# LDC-3700 SERIES
# LASER DIODE CONTROLLERS

**(LDC-3712, LDC-3722B, and LDC-3742B)**

# INSTRUCTION MANUAL

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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 we will repair or replace the unit, at our option, without charge.

## Limitation

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 notify ILX Lightwave Corporation and thoroughly describe the nature of the problem and give the serial number.

## Returning an Instrument

Before returning an instrument, obtain a return authorization number from the factory. The instrument should be shipped in the original packing carton or one that will provide equal protection. Shipping damage is not covered by this warranty. Send the instrument, transportation pre-paid to the factory, referencing the return authorization number. Repairs will be 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 / PROBLEMS ?

In order to get the most out of your ILX Lightwave product, we ask that you direct any product operation or service related questions or comments to **Customer Support** at 406-586-1244 (fax 406-586-9405, telex 4931552). When calling, please have the following information on hand (if applicable):

1) Product: ______________________

2) Unit Serial Number: ______________________

3) End user name and telephone/fax/telex number

   Name: ______________________

   Company: ______________________

   Phone: ______________________

   Fax: ______________________

   Telex: ______________________

4) Description/sketch of what is connected to ILX Lightwave instrument.

5) Description of the problem.

We look forward to serving you better in the future!

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# Chapter 1

# GENERAL INFORMATION

## 1.1 Introduction

This manual contains operation and maintenance information for the LDC-3700 Series Laser Diode Controllers and optional Model 1231 GPIB/IEEE-488.2 Interface. If you want to get started right away, read Chapter 2, which covers Operation, first.

In the following chapters there are three areas of discussion, one for functions which are common to both the TEC and the LASER controller, one for the functions which pertain to the TEC controller only, and one for functions which pertain to the LASER current source only.

## 1.2 Product Overview

The LDC-3700 Series Laser Diode Controllers are a combination current source/temperature controller. The current source provides a high stability output with a fully redundant current limit and multiple laser protection features. The built-in temperature controller can work with most thermistors and TE modules to deliver precision laser temperature control over a wide range of temperatures. The LDC-3700 Series' fast, sophisticated GPIB option lets you automate your experiment.

## 1.3 Available Options and Accessories

Options and accessories available for the LDC-3700 Series Controllers include the following:

| DESCRIPTION | MODEL NUMBER |
|---|---|
| **GPIB/IEEE-488.2 Interface** | **1231** |
| **Rack mount flange kit** (enables installation into a standard 19 inch wide rack) | **132** |
| **Temperature Controlled Laser Diode Mount** | **4407** |
| **Temperature Controlled Laser Diode Mount** (available with collimating assembly) | **4412** |
| **High Power Laser Diode Mount** | **4442** |
| **CW Filter Cable (included with LDC-3700 Series Controller)** | **320** |
| **Current Source Interconnect Cable (unterminated)** | **301** |
| **TEC Interconnect Cable (unterminated)** | **501** |
| **Calibrated 10 KΩ Thermistor** | **510** |
| **Uncalibrated 10 KΩ Thermistor** | **520** |
| **Uncalibrated AD590LH IC Temperature Sensor** | **530** |
| **Uncalibrated LM335AH IC Temperature Sensor** | **540** |

Other Laser Diode Mounts and Thermistor models are available. Please contact ILX Lightwave for information on additional options for your applications.

## 1.4 Specifications

The specifications for the LDC-3712 are found in Section 1.4.1, the specifications for the LDC-3722B are found in Section 1.4.2, the specifications for the LDC-3742B are found in Section 1.4.3.

### 1.4.1 LDC-3712 Specifications

The specifications for the LDC-3712's laser current source are found in Section 1.4.1.1, the specifications for the LDC-3712's temperature controller are found in Section 1.4.1.2, and the general specifications are found in Section 1.4.1.3.

#### 1.4.1.1 3712 Laser Current Source Specifications

| Current Source | 50 mA Range | 100 mA Range |
|---|---|---|
| Set Point Accuracy | ±0.025 mA | ±0.05 mA |
| Set Point Resolution | 1 μA | 2 μA |
| Compliance Voltage (fixed) | 7 V maximum | 7 V maximum |
| Temperature Coefficient | < 50 ppm/°C | < 50 ppm/°C |
| Stability[1], for 1 hour | < 20 ppm | < 20 ppm |
| Stability[1], for 24 hours | < 50 ppm | < 50 ppm |
| Noise and Ripple[2] | | |
| High Bandwidth Mode | < 3 μA rms | < 6 μA rms |
| Low Bandwidth Mode | < 2 μA rms | < 2.5 μA rms |
| CW Mode (with 320 cable) | < 0.8 μA rms | < 0.8 μA rms |
| Worst Case Transients | | |
| Operational[3]: | <0.4 mA | <0.4 mA |
| Power-line induced[4]: | < 4 mA | < 4 mA |

| Photodiode Feedback | |
|---|---|
| Range | 0 to 5000 μA |
| Output Stability[5] | ±0.02% |
| Set Point Accuracy | ±2.5 μA |
| Bias Voltage | 0 - 5 V reverse bias (± 10%) (adjustable on back panel) |

[1]Stability specifications are measured at half-scale output, after a one hour warmup period.

[2]Extrapolated from resulting intensity fluctuations of a laser diode, measured optically with a 150 kHz bandwidth photodetector. Measurements made with a 1 MHz detector are typically 10% better.

[3]Maximum output current transients resulting from normal operational situations (e.g., power on-off, current on-off) as well as accidental situations (e.g., power line plug removal). For more information refer to ILX Noise and Transient Test Standards publication.

[4]Maximum output current transient resulting from a 200 V power line transient spike. For more information refer to ILX Noise and Transient Test Standards publication.

[5]Specified values are a percent of nominal. Constant-power mode stability specification assumes zero drift in detector responsivity.

| Laser Drive Current Display | 50 mA Range | 100 mA Range |
|---|---|---|
| Output Current Range | 0.000 to 50.000 mA | 0.000 to 100.00 mA |
| Output Current Resolution | 1 uA | 2 uA |
| Output Current Accuracy at 25°C | ±0.025 mA | ±0.05 mA |
| Photodiode Current Range | 0 - 5000μA | 0 - 5000μA |
| Photodiode Current Resolution | 1 μA | 1 μA |
| Photodiode Current Accuracy | ±2.5 μA | ±2.5 μA |
| Responsivity Range | 0 - 600.00 μA/mW | 0 - 600.00 μA/mW |
| Responsivity Resolution | 0.01 μA/mW | 0.01 μA/mW |
| Optical Power Range | 0 - 200.00 mW | 0 - 200.00 mW |
| Output Power Resolution | 0.01 mW | 0.01 mW |

| Current Limit Setting | 50 mA Range | 100 mA Range |
|---|---|---|
| Range | 0.00 - 50.50 mA | 0.00 - 101.00 mA |
| Resolution | 0.25 mA | 0.5 mA |
| Accuracy | ±0.5 mA | ±1 mA |

| Analog Modulation/ Voltage Control | | |
|---|---|---|
| Input | 0 - 10 V, 10 KΩ | 0 - 10 V, 10 KΩ |
| Transfer Function | 5 mA/V | 10 mA/V |
| Transfer Function Accuracy | ±5% of full scale | ±5% of full scale |
| Bandwidth[6] (3 dB) | | |
| High Bandwidth Mode: | DC to 500 kHz | DC to 200 kHz |
| Low Bandwidth Mode: | DC to 10 kHz | DC to 10 kHz |
| CW Mode (with 320 cable): | DC to 30 Hz | DC to 30 Hz |

### 1.4.1.2 3712 Temperature Controller Specifications

| TEC Output[7] | |
|---|---|
| Output Type | Bipolar constant current source |
| Compliance Voltage | 4 Volts at 4 Amps |
| Maximum Current Output | 4 Amps |
| Maximum Output Power[8] | 16 Watts typical |
| Current Limit Control Range | 0 - 4A, ±20 mA |
| Current Limit Accuracy | ±50 mA |
| Ripple / Noise[9] | < 1 mA rms |

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[6]Bandwidth is specified for a 0 to full scale peak-to-peak output.

[7]Output current and power are rated into a one-half ohm load.

[8]Higher output powers can be accomodated by using a booster. Contact ILX Lightwave for further information.

[9]Broadband noise is measured at 100 mA output current, over a bandwidth of 10 Hz - 10 MHz..

## Temperature Control

| | | |
|---|---|---|
| Temperature Range[10] | -99 °C to +199 °C<br>-20 °C to +70 °C with typical 10K thermistor | |
| Resolution and Accuracy[11] | | |
| Temperature | Resolution | Accuracy |
| -20 °C | ±0.1 °C | ±0.2 °C |
| 0 °C | ±0.1 °C | ±0.2°C |
| 20 °C | ±0.1 °C | ±0.2 °C |
| 50 °C | ±0.2 °C | ±0.2 °C |
| LM335 Setting Accuracy | ±0.2 °C | |
| AD590 Setting Accuracy | ±0.2 °C | |
| Short Term Stability[12] | ±0.01 °C or better, over 1 hr. | |
| Long Term Stability[13] | ±0.1 °C or better, over 24 hours | |
| Sensor Type | 2-wire thermistor; AD590 current type; or LM335 voltage type | |
| Usable Thermistor Range | 25 Ω to 450 kΩ, typ. | |
| LM335 Voltage | V(25 °C) = 2980 mV; $V_T$ = 10 mV/°K over rated sensor range | |
| LM335 Bias | 1 mA | |
| AD590 Current | I(25 °C) = 298.2 µA; $I_T$ = 1 µA/°K over rated sensor range | |
| AD590 Bias | +8 VDC | |
| Thermistor Sensing Current | 10 µA or 100 µA (user selectable) | |
| Temperature Calculation Methods | AD590 or LM335 calibrated with two-point method. Termistors are calibrated by storing three constants of the Steinhart-Hart equation in internal non-volatile memory. | |
| Thermistor: | $1/T = (C1 * 10^{-3}) + (C2 * 10^{-4})(\ln R) + (C3 * 10^{-7})(\ln R)^3$ (T in Kelvin) | |
| LM335: | T = C1 + C2 * (V / (10 mV/°K) - 273.15) | |
| AD590: | T = C1 + C2 * (I / (1 µA/°K) - 273.15 | |

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10 Temperature control range depends primarily on the type of thermistor and TE module used. The range can be extended higher and lower by selecting appropriate components. See Appendix B for more details.

11 Accuracy figures quoted are typical for a 10 kΩ thermistor and 100 µA source current setting (10 µA source current setting at -20 °C. Accuracy figures are relative to calibration standard. Both resolution and accuracy are dependent on the user defined configuration of the instrument.

12 Over any 1 hour interval, controlling an LDM-4412 mount @ 25 °C, with a 10K thermistor on 100 µA setting.

13 Over any 24 hour interval, controlling an LDM-4412 mount @ 25 °C, with a 10K thermistor on 100 µA setting.

**3712 Temperature Control (continued)**

**TEC Display**

| | |
|---|---|
| Maximum Current Reading | 4.000 Amps |
| Maximum Temp Reading | 199.9 °C |
| Current Resolution | 0.001 Amps |
| Current Display Accuracy | ±0.02 Amps |
| Temperature Resolution | 0.1 °C |
| Temperature Display Accuracy | ±0.2 °C |
| Thermistor Resistance Resolution | 0.01 kΩ at 10 μA setting; 0.001 kΩ at 100 μA setting |
| Thermistor Resistance Display Accuracy | ±0.05 kΩ at 10 μA setting ±0.005 kΩ at 100 μA setting |

### 1.4.1.3 General LDC-3712 Specifications

**Connectors**

| | |
|---|---|
| Photodiode Monitor and Current Source Connectors: | 9-pin, D-connector, banana jacks for LASER output, BNC for photodiode input |
| External Modulation Connector | BNC, instrumentation amplifier input |
| Temperature Controller: | 15-pin D-connector, banana jacks for TEC output and thermistor input |

**Optional GPIB**

Meets ANSI/IEEE Std 488.1-1987
Meets ANSI/IEEE Std 488.2-1987

**General**

| | |
|---|---|
| Size | 5.6" x 12.5" x 15.6", 145 mm x 320 mm x 346 mm |
| Weight | < 18 lbs (8.2 kg) |
| Power Requirements | 90-110 VAC; 108-132 VAC; 198-242 VAC; 216-264 VAC, 50-60 Hz |
| Temperature | 0 to +50 °C operating; -40 to +70 °C storage |
| Humidity | < 90 % relative humidity, non-condensing. |
| Laser Safety Features: | Keyswitch, interlock and output delay (meets CDRH US21 1040.10) |
| LASER Display type: | 5-digit, green LED |
| TEC Display type: | 5-digit, green LED |

### 1.4.2 LDC-3722B Specifications

The specifications for the LDC-3722B's laser current source are in Section 1.4.2.1, the specifications for the LDC-3722B's temperature controller are in Section 1.4.2.2, and the general specifications are in Section 1.4.2.3.

#### 1.4.2.1 3722B Laser Current Source Specifications

| Current Source | 200 mA Range | 500 mA Range |
|---|---|---|
| Set Point Accuracy | ±100 μA | ±250 μA |
| Set Point Resolution | 4 μA | 10 μA |
| Compliance Voltage (fixed) | 6.5 V maximim | 6.5 V maximum |
| Temperature Coefficient | < 50 ppm/°C | < 50 ppm/°C |
| Stability[14], for 10 min | < 20 ppm | < 20 ppm |
| Stability, for 24 hours | < 50 ppm | < 50 ppm |
| Noise and Ripple[15] | | |
| High Bandwidth Mode: | < 4 μA rms | < 4 μA rms |
| Low Bandwidth Mode: | < 2 μA rms | < 2 μA rms |
| CW Mode (with 320 cable): | < 0.8 μA rms | < 0.8 μA rms |
| Worst Case Transients | | |
| Operational[16]: | < 1 mA | < 1 mA |
| Power-line induced[17]: | < 5 mA | < 5 mA |

| Photodiode Feedback | | |
|---|---|---|
| Range | 5 to 5000 μA | |
| Output Stability[18] | ±0.02% | |
| Accuracy | ±2.5 μA | |
| Bias Voltage | 0 - 5 V reverse bias (± 10%) | (adjustable on back panel) |

| Laser Drive Current Display | 200 mA Range | 500 mA Range |
|---|---|---|
| Output Current Range | 0.00 to 200.00 mA | 0.00 to 500.00 mA |
| Output Current Resolution | 0.01 mA | 0.01 mA |
| Output Current Accuracy at 25°C | ±0.1 mA | ±0.25 mA |
| Photodiode Current Range | 0 - 5000 μA | 0 - 5000 μA |
| Photodiode Current Resolution | 1 μA | 1 μA |
| Photodiode Current Accuracy | ±2.5 μA | ±2.5 μA |
| Responsivity Range | 0 - 600.00 μA/mW | 0 - 600.00 μA/mW |
| Responsivity Resolution | 0.01 μA/mW | 0.01 μA/mW |
| Optical Power Range | 0 - 200.00 mW | 0 - 200.00 mW |
| Output Power Resolution | 10 μW | 10 μW |

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[14]Stability specifications are measured at half-scale output, after a one hour warmup period.

[15]Extrapolated from resulting intensity fluctuations of a laser diode, measured optically with a 150 kHz bandwidth photodetector. Measurements made with a 1 MHz detector are typically 10% better.

[16]Maximum output current transients resulting from normal operational situations (e.g., power on-off, current on-off) as well as accidental situations (e.g., power line plug removal). For more information refer to ILX Noise and Transient Test Standards publication.

[17]Maximum output current transient resulting from a 200 V power line transient spike. For more information refer to ILX Noise and Transient Test Standards publication.

[18]Specified values are a percent of nominal. Constant-power mode stability specification assumes zero drift in detector responsivity.

## 3722B Laser Current Source Specifications (continued)

| Current Limit Setting | 200 mA Range | 500 mA Range |
|---|---|---|
| Range | 0 - 202 mA | 0 - 505 mA |
| Resolution | 1 mA | 2 mA |
| Accuracy | ±2 mA | ±5 mA |

| Analog Modulation/ Voltage Control | | |
|---|---|---|
| Input | 0 - 10 V, 10 KΩ | 0 - 10 V, 10 KΩ |
| Transfer Function | 20 mA/V | 50 mA/V |
| Transfer Function Accuracy | ±5% of full scale | ±5% of full scale |
| Bandwidth[19] (3 dB) | | |
| High Bandwidth: | DC to 500 kHz | DC to 175 kHz |
| Low Bandwidth: | DC to 10 kHz | DC to 4 kHz |
| CW Mode (with 320 cable): | DC to 30 Hz | DC to 30 Hz |

### 1.4.2.2 3722B Temperature Controller Specifications

| TEC Output[20] | |
|---|---|
| Output Type | Bipolar constant current source |
| Compliance Voltage | 4 Volts at 4 Amps |
| Maximum Current Output | 4 Amps |
| Maximum Output Power[21] | 16 Watts typical |
| Current Limit Control Range | 0 - 4A |
| Current Limit Accuracy | ±50 mA |
| Ripple / Noise[22] | < 1 mA rms |

| Temperature Control | |
|---|---|
| Temperature Range[23] | -99 °C to +150 °C<br>-20 °C to +70 °C with typical 10K thermistor |

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[19]Bandwidth is specified for a 0 to full scale peak-to-peak output.

[20]Output current and power are rated into a one-half ohm load.

[21]Higher output powers can be accomodated by using a booster. Contact ILX Lightwave for further information.

[22]Broadband noise is measured at 100 mA output current, over a bandwidth of 10 Hz - 10 MHz.

[23]Temperature control range depends primarily on the type of thermistor and TE module used. The range can be extended higher and lower by selecting appropriate components. See Appendix B for more details.

| Resolution and Accuracy[24] | | |
|---|---|---|
| Temperature | Resolution | Accuracy |
| -20 °C | ±0.1 °C | ±0.2 °C |
| 0 °C | ±0.1 °C | ±0.2°C |
| 20 °C | ±0.1 °C | ±0.2 °C |
| 50 °C | ±0.2 °C | ±0.2 °C |
| LM335 Setting Accuracy | ±0.2 °C | |
| AD590 Setting Accuracy | ±0.2 °C | |
| Short Term Stability[25] | ±0.01 °C or better, over 1 hr. | |
| Long Term Stability | ±0.1 °C or better, over 24 hours | |
| Sensor Type | 2-wire thermistor; AD590 current type; or LM335 voltage type | |
| Usable Thermistor Range | 25 Ω to 450 kΩ, typ. | |
| LM 335 Voltage | V(25 °C) = 2980 mV; $V_T$ = 10 mV/°K over rated sensor range | |
| LM335 Bias | 1 mA | |
| AD590 Current | I(25 °C) = 298.2 µA; $I_T$ = 1 µA/°K over rated sensor range | |
| AD590 Bias | +8 VDC | |
| Thermistor Sensing Current | 10 µA or 100 µA (user selectable) | |
| Temperature Calculation Methods | AD590 or LM335 calibrated with two-point method. Termistors are calibrated by storing three constants of the Steinhart-Hart equation in internal non-volatile memory. | |
| Thermistor: | $1/T = (C1 * 10^{-3}) + (C2 * 10^{-4})(\ln R) + (C3 * 10^{-7})(\ln R)^3$ (T in Kelvin) | |
| LM335: | T = C1 + C2 * (V / (10 mV/°K) - 273.15) | |
| AD590: | T = C1 + C2 * (I / (1 µA/°K) - 273.15 | |

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[24]Accuracy figures quoted are typical for a 10 kΩ thermistor and 100 µA source current setting (10 µA source current setting at -20 °C. Accuracy figures are relative to calibration standard. Both resolution and accuracy are dependent on the user defined configuration of the instrument.

[25]Short term temperature stability is a strong function of the thermal environment of the thermistor and TE module. Room air currents in particular can easily cause fluctuations of 0.1 °C in an exposed mounting configuration.

**TEC Display**

| | |
|---|---|
| Maximum Current Reading | 4.000 Amps |
| Maximum Temp Reading | 199.9 °C |
| Current Resolution | 0.001 Amps |
| Current Display Accuracy | ±0.02 Amps |
| Temperature Resolution | 0.1 °C |
| Temperature Display Accuracy | ±0.2 °C |
| Thermistor Resistance Resolution | 0.01 kΩ at 10 μA setting; 0.001 kΩ at 100 μA setting |
| Thermistor Resistance Display Accuracy | ±0.05 kΩ at 10 μA setting ±0.005 kΩ at 100 μA setting |

### 1.4.2.3 General LDC-3722B Specifications

**Connectors**

| | |
|---|---|
| Photodiode Monitor and Current Source Connectors: | 9-pin, D-connector, banana jacks for LASER output, BNC for photodiode input |
| External Modulation Connector | BNC, instrumentation amplifier input |
| Temperature Controller: | 15-pin D-connector, banana jcaks for TEC output and thermistor input |

**Optional GPIB**

Meets ANSI/IEEE Std 488.1-1987
Meets ANSI/IEEE Std 488.2-1987

**General**

| | |
|---|---|
| Size | 5.6" x 12.5" x 15.6", 145 mm x 320 mm x 346 mm |
| Weight | < 18 lbs (8.2 kg) |
| Power Requirements | 90-110 VAC; 108-132 VAC; 198-242 VAC; 216-264 VAC, 50-60 Hz |
| Temperature | 0 to +50 °C operating; -40 to +70 °C storage |
| Humidity | < 90 % relative humidity, non-condensing. |
| Laser Safety Features: | Keyswitch, interlock and output delay (meets CDRH US21 1040.10) |
| LASER Display type: | 5-digit, green LED |
| TEC Display type: | 5-digit, green LED |

### 1.4.3 LDC-3742B Specifications

The specifications for the LDC-3742B's laser current source are found in Section 1.4.3.1, the specifications for the LDC-3742B's temperature controller are found in Section 1.4.3.2, and the general specifications are found in Section 1.4.3.3.

#### 1.4.3.1 3742B Laser Current Source Specifications

| Current Source | 1000 mA Range | 3000 mA Range |
|---|---|---|
| Range | 0 - 1000.0 mA | 0 - 3000.0 mA |
| Set Point Accuracy | ±5 mA | ±15 mA |
| Set Point Resolution | 20 μA | 60 μA |
| Compliance Voltage (fixed) | 5 V maximum | 5 V maximum |
| Temperature Coefficient | < 50 ppm/°C | < 540 ppm/°C |
| Stability[26], for 1 hour | < 20 ppm | < 20 ppm |
| Stability, for 24 hours | < 50 ppm | < 50 ppm |
| Noise and Ripple[27] | | |
| High Bandwidth Mode: | <10 μA rms | <20 μA rms |
| Low Bandwidth Mode: | < 8 uA rms | < 12 uA rms |
| CW Mode (with 320 cable): | < 2.5 uA rms | < 5 uA rms |
| Worst Case Transients | | |
| Operational[28]: | < 4 mA | < 5 mA |
| Power-line induced[29]: | < 10 mA | < 20 mA |

| Photodiode Feedback | |
|---|---|
| Range | 1 to 10,000 μA |
| Output Stability[30] | ±0.02% |
| Accuracy | ±5 μA |
| Bias Voltage | 5 V reverse bias (± 10%) (adjustable on back panel) |

| Laser Drive Current Display | 1000 mA Range | 3000 mA Range |
|---|---|---|
| Output Current Range | 0.0 to 3000.0 mA | 0.0 to 3000.0 mA |
| Output Current Resolution | 0.1 mA | 0.1 mA |
| Output Current Accuracy at 25°C | ±0.5 mA | ±1.5 mA |
| Photodiode Current Range | 0 - 10,000μA | 0 - 10,000μA |
| Photodiode Current Resolution | 1 μA | 1 μA |
| Photodiode Current Accuracy | ±5 μA | ±5 μA |
| Responsivity Range | 0 - 600.00 μA/mW | 0 - 600.00 μA/mW |
| Responsivity Resolution | 0.01 μA/mW | 0.01 μA/mW |
| Optical Power Range | 0 - 5000.0 mW | 0 - 5000.0 mW |
| Output Power Resolution | 10 μW | 10 μW |

[26]Stability specifications are measured at half-scale output, after a one hour warmup period.

[27]Extrapolated from resulting intensity fluctuations of a laser diode, measured optically with a 150 kHz bandwidth photodetector. Measurements made with a 1 MHz detector are typically 10% better.

[28]Maximum output current transients resulting from normal operational situations (e.g., power on-off, current on-off) as well as accidental situations (e.g., power line plug removal). For more information refer to ILX Noise and Transient Test Standards publication.

[29]Maximum output current transient resulting from a 200 V power line transient spike. For more information refer to ILX Noise and Transient Test Standards publication.

[30]Specified values are a percent of nominal. Constant-power mode stability specification assumes zero drift in detector responsivity.

3742B Laser Current Source Specifications (cont.)

| Current Limit Setting | 1000 mA Range | 3000 mA Range |
|---|---|---|
| Range | 0 - 1010 mA | 0 - 3030 mA |
| Resolution | 5 mA | 15 mA |
| Accuracy | ±10 mA | ±30 mA |

| Analog Modulation/ Voltage Control | | |
|---|---|---|
| Input | 0 - 10 V, 10 KΩ | 0 - 10 V, 10 KΩ |
| Transfer Function | 100 mA/V | 300 mA/V |
| Transfer Function Accuracy | ±5% of full scale | ±5% of full scale |
| Bandwidth[31] (3 dB) | | |
| High Bandwidth Mode: | DC to 100 kHz | DC to 50 kHz |
| Low Bandwidth Mode: | DC to 10 kHz | DC to 10 kHz |
| CW Mode (with 320 cable): | DC to 30 Hz | DC to 30 Hz |

### 1.4.3.2 3742B Temperature Controller Specifications

| TEC Output[32] | |
|---|---|
| Output Type | Bipolar constant current source |
| Compliance Voltage | 4 Volts at 4 Amps |
| Maximum Current Output | 4 Amps |
| Maximum Output Power[33] | 16 Watts typical |
| Current Limit Control Range | 0 - 4A |
| Current Limit Accuracy | ±50 mA |
| Ripple / Noise[34] | < 1 mA rms |

[31]Bandwidth is specified for a 0 to full scale peak-to-peak output.

[32]Output current and power are rated into a one-half ohm load.

[33]Higher output powers can be accomodated by using a booster. Contact ILX Lightwave for further information.

[34]Broadband noise is measured at 100 mA output current, over a bandwidth of 10 Hz - 10 MHz.

## Temperature Control

| | | |
|---|---|---|
| Temperature Range[35] | -99 °C to +199 °C<br>-20 °C to +70 °C with typical 10K thermistor | |
| Resolution and Accuracy[36] | | |
| Temperature | Resolution | Accuracy |
| -20 °C | ±0.1 °C | ±0.2 °C |
| 0 °C | ±0.1 °C | ±0.2°C |
| 20 °C | ±0.1 °C | ±0.2 °C |
| 50 °C | ±0.2 °C | ±0.2 °C |

| | |
|---|---|
| LM335 Setting Accuracy | ±0.2 °C |
| AD590 Setting Accuracy | ±0.2 °C |
| Short Term Stability[37] | ±0.01 °C or better, over 1 hr. |
| Long Term Stability | ±0.1 °C or better, over 24 hours |
| Sensor Type | 2-wire thermistor, AD590 current type; or LM335 voltage type |
| Usable Thermistor Range | 25 Ω to 450 kΩ, typ. |
| LM 335 Voltage | V(25 °C) = 2980 mV; $V_T$ = 10 mV/°K over rated sensor range |
| LM335 Bias | 1 mA |
| AD590 Current | I(25 °C) = 298.2 µA; $I_T$ = 1 µA/°K over rated sensor range |
| AD590 Bias | +8 VDC |
| Thermistor Sensing Current | 10 µA or 100 µA (user selectable) |
| Temperature Calculation Methods | AD590 or LM335 calibrated with two-point method. Termistors are calibrated by storing three constants of the Steinhart-Hart equation in internal non-volatile memory. |
| Thermistor: | $1/T = (C1 * 10^{-3}) + (C2 * 10^{-4})(\ln R) + (C3 * 10^{-7})(\ln R)^3$ (T in Kelvin) |
| LM335: | T = C1 + C2 * (V / (10 mV/°K) - 273.15) |
| AD590: | T = C1 + C2 * (I / (1 µA/°K) - 273.15 |

[35]Temperature control range depends primarily on the type of thermistor and TE module used. The range can be extended higher and lower by selecting appropriate components. See Appendix B for more details.

[36]Accuracy figures quoted are typical for a 10 kΩ thermistor and 100 µA source current setting (10 µA source current setting at -20 °C. Accuracy figures are relative to calibration standard. Both resolution and accuracy are dependent on the user defined configuration of the instrument.

[37]Short term temperature stability is a strong function of the thermal environment of the thermistor and TE module. Room air currents in particular can easily cause fluctuations of 0.1 °C in an exposed mounting configuration.

3742B Temperature Control (cont.)

TEC Display

| | |
|---|---|
| Maximum Current Reading | 4.000 Amps |
| Maximum Temp Reading | 199.9 °C |
| Current Resolution | 0.001 Amps |
| Current Display Accuracy | ±0.02 Amps |
| Temperature Resolution | 0.1 °C |
| Temperature Display Accuracy | ±0.2 °C |
| Thermistor Resistance Resolution | 0.01 kΩ at 10 μA setting; 0.001 kΩ at 100 μA setting |
| Thermistor Resistance Display Accuracy | ±0.1 kΩ at 10 μA setting ±0.01 kΩ at 100 μA setting |

### 1.4.3.3 General LDC-3742B Specifications

Connectors

| | |
|---|---|
| Photodiode Monitor and Current Source Connectors: | 9-pin, D-connector, banana jacks for LASER output, BNC for photodiode input |
| External Modulation Connector | BNC, instrumentation amplifier input |
| Temperature Controller: | 15-pin D-connector, banana jacks for TEC output and thermistor input |

Optional GPIB

Meets ANSI/IEEE Std 488.1-1987
Meets ANSI/IEEE Std 488.2-1987

General

| | |
|---|---|
| Size | 5.6" x 12.5" x 15.6", 145 mm x 320 mm x 346 mm |
| Weight | < 18 lbs (8.2 kg) |
| Power Requirements | 90-110 VAC; 108-132 VAC; 198-242 VAC; 216-264 VAC, 50-60 Hz |
| Temperature | 0 to +50 °C operating; -40 to +70 °C storage |
| Humidity | < 90 % relative humidity, non-condensing. |
| Laser Safety Features: | Keyswitch, interlock and output delay (meets CDRH US21 1040.10) |
| LASER Display type: | 5-digit, green LED |
| TEC Display type: | 5-digit, green LED |

## 1.5 Your Comments

Our goal is to make the best laser diode instrumentation available anywhere. To achieve this, we need your ideas and comments on ways we can improve our products. We invite you to contact us at any time with your suggestions. (Please see the third cover page.)

# Chapter 2

# OPERATION

## 2.1 Introduction

This chapter describes how to install, adjust, and operate the LDC-3700 Series Laser Diode Controllers. It is divided into sections covering installation, familiarization and adjustment, warm-up and environmental considerations, and normal operating procedures.

Section 2.4.1 gives an overview of the LDC-3700 Series Controllers' front panel features, and it presents a guide to quickly familiarize the user with the front panel operations.

## 2.2 Installation

Installation procedures and considerations are covered in Sections 2.2.1 - 2.2.3.

### 2.2.1 AC Power Considerations

The LDC-3700 Series Controllers can be configured to operate at nominal line voltages of 100, 120, 220, or 240 VAC. Normally, this is done at the factory and need not be changed before operating the instrument. However, check to be sure that the voltage printed on the back panel of the instrument matches the power-line voltage in your area. Refer to Chapter 6 Maintenance if it is necessary to reconfigure the input voltage range.

**WARNING**

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

### 2.2.2 Tilt-Foot Adjustment

The LDC-3700 Series Laser Diode Controller has front legs that extend to make it easier to view the LED displays. To use them, place the unit on a stable base and rotate the legs downward until they lock into position.

### 2.2.3 Rack Mounting

The LDC-3700 Series Laser Diode Controller may be rack mounted by installing a rack mount flange on either side of the enclosure. All rack mount accessory kits contain detailed mounting instructions. Refer to Section 1.3 for applicable rack mount accessory part numbers.

## 2.3 Power-Up Sequence

With the LDC-3700 Series Laser Diode Controller connected to an AC power source, turning the key switch clockwise will supply power to the instrument and start the power-up sequence.

During the power-up sequence, the following takes place. For about three seconds all indicators light up, and all of the 7-segment displays indicate "8". Then all lamps are turned off for three seconds. After this, the TEC sensor switch position is shown in the TEC display for three seconds.

