurement. Send the following query to the module:

LAS:CAL:STATUS?

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

6 Enter the measured current in mA by sending the following command:

LAS:CAL:MEAS (current in mA) e.g. LAS:CAL:MEAS 267.878

Note: The internal cal procedure will store this value and briefly change its measurement status to "0" to indicate that it is not yet ready for another measurement. This will occur after each time a new measurement is entered.

7 The controller will set the output current to approximately 75% of its output range. Allow the current to settle for at least 10 seconds.

8 Check to see if the internal cal procedure is ready for the measurement. Send the following query to the module:

LAS:CAL:STATUS?

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

9 Enter the second measured current in mA by sending the following command:

LAS:CAL:MEAS (current in mA) e.g. LAS:CAL:MEAS 527.986

After you have entered the second measured current, the internal calibration procedure will perform the calibration for the laser current setpoint, current measurement, and current limit circuits. The cal procedure will then set the status to the value "2" to indicate that it has finished.

IPD Current Calibration

The following procedure is for remotely calibrating the LASER IPD (photodiode monitor) measurement circuit. The module's internal calibration procedure sets the current to two values. You must enter the resulting IPD (photodiode monitor) current that you measure at both of these points. The module's internal cal procedure will then use this information to calibrate the IPD measurement circuit.

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

2   Connect an ammeter with at least 5000 μA range and at least $\pm$0.1 μA accuracy as shown in the figure. This ammeter is in series with the Photodiode Anode input to the module, and directly measures the photodiode current.

3   Enter the Laser Current Source calibration mode by sending the following command over GPIB:

   LAS:CAL:MDI

   Note: "MDI" stands for "Monitor Diode Current".

4   The internal cal procedure will begin by setting the Laser output current to approximately 25% of its full range. Allow the current to settle for at least 10 seconds.

   If this calibration value is to be measured and entered remotely via a GPIB controlled DMM, for example, the actual value of the current should not be entered until the LDC-3916 controller is ready to receive it.

5   Check to see if the internal cal procedure is ready for the measurement. Send the following query to the module:

   LAS:CAL:STATUS?

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

6   Enter the measured current in μA by sending the following command:

   LAS:CAL:MEAS (current in μA) e.g. LAS:CAL:MEAS 745.321

   Note: The internal cal procedure will store this value and briefly change its measurement status to "0" to indicate that it is not yet ready for another measurement. This will occur after each time a new measurement is entered.

7   The controller will set the output current to approximately 75% of its output range. Allow the current to settle for at least 10 seconds.

8   Check to see if the internal cal procedure is ready for the measurement. Send the following query to the module:

   LAS:CAL:STATUS?

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

9   Enter the measured current in μA by sending the following command:

LAS:CAL:MEAS (current in μA) e.g. LAS:CAL:MEAS 3573.344

After you have entered the second measured photodiode current, the internal calibration procedure will perform the calibration for the photodiode current measurement circuit. The cal procedure will then set the status to the value "2" to indicate that it has finished.

Laser Forward Voltage Measurement Calibration

The following procedure is for remotely calibrating the laser forward voltage measurement circuit. The module's internal calibration procedure sets the current to two values. You must measure and enter the forward voltage at both of these points. The module's internal cal procedure will then use this information to calibrate the voltage measurement system.

1 With the output off, connect a 15Ω 20W load resistor across the Laser Anode sense/drive terminals (pins 8 and 9) and Laser Cathode sense/drive terminals (pins 4 and 5).

2 Connect a calibrated voltmeter across the load resistor ("plus" lead to Anode).

3 Enter the Laser voltage measurement calibration mode by sending the following command over GPIB:

LAS:CAL:LDV

4 The internal cal procedure will begin by setting the Laser output current to approximately 4% of its full range. Allow the current to settle for at least 10 seconds, or until the measured voltage is stable.

If this calibration value is to be measured and entered remotely via a GPIB controlled DMM, for example, the actual value of the current should not be entered until the LDC-3916 controller is ready to receive it.

5 Check to see if the internal cal procedure is ready for the measurement. Send the following query to the module:

LAS:CAL:STATUS?