Then, a self-test is performed to ensure that the unit's hardware and software are communicating. If the unit cannot successfully complete this test, an error message of E-512 or E-513 will be displayed. See Appendix D for a list of error codes.

After this test, the unit is configured to the state it was in when the power was last shut off. The TEC and LASER switches in the ADJUST section are not engaged (illuminated) after power up. The user must push either switch to select the desired operating mode.

The user may choose to "clear" the parameters that appear by recalling "BIN 0" either manually or through the GPIB. When "BIN 0" is called, the front panel will be in the following state:

**3700 Series DEFAULT CONFIGURATION**

**GPIB mode in LOCAL via front panel, or in REMOTE via GPIB**
**Bar graph unlit**
**PARAMETERS not selected**
**TEC and LASER adjust not selected**
**TEC output off**
**TEC DISPLAY enabled, in T mode**
**Constant T mode selected**
**TEC Display showing actual temperature**
**Temperature Set Point = 0°C**
**Resistance/Reference Set Point = 1 ohm or uA or mV**
**(depending on the setting of the SENSOR SELECT switch)**
**$I_{TE}$ Set Point = 0**
**LIM $I_{TE}$ set to 4.0 Amps**
**LIM $T_{HI}$ set to 99.9°C**
**TEC STEP value = 1**
**TEC Tolerance values = 0.2°C, 5 seconds**
**GAIN = 30**
**C1 = 1.125 (x $10^{-3}$)**
**C2 = 2.347 (x $10^{-4}$)**
**C3 = 0.855 (x $10^{-7}$)**
**CAL PD = 0 uA/mW**
**LIM I (high range) = 3000 mA (3742B), 500 mA (3722B), 100 mA (3712)**
**LIM I (low range) = 1000 mA (3742B), 200 mA (3722B), 50 mA (3712)**
**LIM P = 5000 mW (3742B), 2000 mW (3722B), 200 mW (3712)**
**LASER output off**
**LASER DISPLAY enabled, in I mode**
**Constant I, low bandwidth mode selected**
**LASER display showing actual current**
**LASER STEP value = 1**
**LASER Tolerance values = 10.0 mA, 1.0 seconds (3742B), 1.00 mA, 1.0 seconds (3722B/3712)**
**LASER I Set Point = 0**
**LASER $I_{PD}$ Set Point = 0**
**LASER $P_{PD}$ Set Point = 0**
**RECALL BIN number = 0**

**Table 2.1 LDC-3700 Series Default Settings**

### 2.4 Introduction to the LDC-3700 Series Front Panel

The LDC-3700 Series Laser Diode Controller's front panel contains displays and controls for both the TEC and LASER controller hardware. Each of the labeled areas on the front panel (i.e. TEC DISPLAY or GPIB) is described in a separate section later in this chapter. Generally, the controls are simple to operate. The setup parameters, however, are intentionally awkward to use so that their values are not inadvertently changed.

> **Note: Section 2.4.1 gives a quick introduction to the front panel functions by briefly describing the switches and indicators.**

Sections 2.5 and 2.6 describe the GPIB and ADJUST areas, respectively. The functions in these areas are common to both TEC and LASER operation.

Sections 2.7 - 2.10 cover the TEC functional areas of the front panel, including TEC error indicators.

Sections 2.11 - 2.16 describe the LASER functional areas of the front panel, including LASER controller error indicators.

Section 2.17 describes the SAVE and RECALL functions for the front panel parameters.

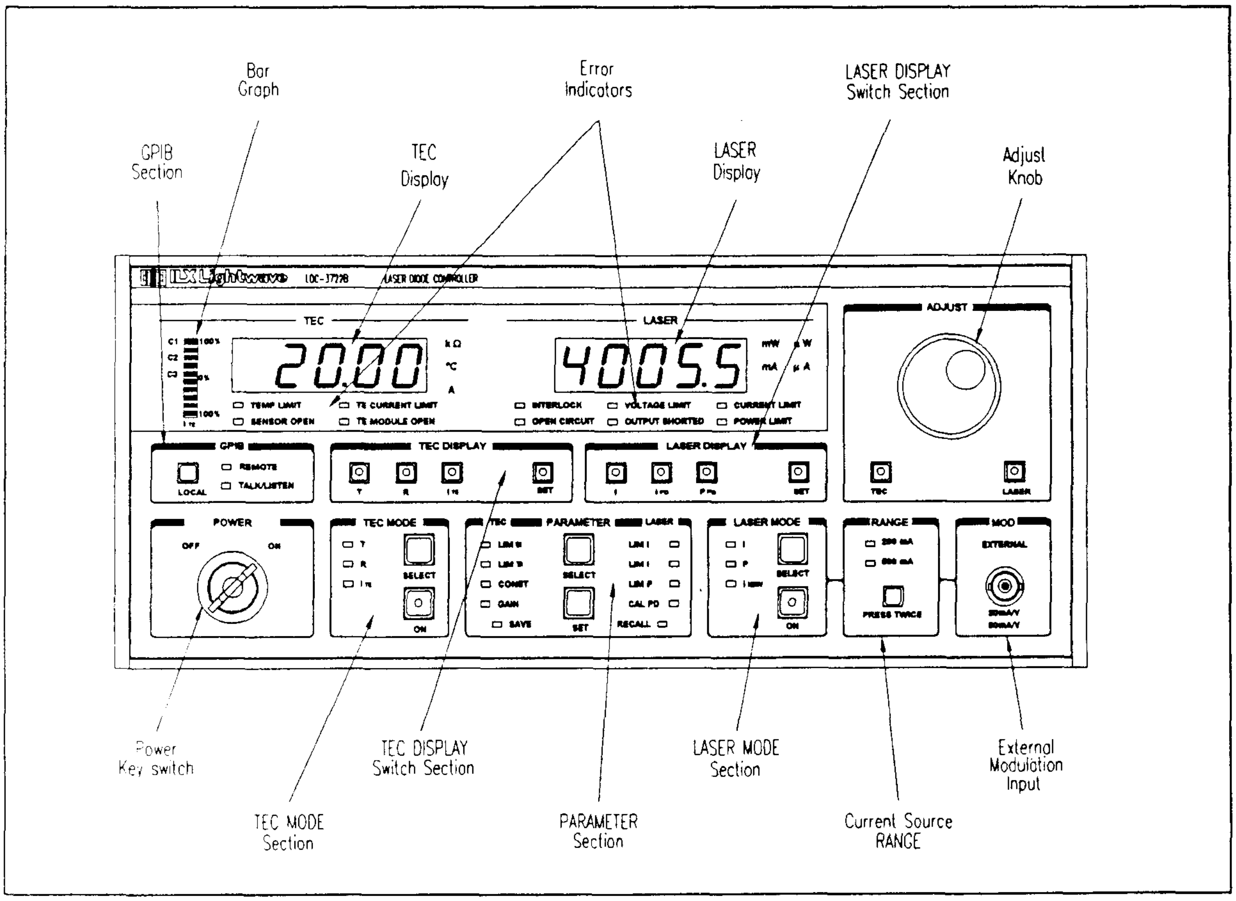



**Figure 2.1 LDC-3722B Front Panel**

### 2.4.1 Front Panel Familiarization

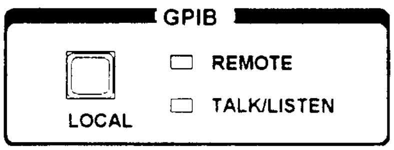
Notice in Figure 2.1 that the TEC functions are near center on the left side, and the LASER functions are near the center on the right side of the front panel. Although an LDC-3722B front panel is shown, Figure 2.1 may be used for front panel familiarization with the LDC-3742B and LDC-3712.

Functions which are common to both TEC and LASER, such as GPIB or ADJUST, are on the outer sides of the front panel. Note also that the PARAMETER area is divided into TEC and LASER components. The TEC parameters are on the left, and the LASER parameters are on the right, while the common SAVE and RECALL parameters are at the bottom.

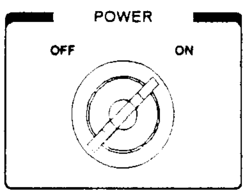
Refer to Figure 2.1 for the following discussions of the LDC-3700 Series Laser Diode Controllers front panel sections. The key words are in bold type for quick identification.

#### 2.4.1.1 General Functions

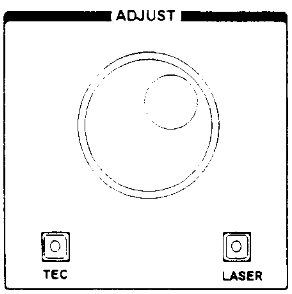
This section gives a brief synopsis of functions which effect both TEC and LASER controller operation.



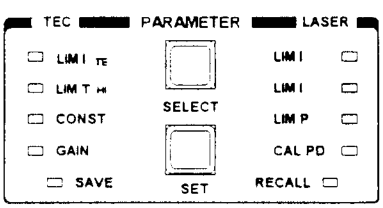

The **GPIB section** is used when the optional remote GPIB operations are implemented. (For more information, see Section 2.5).




The **POWER switch** is used to power-up the LDC-3700 Series Laser Diode Controller.




The ADJUST section contains the **ADJUST knob** for entering values, and it contains the (ADJUST) TEC and LASER switches for selecting the adjustment mode. (For more information, see Section 2.6).




The **PARAMETER section** is divided into TEC and LASER components. When the (ADJUST) TEC mode is selected, repeatedly pressing the (PARAMETER) SELECT switch will cycle through the TEC parameters. Likewise, when the (ADJUST) LASER mode is selected, repeatedly pressing the (PARAMETER) SELECT switch will cycle through the LASER parameters. The (PARAMETER) SET switch is used to enter the SET mode for changing parameter values. (For more information, see Sections 2.9 and 2.13).

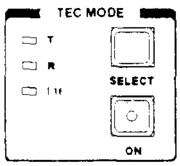
The **SAVE** and **RECALL** parameter functions are used to quickly configure the LDC-3700 Series Laser Diode Controller's parameters to user-determined preset values. In order to use these functions, both of the ADJUST modes (TEC and LASER) must be off, (ADJUST) TEC and (ADJUST) LASER indicators unlit.

With neither ADJUST mode selected, pressing the (PARAMETER) SELECT switch will cycle between the SAVE and RECALL parameter functions. The (PARAMETER) SET switch is used to enter SAVE and RECALL values in a similar manner as with the other parameters. (For more information, see Section 2.17).

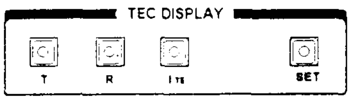
When the unit is powered-up, the parameters will automatically be restored to the same values that were present at the last power-down. Furthermore, all of the saved setups will be "remembered", and easily recalled.

### 2.4.1.2 TEC Functions

This section gives a brief synopsis of the TEC controller sections on the LDC-3700 Series Laser Diode Controller front panel.

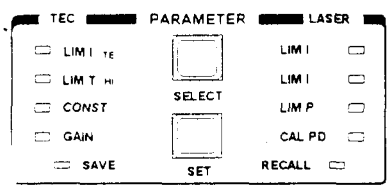



The **TEC MODE section** is used to turn the TEC output on/off and select the output control mode. Repeatedly pressing the (TEC MODE) SELECT switch cycles through the constant temperature (T), resistance/linear sensor reference (R), or TE current ($I_{TE}$) control modes. The LED indicators show the selected mode. (For more information, see Section 2.7).



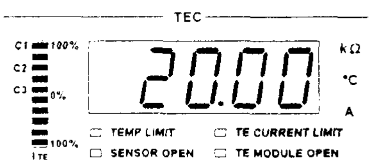

The **TEC DISPLAY switch section** is used to select the measured T, R, or $I_{TE}$ values or the set point value. The set point is determined by the TEC MODE selection. (For more information, see Section 2.8).

When the (ADJUST) TEC mode is selected, the TEC set point may be displayed and adjusted (automatically) by simply turning the ADJUST knob. (For more information, see Section 2.6.1).




The **TEC parameters** are TE current limit (LIM $I_{TE}$), high temperature limit (LIM $T_{HI}$), constants (CONST) for converting from sensor measurements to temperature, and control loop gain (GAIN). (For more information, see Section 2.9).

When the CONST parameter is selected, the constants C1, C2, and C3 are sequenced by pressing the (PARAMETER) SELECT switch, and the corresponding indicator on the bar graph will become lit.




The **TEC display** is used to show TEC control (measured and set point) and parameter values. It may also display errors which relate to TEC operation.

The **TEC error indicators** become lit when the corresponding TEC conditions occur. (For more information, see Section 2.10).

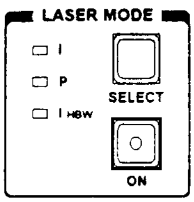
The **Bar graph** is used to display the TEC output as a percentage of TEC current limit (LIM $I_{TE}$) value. It is also used in conjunction with the (TEC) CONST parameter to indicate which constant is being displayed on the TEC display. (For more information, see Section 2.7).

**Conditions Which Will Automatically Shut Off the TEC OUTPUT**

1. High Temperature Limit
2. TEC Interlock Disabled (see Section 5.7.2)
3. Booster Changed (While Output On), (see Section 5.8)
4. Sensor Open (While Output On)
5. TEC Module Open (While Output On)
6. SENSOR SELECT Switch Moved (While Output On)
7. Sensor Shorted (While Output On)

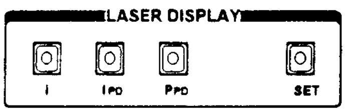
### 2.4.1.3 LASER Functions

This section gives a brief synopsis of the LASER controller sections on the LDC-3700 Series Laser Diode Controller front panel. For more detailed information, see sections 2.11 - 2.16.

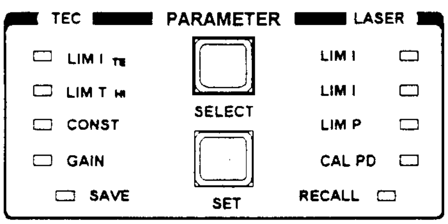



The **LASER MODE section** is used to turn the LASER output on/off and select the output control mode. Repeatedly pressing the (LASER MODE) SELECT switch cycles through the current (I), light power (P), or high bandwidth current ($I_{HBW}$) control modes. The LED indicators show the selected mode. (For more information, see Section 2.11)

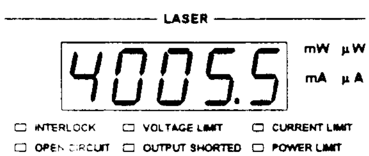
A constant $I_{PD}$ mode may be used when P mode is selected, and the CAL PD parameter value is set to zero.




The **LASER DISPLAY switch section** is used to select the measured I, $I_{PD}$, or $P_{PD}$ values or the set point value. The set point is determined by the LASER MODE selection. (For more information, see Section 2.12)

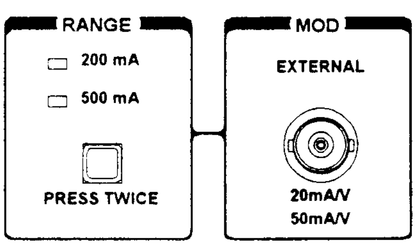



The **LASER parameters** are LASER current limit (LIM I) for low (blue) and high (black) output ranges, laser light power limit (LIM P), and monitor photodiode responsivity (CAL PD) for converting from monitor current to light power. (For more information, see Section 2.13)




The **LASER display** is used to show LASER control (measured and set point) and parameter values. It may also display errors which relate to LASER operation.

The LASER error indicators become lit when the corresponding LASER conditions occur. (For more information, see Section 2.14). The OUTPUT SHORTED light comes on whenever the LASER output is off.




The **RANGE section** is used to switch between the high and low laser current output ranges. Press twice within one second to change the range (output must be off). (For more information, see Section 2.15)

The **MOD section** is used to connect a modulation signal which is applied to the laser. (For more information, see Section 2.16)

**Conditions Which Will Automatically Shut Off the LASER OUTPUT**

1. LASER High Power Limit
2. LASER Interlock/Key Lock State Changed (see Section 5.7.1)
3. LASER Open Circuit (While Output On)
4. TEC High Temperature Limit Condition

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## 2.5 GPIB Section

The GPIB section is located just above the POWER section at the left side of the LDC-3700 Series Laser Diode Controller front panel (see Figure 2.1).

The GPIB section contains the LOCAL switch and the REMOTE and TALK/LISTEN indicators. The functions of the indicators and switch are related to GPIB operations, as described below.

The **LOCAL switch** is used for several functions. When the unit is in REMOTE mode, pressing the LOCAL switch returns the unit to LOCAL control mode unless the Local Lockout state has been activated by the host computer. (Local Lockout disables all LDC-3700 Series Laser Diode Controller front panel switches until this condition is changed by the host computer.) When the unit is in LOCAL mode, pressing the LOCAL switch causes the GPIB address to be displayed, e.g. "    1", and the GPIB address may be changed by turning the ADJUST knob while also pressing the (PARAMETER) SET switch. The usable GPIB address range is 0 - 30.

The **REMOTE indicator** is lit when the unit is in GPIB remote mode. When the unit is put in Local Lockout Mode by the host computer, the REMOTE indicator will flash at a 1 Hz rate to indicate that the front panel is completely disabled by Local Lockout.

The **TALK/LISTEN indicator** is illuminated when the unit is communicating over the GPIB bus. The indicator light is on for a minimum of 0.2 seconds.

## 2.6 ADJUST Section

The ADJUST section is located on the right side of the LDC-3700 Series Laser Diode Controller front panel. It consists of the ADJUST (main control) knob and the TEC and LASER mode enable switches.

The **ADJUST knob** is used to change the set points, enter parameter values, enter the GPIB address, or enter instrument calibration data.

The (ADJUST) TEC switch is used to enter or exit TEC mode. If the (ADJUST) TEC switch is pressed when the (ADJUST) TEC indicator LED is unlit, the unit enters TEC mode and the (ADJUST) TEC LED becomes lit.

The (ADJUST) LASER switch is used to enter or exit LASER mode. If the (ADJUST) LASER switch is pressed when the (ADJUST) LASER indicator LED is unlit, the unit enters LASER mode and the (ADJUST) LASER LED becomes lit.

Only one (or none) ADJUST mode, TEC or LASER, may be operating at any given time. In order to use the SAVE or RECALL functions, both the TEC and LASER ADJUST modes must be disengaged (both ADJUST indicators unlit).

### 2.6.1 Automatic Set Point Adjustment

If the ADJUST knob is turned during operation, while a measured TEC value is being displayed and the (ADJUST) TEC switch is selected, the TEC display will indicate the set point of the selected operating mode (T, R, or $I_{TE}$). This control mode set point display will continue for three seconds, and then the display will revert to its former state (a measured value).

For example, assume that (ADJUST) TEC mode is in effect and T is selected as the TEC MODE, but the (TEC DISPLAY) R switch is selected and the sensor (thermistor) resistance is displayed on the TEC display. If the ADJUST knob is turned, the TEC display will then show the temperature set point for 3 seconds. After 3 seconds the TEC display will revert to showing the measured R value.

Likewise, if the ADJUST knob is turned during operation, while a measured LASER value (I, $I_{PD}$, or $P_{PD}$) is being displayed and the (ADJUST) LASER switch is selected and the (LASER MODE) ON switch is off, the LASER display will indicate the set point of the selected operating mode ($I/I_{HBW}$ or P). This control mode set point display will continue for 3 seconds, and then the display will revert to its former state (a measured value).

For example, assume that (ADJUST) LASER mode is in effect, the (LASER MODE) ON switch is off, and I is selected as the LASER MODE, but $I_{PD}$ is selected in the LASER DISPLAY switch section and the photodiode current is displayed on the LASER display. If the ADJUST knob is turned, the LASER display will then show the LASER current set point for three seconds. After three seconds the LASER display will revert to showing the measured $I_{PD}$ value.

Note, in the LASER DISPLAY switch section, the $I_{PD}$ and $P_{PD}$ display modes both correspond to the P control mode, while the I display mode corresponds to either I or $I_{HBW}$ control modes of the LASER MODE section.

## 2.7 TEC MODE Section

The TEC MODE selection determines which parameter is used to control the output of the TEC controller. One of the following may be selected at one time: constant temperature (T), constant thermistor resistance/linear sensor reference (R), or constant TEC current ($I_{TE}$) mode.

The **(ADJUST) TEC indicator** must be lit before adjusting the parameters of the TEC MODE functions. Refer to Figure 2.2 for the discussion of the features in the TEC MODE section of the LDC-3700 Series Laser Diode Controller front panel.

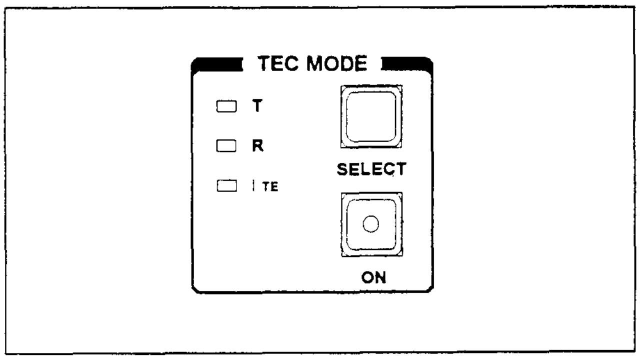



**Figure 2.2 LDC-3700 Series TEC MODE Section**

### 2.7.1 TEC MODE SELECT

The SELECT switch is used for selecting one of the three TEC modes available. The chosen mode will be indicated by the corresponding lit LED indicator.

If the SELECT switch is pressed repeatedly, the TEC modes are cycled through in the order T, R, $I_{TE}$, then back to T, and so on, with the appropriate TEC MODE indicator being lit.

### 2.7.2 TEC MODE Indicators

The **T indicator** becomes lit when the unit is in the temperature control mode. When the unit is in constant temperature mode, the TEC is controlled to the constant T set point value.

The **R indicator** becomes lit when the unit is in the sensor resistance/reference control mode. When the unit is in constant R mode, the TEC is controlled to the constant R set point value (in KΩ, for back panel SENSOR SELECT settings of 100 or 10 uA thermistor sensor currents; in mV, for the LM335; and in uA, for the AD590 setting).

The **$I_{TE}$ indicator** becomes lit when the unit is in the TEC drive current control mode. When the unit is in constant TEC current mode, the TEC is controlled to the constant $I_{TE}$ set point value.

### 2.7.3 TEC MODE ON

This ON switch is used for turning the TEC output on and off. The ON switch has a toggling action. Push it once to turn the TEC output on, and push it again to turn the TEC output off. The TEC output is off whenever the unit is first powered up, and the TEC output is toggled off whenever TEC control modes are switched.

The (TEC MODE) ON indicator becomes lit when the TEC output is on. The TEC output will drive to the set point value of the corresponding selected (indicator lit) TEC MODE, T, R, or $I_{TE}$.

When the TEC output is on, the bar graph display will indicate the level of $I_{TE}$ current, as a percentage of the $I_{TE}$ limit value. The TE CURRENT LIMIT indicator will become lit if the LIM $I_{TE}$ current limit is reached.

## 2.8 TEC DISPLAY Switch Section

The TEC DISPLAY switch section is used to select the TEC set point or measured T, R, or $I_{TE}$ values to appear on the TEC display.

Any of the TEC measured values may be selected by pressing the desired TEC DISPLAY section switch. When the selection is made to read a measured value by pressing its switch, the (TEC DISPLAY) SET indicator LED will go off (if previously on). In order to read the set point value on the TEC display again, the (TEC DISPLAY) SET switch must be pressed.

Refer to Figure 2.3 for the discussion of the TEC DISPLAY switch section features.

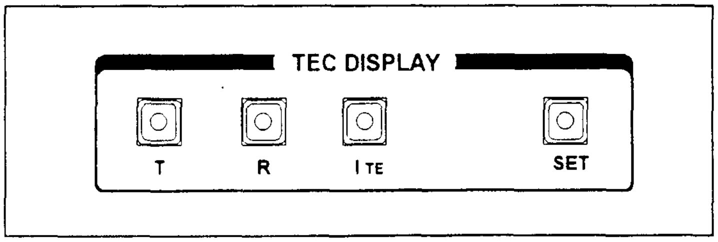



**Figure 2.3 LDC-3700 Series TEC DISPLAY Switch Section**

### 2.8.1 TEC DISPLAY SET

When the (TEC DISPLAY) SET switch is pressed, the (TEC DISPLAY) SET switch indicator and the (TEC DISPLAY) indicator of the set point mode (T, R, or $I_{TE}$) will become lit, if they are not already lit. The set point may then be changed by turning the ADJUST knob, within 3 seconds of releasing the (TEC DISPLAY) SET switch. The (TEC DISPLAY) SET switch may be held in while the ADJUST knob is being turned, but it is not necessary.

Three seconds after releasing the ADJUST knob, or the (TEC DISPLAY) SET switch (whichever occurs later), the new value will be stored in non-volatile memory, and the TEC display will revert to the original display mode (T, R, or $I_{TE}$) which was being displayed before the adjustment was made.

If the TEC DISPLAY is set to a mode that is different from the selected TEC MODE when the ADJUST knob is turned, the TEC DISPLAY will automatically switch to the same mode selected in the TEC MODE section (see Section 2.6.1).

The (TEC DISPLAY) SET mode is determined by the TEC MODE selection. If it is desired to change a set point for a mode other than the present TEC MODE selection, it is first necessary to select the desired TEC MODE (see Section 2.7.2).

### 2.8.2 TEC DISPLAY Indicators and Switches

The **T indicator** becomes lit when temperature is displayed. When the T switch is pressed, the display will show measured temperature in °C. If the SET switch is then pressed (and T mode is selected in the TEC MODE section), the display will show the temperature set point value in °C.

The **R indicator** becomes lit when the thermistor resistance or sensor reference is displayed. When the R switch is pressed, the display will show the measured thermistor resistance in KΩ, or the measured LM335 voltage in mV, or the measured AD590 current in uA, depending on the position of the back panel SENSOR SELECT switch. If the SET switch is then pressed (and R mode is selected in the TEC MODE section), the display will show the thermsitor resistance set point value in KΩ, or the LM335 set point voltage in mV, or the AD590 set point current in uA, depending on the position of the SENSOR SELECT switch.

The **$I_{TE}$ indicator** becomes lit when the TEC drive current is displayed. When the $I_{TE}$ switch is pressed, the display will show the measured TEC drive current in Amps. If the SET switch is then pressed (and $I_{TE}$ mode is selected), the TEC display will show the TEC drive current set point value, in Amps.

The (TEC DISPLAY) **SET indicator** becomes lit when the display is showing the set point for the selected (lit) TEC value. The SET indicator goes off when the display is showing a measured TEC value.

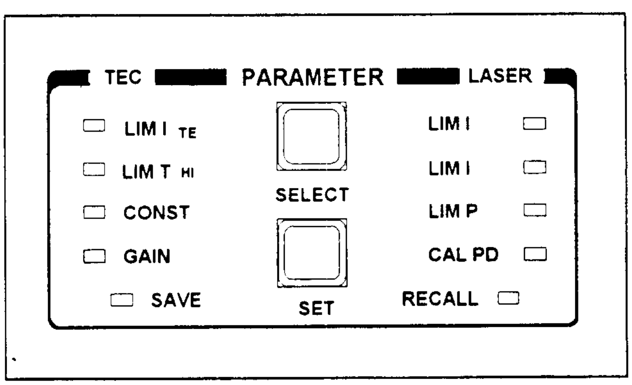



**Figure 2.4 LDC-3700 Series PARAMETER Section**

## 2.9 TEC PARAMETER Section

The (ADJUST) TEC mode indicator must be lit (TEC mode selected) before adjusting the TEC PARAMETER values.

The following sections describe the function and form of each of the parameters which may be adjusted from the unit's front panel. Refer to Figure 2.4.

### 2.9.1 TEC PARAMETER SELECT

The (PARAMETER) SELECT switch is used to enter SELECT mode. While the ADJUST TEC mode is engaged (indicator lit), press the (PARAMETER) SELECT switch to enter this mode.

When the SELECT mode is first entered, the LIM $I_{TE}$ indicator becomes lit, and the unit displays the current limit value, in Amps. All indicators in the TEC DISPLAY switch section are turned off. If the (PARAMETER) SELECT switch is released, this state continues for three seconds, after which the instrument reverts to its former state.

If the (PARAMETER) SELECT switch is pressed repeatedly, successive parameter values are displayed, with the appropriate parameter setup indicator LED being lit. The order of cycling through the parameter list is LIM $I_{TE}$, LIM $T_{HI}$, CONST (C1, C2, and C3), GAIN, then back to LIM $I_{TE}$, and so on. While the CONST parameters are selected, the corresponding CONST number (1, 2, or 3) is indicated on the bar graph display.

### 2.9.2 TEC PARAMETER SET

The (PARAMETER) SET switch is used to enter SET mode, where parameter values are stored into non-volatile memory.

If the (PARAMETER) SET switch is pressed while the unit is in SELECT mode, the unit will enter SET mode. While the (PARAMETER) SET switch is held in, the selected parameter value can be change by rotating the ADJUST knob. The new value is stored in non-volatile memory when the (PARAMETER) SET switch is released.

### 2.9.3 LIM $I_{TE}$

The LIM $I_{TE}$ function limits the TEC output current so that the unit does not provide more current than your device can safely handle. During operation, when the TEC current limit is reached, the TE CURRENT LIMIT error indicator will flash.

If the GPIB option is installed, the TE current limit condition may be used to shut the TEC output off via the TEC:ENABle:OUTOFF command.

To read the current limit, press the (PARAMETER) SELECT switch until the LIM $I_{TE}$ indicator is lit. If the LIM $I_{TE}$ value is to be changed, press and hold in the (PARAMETER) SET switch, turn the ADJUST knob until the desired value is displayed, then release the SET switch. When the SET switch is released, the new value will be stored in non-volatile memory. The TEC current limit is displayed in Amps.

When the TEC output is on, the bar graph display will indicate the level of $I_{TE}$ current, as a percentage of the LIM $I_{TE}$ value.

### 2.9.4 LIM $T_{HI}$

The LIM $T_{HI}$ function sets the maximum TEC output temperature, in °C. During operation, when this limit is reached, the TEMP LIMIT error indicator will flash. Normally, this limit will cause the TEC output to be shut off, unless this ability is disabled remotely via the TEC:ENABle:OUTOFF command.

To read the upper temperature limit, press the (PARAMETER) SELECT switch until the LED by LIM $T_{HI}$ is lit. The TEC display will show the value of the LIM $T_{HI}$ (in °C).

To change the upper temperature limit, sequence the parameters to the LIM $T_{HI}$ value. Press and hold in the (PARAMETER) SET switch, turn the ADJUST knob until the desired new value is on the TEC display, then release the (PARAMETER) SET switch. When the (PARAMETER) SET switch is released, the new value will be stored in non-volatile memory.

### 2.9.5 CONST

These are the constants of the Steinhart-Hart equation that the user enters to calibrate the TEC for different thermistors' temperature conversions. The Steinhart-Hart equation is used to derive temperature from the non-linear resistance of an NTC (Negative Temperature Coefficient) thermistor.

When a linear sensor device (such as an AD590 or LM335) is used, only C1 and C2 need to be entered, and a linear equation is used.

The range of values for C1, C2, and C3 are -9.999 to +9.999.

To read a C1, C2, or C3 constant, press the (PARAMETER) SELECT button until it sequences to CONST. The CONST indicator will become lit, and the appropriate LED on the $I_{TE}$ bar graph will be lit to indicate which constant is selected. To change the value, press and hold in the (PARAMETER) SET switch, and turn the ADJUST knob until the correct value is displayed. Release the (PARAMETER) SET switch to store the new value in non-volatile memory.

Appendix A contains an explanation of the Steinhart-Hart equation, the values of these constants for some common thermistors, and a computer program to determine these values for any thermistor.

Appendix C contains information on sensor calibration constants for AD590 and LM335 sensors. Since these devices are used over their linear range, the constants C1 and C2 are used in this case to determine a linear approximation of the temperature, rather than the Steinhart-Hart non-linear approximation which applies for thermistors. The appropriate algorithms are automatically implemented whenever the sensor type is selected via the back panel SENSOR SELECT switch. However, C1 and C2 must be changed by the user.

### 2.9.6 GAIN

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 (1 is lowest), the TE cooler will take longer to reach the temperature set-point. If it is set too high (300 is highest), the actual temperature may overshoot and may cycle around the set temperature.

The GAIN indicator becomes lit when the control loop gain level is displayed. The allowed GAIN values are: 1, 3, 10, 30, 100 and 300. These values actually define the proportional loop gain.

The gain setting depends on the type of TE cooler that you are using, but we can suggest guidelines for selecting the proper gain. Set the gain to 1 and increase it until the actual temperature oscillates around the set temperature. Then reduce the gain to the next lower value.

To read the gain setting, press the (PARAMETER) SELECT switch until the GAIN indicator is lit. The TEC display will show the value of the GAIN setting. To change the GAIN, sequence the parameters to the GAIN value. Press and hold in the (PARAMETER) SET switch, turn the ADJUST knob until the desired new value is on the TEC display, then release the (PARAMETER) SET switch. When the (PARAMETER) SET switch is released, the new value will be stored in non-volatile memory.

### 2.9.7 Bar Graph

When the TEC output is on, the bar graph display will indicate the level of $I_{TE}$ current, as a percentage of the LIM $I_{TE}$ value, for both positive and negative polarities.

When the CONST parameter is selected, the bar across from C1 or C2 or C3 becomes lit, as they are selected by pressing the (PARAMETER) SELECT switch.

## 2.10 TEC Error Indicators

The functions of the TEC error indicators are shown in Table 2.2. Refer to Figure 2.5 during the discussion of the TEC error indicators.

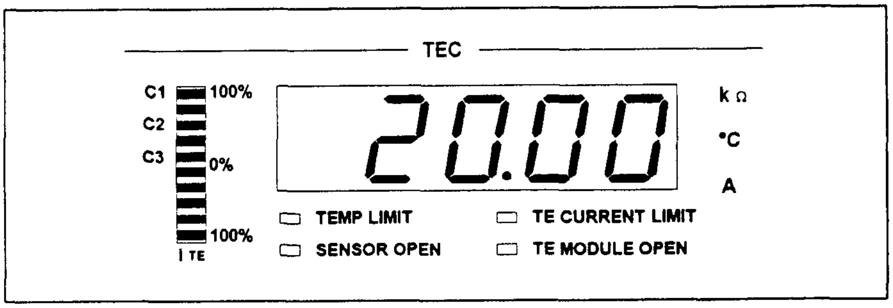



**Figure 2.5 LDC-3700 Series TEC Error Section**

**3700 Series TEC ERROR INDICATORS**

| Error Condition | Action |
|---|---|
| Temperature limit | TEMP LIMIT light flashes at 1 Hz |
| Open sensor | Output off, SENSOR OPEN indicator LED flashes at 1 Hz |
| TE Current limit | TE CURRENT LIMIT light flashes at 1 Hz |
| TE Module Open | TE MODULE OPEN indicator LED flashes at 1 Hz (not in effect when booster source is used) |
| TE Compliance Voltage Limit | TE CURRENT LIMIT light flashes at 2 Hz |

**Table 2.2 TEC Error Indicators**

## 2.11 LASER MODE Section

The (LASER MODE) SELECT switch determines which LASER mode is used to control the output of the LASER current source. One of the following may be selected at one time: constant current (I), constant optical (light) power (P), or constant current with a high bandwidth output ($I_{HBW}$) mode.

The (ADJUST) LASER indicator must be lit before changing the values of the LASER MODE functions. Refer to Figure 2.6 for the discussion of the LASER MODE section features.

Constant **I** mode is the normal mode for driving lasers. This mode uses a low-pass filter on the laser drive current output to significantly reduce noise. In this mode a modulation input of up to 10 kHz may be used, via the front panel MOD EXTERNAL connector.

Constant **P** mode is also a low bandwidth mode. It is used when it is desired to control the optical power of the laser via a monitor photodiode feedback arrangement.

When P mode is selected, the unit will be in either $I_{PD}$ or $P_{PD}$ modes, depending on the setting of the **CAL PD** (monitor photodiode responsivity) parameter. If the CAL PD value is non-zero, the unit will operate in constant $P_{PD}$, monitor photodiode power (light power) mode. (For more information on the CAL PD parameter, see Section 2.13.5).

However, the LDC-3700 Series Laser Diode Controller has a special mode for operating at a constant monitor photodiode current when the CAL PD parameter value is set to zero. This constant $I_{PD}$ mode is useful for driving a laser when the monitor photodiode's responsivity is not known, but a desired constant light output can be determined to produce a constant monitor photodiode current. The constant $I_{PD}$ mode is also used for monitor feedback calibration.

Constant $I_{HBW}$ is a high bandwidth constant current mode. This mode allows the laser drive current output to be modulated via the front panel MOD EXTERNAL connector. See Chapter 1 for bandwidth specifications.

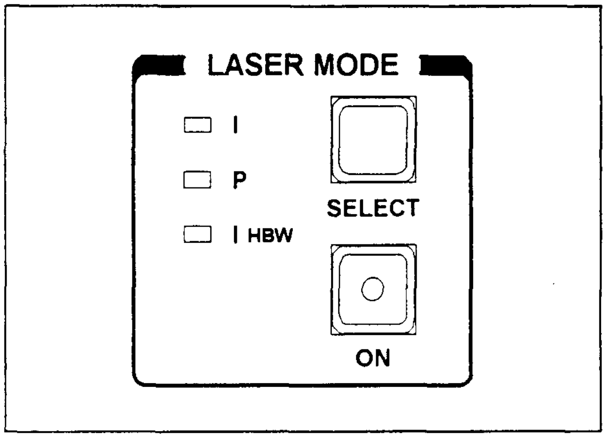



**Figure 2.6 LDC-3700 Series LASER MODE Section**

### 2.11.1 LASER MODE SELECT

The (LASER MODE) SELECT switch is used to select one of the three available LASER operating modes. When a mode is selected, the corresponding LED becomes lit.

If the (LASER MODE) SELECT switch is pressed repeatedly, the modes are cycled through in the order I, P, $I_{HBW}$, and back to I, and so on, with the appropriate mode indicator being lit.

### 2.11.2 LASER MODE Indicators

The I indicator becomes lit when the unit is in the constant current control mode. When constant I mode is selected, the LASER output is controlled to the constant I set point value.

The P indicator becomes lit when the unit is in constant optical power control mode. When constant P mode is selected, the LASER output is controlled to the constant $I_{PD}$ (monitor PD current) or $P_{PD}$ (monitor PD power, when the CAL PD value is non-zero) set point value.

The $I_{HBW}$ indicator becomes lit when the unit is in high bandwidth constant current control mode. When constant $I_{HBW}$ mode is selected, the LASER output is controlled to the constant I set point value.

### 2.11.3 LASER MODE ON

The (LASER MODE) ON switch is used to turn the LASER output on and off. When the LASER output is off, an internal short is placed across the LASER output. This condition is indicated by the OUTPUT SHORTED indicator becoming lit.

The (LASER MODE) ON switch has a toggling action. Push it once to turn the LASER output on, and push it again to turn the LASER output off. The output is off when the unit is powered up. The (LASER MODE) ON indicator becomes lit when the LASER current output is on. The LASER output will drive to the value set by the corresponding LASER MODE.

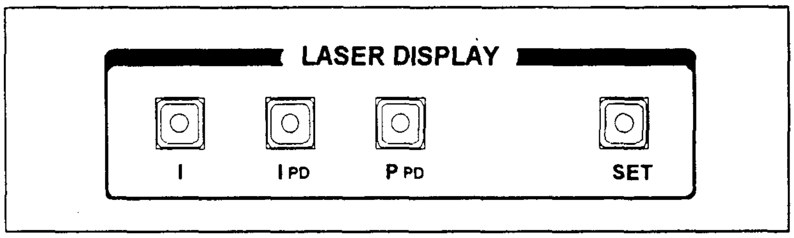



**Figure 2.7 LDC-3700 Series LASER DISPLAY Switch Section**

## 2.12 LASER DISPLAY Switch Section

The LASER DISPLAY switch section is used to select the LASER set point or measured I, $I_{PD}$, or $P_{PD}$ values to appear on the LASER display.

The corresponding LASER MODE must first be selected in order to read and/or adjust the set point value. For example, I or $I_{HBW}$ modes are first selected before reading the I set point display, and P mode must be selected before reading the $I_{PD}$ or $P_{PD}$ displays.

Any of the (LASER) measured values may be selected by pressing the desired LASER DISPLAY switch. When a measured value is selected by pressing the corresponding LASER DISPLAY switch, the (LASER DISPLAY) SET indicator LED will go off (if it was previously on). Refer to Figure 2.7 during the discussion of the LASER DISPLAY switch section features.

### 2.12.1 LASER DISPLAY SET

When the (LASER DISPLAY) SET switch is pressed, the (LASER DISPLAY) indicator for the corresponding mode will also become lit, if it is not already lit. The set point may then be changed by turning the ADJUST knob, within three seconds of releasing the (LASER DISPLAY) SET switch. The (LASER DISPLAY) SET switch may be held in while the ADJUST knob is turned, but it is not necessary.

After an adjustment has been made, and the (LASER DISPLAY) SET switch and ADJUST knob are released, the (LASER DISPLAY) SET mode will time out in three seconds, the new set point will be stored in non-volatile memory, and the LASER display will revert to the original display mode (I, $I_{PD}$, or $P_{PD}$) which was displayed before the set point adjustment was made.

If the LASER DISPLAY is set to a mode that is different from the selected LASER MODE when the ADJUST knob is turned, the LASER DISPLAY will automatically switch to the same mode selected in the LASER MODE section (see Section 2.6.1).

The (LASER DISPLAY) SET mode is determined by the LASER MODE selection. If it is desired to change a set point for a mode other than the present LASER MODE selection, it is first necessary to select the desired LASER MODE (see Section 2.11.2).

When (LASER MODE) P is selected, and the (LASER DISPLAY) SET switch is pressed, the (LASER DISPLAY) $I_{PD}$ or $P_{PD}$ indicator will become lit. If the CAL PD value is zero, the $I_{PD}$ set point will be displayed, since the unit is in constant photodiode current mode. If the CAL PD value is non-zero, the $P_{PD}$ set point will be displayed, since the unit is in constant photodiode power mode.

### 2.12.2 LASER DISPLAY Indicators and Switches

The **I** indicator becomes lit when laser drive current is displayed. When the I switch is pressed, the display will show measured laser current in mA. If the (LASER DISPLAY) SET switch is then pressed (and I mode is selected in the LASER MODE section), the display will show the laser current set point value in mA.

The $\mathbf{I_{PD}}$ indicator becomes lit when monitor photodiode current is displayed. When the $I_{PD}$ switch is pressed, the LASER display will show measured PD monitor current in uA. If the (LASER DISPLAY) SET switch is then pressed (and P mode is selected in the LASER MODE section, and the CAL PD value is zero), the display will show the monitor PD current set point value, in uA.

The $\mathbf{P_{PD}}$ indicator becomes lit when the user-programmed optical power is displayed. When the $P_{PD}$ switch is pressed, the LASER display will show measured optical power in mW, as it relates to the monitor photodiode current (see Section 2.13.5). If the (LASER DISPLAY) SET switch is then pressed (and I or $I_{HBW}$ mode is selected in the LASER MODE section and the CAL PD value is non-zero), the display will show the optical power set point value, in mW.

If the CAL PD parameter value is zero, and the P mode is selected in the LASER MODE section, the unit will operate in constant $I_{PD}$ mode, and the $P_{PD}$ display will indicate "-.-" when the $P_{PD}$ display is selected.

The (LASER DISPLAY) **SET indicator** becomes lit when the display is showing the SET (set point) value. The (LASER DISPLAY) SET indicator goes off when the display is showing a measured value.

## 2.13 LASER PARAMETER Section

The LASER switch (in the ADJUST section) must be engaged (indicator lit) to adjust the LASER PARAMETER values.

The following sections describe the function and form of the LASER PARAMETER Selections. Refer to Figure 2.8 for the discussion of the LASER PARAMETER features.

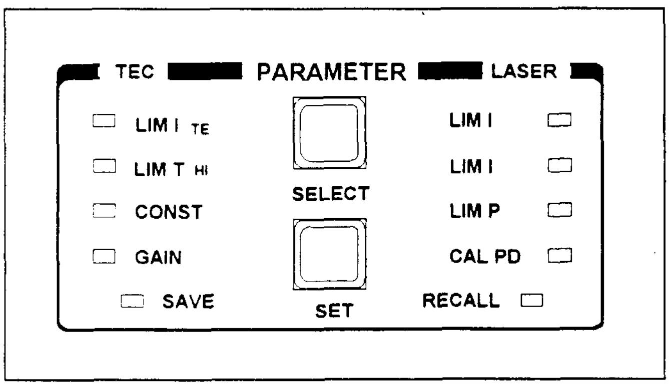



**Figure 2.8 LDC-3700 Series LASER PARAMETER Section**

### 2.13.1 LASER PARAMETER SELECT

The (PARAMETER) SELECT switch is used to enter this SELECT mode. While the (ADJUST) LASER indicator is lit (LASER mode selected), press the (PARAMETER) SELECT switch to enter this mode.

When the (LASER PARAMETER) SELECT mode is first entered, the LIM I indicator becomes lit, and the unit displays the current limit value, in mA. All LED indicators in the LASER DISPLAY switch section are turned off. If the (PARAMETER) SELECT switch is released, this state continues for three seconds, after which the unit reverts to its former state.

If the (PARAMETER) SELECT switch is pressed repeatedly, successive (LASER) parameter values are displayed, and the appropriate (LASER) parameter indicator LED becomes lit. The order of cycling through the (LASER) parameter list is LIM I (blue - low range), LIM I (black - high range), LIM P, CAL PD, then back to LIM I, and so on.

### 2.13.2 LASER PARAMETER SET

The (PARAMETER) SET switch is used to enter SET mode, where parameter values are stored into non-volatile memory.

If the (PARAMETER) SET switch is pressed while the unit is in SELECT mode, the unit will enter SET mode. While the (PARAMETER) SET switch is held in, the selected parameter value can be change by rotating the ADJUST knob. The new value is stored in non-volatile memory when the (PARAMETER) SET switch is released.

### 2.13.3 LIM I

The LIM I parameter is used to set the absolute upper limit for LASER output current. During operation, when the LASER current limit is reached, the CURRENT LIMIT error indicator flashes.

If the optional GPIB is implemented, the LASER current limit condition may be used to turn the LASER output off via the LASer:ENABle:OUTOFF command.

The (blue) LIM I indicator becomes lit when the low range laser current limit is displayed. The (black) LIM I indicator becomes lit when the high range laser current limit is displayed

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

### 2.13.4 LIM P

The LIM P is the absolute limit of optical power, as detected by the unit via the monitor PD feedback scheme. In order for this limit to be meaningful, the monitor photodiode responsivity (CAL PD) must be adjusted correctly. See Section 2.13.5.

This limit is a software limit only. The LASER output is normally turned off if this limit is reached (unless this condition to turn the LASER output off is disabled via the remote LASer:ENABle:OUTOFF command). The maximum LIM P value is 200.0 mW (LDC-3712), 1000.0 mW (LDC-3722B), and 5000 mW (LDC-3742B).

During operation, when the LASER power limit is reached, the POWER LIMIT error indicator flashes.

### 2.13.5 CAL PD

The CAL PD indicator becomes lit when the monitor photodiode responsivity parameter is displayed. The responsivity is displayed in uA/mW. The responsivity is entered by the user (in uA/mW) after performing the following measurements:

1. Measure (with a calibrated detector) the output power of the device.
2. Measure the corresponding photodiode current.
3. Calculate the responsivity by dividing the optical power into the corresponding photodiode current.

This value is normally used to convert between optical power and optical current of the monitor photodiode. This parameter is used to convert between $I_{PD}$ and $P_{PD}$ values. However, when the CAL PD value is set to zero, the unit may be operated in constant $I_{PD}$ mode.

When the CAL PD value is zero, the LASER output will be controlled to the $I_{PD}$ set point value, and the $P_{PD}$ display will indicate "-.-" when it is selected.

## 2.14 LASER Error Indicators

The functions of the LDC-3700 Series Laser Diode Controller's LASER error indicators are shown in Table 2.3. Refer to Figure 2.9 during the discussion of the LASER error indicators.

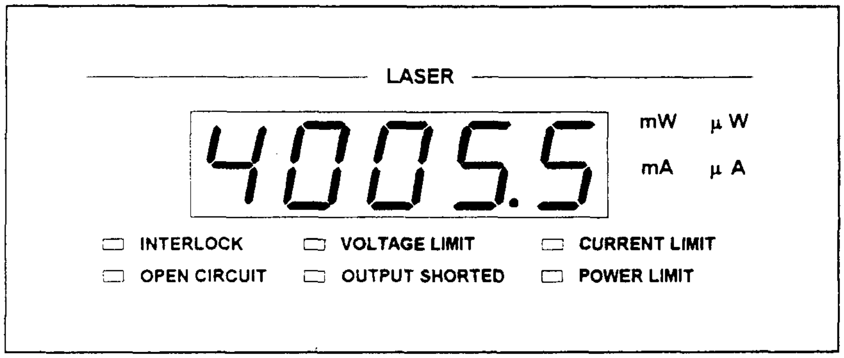



**Figure 2.9 LASER Error Indicators**

**LASER Error Indicators**

| Error Condition | Action |
|---|---|
| Interlock | Output off, INTERLOCK light flashes at 1 Hz |
| Open circuit | Output off, OPEN CIRCUIT light flashes at 1 Hz. If this condition was caused by an excessively high compliance voltage, the VOLTAGE LIMIT light will also be turned on. |
| Output shorted | OUTPUT SHORTED light comes on. This indicator becomes lit whenever the LASER output is off. |
| Current limit | CURRENT LIMIT light flashes at 1 Hz |
| Voltage limit | VOLTAGE LIMIT light flashes at 1 Hz |
| Optical Output Power Limit | Output off, POWER LIMIT light flashes at 1 Hz |

**Table 2.3 LASER Error Indicators**

## 2.15 RANGE Section

The PRESS TWICE switch is pressed to switch from the Low to High Laser Drive Current range, and vice versa. It must be pressed twice quickly (within less than 1 second) to switch between modes, and the LASER output must be off (LASER MODE ON indicator unlit) in order to change ranges. See Figure 2.10.

If the LASER output is on when the (RANGE) PRESS TWICE switch is pressed, the LDC-3700 Series Laser Diode Controller will beep to indicate that the range cannot be changed while the LASER output is on.

## 2.16 MOD Section

The (MOD) EXTERNAL connector (BNC) allows a modulation signal to be applied to the laser. The bandwidth depends on the selected current range and bandwidth mode (see specifications, Chapter 1). Bandwidth specifications are measured across a 1 Ω load. The modulation port input impedance is 10 kΩ. The transfer function (mA/V) in Figure 2.10 is shown for the LDC-3722B. This transfer function varies by model and Laser Drive Current Output range. The transfer function for the low and high current ranges of the LDC-3712 and LDC-3742B are 5 mA/V and 10 mA/V, and 100 mA/V and 300 mA/V, respectively.

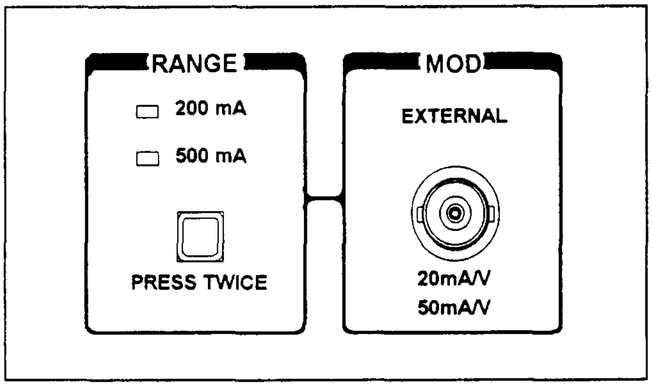



**Figure 2.10 LDC-3700 Series MOD Sections**

## 2.17 SAVE and RECALL Parameter Functions

The SAVE and RECALL parameter functions are used to store and retrieve the LDC-3700 Series Laser Diode Controller's parameter configurations for future use. For example, a specific test setup may be saved for later use via the SAVE function, and then another setup may be used presently. Then, when the user desires to perform the specific test again, its setup is simply recalled via the RECALL function. This saves setup time, and it reduces the chance of setup error for tests which are repeated periodically.

Refer to Figure 2.8 for the discussion of the SAVE and RECALL parameters.

Non-volatile memory is used for saving the instrument parameters. When a save operation is performed, all of the parameters which are currently in effect on the unit are stored. The user selects a "bin" number (1 - 10) for saving the parameters. Then, when that "bin" number is recalled, the unit is restarted and the parameters are reconfigured to the previously stored values.

To enter the SAVE/RECALL mode, first exit both TEC and LASER modes. If either TEC or LASER mode is engaged, the corresponding LED indicator will be lit in the ADJUST section of the front panel. To exit, press the switch of the indicated (lit) mode, so that both indicators are off. Then press the SELECT switch in the PARAMETERS section of the front panel.

When the **SELECT switch** is pressed in SAVE/RECALL mode, the unit enters the SELECT mode. Then, the SAVE indicator LED becomes lit and the unit displays the SAVE "bin" number. If the SELECT switch is pressed again, the RECALL indicator LED becomes lit, and the unit displays the RECALL "bin" number. If the SELECT switch is released, the SELECT mode state continues for three seconds, after which the instrument reverts to its former state.

The **SAVE indicator** becomes lit when the unit is displaying a save bin number. The "bin" number is displayed as a number in the range 1 - 10. "Bin" 0 holds the reset (default) parameters.

The **RECALL indicator** becomes lit when the unit is displaying a recall "bin" number. The "bin" number is displayed as a number in the range 0 - 10. "Bin" 0 is reserved for the reset (default) parameters.

If the (PARAMETER) SET switch is pressed while the unit is in this SELECT mode, then the unit will enter SET mode. While the (PARAMETER) SET switch is pressed, the selected "bin" number can be changed by rotating the ADJUST knob. The new value is accepted when (PARAMETER) SET switch is released.

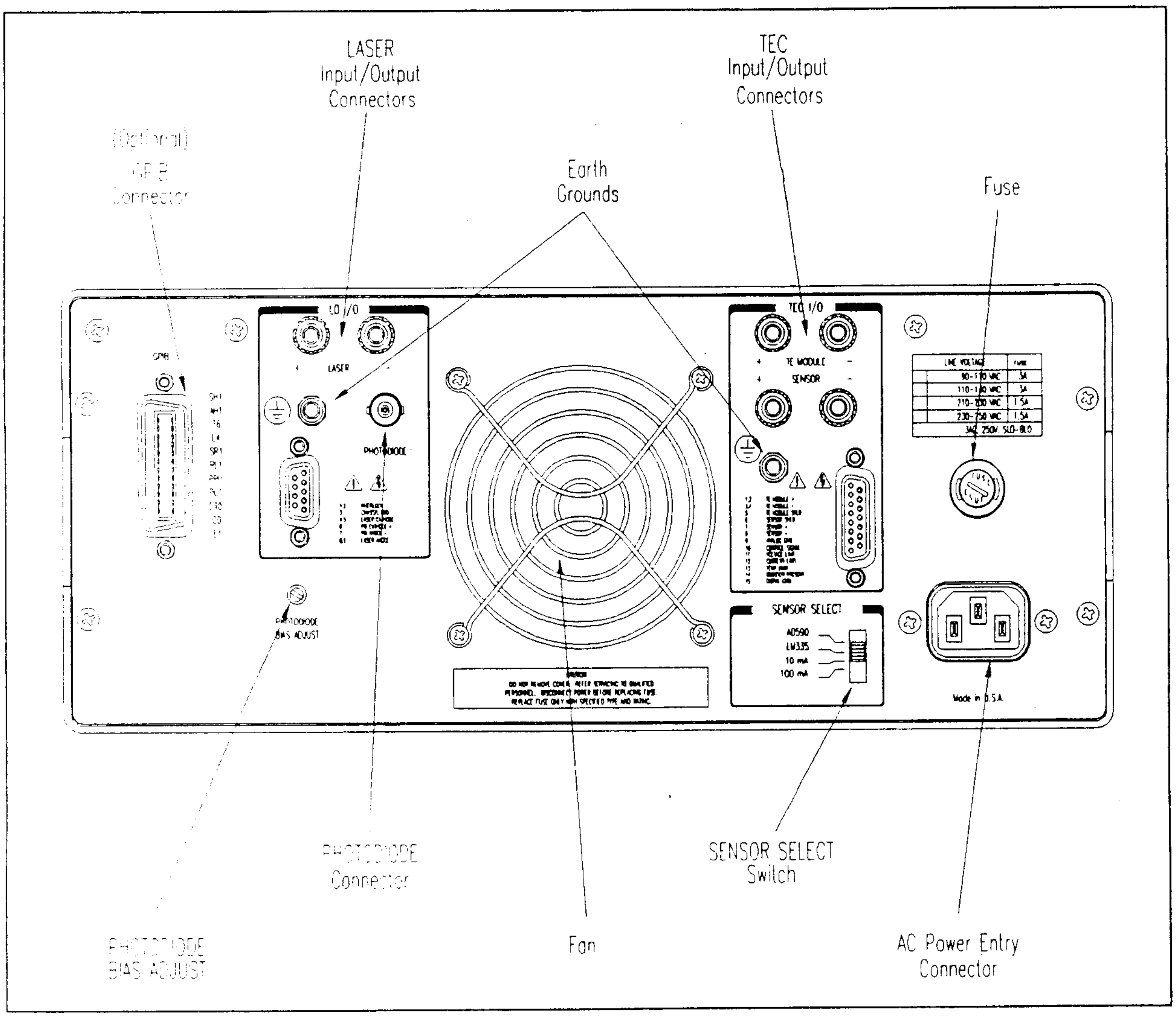



**Figure 2.11 LDC-3700 Series Back Panel**

## 2.18 Back Panel Controls and Connections

Refer to Figure 2.11 for the following discussions of back panel controls and connectors.

### 2.18.1 SENSOR SELECT Switch

The SENSOR SELECT switch is used to select sensor type and, in the case of thermistor sensor, the source current level. Table 2.4 shows the SENSOR SELECT positions and corresponding position code. When the sensor switch is changed during TEC mode operation, the new sensor position code will be indicated on the TEC display for three seconds.

**SENSOR SELECT POSITION CODES**

| SWITCH POSITION | CODE |
|---|---|
| 100 uA | --01 |
| 10 uA | --02 |
| LM335 | --03 |
| AD590 | --04 |

**Table 2.4 SENSOR SELECT Switch Positions**

The 10 uA and 100 uA designations are for the current source level; thermistor sensor type is implied. When using a thermistor, the supply current depends on the thermistor operating temperature range and the required temperature resolution. Guidelines for setting this switch are contained in Appendix B.

The AD590 sensor operates as a current source which is proportional to the sensed temperature. The LM335 sensor operates as a voltage source which is proportional to the sensed temperature. Both of these sensors are approximately linear over their operating ranges. When they are used, the constants C1 and C2 are used for a two-point conversion. For more information on setting the constants for use with these sensors, see Section 2.9.5 and Appendix C.

### 2.18.2 TEC Connector

At the right of center, when facing the back panel, you will find the 15-pin D-connector for the TEC MODULE. This connector is used for the input and output connections, as shown by the pin-out diagram of Figure 2.12.

| | |
|---|---|
| 1, 2 | TE Module (+) |
| 3, 4 | TE Module (-) |
| 5 | TE Module Shield |
| 6 | Sensor Shield |
| 7 | Sensor (+) |
| 8 | Sensor (-) |
| 9 | Analog Ground |
| 10 | Control Signal |
| 11 | Voltage Limit |
| 12 | Current Limit |
| 13 | Temp. Limit |
| 14 | Booster Present |
| 15 | Digital Ground |

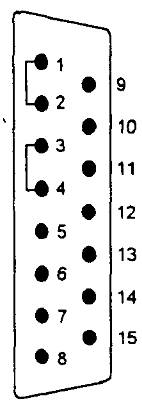



**Figure 2.12 Back Panel TEC Connector**

### 2.18.3 TEC Grounding Considerations

The TEC outputs of the LDC-3700 Series Laser Diode Controller are isolated from chassis ground, allowing either output terminal to be grounded at the user's option. The thermistor's (-) terminal and the TEC module's (-) terminals are internally connected.

### 2.18.4 The LASER Connectors

At the left of center, when facing the back panel, you will find a 9-pin D-connector for the LD connections. The pinout diagram for this connector is shown in Figure 2.13.

| | |
|---|---|
| 1, 2 | Interlock |
| 3 | Chassis Ground |
| 4, 5 | Laser Cathode |
| 6 | PD Cathode (+) |
| 7 | PD Anode (-) |
| 8, 9 | Laser Anode |

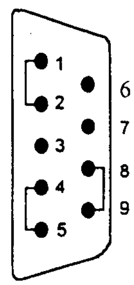



**Figure 2.13 Back Panel LD Connector**

### 2.18.5 Connecting to Your Laser

When connecting laser diodes and other sensitive devices to the LDC-3700 Series Laser Diode Controller, we recommend that the unit be powered up and the LASER output be off (LASER MODE ON LED unlit). 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.

### 2.18.6 Laser Diode Connections and Shielding

**IMPORTANT**

**Before connecting the laser diode to the LDC-3700 Series Laser Diode Controller, be sure that the front panel (LASER MODE) ON switch is in the OFF position (ON LED unlit). Before turning on the LASER output, be sure that the current limit has been correctly set.**

**The interlock pins (1 and 2) on the LASER connector must be shorted in order to turn on the LASER output current.**

Figures 2.14 A - D show the possible configurations of connecting laser diodes and photodiodes with the LDC-3700 Series Laser Diode Controllers.