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

6 Enter the measured voltage in Volts by sending the following command:

LAS:CAL:MEAS (voltage in Volts) e.g. LAS:CAL:MEAS 0.59

Note: The internal cal procedure will store this value and briefly change its measurement status to "0" to indicate that it is not yet ready for another measurement. This will occur after each time a new measurement is entered.

7 The controller will set the output current to approximately 18% of its output range. Allow the current to settle for at least 10 seconds.

8 Check to see if the internal cal procedure is ready for the measurement. Send the following query to the module:

LAS:CAL:STATUS?

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

9 Enter the second measured voltage in Volts by sending the following command:

LAS:CAL:MEAS (voltage in Volts) e.g. LAS:CAL:MEAS 2.74

After you have entered the second measured voltage, the internal calibration procedure will perform the calibration for the laser forward voltage measurement circuit. The cal procedure will then set the status to the value "2" to indicate that it has finished.

This ends the calibration guide.

Troubleshooting Guide

This section is a guide to troubleshooting the 3916370 Series Controller Modules. Some of the more common symptoms are listed here, and the appropriate troubleshooting actions are given. We recommend that the user start at the beginning of this guide. Read the symptom descriptions, and follow the steps for the corrective actions which apply. If you encounter problems which are beyond the scope of this guide, contact ILX Lightwave Customer Service.

SYMPTOM	CORRECTIVE ACTIONS
GENERAL	
LDC-3916 Series unit will not power up	Check AC power line voltage and power word connection
Power on, but outputs have been shut off. Instrument may be "locked up" or instrument resets itself.	This may occur if the instrument loses power (AC line) briefly or line voltage drops below specification. If instrument is "locked up", power it off and then on to restart.
LASER CONTROLLER	
Power on, but no current output	Check interlock pins on LASER input connector on instrument rear panel. These pins must be shorted either directly or through a switch. The front-panel Laser Enable switch should also be on. If Open Circuit is indicated (E503), check the load connections and cable and then try again. Be sure the cable connector is securely fastened to the back of the module(s). Make sure that Anode Voltage Sense and Cathode Voltage Sense (pins 8 and 4) are connected to your laser.
Output current at limit, can't be lowered	If IPD or PPD mode is used, check the monitor diode (feedback) connections. Make sure that the polarity of the monitor photodiode is correct. Also check if the photodiode bias is off. If in I_{LBW} or I_{HBW} mode, check the current set point and I LIMIT setting. Setting the output below the limit may require several turns of the adjust knob if the set point 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	Make sure that the ISET adjust parameter is highlighted. Check the I LIMIT parameter; it should be set above 0 and above the laser operating current. Check the V LIMIT parameter, the voltage limit should be set above the operating voltage of your laser load.
Power Mode operation has high output current, but little or no power is measured	Check the photodiode bias. If it is off, the circuit may act as an open feedback loop. Set the bias to on (-5V).
Output exceeds power limit	It is possible via GPIB to disable turning off the output when the power limit is exceeded. Ensure that this is not the case. Default at power up is to enable this safety feature. The "Power Limit" is not a hardware limit. It serves as a warning that the power measurement has exceeded the limit set point.
Open Circuit Error occurs during calibration	Check load connections. Check that measuring meter does not auto-range (use non-auto-ranging modes).
Calibration is aborted unintentionally	Calibration modes will be aborted if an open circuit is detected or if entered measurements are invalid.
TEC CONTROLLER	
Power on, but no TE current output	Check the load connections and operating mode.
Power on, but temperature is not controlled	If SENSOR OPEN indication, check the sensor connections. Check that the proper sensor current range is selected (either 10 μA or 100 μA). Check that C1 and C2 and C3 are correct values for your thermistor. Check that the GAIN setting is not too low and that the LIM I$_{TE}$ value is not too low for your thermal load.
Unable to adjust output or parameter	Ensure that the desired parameter is highlighted. Check thermoelectric module current limit if in constant ITE mode, make sure it is higher than module rating.

Output goes off intermittently	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. Check the TE module connections. A high impedance on the TE load may cause the output to exceed the compliance voltage momentarily. If enabled via GPIB, this condition will shut off the output. Check the sensor connections at the module and the load. Switching modes while the output is on will disable the output.

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