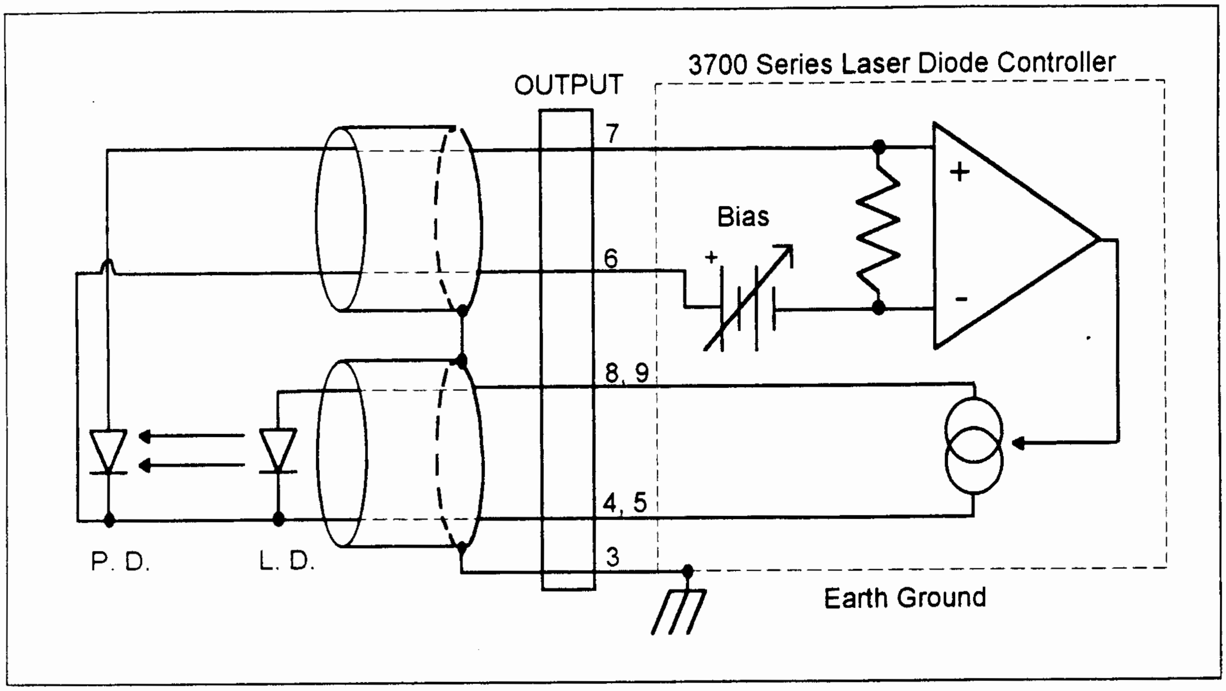



**Figure 2.14A Common Laser Cathode - Photodiode Cathode**

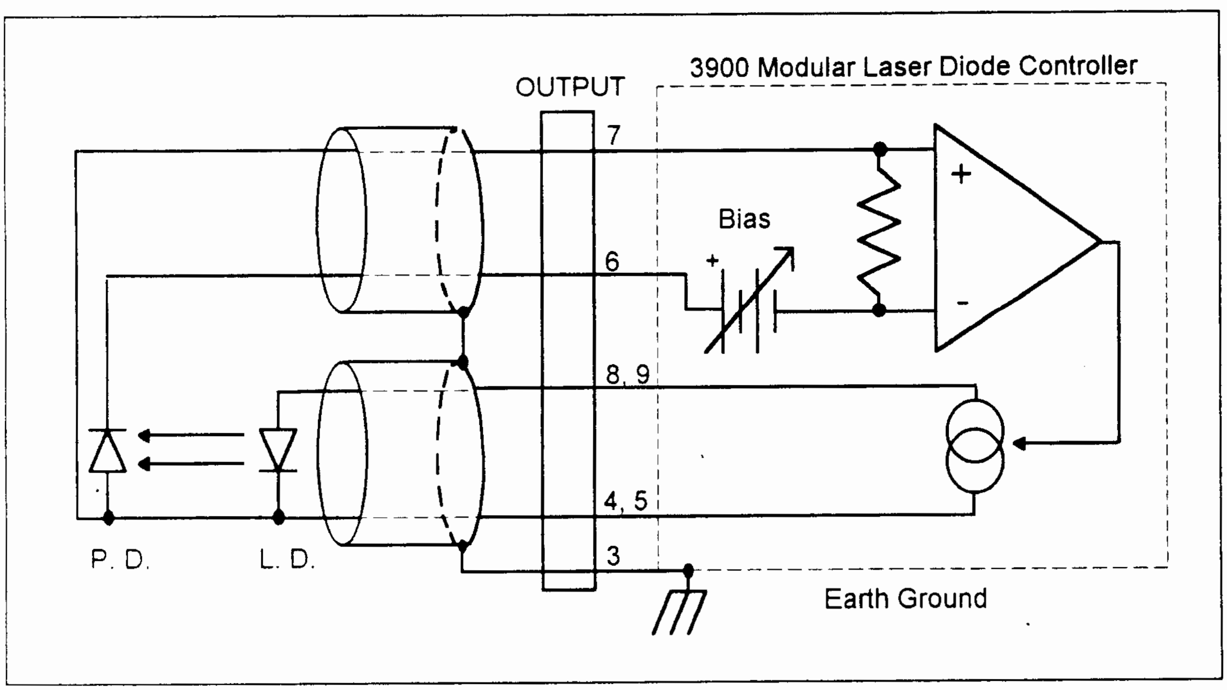



**Figure 2.14B Common Laser Cathode - Photodiode Anode**

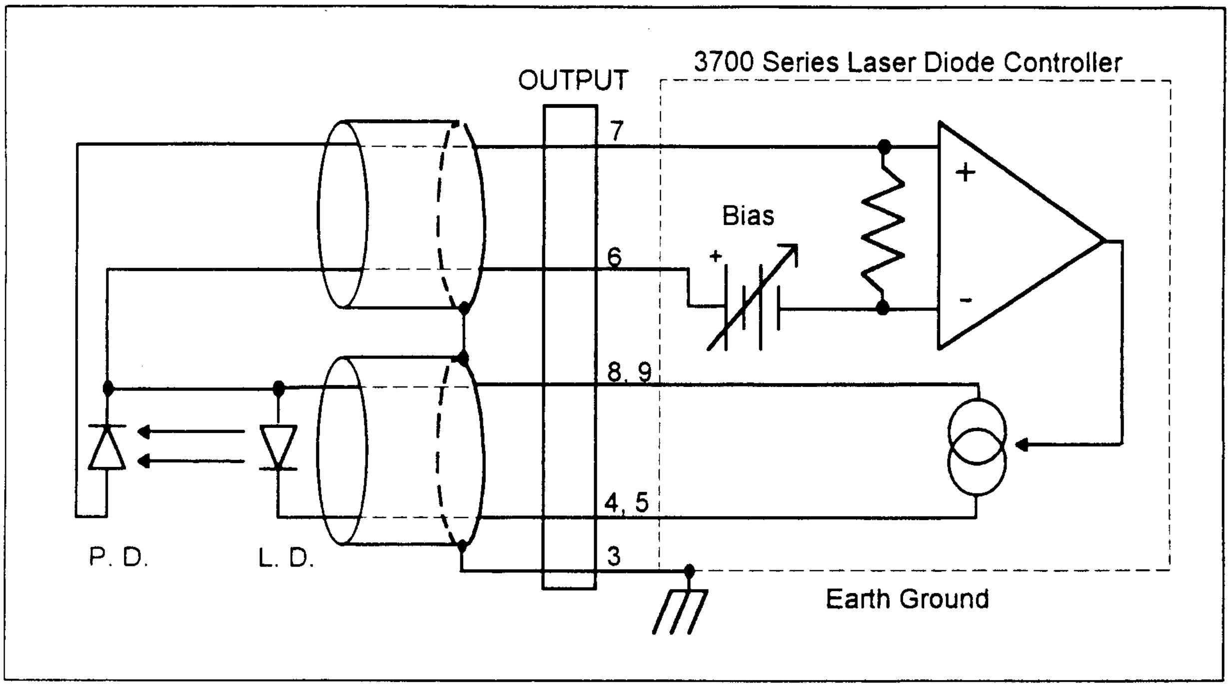



**Figure 2.14C Common Laser Anode - Photodiode Cathode**

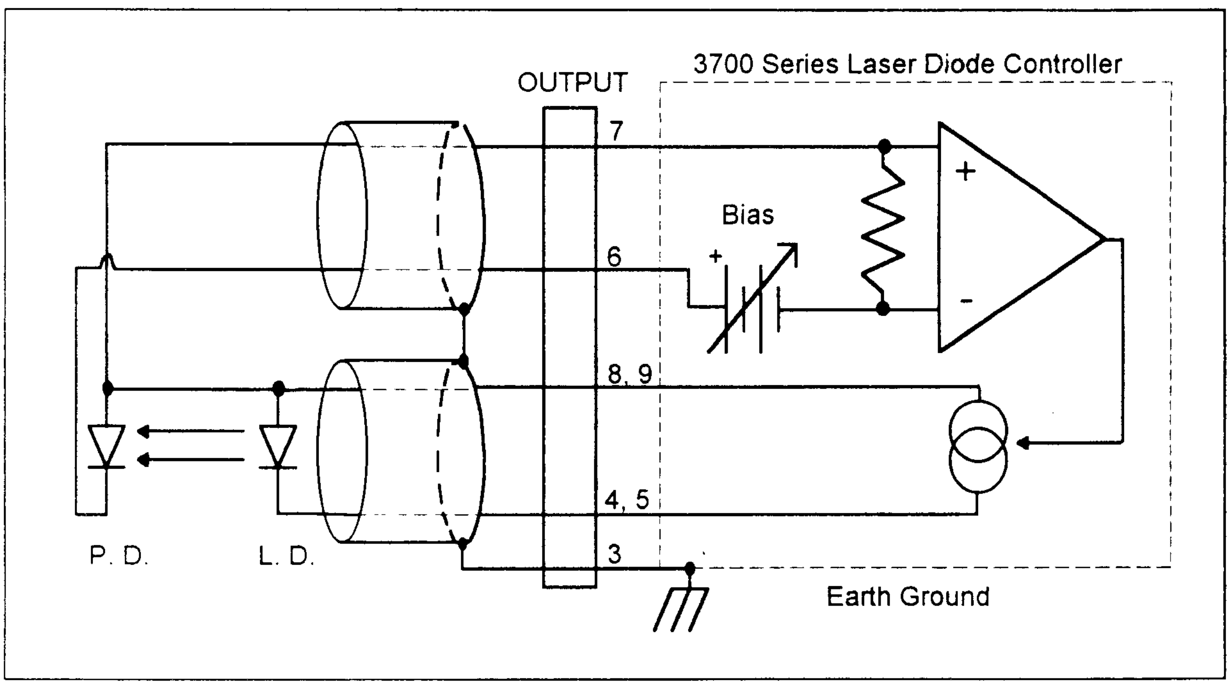



**Figure 2.14D Common Laser Anode - Photodiode Anode**

**IMPORTANT**

**The cable connections to the laser must be secure enough that they won't open-circuit, should they be jostled or bumped. Should an open circuit occur during laser operation, the LASER output will be turned off (ON LED unlit) automatically.**

**Experience indicates that should an open circuit occur during laser operation (while the LASER is ON), the laser may be damaged by a momentary circuit break-and-remake before the final circuit break. Therefore, although the LDC-3700 Series Laser Diode Controller provides a proprietary debounce protection circuit for the LASER output, secure cabling is important.**

It is recommended that the connections to the LDC-3700 Series Laser Diode Controller output be made using twisted wire pairs with an earth-grounded shield (see Figures 2.14 A - D). The output terminals of the unit 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.

### 2.18.7 Photodiode Feedback Connections

The main LD I/O connector on the back panel contains the current supply output. The photodiode signal is input at the connector at pins 6 and 7 (see Figure 2.13). The LDC-3700 Series Laser Diode Controller provides an adjustable reverse bias of 0 - 5 V for the photodiode. To set the photodiode bias to 5 volts reverse bias, turn the back panel PHOTODIODE BIAS ADJUST fully clockwise. To set the photodiode bias to 0 volts reverse bias, turn the back panel PHOTODIODE BIAS ADJUST fully counter-clockwise.

The photodiode feedback may also be connected via the PHOTODIODE (BNC) connector, located above the main 9-pin LD I/O connector.

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. Figures 2.14A - 2.14D show the recommended connections and shielding for the various configurations of laser diode modules and photodiode feedback schemes.

The photodiode and laser inputs of the LDC-3700 Series Laser Diode Controller 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 4.2A - 4.2D 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 4.2, but the common connection (between the photodiode and the laser) is optional.

### 2.18.8 Grounding Considerations

The LASER outputs of the LDC-3700 Series Laser Diode Controller are isolated from chassis ground allowing either output terminal to be grounded at the user's option. Figure 2.14 shows the proper earth-ground shielding for laser diode/photodiode connections.

### 2.18.9 GPIB Connector

When the optional Model 1231 GPIB is installed, its connector is located on the back panel, directly behind the ADJUST section of the front panel.

## 2.19 General Operating Procedures

The following sections present some guidelines for operation, as well as some common operating procedures. Remote operations are discussed in Chapter 4.

### 2.19.1 Warm-Up and Environmental Considerations

Operate the LDC-3700 Series Laser Diode Controller at an ambient temperature in the range of 0 to +40 °C. Storage temperatures should be in the range of -40 to +70 °C. To achieve rated accuracy, let the LDC-3700 Series Laser Diode Controller warm up for about 1 hour before use.

### 2.19.2 TEC Mode Operation

You can operate the TEC controller portion of the LDC-3700 Series Laser Diode Controller in several modes, constant T, constant R, or constant $I_{TE}$. This example is for constant T mode, the most commonly used mode. However, the other operating modes follow similar procedures.

a. Plug the LDC-3700 Series Laser Diode Controller into an AC power source supplying the correct voltage and frequency for your unit (refer to the back panel for the correct ratings).

b. Turn on the LDC-3700 Series Laser Diode Controller. The TEC OUTPUT stage will be off at power-up and the unit will automatically configure its parameters to the state which existed when the power was last shut off.

c. Check the setting of the SENSOR SELECT switch for the desired operation. The sensor code will be displayed for three seconds during the power-up sequence (see Section 2.3).

d. Press the TEC switch in the ADJUST section of the front panel to enter TEC mode. Press the SELECT switch in the TEC MODE section until the T mode is selected.

e. Press the SELECT switch (in the PARAMETER section) and check the setting of LIM $I_{TE}$, LIM $T_{HI}$, GAIN, and C1, C2, and C3 to insure that they are compatible with the equipment you are using. Refer to Section 2.9 if you need to change them.

   If a pre-configured setup is to be recalled, use the RECALL feature (see Section 2.17) and then recheck the parameter settings for confirmation.

f. Press the T switch and SET switch (in the TEC DISPLAY switch section) and check the set point temperature. If it requires changing, turn the knob until the desired value is displayed.

g. Turn the TEC output on by pressing the ON switch (in the TEC MODE section). The unit will automatically control the temperature to the set point.

h. When the unit is powered off, the state of the unit at power-down is saved in non-volatile memory.

### 2.19.3 LASER Mode Operation

You can operate the LASER current source portion of the LDC-3700 Series Laser Diode Controller in several modes, constant I, constant P, or constant I, high bandwidth. This example is for constant I mode, the most commonly used mode. However, the other operating modes follow similar procedures.

a. Plug the LDC-3700 Series Laser Diode Controller into an AC power source supplying the correct voltage and frequency for your unit (refer to the back panel for the correct ratings).

b. Turn on the LDC-3700 Series Laser Diode Controller. The LASER OUTPUT stage will be off at power-up and the unit will automatically configure its parameters to the state which existed when the power was last shut off.

c. Press the LASER switch in the ADJUST section of the front panel to enter LASER mode. Press the SELECT switch in the LASER MODE section until the I mode is selected.

d. Press the SELECT switch (in the PARAMETER section) and check the setting of LIM I to insure that it is compatible with the laser you are using. Refer to Section 2.13 if you need to change the current limit. If a pre-configured setup is to be recalled, use the RECALL feature (see Section 2.17) and then recheck the parameter settings for confirmation.

e. Press the I switch and SET switch (in the LASER DISPLAY switch section) and check the set point (operating) current. If it requires changing, turn the knob until the desired value is displayed.

f. Turn the LASER output on by pressing the ON switch (in the LASER MODE section). The unit will automatically drive the laser to the set point current.

g. When the unit is powered off, the state of the unit at power-down is saved in non-volatile memory.

### 2.19.4 Simultaneous TEC and LASER Mode Operation

Follow the steps outlined in Sections 2.19.2 and 2.19.3 for each of the operating modes. When both TEC and LASER modes are in operation, the following should also be considered.

a. When alternating adjustments of the LASER and TEC operations, the corresponding switch in the ADJUST section of the front panel must be pressed.

b. The SAVE and RECALL parameter functions save the LASER and TEC parameters simultaneously.

## Chapter 3

# GPIB/IEEE-488.2 REMOTE OPERATION

### 3.1 Introduction

When the model 1231 GPIB/IEEE-488.2 interface is installed and the instrument is connected to a host computer, the LDC-3700 Series Laser Diode Controller can be used as a remotely controlled laser diode testing instrument. Possible applications include automatic L/I curve data gathering over a range of controlled temperatures.

In remote operating mode, the LDC-3700 Series Laser Diode Controller offers all of the features accessible from the front panel and some advanced features which can only be accessed via the interface bus. In remote mode you have access to commands for functions not found on the front panel, such as the INC and DEC commands which automatically increment or decrement the set point by a user-defined step value, calculation of measured temperature to 6-digit resolution, LASER voltage measurement, and control of the conditions which cause the TEC and LASER controller outputs to be shut off.

The model 1231 GPIB/IEEE-88.2 interface allows GPIB/IEEE-488.2 bus control of the LDC-3700 Series Laser Diode Controller. Information can also be read by the host computer and printed or stored. Other features include:

- A concise and straight-forward command set
- Full talk/listen capability
- Full serial poll capability, with SRQ
- Full local/remote capability including LOCAL LOCKOUT
- Meets ANSI/IEEE-488.2-1987 standards

This chapter is a guide to the syntax and usage of the various IEEE/488.2 common commands available for the LDC-3700 Series Laser Diode Controller. It also includes advanced programming tips for remote use with the device-dependent commands, hardware diagrams, and other information relating to remote operation.

This chapter is divided into three parts. The first part has the information for using the GPIB with the LDC-3700 Series Laser Diode Controller. It also has sections for each common GPIB (ANSI/IEEE-488.2) command which is supported by the LDC-3700 Series Laser Diode Controller.

The second part contains information on advanced programming techniques, and status reporting.

The third part contains information on remote interface messages; these low-level messages are generally transparent to the user.

### 3.1.1 Preparation for Bus Control

To use the LDC-3700 Series Laser Diode Controller remotely, you will need to install an IEEE-488 interface adapter in your host computer. These adapters and support software are available from several manufacturers and can be installed in most computers. This manual assumes that you have a basic knowledge of the GPIB/IEEE-488 interface bus and how to use it for instrument control. This chapter also assumes that you are familiar with the controls on the LDC-3700 Series Laser Diode Controller. Review Chapter 2 if you need more details on how to operate the LDC-3700 Series Laser Diode Controller.

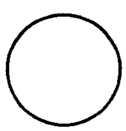
The talk and listen addresses on the LDC-3700 Series Laser Diode Controller are identical. This GPIB address is read locally by pressing the GPIB LOCAL switch and reading the display. To set the GPIB address, press and hold in the (PARAMETER) SET switch while displaying the GPIB address. Turn the ADJUST knob until the desired address value is displayed, then release the SET switch. The new GPIB address will then be stored in non-volatile memory, independent of the SAVE and RECALL "bin" number. The allowable address range is 0 - 30 for primary GPIB addressing. It is not normally possible to exceed this range. However, if the GPIB address were to exceed 30, it will not hang up the bus. If the GPIB address is ever displayed as a value greater than 30, service of the LDC-3700 Series Laser Diode Controller would be required, since this value is normally limited by the LDC-3700 Series Laser Diode Controller's firmware. Extended GPIB addressing is not implemented on the LDC-3700 Series Laser Diode Controller at this time.

## 3.2 ANSI/IEEE-488.2 Definitions

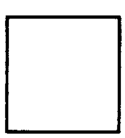
The following sections contain the relevant definitions for syntax diagrams and syntax elements for the LDC-3700 Series Laser Diode Controller commands, as defined by the IEEE-488.2 standard. A complete listing of that standard is not practical here, but these definitions are applicable to the remote operation of the LDC-3700 Series Laser Diode Controller.

### 3.2.1 Syntax Diagrams

The syntax diagrams in Section 4.4 show the most complete form of command construction, but they don't show every possible construction. Some of the other possibilities which are not shown in the syntax diagrams of Section 4.4 are discussed in Section 3.5, Advanced Programming. These syntax diagrams conform to the ANSI/IEEE-488.2-1987 standard, and the terminology presented here reflects that standard.



The oval (or round) shape contains a terminal syntactic element. These represent a basic function, such as a single ASCII character, which cannot be divided.



Rectangles contain non-terminal syntactic elements. These represent elements which are expandable to a diagram of terminal syntactic elements. However, they are presented as a unit for clarity or emphasis.

Lines and arrows indicate correct paths through the syntax diagram. A reverse line around an element indicates that the element may be repeated indefinitely. A forward arrow around an element indicates that the element may be omitted.

### 3.2.2 White Space

White space is defined by the syntactic diagram shown in Figure 3.1, where <white space character> is defined as a single ASCII-encoded byte in the range 00-09, 0B-20 (0-9, 11-32 decimal). This range includes the ASCII control characters, carriage return, and the space, but excludes the new line character.

In most practical programming situations, the space character (space bar) would be used as white space. White space is generally used for separating other syntactic elements. White space is processed by the LDC-3700 Series Laser Diode Controller without interpretation.

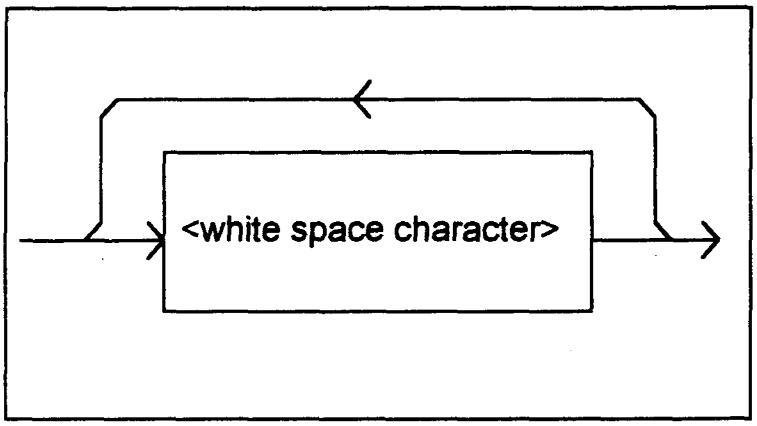



**Figure 3.1 White Space Syntactic Diagram**

### 3.2.3 Power-on Conditions

At power-on, the LDC-3700 Series Laser Diode Controller complies with the ANSI/IEEE Std 488.2-1987 requirements. It will initialize the setup parameters to be the same as when the power was last shut down. The default conditions may be recalled by using the *RST command. The default conditions are outlined in Section 3.2.12.

### 3.2.4 <nrf value>

The symbol, <nrf value>, refers to the flexible numeric representation, as defined by the IEEE-488.2 standard. All this means is that numbers may be represented in one of three forms, integer, floating point, or engineering/scientific notation. For example the number "twenty" can be represented by an ASCII string of:

| | | | | | | |
|---|---|---|---|---|---|---|
| 20 | or | +20, | | | | |
| 20.0 | or | +20.0, | | | | |
| 2.0E+1 | or | +2.0E+1 | or | 2.0e+1 | or | +2.0e+1 |

These three forms are denoted, NR1, NR2, and NR3, respectively, by the IEEE-488.2 standard. For more information on the precise syntax of these definitions, refer to the IEEE-488.2 standard.

### 3.2.5 <PROGRAM MESSAGE TERMINATOR>

When you send a command using the standard format, the host computer (or GPIB driver) usually puts a <CR><NL><^END> (carriage return-line feed-EOI) on the data bus following the command string. The IEEE-488.2 standard requires either <NL><^END>, <NL>, or <^END> as an acceptable <PROGRAM MESSAGE TERMINATOR>, while the <CR> is treated as <white space> (ignored). The LDC-3700 Series Controller will accept any <PROGRAM MESSAGE TERMINATOR> shown in Figure 3.2. The LDC-3700 Series Laser Diode Controller terminates its responses with a <NL><^END> (unless the user changes the terminator via the TERM command).

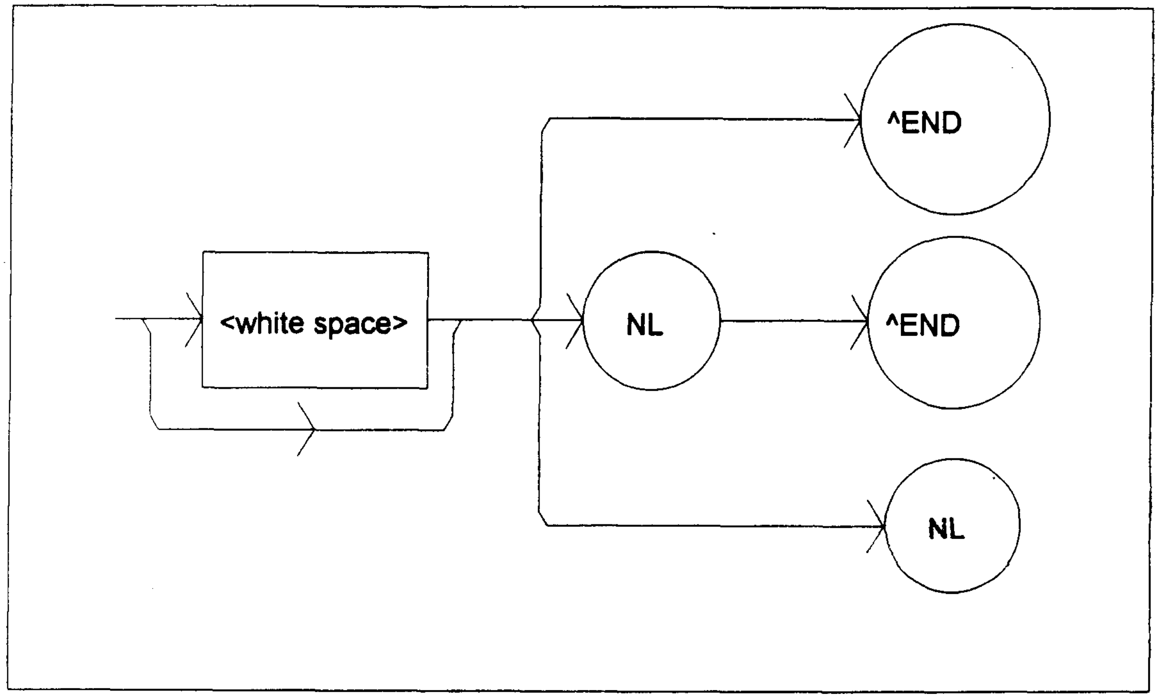



**Figure 3.2 <PROGRAM MESSAGE TERMINATOR> Syntax Diagram**

If you encounter problems with GPIB communications with the LDC-3700 Series Laser Diode Controller, refer to your GPIB driver manual for the exact syntax of the output terminator. See also, Appendix G.

### 3.2.6 <PROGRAM MESSAGE UNIT SEPARATOR>

A <PROGRAM MESSAGE UNIT SEPARATOR> is used to separate sequential <PROGRAM MESSAGE UNIT> elements (commands) from one another within a <PROGRAM MESSAGE>. The syntax for a <PROGRAM MESSAGE UNIT SEPARATOR> is shown in Figure 3.3.

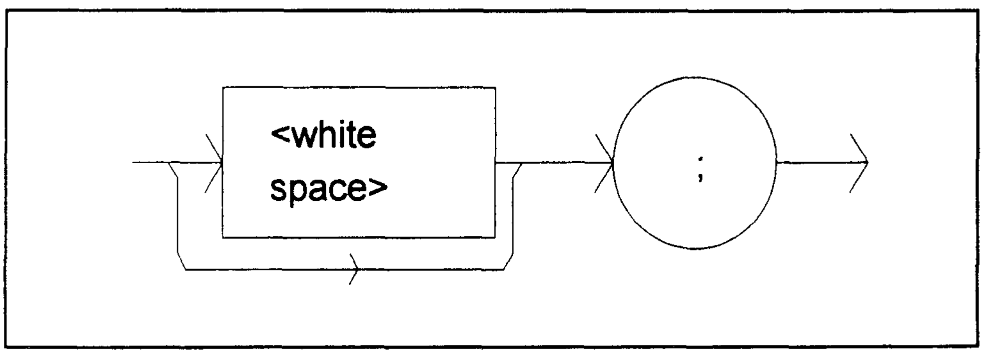



**Figure 3.3 <PROGRAM MESSAGE UNIT SEPARATOR> Syntax Diagram**

### 3.2.7 <PROGRAM HEADER SEPARATOR>

The <PROGRAM HEADER SEPARATOR> separates the <COMMAND PROGRAM HEADER> (3700 Series Laser Diode Controller command) from the <PROGRAM DATA> (first parameter after the command). In the case of the LDC-3700 Series Laser Diode Controller, a single white space must be used to separate the command from the first parameter. Note however, commands may be compounded, see Section 3.2.8.

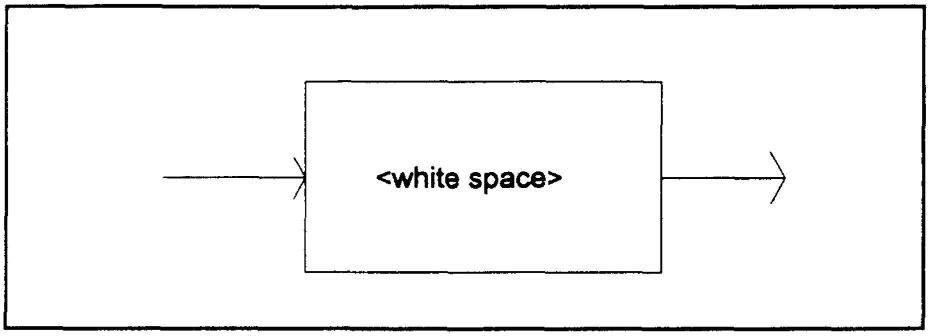



**Figure 3.4 <PROGRAM HEADER SEPARATOR> Syntax Diagram**

### 3.2.8 <compound command program header>

A <compound command program header> is a compound command heading which may be followed by <program data> (parameters). The LDC-3700 Series Laser Diode Controller command structure is a tree, as shown in Figure 4.2. A compound command or <compound command program header> determines the proper command by following a path from the root node. This is similar to determining a path for a file by starting with the root directory and listing the intermediate subdirectories. The syntax for a <compound command program header> is shown in Figure 3.5. The syntax diagram for a <compound query program header> is shown in Figure 3.6.

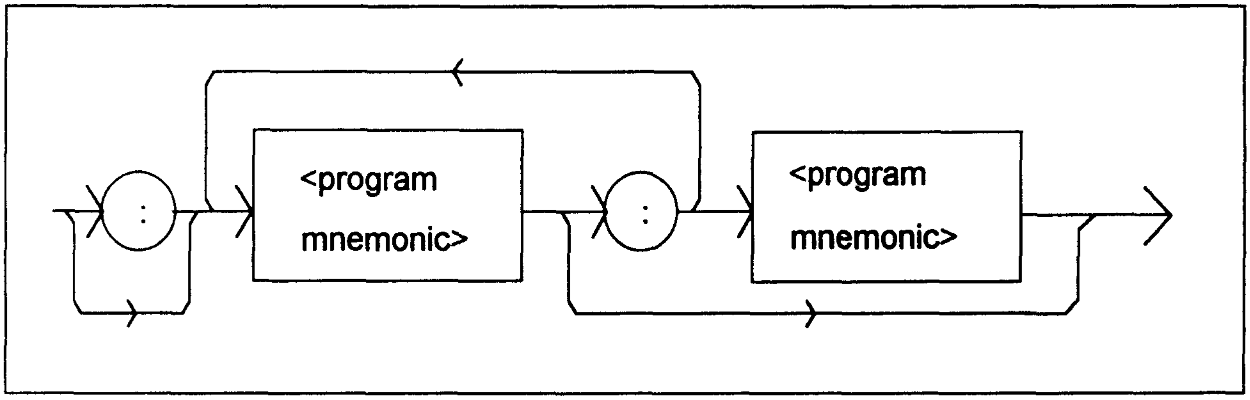



**Figure 3.5 <compound command program header> Syntax Diagram**

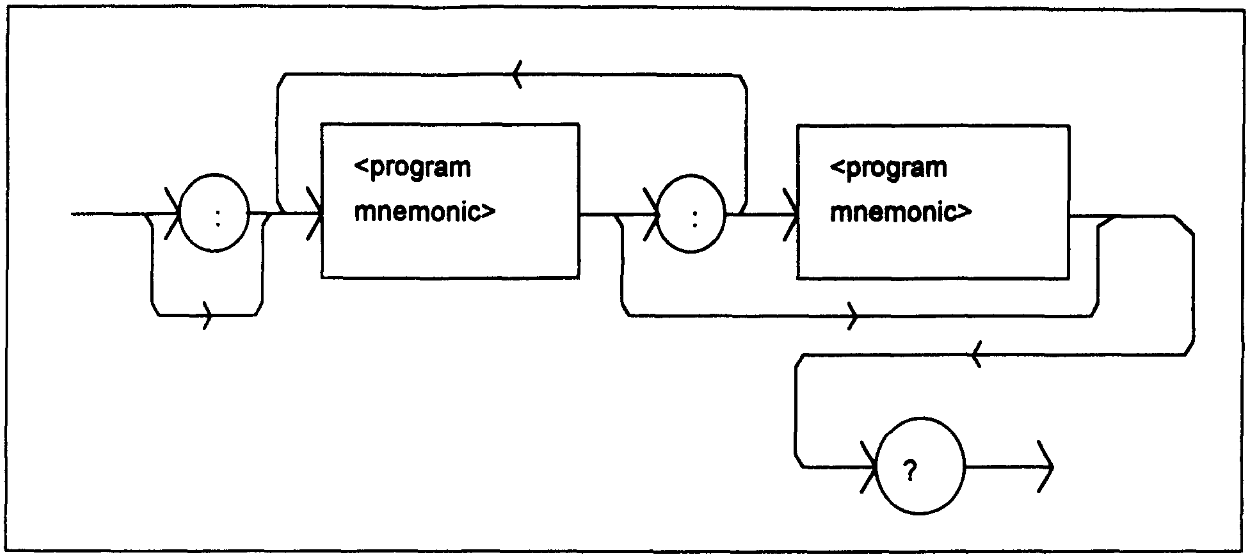



**Figure 3.6 <compound query program header> Syntax Diagram**

A <program mnemonic> is a command or command path identifier. For example, the <PROGRAM MESSAGE> "LAS:Inc" consists of the command "Inc" and the path identifier "LAS". All of the legal <compound command program headers> may be traced by starting from the root node of the command structure and moving down by levels to paths, and finally to the command (see Figure 4.2).

A <PROGRAM MESSAGE TERMINATOR> causes the next command search to begin at the root node. A leading colon (:) on a <PROGRAM MESSAGE UNIT> will cause the LDC-3700 Series Laser Diode Controller to begin searching for the command at the root node. Otherwise (after a semicolon), the LDC-3700 Series Laser Diode Controller will first search the most recently used node for the command. It will continue to search the command tree until it finds a legal command path, by searching each previously used node up to the root. If no legal path is found, the LDC-3700 Series Laser Diode Controller will generate an error message. For more information on creating and using LDC-3700 Series Laser Diode Controller commands, see Section 3.5, Advanced Programming.

### 3.2.9 <PROGRAM DATA> (Parameters)

Parameters (and other <PROGRAM DATA>) may be entered after a command in a <PROGRAM MESSAGE UNIT>. The <COMMAND PROGRAM HEADER> (command) and first <PROGRAM DATA UNIT> (parameter) must be separated by a <PROGRAM HEADER SEPARATOR> (white space), see Section 3.2.6.

### 3.2.10 <ARBITRARY BLOCK PROGRAM DATA>

This element allows any 8-bit bytes (including extended ASCII) to be transmitted in a message. The syntax for an <ARBITRARY BLOCK PROGRAM DATA> element is:

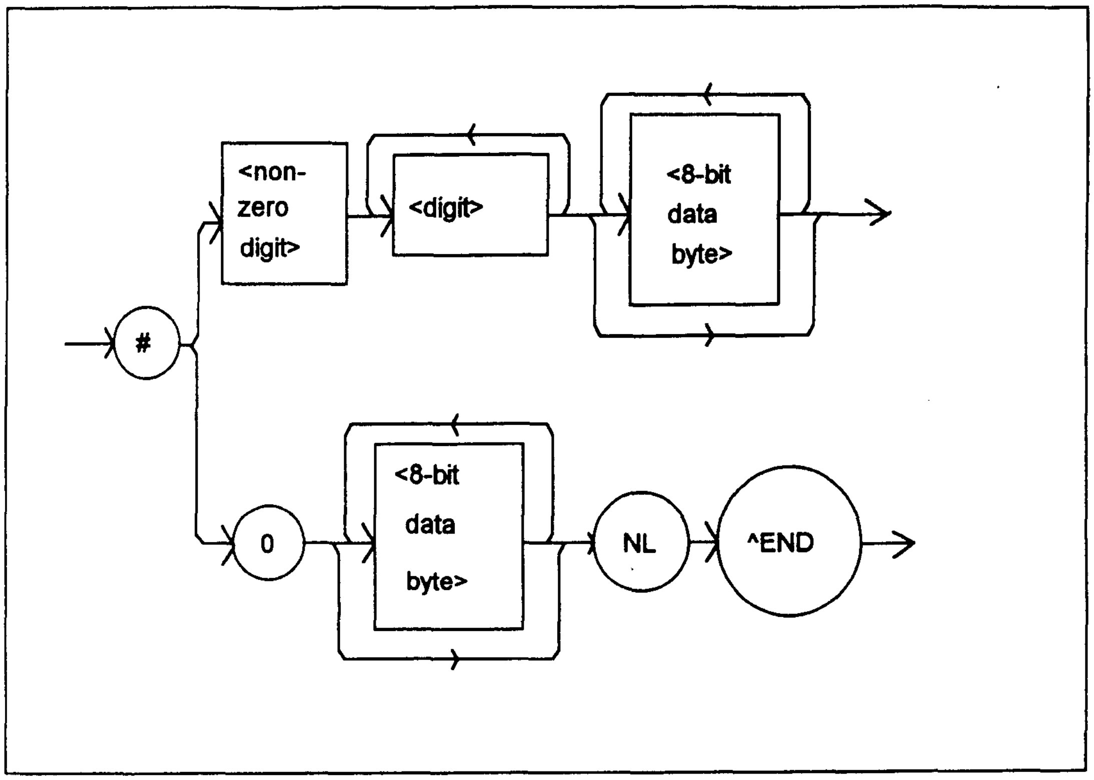



**Figure 3.7 <ARBITRARY BLOCK PROGRAM DATA> Syntax Diagram**

-where a non-zero digit is defined as a single ASCII encoded byte in the range 31 -39 (49 - 57 decimal). 8-bit data byte is defined as an 8-bit byte in the range 00 -FF (0 -255 decimal). NL is a new line (LF) and ^END is an end or identify (EOI).

This element is used only with a *PUD command to the LDC-3700 Series Laser Diode Controller.

### 3.2.11 <PROGRAM DATA SEPARATORS>

When there is a list of <PROGRAM DATA UNITS> (parameters) following a <PROGRAM HEADER SEPARATOR> (white space), the <PROGRAM DATA UNITS> must be separated with a <PROGRAM UNIT SEPARATOR>. The syntax diagram for a <PROGRAM UNIT SEPARATOR> is shown in Figure 3.8.

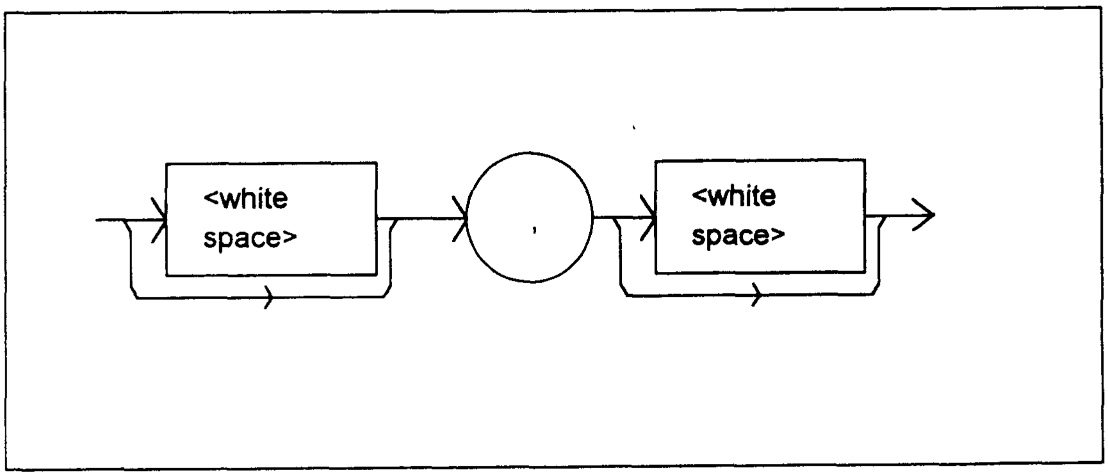



**Figure 3.8 <PROGRAM DATA SEPARATOR> Syntax Diagram**

### 3.2.12 Default Parameters

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

However, if a reset is performed via a *RST command (or a RCL 0 command), the following parameters will be set to the default state shown in Table 3.1.

**LDC-3700 CONFIGURATION AFTER *RST**

GPIB in local via front panel; in remote via GPIB
Bar graph off
PARAMETERS not selected
TEC and LASER adjust not selected
TEC output off
TEC DISPLAY enabled, in T mode
Constant T mode selected
TEC Display showing actual temperature
Temperature Set Point = 0 °C
Resistance/Reference Set Point = 1 ohm or uA or mV (depending on
    the setting of the SENSOR SELECT switch)
ITE Set Point = 0
LIM ITE set to 4.0 Amps
LIM THI set to 99.9 °C
TEC STEP value = 1
TEC Tolerance values = 0.2 °C, 5 seconds
GAIN = 30
C1 = 1.125 (x $10^{-3}$)
C2 = 2.347 (x $10^{-4}$)
C3 = 0.855 (x $10^{-7}$)
CAL PD = 0.0

LIM I (high) = 3000 mA (3742B), 500 mA (3722B), 100 mA (3712)
LIM I (low) = 1000 mA (3742B), 200 mA (3722B), 50 mA (3712)
LIM P = 5000 mW
LASER output off
Range = low
LASER DISPLAY enabled, in I mode
Constant I, low bandwidth, mode selected
LASER display showing actual current
LASER STEP value = 1
LASER Tolerance values = 10.0 mA, 1.0 seconds (3742B/3722B);
    1.00 mA, 1.0 seconds (3712)
LASER I Set Point = 0
LASER IPD Set Point = 0
LASER PPD Set Point = 0
RECALL BIN number = 0

**Table 3.1 State of the LDC-3700 Series Laser Diode Controller After *RST**

### 3.3 Getting Started with GPIB

This section is intended as a quick guide to the GPIB syntax and commands used by the LDC-3700 Series Laser Diode Controller. The LDC-3700 Series Laser Diode Controller's unique (device-dependent) commands are described in Chapter 4.

#### 3.3.1 Overview of the LDC-3700 Series Laser Diode Controller Syntax

Generally, a command or query is entered (spelled) as shown in Table 4.1. The command/query MUST CONTAIN all of the letters which are shown in upper case in Figure 4.2 and Table 4.1. However, the LDC-3700 Series Laser Diode Controller's command parser is NOT CASE SENSITIVE so upper or lower case may be used in any combination. The lower case letters shown with the commands in Section 4.4 (LDC-3700 Series Device-Dependent Commands) are optional letters, and may be used for clarity. For example, the following commands are equal, and only the first three letters "DIS" are required, while the other letters, "play" are optional.

"LAS:DIS1", "LAS:DISPLAY 1", and "LAS:DisP1".

The syntax of the LDC-3700 Series Laser Diode Controller commands follows the rules laid out in the IEEE-488.2 standard. Colons (:) indicate the start of a new command path, while semicolons (;) indicate a separation of commands within a command string. A leading semicolon on a command may be used to return the LDC-3700 Series Laser Diode Controller command parser to the command path root (see Figure 4.2).

Spaces or white space (see Section 3.3.2 for a definition of white space) may be placed anywhere in a command string (after the command header or query question mark), and must be used to separate the command (header) from the first parameter (or program data). The following examples show valid syntax for commands with the LDC-3700 Series Laser Diode Controller:

"TEC:MODE:t; TEC:T 25; TEC:Const 1, 2, 3.5; TEC:OUT 1"
":TEC:DIS 1; tec:set:t?;
"Laser:limit:ldi 400"
"LAS:display:ldi"

The following are examples of invalid syntax for the LDC-3700 Series Laser Diode Controller. These command strings would produce an erroneous result, as explained:

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

#### 3.3.2 Using Commands with Parameters

Some commands expect a parameter. For example, if the temperature set point is to be entered, the command could be "TEC:T 30". This would set the LDC-3700 Series Laser Diode Controller's set point temperature to 30°C. If a single parameter is expected, it should follow the command with at least one space between the command and the parameter.

The nominal value for on/off parameters is 1 = on, 0 = off. For example, the command:

| | |
|---|---|
| "TEC:Display:Set 1" | -turns the set point display on, and |
| "TEC:Display:Set 0" | -turns the set point display off. |

The words "on" and "off" may be substituted in the above example:

| | |
|---|---|
| "TEC: Display:Set On" | -turns the set point display on, and |
| "TEC:Display:Set Off" | -turns the set point display off. |

For more information on parameter name substitutions, see Section 3.2.1.

If multiple parameters are expected, they should be separated with commas. For example, to set the Steinhart-Hart constants on the LDC-3700 Series Laser Diode Controller (C1, C2, and C3) the following command could be sent:

"TEC:CONST 1.111, 2.004, 0.456".

If not all of the parameters need to be changed, i.e. C2 only, the other parameters may be omitted as in:

"CONST ,2.004, "

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

"LAS:LDI?"

The LDC-3700 Series Laser Diode Controller uses a terminator of <NL><^END> (new line EOI). In almost all cases, these terminators are automatically inserted by the host (user's) computer or GPIB driver. For more information, see Section 3.2.5 or the IEEE-488.2 standard definition.

### 3.4 Common Commands and Queries

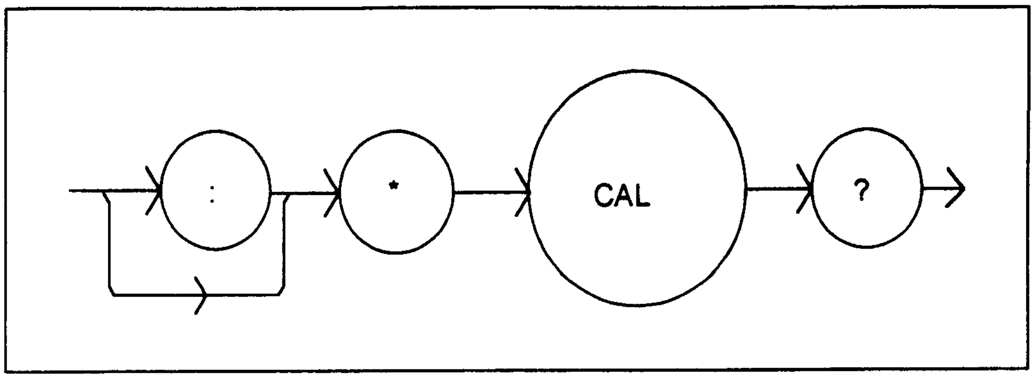
This section contains a list of the common commands and queries which are supported by the LDC-3700 Series Laser Diode Controller. The common commands and queries are distinguished by the * which begins each mnemonic. The common commands and queries are listed in alphabetical order, and a brief description of their functions is given. For more information on these commands, refer to an ANSI/IEEE 488.2-1987 standards reference.

#### 3.4.1 *CAL?

This is the calibration query. When it is sent, the LDC-3700 Series Laser Diode Controller performs the A to D calibration procedure. After this query is sent, the LDC-3700 Series Laser Diode Controller responds with a message indicating that calibration has been completed successfully or unsuccessfully. A response of 0 means no errors, any other number means an error in calibration was detected.

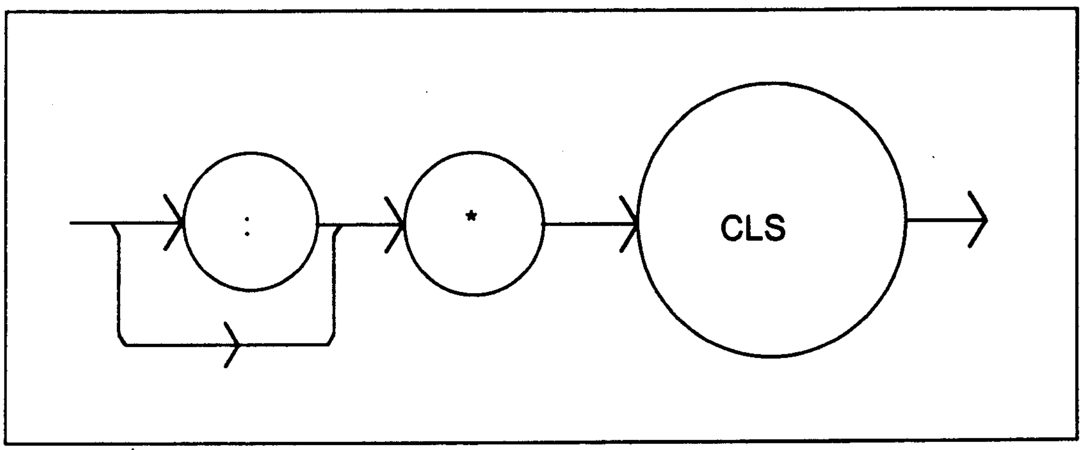
An auto-calibration is performed each time the LDC-3700 Series Laser Diode Controller accumulates 10 minutes of inactive time since the last auto-calibration.

The syntax for the *CAL? query is:



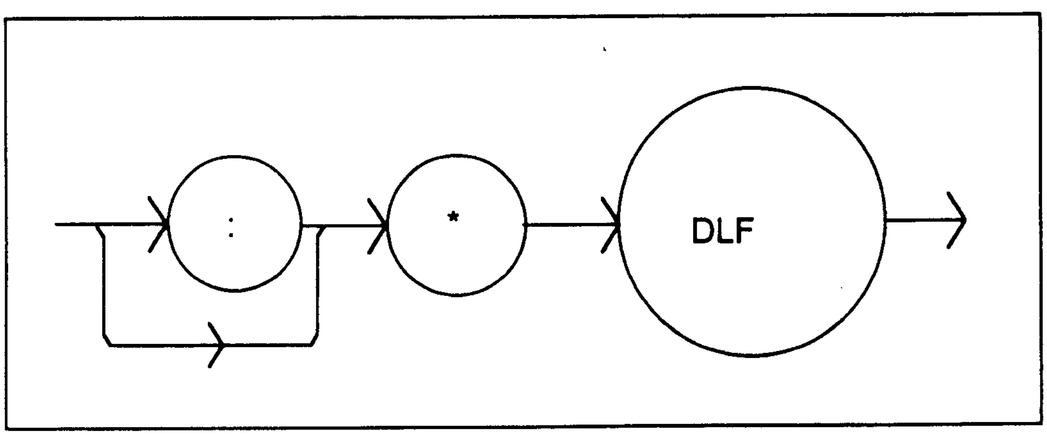

### 3.4.2 *CLS

This is the Clear Status command. It is used to clear the status event registers. It may be used, for example, to clear the Event Status Register, the Standard Event Status Register, and the Error Queue before enabling SRQ generation from instrument events. The syntax for the *CLS command is:




### 3.4.3 *DLF

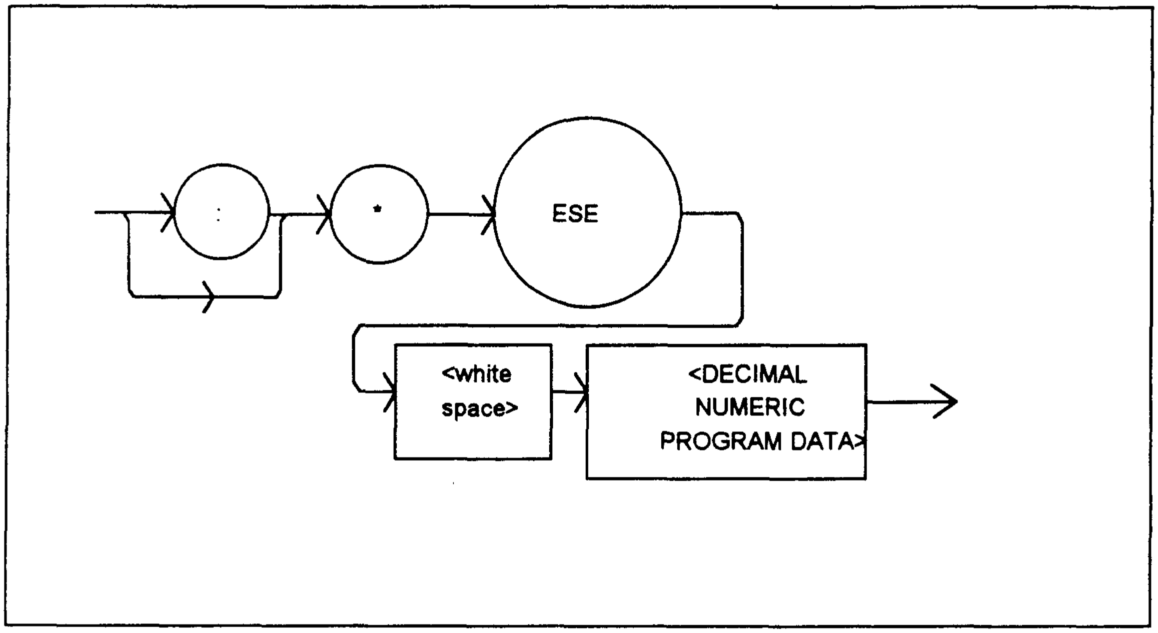
This is the Disable Listener Function command. It is used to cause the LDC-3700 Series Laser Diode Controller to cease being a listener. The syntax for the *DLF command is:

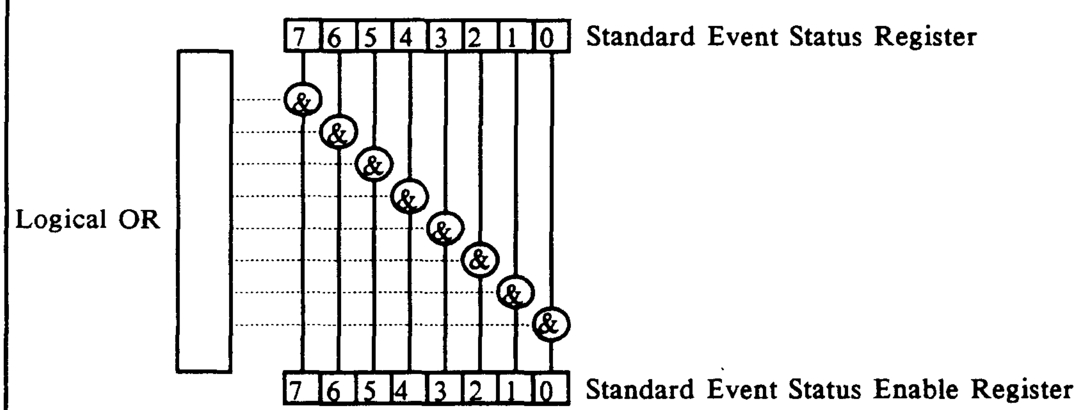


### 3.4.4 *ESE

This is the Standard Event Status Enable command. This command enables the Standard Event Status Register to update bit 5 of the status byte. The Structure of the Standard Event Status Enable Register and Standard Event Status Register are shown in Figure 3.9. The contents of these two registers is logically ANDed then the bits are ORed to get the Event Summary Bit message.

The syntax for the *ESE command is:




<u>Bit Reference</u>

| | |
|---|---|
| 0- Operation Complete | 4- Execution Error |
| 1- N/A | 5- Command Error |
| 2- Query Error | 6- N/A |
| 3- Device Dependent Error | 7- Power On |

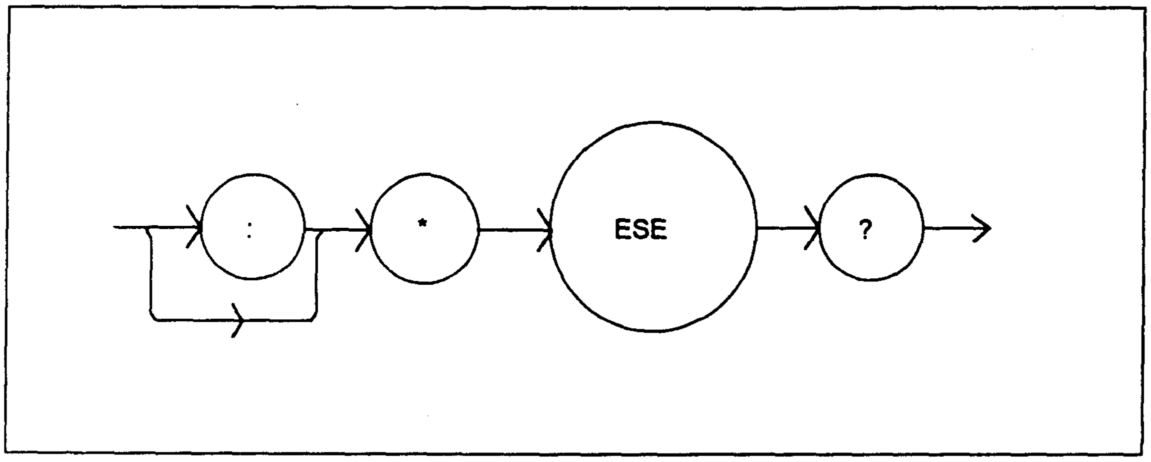
**Figure 3.9 Standard Event Status Register/Standard Event Status Enable Register**

Setting bit 0 allows the user to poll or generate SRQ from any overlapped commands after any previous operations are completed. This may be useful for ensuring that an operation, such as OUTPUT on, is complete before a measurement is made. Although this could be performed without using service requests, an interrupt-driven program makes more efficient use of the GPIB than polling or waiting (*WAI) routines. (See also Section 3.7.2).

### 3.4.5 *ESE?

This query will cause the LDC-3700 Series Laser Diode Controller to return the value of the Standard Event Enable Register. This allows the user to determine which status bits can set the summary bit (bit 5) in the status byte register. The response will be the sum of all of the enabled bits, as represented in Figure 3.9.

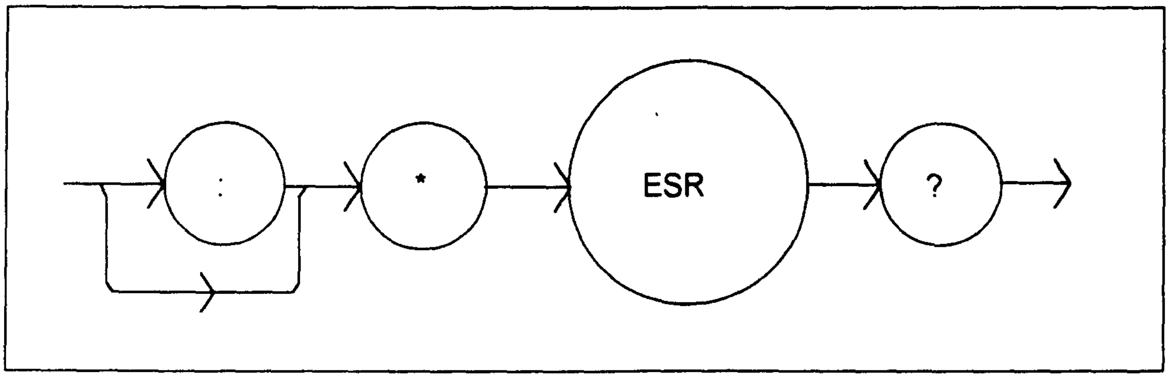
The syntax for the *ESE? query is:




### 3.4.6 *ESR?

This query will cause the LDC-3700 Series Laser Diode Controller to return the value of the Standard Event register. This allows the user to determine which type of error has occurred, for example. The value of the response will be the sum of the bits as represented in Figure 3.9.

The syntax for the *ESR? query is:

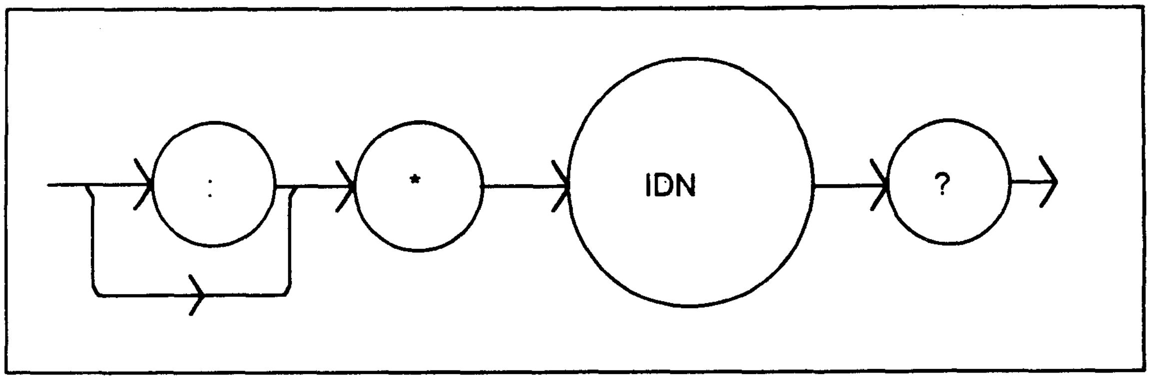


### 3.4.7 *IDN?

This query will cause the LDC-3700 Series Laser Diode Controller to return the following identification string:

ILX, LDC-3700 Series Laser Diode Controller,(7-digit serial number),(2-digit software version number). This identifies the specific device for the user. The manufacturer, model, serial number, and version number are listed in order.

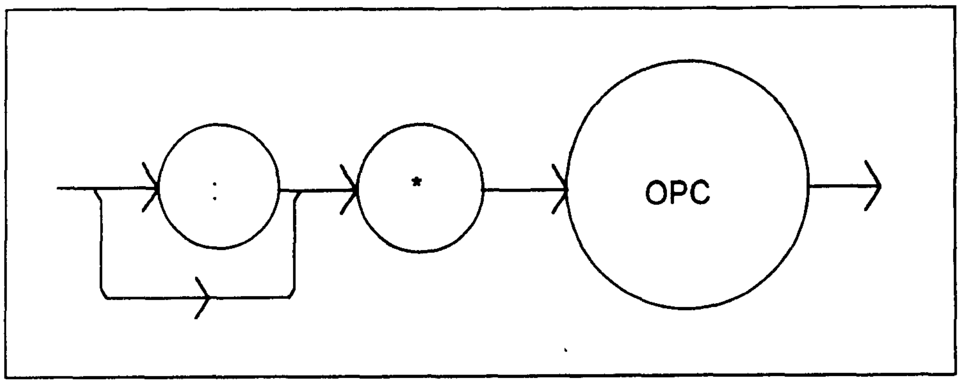
The syntax for the *IDN? query is:




### 3.4.8 *OPC

The *OPC command causes the LDC-3700 Series Laser Diode Controller to generate the operation complete message in the Standard Event Status Register when all pending overlapped commands have been completed.

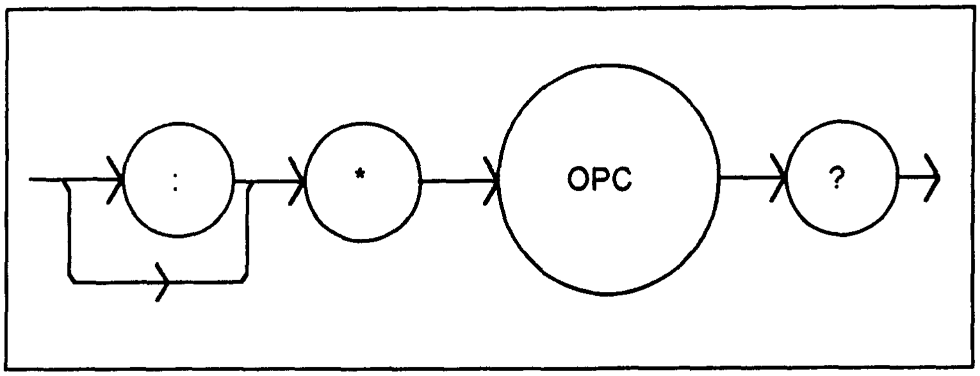
The syntax for the *OPC command is:



### 3.4.9 *OPC?

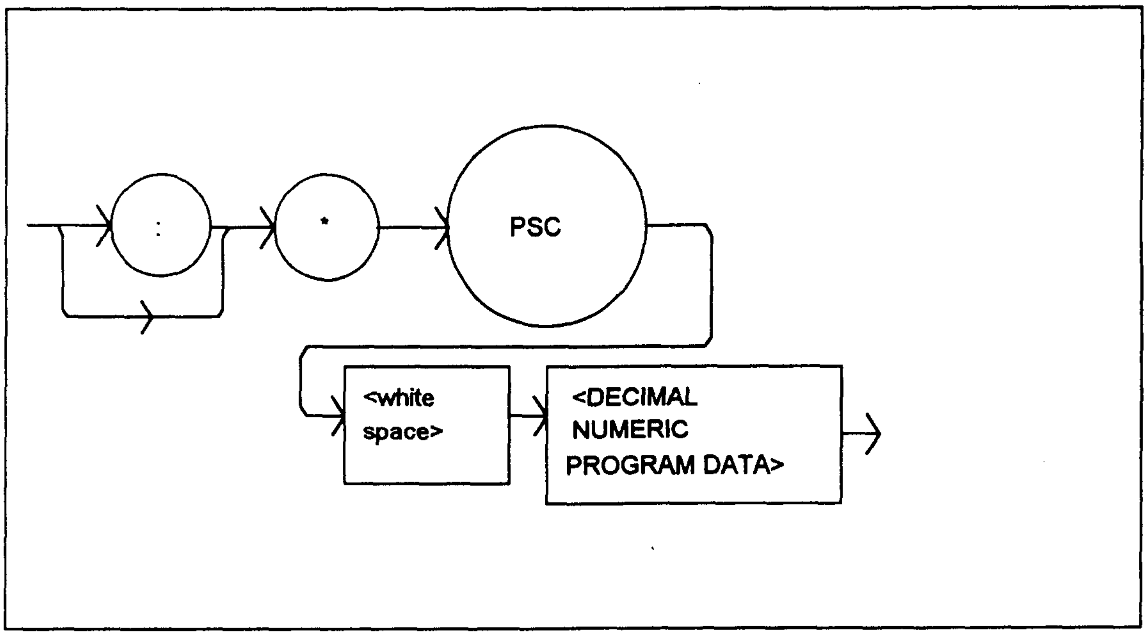
This query places an ASCII character 1 into the LDC-3700 Series Laser Diode Controller's Output Queue when all pending operations have been finished. (See also Section 3.7.2).

The syntax for the *OPC? query is:




### 3.4.10 *PSC

The Power-on Status Clear command controls the automatic power-on clearing of the Service Request Enable Register, the Standard Event Status Enable Register, the Event Status Enable Register, the Condition Status Enable Register, and the Parallel Poll Enable Register. The syntax for this command is:




where the data is a Boolean value:

0 - Power-on-status-clear flag is set FALSE, therefore allowing SRQ interrupts after power on.

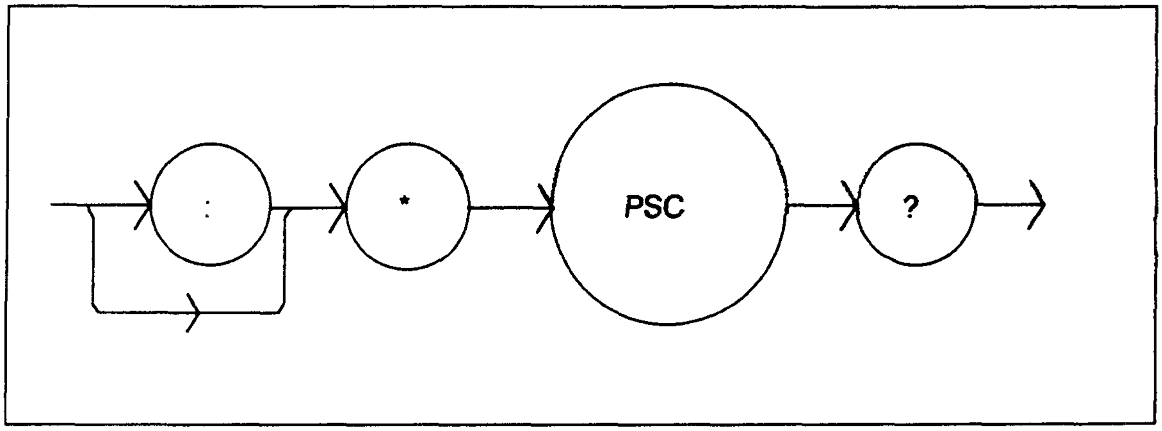
1 - Power-on-status-clear flag is set TRUE, therefore clearing all enable registers and disallowing SRQ interrupts to be asserted after power-on.

When the "*PSC 1" command is sent, the LDC-3700 Series Laser Diode Controller will clear the above-mentioned enable registers (set them all to 0) at power-up. This may be done to avoid any undesirable service requests after a power on/off cycle of the LDC-3700 Series Laser Diode Controller.

The factory default value for this bit is 0, Power-on Status Clear is disabled. Therefore, the values of the enable registers are restored from their condition at the last power-down when a power-up occurs.

### 3.4.11 *PSC?

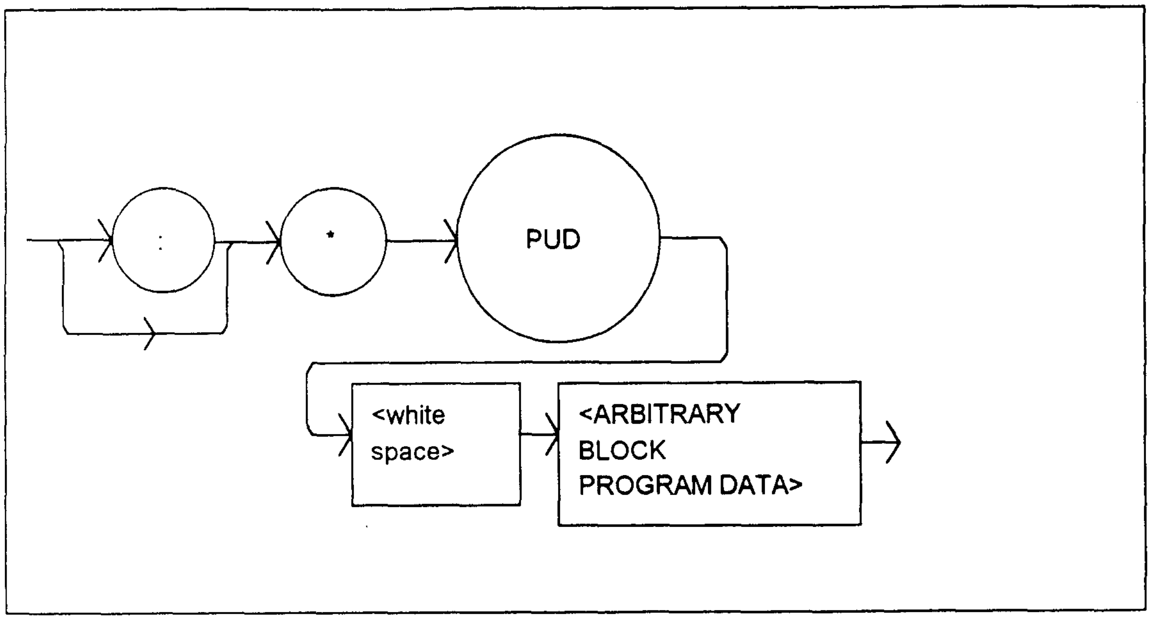
The Power-on Status Clear Query allows the programmer to query the LDC-3700 Series Laser Diode Controller's power-on-status-clear flag. A response of 0 means that the Standard Event Status Enable Register, Service Request Enable Register, the Event Status Enable Register, the Condition Status Enable Register, and the Parallel Poll Enable Register will retain their values when power is restored to the LDC-3700 Series Laser Diode Controller. A returned value of 1 indicates that the registers listed above will be cleared when power is restored to the LDC-3700 Series Laser Diode Controller. The syntax for this query is:




### 3.4.12 *PUD

The Protected User Data command stores data unique to the LDC-3700 Series Laser Diode Controller, such as calibration date, serial numbers, etc. This data is protected by restricted entry ("SECURE <nrf>" command) and is usually only entered at the time of service or calibration.

This data is a fixed size of 21 bytes. The syntax of the *PUD command is:



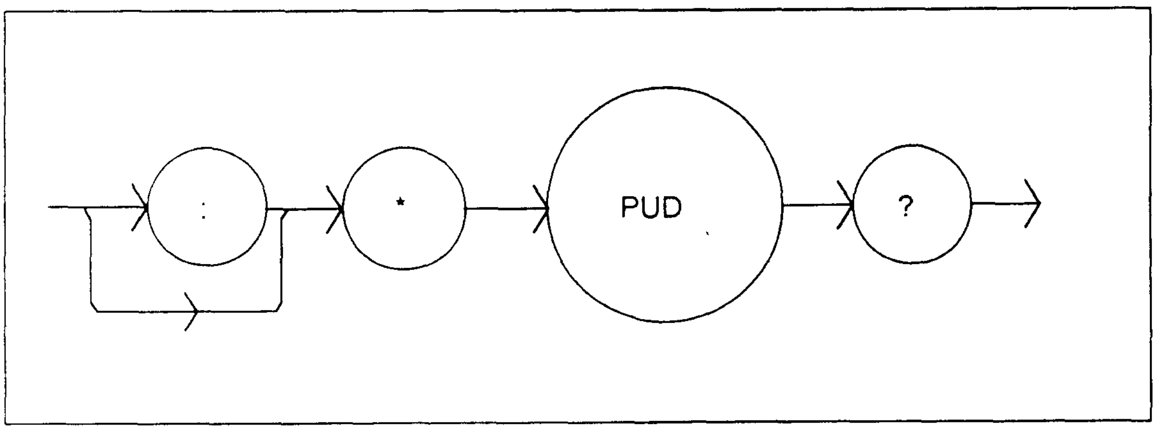

-where the user's input (unique data) is exactly 21 bytes.

### 3.4.13 *PUD?

The Protected User Device query allows the user to retrieve the contents of the *PUD storage area. The response is the contents of the unique data which was last entered. The syntax of the *PUD? query is:

The initial (factory set) response value of the *PUD? query is:

#221nnnnnnnnLLOOMMDDYYABC



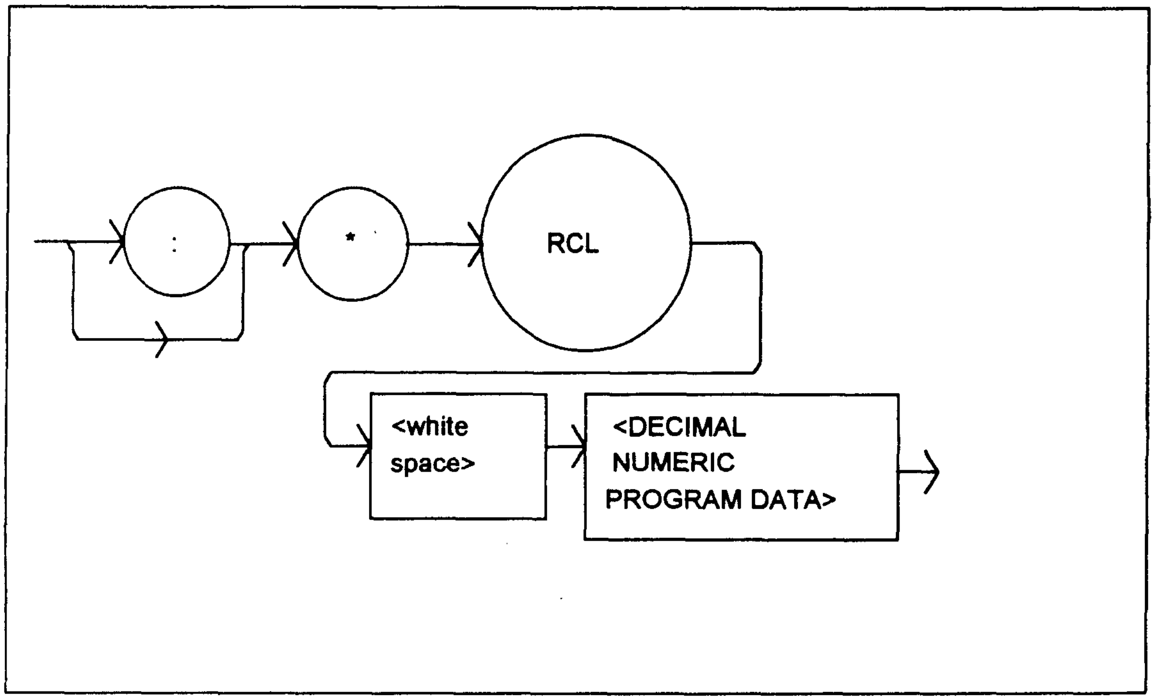

-where the response is <ARBITRARY BLOCK RESPONSE DATA>: nnnnnnnn represents the 8-digit serial number, LL represents the hardware revision level, OO represents option information, MMDDYY represents the date of calibration (month, day, year), and ABC represents the initials of the calibrating technician.

### 3.4.14 *RCL

The *RCL (Recall) command restores the LDC-3700 Series Laser Diode Controller to the setup state which is in its local memory (Bin 0 - 10). The following criteria are restored when the *RCL command is given:

1. The LDC-3700 Series Laser Diode Controller is in the parameter state which was last stored in that bin.
2. The outputs (LASER and TEC) are both off.

The syntax for the *RCL command is:




where the data value must round off to an integer between 0 and 10. A value of 0 means the recalled state shall be the same as that of a *RST command (see Table 3.1). Up to 11 different stored recall states can be used. Ten of these recall states (1 - 10) are saved by using the *SAV command.

### 3.4.15 *RST

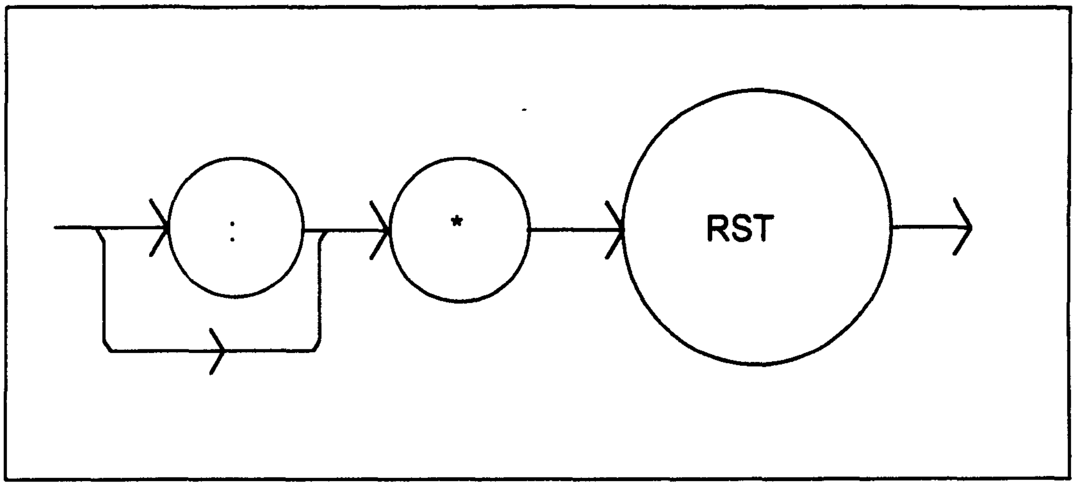
The *RST (Reset) command performs a device reset. This has the same effect as *RCL 0 (see Table 3.1), but additionally the LDC-3700 Series Laser Diode Controller's OCIS and OQIS idle states are set with the *RST command.

The Operation Complete Command Idle State (OCIS) is the state which the LDC-3700 Series Laser Diode Controller is in when it is no longer waiting for any operation to complete, after an *OPC command has been executed.

The Operation Complete Query Idle State (OQIS) is the state which the LDC-3700 Series Laser Diode Controller is in when it is no longer waiting for any operation to complete, after an *OPC? query has been executed.

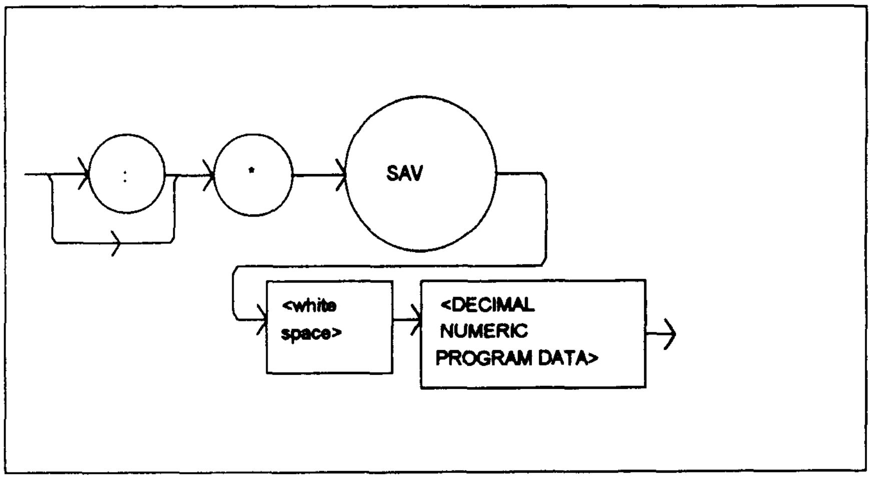
These idle states allow the LDC-3700 Series Laser Diode Controller to complete its reset process (and have no operations pending) before continuing with any other commands after the *RST is executed.

The syntax for the *RST command is:




### 3.4.16 *SAV

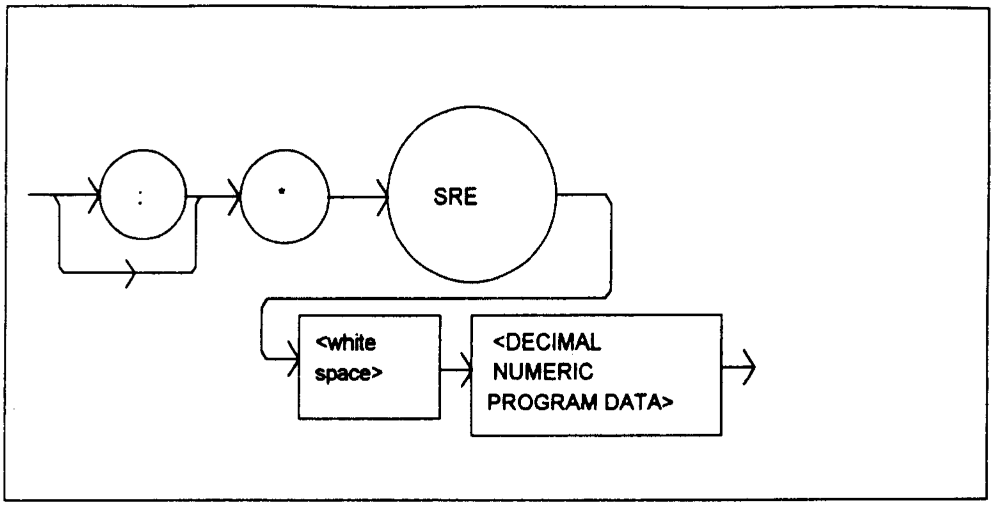
The Save command stores the current state of the LDC-3700 Series Laser Diode Controller in non-volatile local memory. A particular state is then recalled by using the *RCL recall command (see Section 3.3.17). There are 10 unique states which can be stored. The syntax of the *SAV command is:



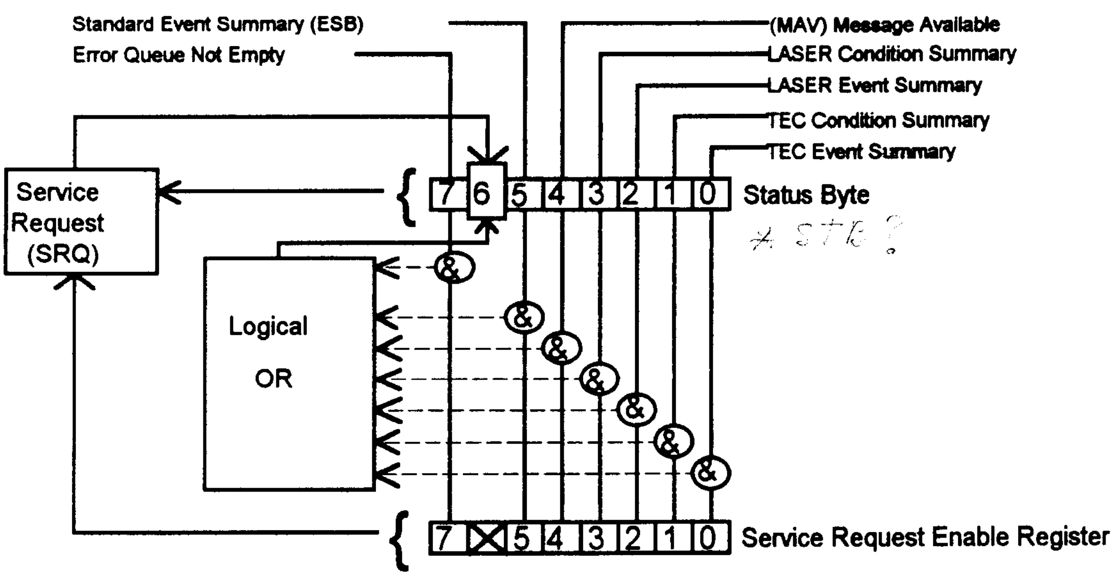

-where the data value must round off to an integer between 1 and 10. The rounded integer value corresponds to a unique saved state which can be recalled by using the same value with the *RCL command.

### 3.4.17 *SRE

The Service Request Enable command sets the Service Request Enable Register bits to allow the LDC-3700 Series Laser Diode Controller to generate the user-selectable service requests. The syntax of the *SRE command is:




-where the value of the numeric data rounds off to an integer between 0 and 255. The value of the numeric data corresponds to the bits enabled (see Figure 3.10)



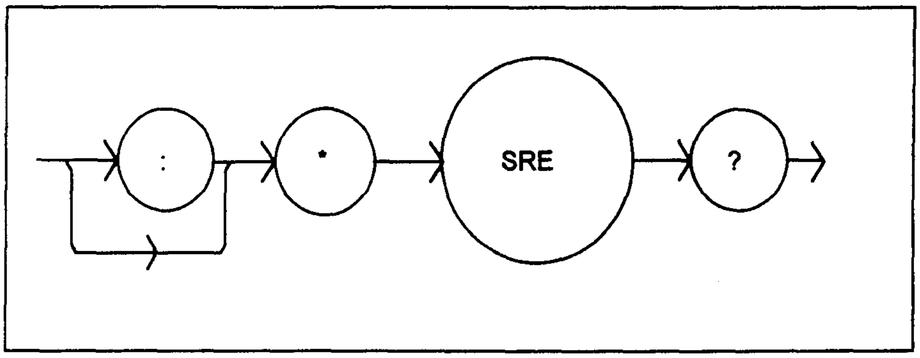

Bit Reference

0- TEC Event Summary
1- TEC Condition Summary
2- LASER Event Summary
3- LASER Condition Summary
4- Message Available
5- Event Status Summary
6- Request Service/Master Status Summary
7- Error Message Available

**Figure 3.10 Service Request Enable Register**

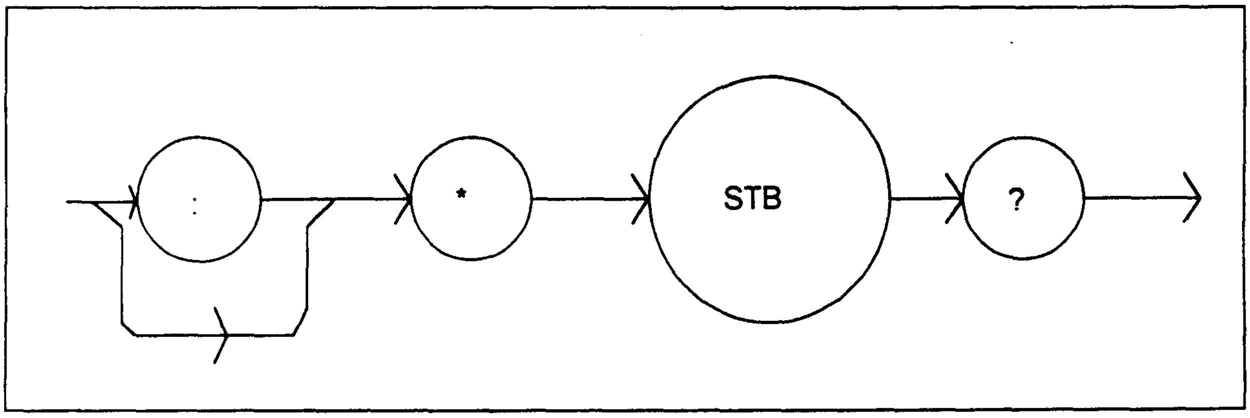
### 3.4.18 *SRE?

The Service Request Enable query allows the user to determine the current contents of the Service Request Enable Register. When this query is made, the response is the binary integer value of the contents of the register (see Figure 3.10). The syntax of the *SRE? query is:



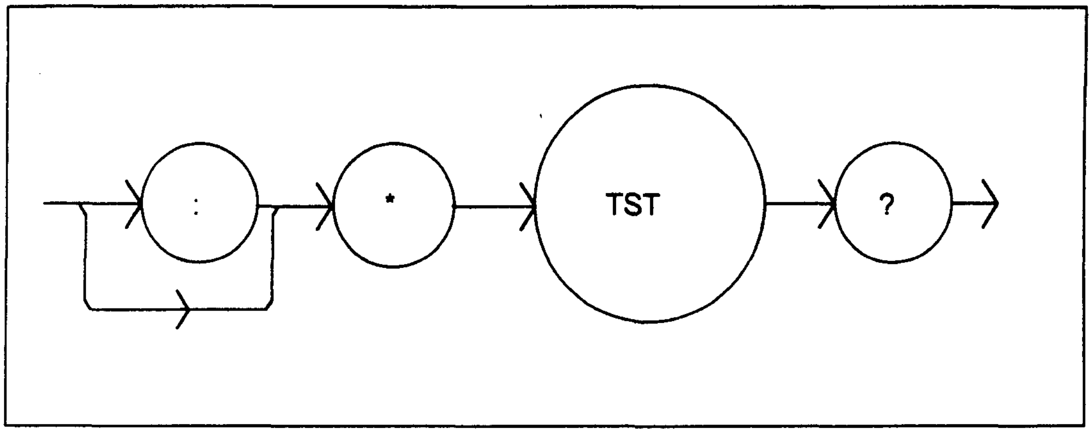

### 3.4.19 *STB?

The Read Status Back query allows the programmer to read the status byte and Master Summary Status bit. The response to this query is an integer value of the contents of the Status Byte Register, where bit 6 represents the MSS (Master Summary Status) bit and not the RQS message (see Figure 3.10). The syntax of the *STB? query is:



### 3.4.20 *TST?

The Self-Test query causes an internal self-test and returns a response when the self-test is complete. The syntax of the TST? query is:

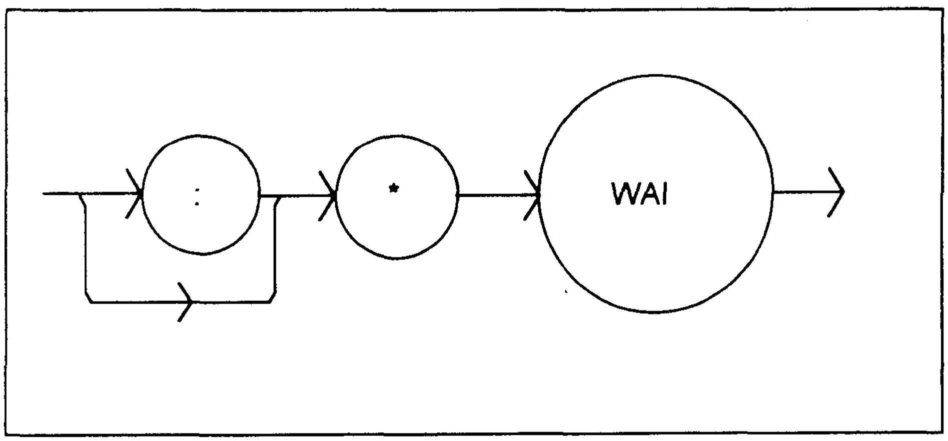



The response is <DECIMAL NUMERIC RESPONSE DATA>, where the value of the response is 0 if the self-test completes with no errors. If the response is a value other than 0, the self-test was not completed or it was completed with errors detected.

### 3.4.21 *WAI

The Wait-to-Continue command prevents the LDC-3700 Series Laser Diode Controller from executing any further commands until the No-Operation-Pending flag is true. This allows the programmer to make the LDC-3700 Series Laser Diode Controller wait for the completion of an operation before continuing. For more information on the operation complete (OPC) flag, see section 3.7.2.

The syntax for the *WAI command is:



### 3.5 Advanced Programming

Once you have become familiar with the command syntax and structure, you may take advantage of some programming shortcuts which are available. Due to the "tree-walking" capabilities of the LDC-3700 Series Laser Diode Controller software, the user may elect to write command strings without constantly repeating the entire command path for each command.

#### 3.5.1 Path Specification

The first command in the string must have its entire path entered. But once a path level is reached, other commands which are at the same level (or higher level) may then be entered without repeating the path. To accomplish this, the semicolon (;) must be used to separate the commands in the string, as usual. However, the command following the semicolon need not specify its full path, if the same path which was previously written out could be used for the new command.

For example, the following legal command string could be used to (1) set the LDC-3700 Series Laser Diode Controller TEC display to the measured temperature and (2) set the TEC display for the (temperature) set point value:

"TEC:DIS:T; SET"

The path "TEC:DIS:" is "remembered" by the LDC-3700 Series Laser Diode Controller software in this case. If the "SET" command were not found at this level, the software would walk back to the "TEC:" level and search for a "TEC:SET" command. If it is not found there, it will search at the next higher level, and so on until it finds the command or not. If the command is not found, an error message will be generated.

The following is an example of command "tree-walking", where (1) the LASER display is set for the current set point, and (2) the LASER output is turned on:

"Laser:display:set; out on"

The command "out" is first searched at the "LAS:DIS:" level. Since the command "LAS:DIS:OUT" does not exist, the next higher level "LAS:" is searched. There the command "LAS:OUT" is found, and the parameter "on" is legal, so there is no error.

Care must be taken to avoid errors which are caused by trying to implement commands from the wrong path or level. For example, the following command string was intended to (1) read back the set point resistance and (2) read back the measured resistance:

"TEC:SET:R?; R?"

Instead, the output would return the set point resistance twice. When the second "R?" is found, the software will first search for that command at its current level. Since it finds it there it will be executed. If this command did not exist at this level, the software would search down to the "TEC:" level and find and execute the intended command, "TEC:R?".

In order to ensure the proper command is executed for the example above, the following command string should have been issued:

"TEC:SET:R?; TEC:R?"

If you are not sure of the path level of a command, refer to the LDC-3700 Series Laser Diode Controller Command Path Structure diagram, Figure 4.2. For this discussion, the root level is the highest level, and moving down the diagram (Figure 4.2) decreases the level.

Once the software has "walked" to a lower path level, it remains at that level when it receives the next command. For example, to (1) set the LASER display to show the set point, (2) decrement the set point, and (3) set the TEC display to show the measured temperature, the following command string could be used:

"LAS:DIS:SET; DEC; TEC:DIS:T"

When the "DEC" command is reached, the software is at the "LAS:DIS:" level. Since there is no "DEC" command there, it walks back up to the "LAS" level, and there it finds the "LAS:DEC" command.

The reason that the full path (including "TEC:") must be specified for the last part (TEC:DIS:T) is that otherwise it would look for the DIS:T command in the LAS:DIS: path, not find it, and generate error E-123.

After the second semicolon is reached (DEC;) the software will first look for the next word (TEC) at the current path. Since it is not found it will walk back up the tree until it finds it at the root level. Once the search walks up to the root level, it will not walk down any other paths, unless the path is specified.

The only exception to the rule described above is when common commands are used. In that case, the software remembers which level the user was at before the common command was found, and it returns to that same level after finding and executing the common command. Therefore the following command string is legal:

"TEC:DIS:T; *WAI; DEC"

Here, (1) the display is set to show the measured temperature (2) the software waits for the previous command to be executed, and (3) the set point is decremented one step.

### 3.5.2 *Timing Considerations*

Although the shortcuts mentioned in Section 3.5.1 reduce the command length, they may not necessarily optimize the speed of program execution. The following tip may be useful if speed of execution of a command is critical. If a command follows a semicolon (;) in a command string, and it is not at the root level, using the colon (:) will aid the software in locating the command, and time will be saved.

For example, the following command string will execute slightly faster (as shown) than it would if the first colon (:) after the second semicolon (;) was not included. This would save the time of two binary searches, one at the LAS:DEC level and one at the LAS: level.

"LAS:DIS:SET; DEC; :TEC:DIS:T"

In other cases, the hardware may not be able to react as quickly as the commands are executed. For example, if the set point is greatly incremented (i.e. by 10 °C) and a measurement is taken before that new set-point temperature has been reached, a decision based on the accuracy of the measured value may not produce the desired reaction. In other words, the test could be invalid due to a premature measurement. For cases like this, the *WAI command is useful. The *WAI command will suspend the execution of the next command until the previous command has been completed.

## 3.6 Error Messages

Error messages may appear on the TEC or LASER displays when error conditions occur which force the output off or reflect hardware errors in the respective functions of the LDC-3700 Series Laser Diode Controller. For example, a module open error in the TEC side of the LDC-3700 Series Laser Diode Controller will be displayed on the TEC display.

In most cases, the error message will appear for three seconds and then the display will revert to its former state. In the case of multiple error messages, the LDC-3900 will show each new message as soon as it is detected.

In remote operation, the current error list can be read by issuing the "ERR?" query. When this is done, a string will be returned containing (up to 10 of) the error messages which are currently in the error message queue.

Appendix D contains an explanation of the error messages which may be reported remotely by the LDC-3700 Series Laser Diode Controller.

## 3.7 Status Reporting

Figure 3.11 shows the status reporting scheme of the LDC-3700 Series Laser Diode Controller. Each of the registers which may be accessed by a command or query has the appropriate command or query written above or below the register representation. For example, the LASER Condition Register may be queried via the "LASer:COND?" query, as shown by its register heading in Figure 3.11.

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

### 3.7.1 Event and Condition Registers

The Event Registers are used to report events which occur during the operation of the LDC-3700 Series Laser Diode Controller. Events differ from conditions in that events signal an occurrence once, and are not reset until the Event Register is queried or the LDC-3700 Series Laser Diode Controller is powered off. Conditions reflect the current state of the device, and therefore may change many times during operation. Querying a Condition Register does not change its contents.

The LDC-3700 Series Laser Diode Controller contains Event and Condition Registers for TEC and LASER controller operations. It also contains the Standard Event Status Register which reports events for general operation of the LDC-3700 Series Laser Diode Controller. The Standard Event Status Register conforms to the IEEE-488.2 standard.

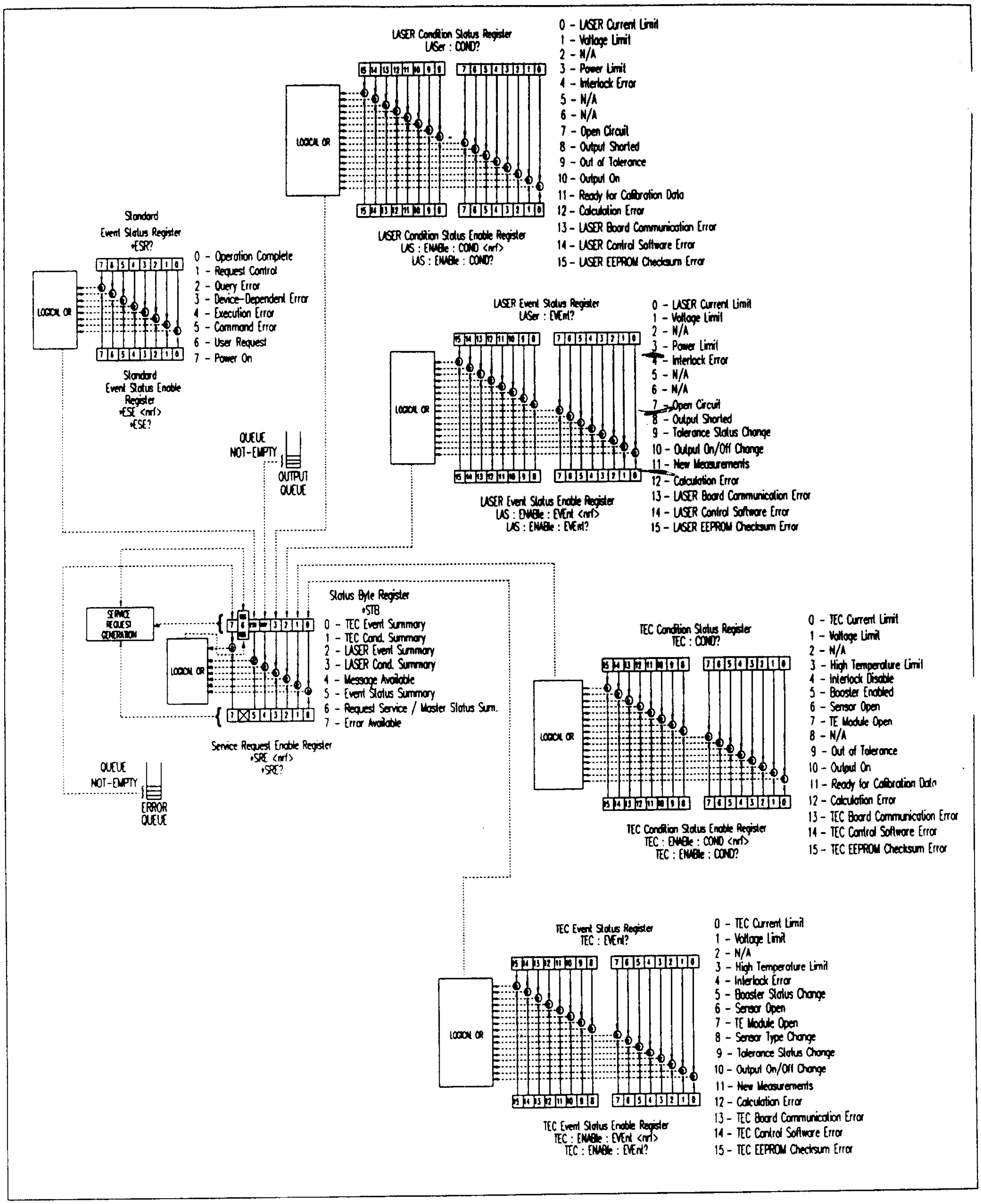



**Figure 3.11 LDC-3700 Series Laser Diode Controller Status Reporting Schematic Diagram**

### 3.7.2 Operation Complete Definition

Note that bit 0 of the Standard Event Status Register contains the status of the Operation Complete flag (see *OPC, Section 3.4.8). Enabling this bit via the *ESE command allows the user to update bits of the status byte. Then, if the SRE mask has bit 5 set, and the user issues an *OPC command, an SRQ will be issued upon completion of the currently processed commands. This may be used to initiate service request routines which depend on the completion of all previous commands.

For example, the user may set the TEC output to 30°C, enable the SRQ on Operation Complete, and have an SRQ handling routine in the user's software which begins a new measurement after the 30°C value has been reached.

This allows the use of the operation complete features of the LDC-3700 Series Laser Diode Controller, such as the "TOLerance" commands, without the need for program looping or polling which can tie up the GPIB.

Operation Complete on the LDC-3700 Series Laser Diode Controller is defined as:

1) The LASER controller, which is updating the current source hardware, is idle.

2) The TEC controller, which is updating the temperature controller hardware, is idle.

3) No EEPROM (non-volatile) memory write cycles are in progress.

4) New LASER current and photodiode measurements are available, updated approximately every 600 mSec.

5) New TEC sensor and ITE measurements are available, updated approximately every 400 mSec.

6) No Display time-out clocks are running.

7) No calibration routines are running.

8) LASER output is off, or it is on and within tolerance.

9) TEC output is off, or it is on and within tolerance.

> NOTE - Care must be taken when using the *OPC, *OPC?, and *WAI commands when settling times are long (i.e. a large step in temperature is made and the temperature tolerance is tight). In some cases the operation completion may far exceed the standard GPIB time-out setting. If the GPIB times out while waiting for a response which indicates completion, either set the GPIB time-out longer or use SRQ generated interrupts in the program. See your GPIB manual for time-out configuration or SRQ programming setup.
>
> The *OPC, *OPC?, and *WAI commands should not be used inside a calibration routine, except to detect the completion (exiting) of calibration. Notice that Operation Complete criteria 7 will hold the OPC flag false throughout calibration. If the program waits until the OPC flag is true before entering a calibration value, it will wait forever.

### 3.7.3 Command Timing and Completion

This section describes, for each device-dependent command, whether that command is performed in an overlapped or sequential manner. In other words, it states whether the next command may begin while this command is being executed, or if the next command must wait until this command is completed before its execution begins. The conditions for setting the operation complete flag are given in Section 3.7.2.

All LDC-3700 Series Laser Diode Controller device-dependent commands are executed in an overlapped manner, and the operation complete flag is set after the conditions outlined in Section 3.7.2 have been satisfied.

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

In normal operation, the overlapped commands execute faster than would appear by querying the OPC flag. This is due to the nature of the non-volatile memory storage process. Commands which change the status of the instrument limits, or change its mode or current range, step value, or status enable registers, will not have their OPC flag set until all current writing to non-volatile memory has been completed. This is done to ensure that the OPC flag is never set prematurely. However, in most cases, the individual operation will be completed immediately.

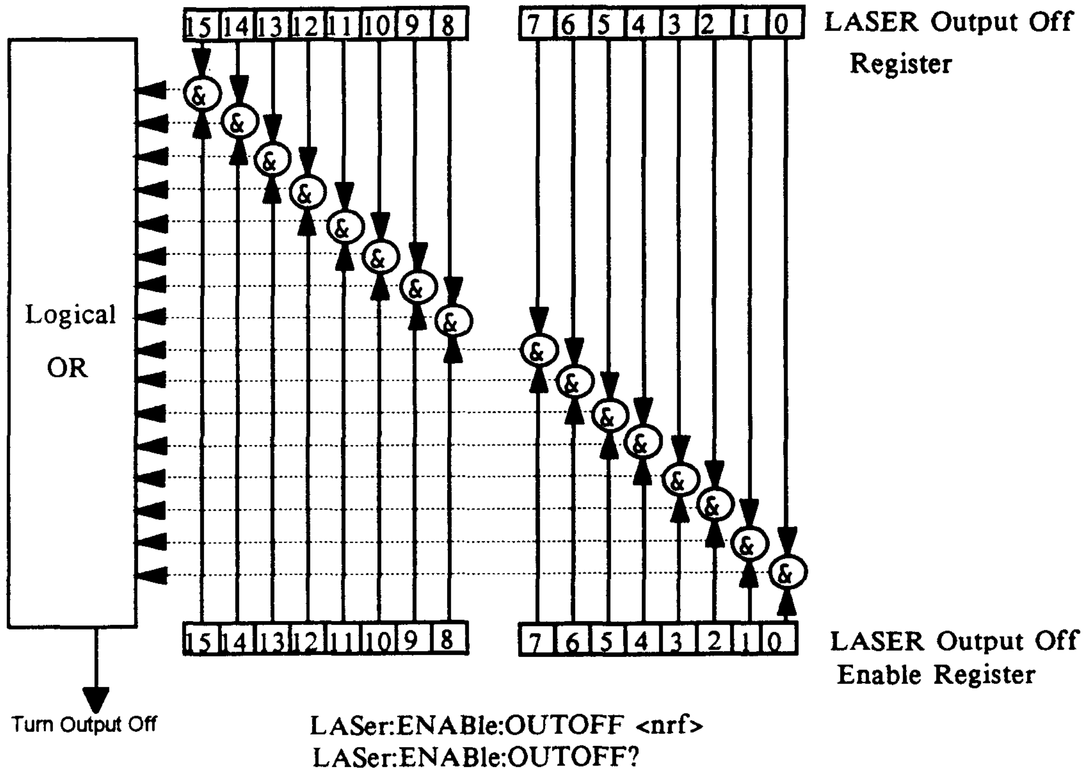
The speed of writing to non-volatile memory (EEPROM) is slow compared to processor speed, and the new information (to be written) is placed on a queue to reduce the processor overhead for non-volatile storage operations. However, the new information (e.g. new parameter value) is buffered and is essentially stored as soon as the command which created it is parsed. Therefore, even though the OPC flag may not be set immediately after a new parameter value is created, the new value is stored for all intents and purposes, and command throughput is not directly related to the OPC rate.

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

## 3.8 Output Off Registers

The Output Off Enable Registers allow the user to determine which conditions and events in the TEC and LASER controllers will cause their outputs to be turned off. These registers are configured in a manner which is similar to the status reporting registers. However, their outputs are not reported in the Status Byte Register. Rather, they go to the hardware which controls the output switching. The events and conditions which may be set to cause the TEC and LASER outputs to be turned off are shown in Figures 3.12 and 3.13.

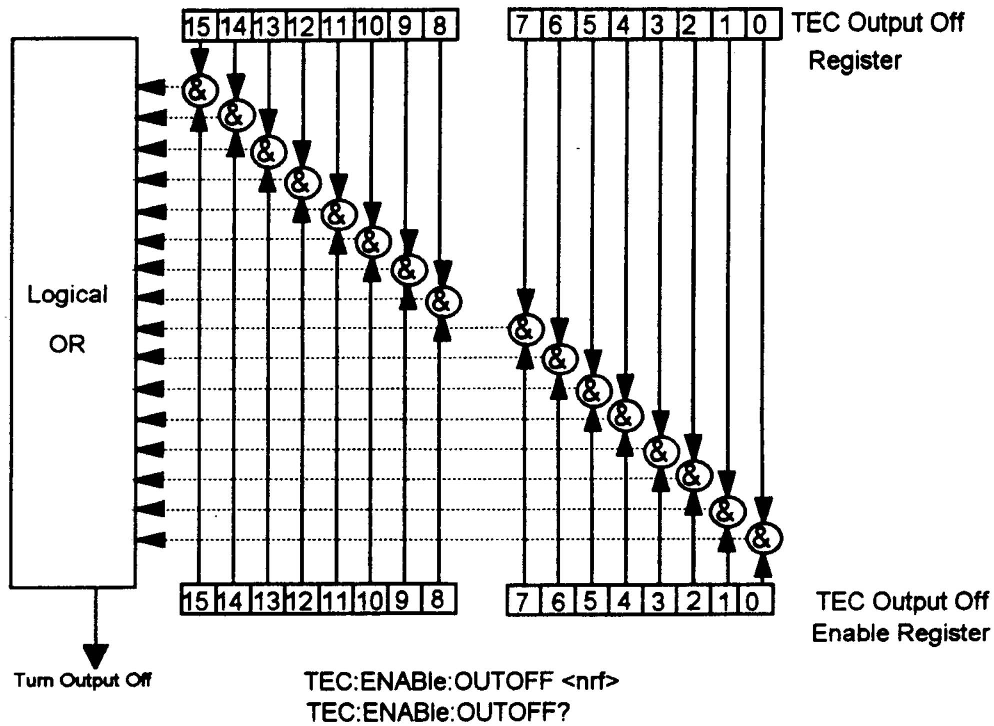
The default (factory) settings for these registers are shown in Table 3.2. These settings are not effected by the *PSC (Power-On Status Clear) command.




Bit Reference

0- LASER Current Limit
1- LASER Voltage Limit
2- N/A
3- LASER Power Limit (output on)
4- N/A
5- N/A
6- N/A
7- LASER Open Circuit (output on)
8- N/A
9- LASER Output Changed to be out of Tolerance
10- TEC Output is Off Event
11- TEC High Temperature Limit Condition
12- Hardware Error
13- N/A
14- N/A
15- N/A

**Figure 3.12 LDC-3700 Series Laser Diode Controller LASER Output Off Register**




**Bit Reference**

0- TEC Current Limit
1- TEC Voltage Limit
2- N/A
3- High Temperature Limit
4- N/A
5- Booster Changed (while output on) Eve.
6- Sensor Open (while output on) Cond.
7- TEC Module Open (output on) Cond.
8- Sensor Type Change (while output on) Eve.
9- Outside of TEC Tolerance Cond.
10- Sensor Shorted (while output on) Cond.
11- N/A
12- Software Error Cond.
13- N/A
14- N/A
15- N/A

**Figure 3.13 LDC-3700 Series Laser Diode Controller TEC Output Off Register**

**LDC-3700 OUTPUT OFF REGISTERS' DEFAULT SETTINGS**

| LASER Output Off Register | | TEC Output Off Register | |
|---|---|---|---|
| 0- disabled | 8- N/A | 0- disabled | 8- enabled |
| 1- disabled | 9- disabled | 1- disabled | 9- disabled |
| 2- N/A | 10- disabled | 2- N/A | 10- enabled |
| 3- enabled | 11- enabled | 3- enabled | 11- N/A |
| 4- N/A | 12- disabled | 4- N/A | 12- disabled |
| 5- N/A | 13- N/A | 5- enabled | 13- N/A |
| 6- N/A | 14- N/A | 6- enabled | 14- N/A |
| 7- enabled | 15- N/A | 7- enabled | 15- N/A |

**Table 3.2 LDC-3700 Series Default Settings for Output Off Registers**

### 3.9 Input Buffer and Output Data

The Input buffer of the LDC-3700 Series Laser Diode Controller is 80 bytes. However, the user's <PROGRAM MESSAGE> may be longer.

The output (response) data of the LDC-3700 Series Laser Diode Controller is sent in blocks of up to 80 bytes in length. It is sent using high speed DMA within the LDC-3700 Series Laser Diode Controller, but may be of indefinite length. Although some commands have a definite length response, such as the MESsage? query, the response length is indefinite because the LDC-3700 Series Laser Diode Controller will respond to multiple queries in a single response output. The user may enter as many queries as desired in a single input message, and the LDC-3700 Series Laser Diode Controller will respond to all of them in the same output message, if possible. For example, the user may enter the following command:

"Mes?; Rad?; TEC:T?; Err?"

The response may appear in this manner:

"TEST1            ,DEC,25.0,0"

All query responses are evaluated at the time the query is parsed, and not at the time the response message is sent. In most cases this does not create a problem since the time between parsing a query and sending its response is small, unless the GPIB controller takes a long time to request the response.

### 3.10 Remote Interface Messages

The following sections are intended as a reference for using the LDC-3700 Series Laser Diode Controller with the GPIB option when an understanding of the lower level interface messages is required. These sections deal with the remote interface messages which are available with the LDC-3700 Series Laser Diode Controller, and they contain a list of the Interface Function subsets. This information is generally not required by the user unless there is a question of compatibility of the LDC-3700 Series Laser Diode Controller with a specific controller. A list of interface messages which are not supported by the LDC-3700 Series Laser Diode Controller is shown in Section 3.10.3. These messages will be ignored by the LDC-3700 Series Laser Diode Controller.

The interface messages listed in this chapter are handled by the 9914 GPIB interface IC and the 80C188 processor in the LDC-3700 Series Laser Diode Controller, and are transparent to the higher level commands. However, they may be explicitly used in some GPIB programs. A list of the LDC-3700 Series Laser Diode Controller's allowable interface messages is shown in Section 3.9.2.

#### 3.10.1 Interface Function Subsets

Table 3.3 contains the remote Interface Function Subsets which are supported by the LDC-3700 Series Laser Diode Controller. For more information, see the ANSI/IEEE-488.1-1987 standard.

**LDC-3700 Series INTERFACE FUNCTION SUBSETS**

| | |
|---|---|
| SH1 | Source Handshake - complete compatibility |
| AH1 | Acceptor Handshake - complete capability |
| T6 | Talker Functions |
| L4 | Listener Functions |
| SR1 | Service Request - complete capability |
| RL1 | Remote Local Function - complete capability |
| PP0 | Remote Configuration Parallel Poll - no capability |
| DC1 | Device Clear - complete capability |
| DT0 | Device Trigger - no capability |
| C0 | Controller Function - no capability |
| E2 | Three-state bus drivers (where allowed) |

**Table 3.3 LDC-3700 Series Interface Function Subsets**

### 3.10.2 LDC-3700 Series Remote Messages

The following list contains GPIB remote messages which are compatible with the LDC-3700 Series Laser Diode Controller GPIB driver.

**LDC-3700 Series ALLOWED GPIB INTERFACE MESSAGES**

| | | | |
|---|---|---|---|
| ACG | LAG | PPR2 | RQS |
| ATN | LLO | PPR3 | SCG |
| DAB | MLA | PPR4 | SDC |
| DAC | MTA | PPR5 | SPD |
| DAV | OTA | PPR6 | SPE |
| DCL | PCG | PPR7 | SRQ |
| END | PPC | PPR8 | STB |
| GTL | PPE | PPU | TAG |
| IDY | PPD | REN | UCG |
| IFC | PPR1 | RFD | UNL |
| | | | UNT |

**Table 3.4 LDC-3700 Series Allowable GPIB Interface Messages**

### 3.10.3 Non-Supported Remote Interface Messages

Table 3.5 contains GPIB interface messages which are known to be incompatible with the LDC-3700 Series Laser Diode Controller. Other interface messages which do not appear in Section 3.9.2 may also be incompatible with the LDC-3700 Series Laser Diode Controller.

**NON-SUPPORTED INTERFACE MESSAGES FOR LDC-3700**

| | | | | | |
|---|---|---|---|---|---|
| EOS | GET | MSA | NUL | OSA | TCT |

**Table 3.5 Non-Supported Interface Messages for LDC-3700 Series Laser Diode Controllers**

# Chapter 4

# COMMAND REFERENCE

## 4.1 Introduction

This chapter is a guide to the syntax and usage of the various device-dependent commands for the LDC-3700 Series Laser Diode Controller. It contains a reference section for all of the device-dependent commands, including those which may only be accessed via remote operation. Therefore, it is of primary interest to users who wish to utilize the GPIB option.

This chapter is divided into two parts. The first part contains an overview of the remote commands and syntax used by the LDC-3700 Series Laser Diode Controller. If you are not interested in remote operation, skip Sections 4.2 and 4.3.

The second part contains all of the LDC-3700 Series Laser Diode Controller 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. The error messages which may be displayed on the LDC-3700 Series Laser Diode Controller front panel are listed in Appendix D.

A short BASIC program example for remote operation of the LDC-3700 Series Laser Diode Controller is given in Section 4.6.

The common GPIB (ANSI/IEEE-488.2) commands which are supported by the LDC-3700 Series Laser Diode Controller are described in Chapter 3.

## 4.2 Overview of the LDC-3700 Series Laser Diode Controller Command Set

There are two types of device commands, commands - which cause the LDC-3700 Series Laser Diode Controller to do something, and queries - which return a stored value or state of the instrument. Queries must be terminated with a question mark (?), while commands may require a parameter(s) to follow.

"TEC:DIS 1"

For example, the "1" in the command "TEC:DIS 1", enables the LDC-3700 Series Laser Diode Controller TEC display, while a "0" would disable (blank) the TEC display. Table 4.1 (Section 4.2.1) contains the allowed substitute mnemonics for 1 and 0.

This command emulates the front panel operation of (1) selecting the TEC display section of the front panel, (2) selecting the display section, and (3) turning it on.

Most of the commands which emulate the front panel operation are just as intuitive (see Table 4.2). In Table 4.2 the required letters for each command are shown. Section 4.4 contains a detailed account of each command and tells which are also supported by front panel operations. In Section 4.4, each command is spelled out with the required letters in upper case and the optional letters in lower case. The optional letters may be used to improve program readability.

### 4.2.1 Substitute Parameter Names

For clarity in programming, the (Boolean) values of one and zero may also be represented by the appropriate substitute parameter names, as shown in Table 4.1.

**SUBSTITUTE PARAMETER NAMES**

| SUBSTITUTE NAME | VALUE |
|---|---|
| ON | 1 |
| OFF | 0 |
| OLD | 1 |
| NEW | 0 |
| TRUE | 1 |
| FALSE | 0 |

**Table 4.1 Substitute Parameter Names**

The ON parameter name could be used in place of the 1 in the example in Section 4.2 as follows:
"TEC:DIS ON"

### 4.2.2 Compound Command Structure

Many of the LDC-3700 Series Laser Diode Controller remote commands require a compound structure. This is done to distinguish between different commands of the same type and to designate which side of the LDC-3700 Series Laser Diode Controller the command is intended, TEC (thermoelectric controller) or LAS (laser current source).

The compound command structure is similar to a directory path structure, as found in DOS. For example, commands which deal with the LDC-3700 Series Laser Diode Controller's TEC have the path "TEC:", as in the command to set the TEC display to measured resistance,

"TEC:DIS:R"

This structure is illustrated in Figure 4.2. Table 4.2 lists all of the LDC-3700 Series Laser Diode Controller's device-dependent commands, with the full path shown for each command and a brief explanation of its usage. For more information, see Section 4.4.

Section 4.4 presents a more detailed look at the LDC-3700 Series Laser Diode Controller device-dependent commands, including syntax diagrams, and example usage.

## 4.3 Common Commands

Another type of command is the "common command". These commands are common to instruments which support the ANSI-IEEE-488.2 standard and are not necessarily reflected by front panel operations. Some of the common commands are useful for advanced programming techniques, such as generating service requests. However, common commands are not necessary for remote operation, and the beginning programmer may chose to ignore them entirely. The common commands are documented in Chapter 3.

Two common commands which are reflected by front panel operations are *SAV and *RCL. These commands remotely perform the same operations as when the SAVE and RECALL parameters are changed during Local (front panel) operation.

LDC-3700 Series DEVICE-DEPENDENT COMMANDS

| NAME | NUMBER OF PARAMETERS EXPECTED | FUNCTION |
|---|---|---|
| BEEP | 1 | Enables/disables the beeper, or beeps once. |
| BEEP? | NONE | Returns the enable status of the beeper. |
| DELAY | 1 | Used to create a delay in the execution of further commands. |
| ERR? | NONE | Returns errors generated since the last query. |
| LAS:CALMD | 1 | Used to set the CAL PD (monitor responsivity) constant. |
| LAS:CALMD? | NONE | Returns the CAL PD (monitor responsivity) constant. |
| LAS:CAL:LDI | NONE | Used to enter the constant I calibration mode. |
| LAS:CAL:LDI? | NONE | Returns the ready state for entering the constant I calibration value. |
| LAS:CAL:LDV | NONE | Used to enter the laser voltage calibration mode. |
| LAS:CAL:LDV? | NONE | Returns the ready state for entering the laser voltage calibration value. |
| LAS:CAL:MDI | NONE | Used to enter the monitor photodiode feedback current calibration mode. |
| LAS:CAL:MDI? | NONE | Returns the ready state for entering the monitor PD current calibration value. |
| LAS:COND? | NONE | Returns the value of the LAS condition register. |
| LAS:DEC | 0, 1 or 2 | Used with LAS:STEP command to decrement the set point value by one or more steps. |
| LAS:DIS | 1 | Turns the LAS display on or off. |
| LAS:DIS? | NONE | Returns the LAS display value. |
| LAS:DIS:LDI | NONE | Turn on/off LAS display to show output current. |
| LAS:DIS:LDI? | NONE | Returns on/off status of DIS I switch. |
| LAS:DIS:MDI | NONE | Turn on/off display to show PD monitor current. |
| LAS:DIS:MDI? | NONE | Returns on/off status of DIS IPD switch. |
| LAS:DIS:MDP | NONE | Turns on/off display to show PD monitor power. |
| LAS:DIS:MDP? | NONE | Returns on/off status of DIS PPD switch. |
| LAS:DIS:PARAM | NONE | Enables Display to show parameter values. |
| LAS:DIS:SET | NONE | Same action as setting LAS DIS SET switch. |
| LAS:DIS:SET? | NONE | Returns on/off status of LAS DIS SET switch. |
| LAS:ENAB:COND | 1 | Sets the enable register for LAS 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:EVENT? | NONE | Returns the value of the LAS event register. |
| LAS:INC | 0, 1 or 2 | Used with LAS STEP command to increment the LAS set point value by one or more steps. |
| LAS:LDI | 1 | Used to set the LAS constant current source set point value. |

**Table 4.2 LDC-3700 Series Device-Dependent Commands**

| NAME | NUMBER OF PARAMETERS EXPECTED | FUNCTION |
|---|---|---|
| LAS:LDI? | NONE | Used to return the constant current source measured value (measured about every 600 mS). |
| LAS:LDV | 1 | Used to set the laser voltage value for calibration. |
| LAS:LDV? | NONE | Used to return the measured laser voltage value (measured about every 600 mS). |
| LAS:LIM:I1 | 1 | Used to set the LASER constant current source limit value (100 mA range for 3712, 1000 mA range for 3742B). |
| LAS:LIM:I1? | NONE | Used to return the LASER constant current source limit value (100 mA range for 3712, 1000 mA range for 3742B). |
| LAS:LIM:I2 | 1 | Used to set the LASER constant current source limit value (200 mA range for 3722B). |
| LAS:LIM:I2? | NONE | Used to return the LASER constant current source limit value (200 mA range for 3722B). |
| LAS:LIM:I3 | 1 | Used to set the LASER constant current source limit value (3000 mA range for 3742B). |
| LAS:LIM:I3? | NONE | Used to return the LASER constant current source limit value (3000 mA range for 3742B). |
| LAS:LIM:I5 | 1 | Used to set the LASER constant current source limit value (50 mA range for 3712, 500 mA range for 3722B). |
| LAS:LIM:I5? | NONE | Used to return the LASER constant current source limit value (50 mA range for 3712, 500 mA range for 3722B). |
| LAS:LIM:MDP | 1 | Used to set the constant optical power (from monitor PD) limit value. |
| LAS:LIM:MDP? | NONE | Used to return the optical power (from monitor PD) limit value. |
| LAS:MDI | 1 | Used to set the constant optical power set point, if PD responsivity is 0. |
| LAS:MDI? | NONE | Used to return the monitor PD current measured value (measured about every 600 mSec.) |
| LAS:MDP | 1 | Used to set the constant optical power set point, if PD responsivity is non-zero. |
| LAS:MDP? | NONE | Returns the actual monitor PD power value (measured about every 600 mSec.). |
| LAS:MODE? | NONE | Returns the mode, I (current), IHBW (current, high bandwidth) or P (optical power). |
| LAS:MODE:IHBW | NONE | Sets the LDC-3700 Series Laser Diode Controller to constant current, high bandwidth mode. |
| LAS:MODE:ILBW | NONE | Sets the LDC-3700 Series Laser Diode Controller to constant current (low bandwidth) mode. |
| LAS:MODE:MDP | NONE | Sets the LDC-3700 Series Laser Diode Controller to constant optical power mode. |
| LAS:OUT | 1 | Same action as setting the LAS OUTPUT switch on/off. |
| LAS:OUT? | NONE | Returns the LAS OUTPUT switch status. |

**Table 4.2 LDC-3700 Series Laser Diode Controller Device-Dependent Commands (cont.)**

## LDC-3700 Series DEVICE-DEPENDENT COMMANDS (CONT.)

| NAME | NUMBER OF PARAMETERS EXPECTED | FUNCTION |
|---|---|---|
| LAS:RAN | 1 | Sets the LDC-3700 Series Laser Diode Controller's current output range. |
| LAS:RAN? | NONE | Returns the LDC-3700 Series Laser Diode Controller's current output range. |
| LAS:SET:LDI? | NONE | Returns the constant I (current) set point. |
| LAS:SET:MDI? | NONE | Returns the constant optical power set point, if the PD responsivity is 0. |
| LAS:SET:MDP? | NONE | Returns the constant P (optical power) set point, if the PD responsivity is non-zero. |
| LAS:STEP | 1 | Used to set the LAS step value for use with DEC or INC commands. Defaults to a step of 1; 1 step is equal to the display resolution for the parameter, i.e. 1 uA for Ipd. Range is 1 - 9999 steps. |
| LAS:STEP? | NONE | Returns the LAS step value. |
| LAS:TOL | 2 | Used to set the LAS set point tolerance value and time period value for validation, i.e. used to determine if a set point has been reached - must be within tolerance for the time period. |
| LAS:TOL? | NONE | Used to return the LAS set point tolerance value and time period value for validation, i.e. used to determine if a set point has been reached -must be within tolerance for the time period. |
| MES | 1 | Used to enter a string message of up to 16 bits. |
| MES? | NONE | Returns a previously stored ASCII message. |
| RAD | 1 | Used to set the radix type for numerical data. Decimal, binary, octal, and hexadecimal are allowed. |
| RAD? | NONE | Used to return the radix type for numerical data. Decimal, binary, octal, and hexadecimal are allowed. |
| SECURE | 1 | To be used by authorized service personnel only, to gain access to protected data. |
| TEC:CAL:ITE | NONE | Used to enter the TEC current source calibration mode. |
| TEC:CAL:ITE? | NONE | Returns the ready state for entering a current source calibration value. |
| TEC:CAL:SEN | NONE | Used to enter the sensor calibration mode; sensor type depends on rear panel sensor switch setting. |
| TEC:CAL:SEN? | NONE | Returns the ready state for entering a sensor calibration value. |
| TEC:COND? | NONE | Returns the value of the TEC condition register. |
| TEC:CONST | 1 - 3 | Used to enter the Steinhart-Hart constants for R-T conversion. Also used to enter constants for AD590 and LM335. |
| TEC:CONST? | NONE | Used to read back the Steinhart-Hart constants for R-T conversion. Also used to read back constants for AD590 and LM335. |

**Table 4.2 LDC-3700 Series Laser Diode Controller Device-Dependent Commands (Cont.)**

| NAME | NUMBER OF PARAMETERS EXPECTED | FUNCTION |
|---|---|---|
| TEC:DEC | NONE | Used with STEP command to decrement the set point value by one step. |
| TEC:DIS | 1 | Turns the TEC display on or off. |
| TEC:DIS? | NONE | Returns the TEC display value. |
| TEC:DIS:ITE | NONE | Turn on/off TEC display to show TEC current. |
| TEC:DIS:ITE? | NONE | Returns on/off status of DIS ITE switch. |
| TEC:DIS:R | NONE | Turn on/off display to show the resistance/reference value. |
| TEC:DIS:R? | NONE | Returns on/off status of DIS R switch. |
| TEC:DIS:SET | NONE | Same action as setting TEC DIS SET switch. |
| TEC:DIS:SET? | NONE | Returns on/off status of TEC DIS SET switch. |
| TEC:DIS:T | NONE | Turns on/off TEC display to show temperature. |
| TEC:DIS:T? | NONE | Returns on/off status of DIS T switch. |
| 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 | Used to set the LDC-3700 Series Laser Diode Controller TEC control loop gain parameter. |
| TEC:GAIN? | NONE | Used to return the LDC-3700 Series Laser Diode Controller TEC control loop gain parameter. |
| TEC:INC | NONE | Used with TEC:STEP command to increment the TEC set point value by one step. |
| TEC:ITE | 1 | Used to set the TEC current (ITE) set point. |
| TEC:ITE? | NONE | Returns the measured TEC current (ITE) value (measured about every 400 mSec). |
| TEC:LIM:ITE | 1 | Used to set the TEC constant current source limit value. |
| TEC:LIM:ITE? | NONE | Used to return the constant current source limit value. |
| TEC:LIM:THI | 1 | Used to set 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 (resistance/reference) or T (temperature). |
| TEC:MODE:ITE | NONE | Sets the LDC-3700 Series Laser Diode Controller to constant TEC current mode. |
| TEC:MODE:R | NONE | Sets the LDC-3700 Series Laser Diode Controller to constant thermistor resistance/linear sensor reference mode. |
| TEC:MODE:T | NONE | Sets the LDC-3700 Series Laser Diode Controller to constant temperature mode. |
| TEC:OUT | 1 | Same action as setting the TEC OUTPUT switch on/off. |
| TEC:OUT? | NONE | Returns the TEC OUTPUT switch status. |

**Table 4.2 LDC-3700 Series Device-Dependent Commands (Cont.)**

| NAME | NUMBER OF PARAMETERS EXPECTED | FUNCTION |
|---|---|---|
| TEC:R | 1 | Sets the constant R (resistance/reference) set point. |
| TEC:R? | NONE | Returns the measured R (resistance/reference) value (measured about every 400 mSec). |
| TEC:SEN? | NONE | Returns the position of the SENSOR SELECT switch. |
| TEC:SET:ITE? | NONE | Returns the constant ITE (TEC current) set point. |
| TEC:SET:R? | NONE | Returns the constant R (resistance/reference) set point. |
| TEC:SET:T? | NONE | Returns the constant T (temperature) set point. |
| TEC:STEP | 1 | Used to set the TEC step value for use with DEC or INC commands. Defaults to a step of 1, 1 step equals 0.1°C, 1 mA (ITE), 1 ohm, 0.1 mV, or 0.01 uA (AD590). Range is 1 - 9999 steps. |
| TEC:STEP? | NONE | Returns the value of the TEC step. |
| TEC:T | 1 | Used to set the TEC constant T (temperature) set point. |
| TEC:T? | NONE | Returns the TEC measured temperature value (measured about every 400 mSec.). |
| TEC:TOL | 1 or 2 | Used to set the TEC set point tolerance value and time period value for validation, i.e. used to determine if a set point has been reached - must be within tolerance for the time period. |
| TEC:TOL? | NONE | Used to return the TEC set point tolerance value and time period value for validation, i.e. used to determine if a set point has been reached -must be within tolerance for the time period. |
| TERM | 1 | Sets the program message terminator. |
| TERM? | NONE | Returns the value of the program message terminator. |
| TIME? | NONE | Returns the elapsed time since the LDC-3700 Series Laser Diode Controller was last powered up. |
| TIMER? | NONE | Returns the elapsed time since the timer was last reset. |

**Table 4.2 LDC-3700 Series Laser Diode Controller Device-Dependent Commands (Cont.)**

## 4.4 LDC-3700 Series Device-Dependent Commands

This section contains all of the device-dependent commands for the LDC-3700 Series Laser Diode Controller, listed in alphabetical order. Sub-sections for each path are presented, listing the commands which are legal for that path. See Figure 4.2 for command path tree structure. All of the LDC-3700 Series Laser Diode Controller's common commands and queries are listed in Section 3.4. The lower level remote interface messages are also listed in Chapter 3.

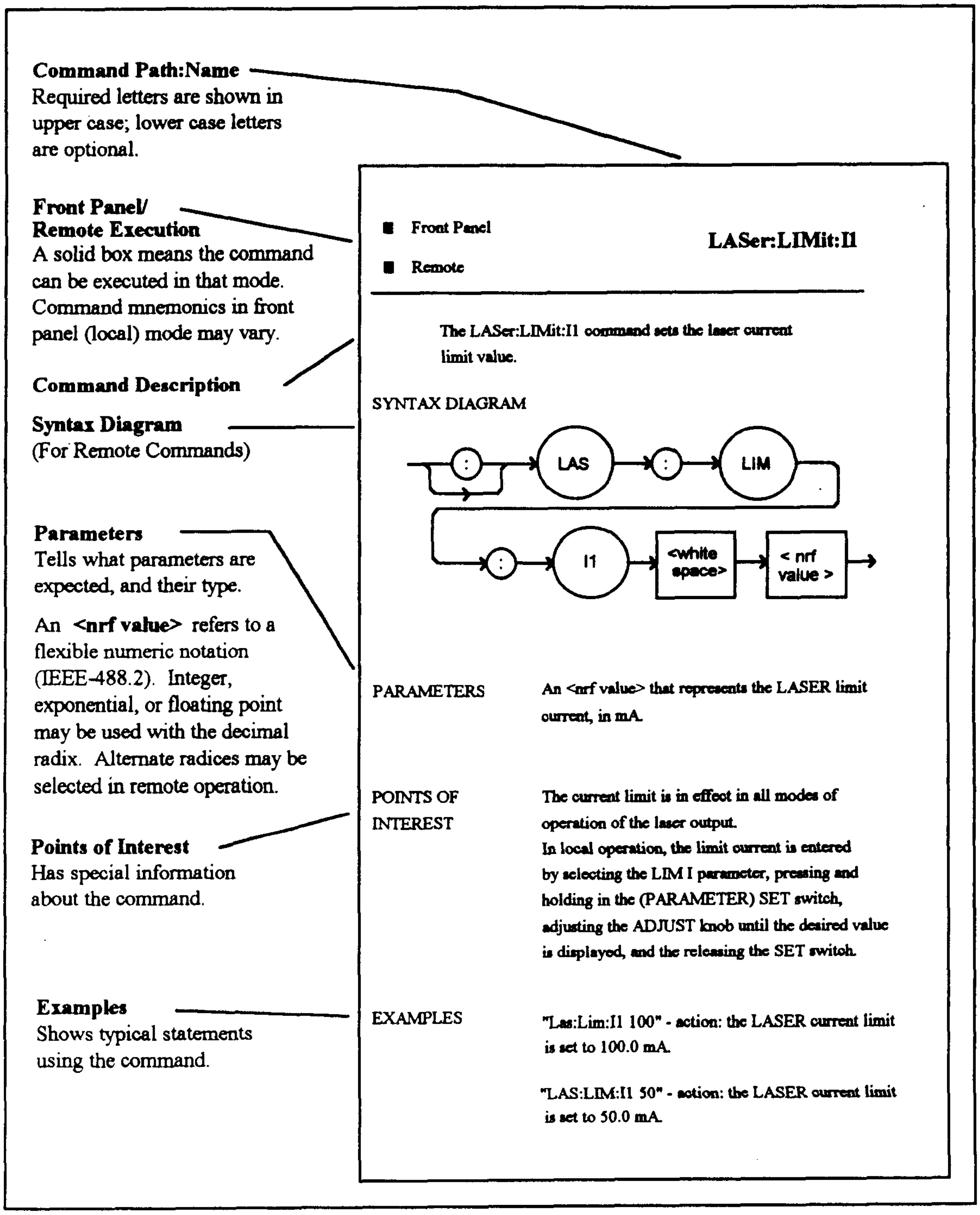



**Figure 4.1 Command Description Format**

### 4.4.1 Command Paths

The LDC-3700 Series Laser Diode Controller device-dependent commands are structured into tree format (see Figure 4.2). Each of the legal paths is listed below, followed by its list of path options, each of which is followed by the commands themselves.

It is recommended that the first-time user begin learning the commands by using the full path notation. Once you are familiar with the commands, you may wish to take advantage of the shortcuts allowed for command paths (see Section 3.5).

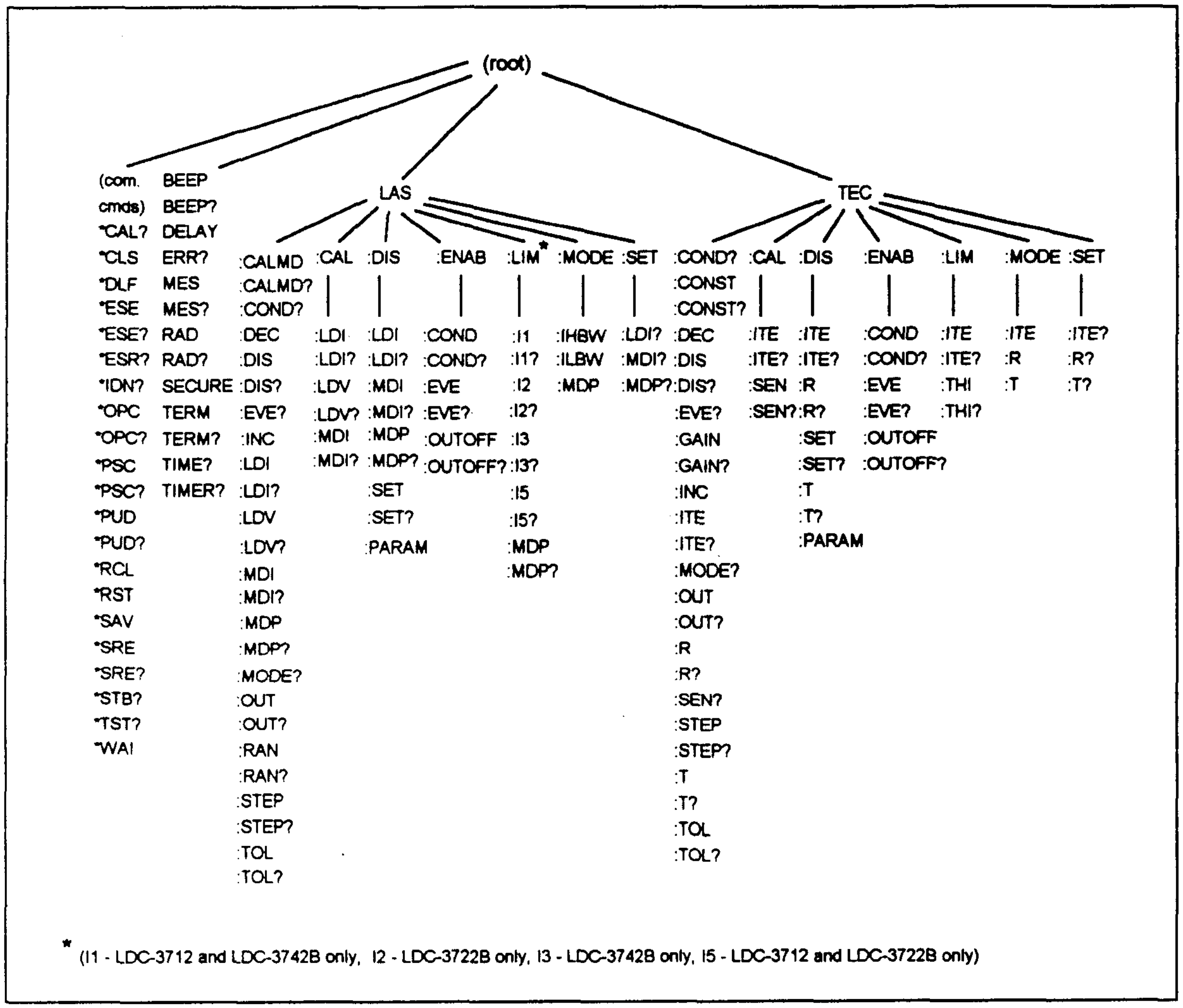



**Figure 4.2 LDC-3700 Series Laser Diode Controller Command Path Structure**

### 4.4.2 LDC-3700 Series Laser Diode Controller Device-Command Reference

The following pages contain a reference for the device-dependent commands of the LDC-3700 Series Laser Diode Controller. This reference contains useful information for both local and remote operation of the LDC-3700 Series Laser Diode Controller.

References to the front panel labels are capitalized in the following reference pages (as is done throughout this manual). Therefore, a reference to the LASER display is meant to signify the actual 5-digit display labeled LASER on the front panel of the LDC-3700 Series Laser Diode Controller, while a reference to the LASER DISPLAY refers to the same-labeled switch area of the LDC-3700 Series Laser Diode Controller.

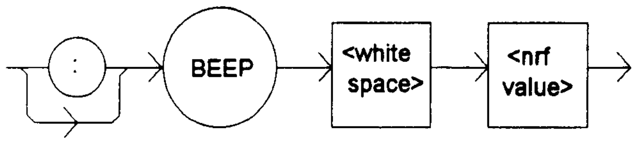
In some references, parentheses are used to signify the labeled area for a particular switch or LED indicator on the front panel. For example, (TEC DISPLAY) SET refers to the switch labeled "SET" in the TEC DISPLAY area of the front panel.

☐ Front Panel
■ Remote

# BEEP

The BEEP command controls the LDC-3700 Series Laser Diode Controller's beeper. The beeper can be used to signal error or warning conditions.

SYNTAX DIAGRAM




PARAMETERS An <nrf value>, 0 = OFF (totally disabled); 1 = ON, enabled for normal operation; and 2 = beep once.

POINTS OF INTEREST Disabling the BEEP will prevent the audible beeper signal from working during front panel operation, including the calibration signals. The parameter must be a numeric value (0, 1, or 2), and not a character data substitute (such as ON or OFF).

EXAMPLES "BEEP 0" -action: The beeper is disabled.

"BEEP 1" -action: The beeper is enabled for normal operation.

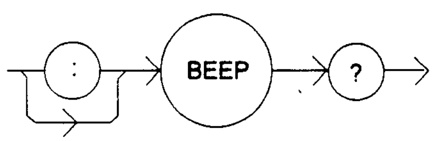
"BEEP 2" -action: The beeper is beeped once.

☐ Front Panel
■ Remote

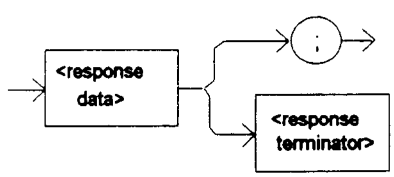
# BEEP?

The BEEP? query returns the enable status of the LDC-3700 Series Laser Diode Controller's beeper.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where a <response data> of 0 = OFF (totally disabled); 1 = ON, enabled for normal operation.

POINTS OF INTEREST

Disabling the BEEP will prevent the audible beeper signal from working during front panel operation, including the calibration signals.

The beeper is normally enabled, unless it is specifically disabled via the "BEEP 0" remote command.

EXAMPLES

"BEEP?" -response: 0, means the beeper is disabled.

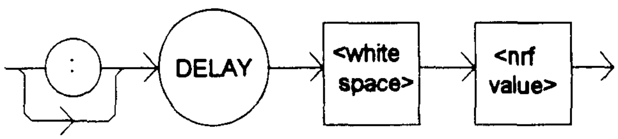
"Beep?" -response: 1, means the beeper is enabled for normal operation.

☐ Front Panel
■ Remote

## DELAY

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

SYNTAX DIAGRAM




PARAMETERS

An <nrf value> which represents the delay time, in milliseconds.

POINTS OF INTEREST

The Operation-Complete flag is held false until the delay period elapses, but the *OPC? query will not execute until the delay period has elapsed.

This command is useful for creating delays which don't require a lot of program code and don't tie up the GPIB during execution.

EXAMPLES

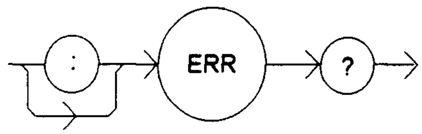
"DELAY 500" -action: Further commands and queries are not executed until 0.5 seconds have elapsed from the time this command is executed.

"Tec:T 22;Delay 2000;Tec:T?" -actions: The TEC is set to 22.0°C, then the LDC-3700 Series Laser Diode Controller waits for about 2.0 seconds before returning the measured temperature.

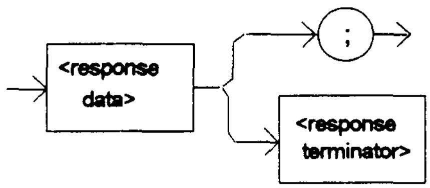
# ERRors?

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

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where each <response data unit> consists of an error code value.

POINTS OF INTEREST The response data will be a list of the current errors. The errors are represented by numbers and are separated by commas. A response of 0 indicates that no errors were reported. The response data is sent as character data.

EXAMPLES "ERR?" -response: 0, means no errors reported.

"Errors?" -response: 201,407, means that the <PROGRAM DATA> (parameter) value out of range error and the High Temperature Limit error were reported since the last query.

# LASer:

The LASer: command path is used to get to the LDC-3700 Series Laser Diode Controller's laser current source commands. The following command paths may be reached from the LASer: command path.

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

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

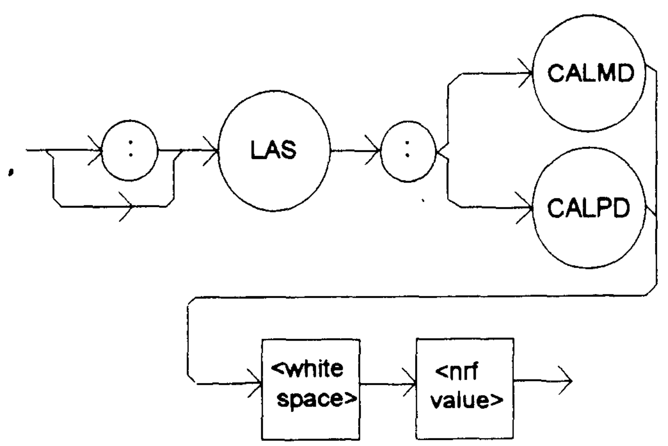
| | | |
|---|---|---|
| LASer:CALMD | LASer:LDI | LASer:OUTput |
| LASer:CALMD? | LASer::LDI? | LASer:OUTput? |
| LASer:COND? | LASer:LDV | LASer:MODE |
| LASer:DEC | LASer::LDV? | LASer:RANge |
| LASer:DISplay | LASer:MDI | LASer:RANge? |
| LASer:DISplay? | LASer:MDI? | LASer:STEP |
| LASer:EVEnt? | LASer:MDP | LASer:STEP? |
| LASer:INC? | LASer:MDP? | LASer:TOLerance |
| | | LASer:TOLerance? |

■ Front Panel
■ Remote

# LASer:CALMD

The LASer:CALMD command sets the laser's photodiode feedback responsivity (the CAL PD parameter).

SYNTAX DIAGRAM




PARAMETERS An <nrf value>, in microamps/milliwatt.

POINTS OF INTEREST

If the parameter is set to 0, the LDC-3700 Series Laser Diode Controller will operate in a constant $I_{PD}$ mode, when Constant P mode is selected.

The parameter should be set to 0 for $I_{PD}$ calibration modes. Otherwise, the value of this parameter is used to convert between $I_{PD}$ and $P_{PD}$ values. The units of this parameter are microamps/milliwatt.

In local operation, the LASER:CALMD value is entered via the CAL PD parameter. When the CAL PD parameter is selected (LED lit), pressing and holding in the (PARAMETER) SET switch will allow the user to enter the parameter value by adjusting the ADJUST knob.

EXAMPLES

"LAS:CALMD 0" -action: sets the CAL PD parameter to 0. This enables the constant $I_{PD}$ mode of operation.

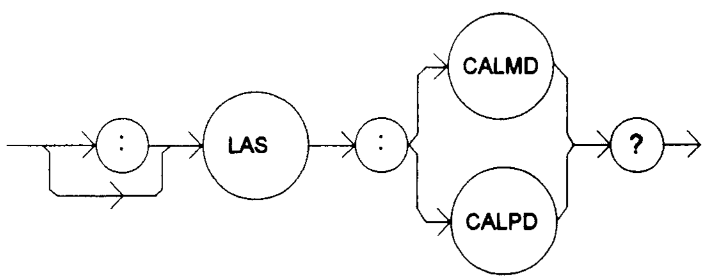
"Laser:Calmd 1" -action: sets the CAL PD parameter to 1.00 microamp/milliwatt. Therefore, a photodiode feedback current of 1 microamp will cause the $P_{PD}$ display to read 1 milliwatt.

■ Front Panel
■ Remote

## LASer:CALMD?

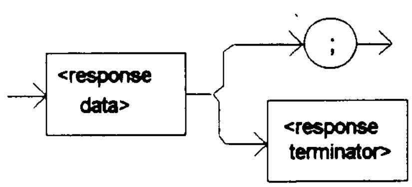
The LASer:CALMD? query returns the value of the laser's photodiode feedback responsivity (CAL PD parameter) setting.

SYNTAX DIAGRAM




PARAMETERS

None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST

If this value is 0, the LDC-3700 Series Laser Diode Controller will be set to operate in constant $I_{PD}$ mode, and the $I_{PD}$ set point value will be in effect. If this value is non-zero, the

LDC-3700 Series Laser Diode Controller will be set to operate in constant $P_{PD}$ mode, and the $P_{PD}$ set point value will be in effect.

If this value is 0, the front panel $P_{PD}$ will display "-.-", and no $P_{PD}$ value can be calculated.

In local operation, the CALMD (CAL PD) value can be read by selecting the CAL PD parameter and visually reading the LASER display.

EXAMPLES "LASER:CALMD?" -response: 0, means the LDC-3700 Series Laser Diode Controller is set for operation in constant $I_{PD}$ mode (if P mode is also selected).

"Las:Calmd?" -response: 1.1, means the LDC-3700 Series Laser Diode Controller is set for operation in constant $P_{PD}$ mode (if P mode is also selected) and the responsivity is set to 1.1 uA/mW. 1.1 uA of photodiode feedback current represents 1 mW of optical power.

■ Front Panel
■ Remote

## LASer:CAL:

The LASer:CAL: command path is used to get to the LDC-3700 Series Laser Diode Controller's laser calibration commands.

In local operation, the LASER calibration mode is reached by pressing the (GPIB) LOCAL and (LASER DISPLAY) I or $I_{PD}$ switches at the same time.

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

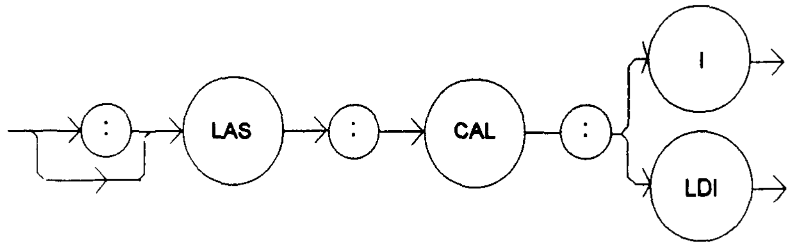
LASer:CAL:LDI
LASer:CAL:LDI?
LASer:CAL:LDV?
LASer:CAL:LDV?
LASer:CAL:MDI
LASer:CAL:MDI?

■ Front Panel
■ Remote

## LASer:CAL:LDI

The LASer:CAL:LDI command is used to enter the LASER current set point, measurement, and limit (in low bandwidth mode) calibration mode.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

Since the limit circuit is the same for both high and low bandwidth modes, it is only calibrated when low bandwidth mode is selected.

After this command is issued, the LDC-3700 Series Laser Diode Controller will allow calibration of the current set point, measurement, and limit (if low bandwidth mode is selected). This procedure is outlined in Section 6.4.2.

The calibration defaults to the selected bandwidth setting. Therefore, it is necessary to select the desired bandwidth (I or $I_{HBW}$), and turn the LASER output on before performing the calibration for that bandwidth.

Calibration is performed at the current set point, wherever it is set. If the LASER output is not ON, the LDC-3700 Series Laser Diode Controller will beep each time you try to enter this mode, indicating a calibration procedural error.

In remote operation, the LASer:CAL:LDI? query may be used to determine if the LDC-3700 Series Laser Diode Controller is ready for the user to enter a value.

In local operation, the LDC-3700 Series Laser Diode Controller will beep once when it is ready for the user to enter a value.

EXAMPLES

"Las:CAL:LdI" -action: the LDC-3700 Series Laser Diode Controller enters calibration mode for LASER current.

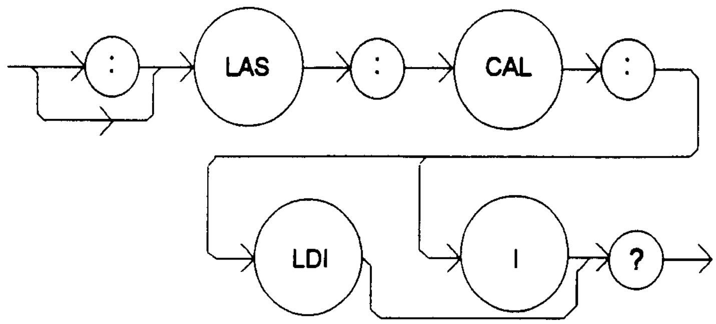
"Las:Cal:LDI" -action: the LDC-3700 Series Laser Diode Controller enters calibration mode for LASER current.

■ Front Panel
■ Remote

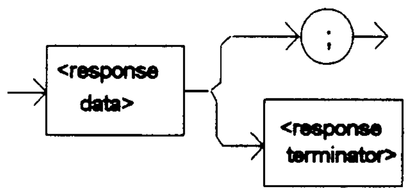
## LASer:CAL:LDI?

The LASer:CAL:LDI? query is used to determine that the LDC-3700 Series Laser Diode Controller is ready for a value to be entered during the calibration cycle of the LASer:CAL:LDI mode.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where 1 = ready, 0 = not ready.

POINTS OF INTEREST After this query is issued and a response of 1 is received, the LDC-3700 Series Laser Diode Controller will be ready for the user to enter a current value via the LASer:LDI command (see Section 6.4.2).

In local operation, the ready state during the calibration cycle is indicated by a beep (if the beeper is enabled) which is issued by the LDC-3700 Series Laser Diode Controller when it is ready for a value to be entered.

EXAMPLES "LASer:CAL:LDI?" -response: 1, means the LDC-3700 Series Laser Diode Controller is ready for the user to enter a current value via the LASer:LDI command.

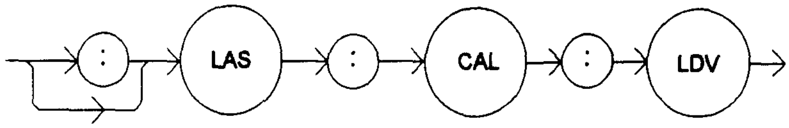
"LASer:Cal:LdI?" -response: 0, means the LDC-3700 Series Laser Diode Controller is not yet ready for the user to enter a LASER current value.

☐ Front Panel
■ Remote

## LASer:CAL:LDV

The LASer:CAL:LDV command is used to enter the LASER voltage measurement calibration mode.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

After this command is issued, the LDC-3700 Series Laser Diode Controller will allow calibration of the laser voltage measurement. This procedure is outlined in Section 6.4.5.

The LASer:CAL:LDV? query may be used to determine if the LDC-3700 Series Laser Diode Controller is ready for the user to enter a value.

EXAMPLES

"Las:CAL:Ldv" -action: the LDC-3700 Series Laser Diode Controller enters calibration mode for LASER voltage.

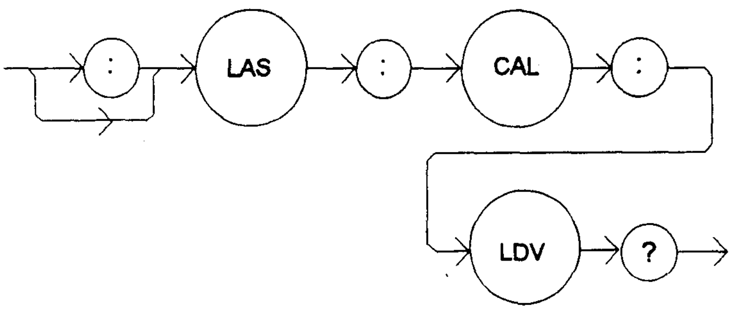
"Las:Cal:LDV" -action: the LDC-3700 Series Laser Diode Controller enters calibration mode for LASER voltage.

□ Front Panel
■ Remote

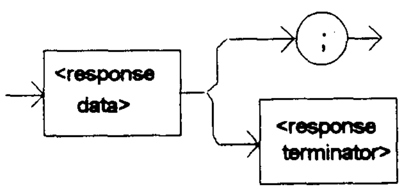
## LASer:CAL:LDV?

The LASer:CAL:LDV? query is used to determine that the LDC-3700 Series Laser Diode Controller is ready for a value to be entered during the calibration cycle of the LASer:CAL:LDV mode.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where 1 = ready, 0 = not ready.

POINTS OF INTEREST

After this query is issued and a response of 1 is received, the LDC-3700 Series Laser Diode Controller will be ready for the user to enter a current value via the LASer:LDV command (see Section 6.4.5).

EXAMPLES

"LASer:CAL:LDV?" -response: 1, means the LDC-3700 Series Laser Diode Controller is ready for the user to enter a voltage value via the LASer:LDV command.

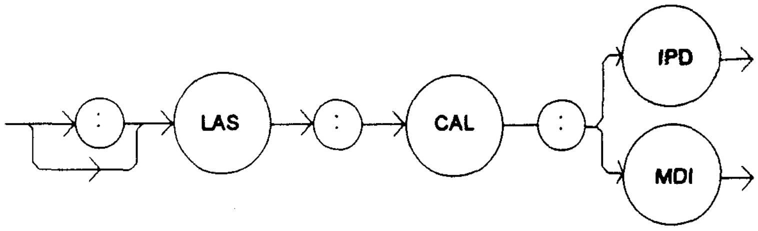
"LASer:Cal:LdV?" -response: 0, means the LDC-3700 Series Laser Diode Controller is not yet ready for the user to enter a LASER voltage value.

■ Front Panel
■ Remote

## LASer:CAL:MDI

The LASer:CAL:MDI command is used to enter the LASER photodiode current calibration mode.

SYNTAX DIAGRAM




PARAMETERS

None.

POINTS OF INTEREST

After this command is issued, the LDC-3700 Series Laser Diode Controller will automatically enter the LASER photodiode current calibration mode for the current LASER range. When the LDC-3700 Series Laser Diode Controller is ready, the user should enter the true measured value. This procedure is outlined in Section 6.4.4.

If the LASER output is not ON, or the CALMD (CAL PD) parameter value is 0, or the P mode is not selected, the LDC-3700 Series Laser Diode Controller will beep each time you try to enter this mode, indicating a calibration procedural error.

In remote operation, the LASer:CAL:MDI? query may be used to determine if the LDC-3700 Series Laser Diode Controller is ready for the user to enter a value via the LASer:MDI command.

In local operation, the LDC-3700 Series Laser Diode Controller will BEEP when it is ready for the user to enter a value.

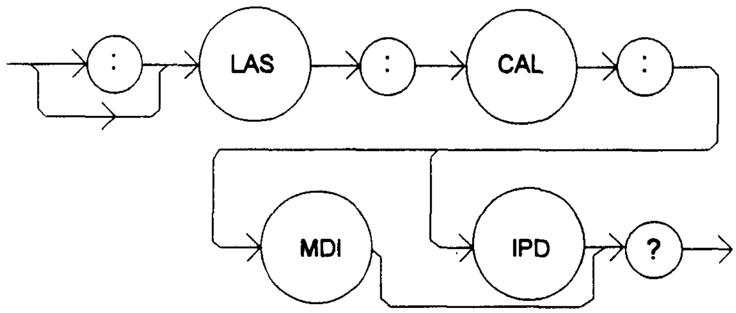
EXAMPLES

"Las:CAL:MDI" -action: the LDC-3700 Series Laser Diode Controller enters the LASER photodiode current calibration mode.

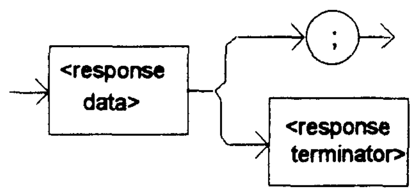
"LAS:Cal:MDI" -action: the LDC-3700 Series Laser Diode Controller enters the LASER photodiode current calibration mode.

The LASer:CAL:MDI? query is used to determine that the LDC-3700 Series Laser Diode Controller is ready for a value to be entered during the calibration cycle of the LASer:CAL:MDI mode.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where 1 = ready, 0 = not ready.

POINTS OF INTEREST

After this query is issued and a response of 1 is received, the LDC-3700 Series Laser Diode Controller be ready for the user to enter a current value via the LASer:MDI command (see Section 6.4.4).

In local operation, the ready state during the calibration cycle is indicated by a beep which is issued by the LDC-3700 Series Laser Diode Controller when it is ready for a value to be entered.

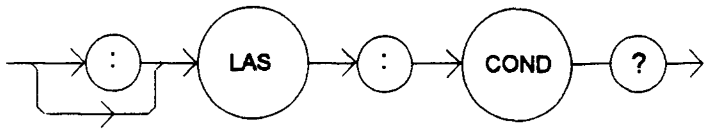
EXAMPLES

"LAS:CAL:MDI?" -response: 1, means the LDC-3700 Series Laser Diode Controller is ready for the user to enter a photodiode current value via the LASer:MDI command.

"Laser:Cal:Mdi?" -response: 0, means the LDC-3700 Series Laser Diode Controller is not yet ready for the user to enter a photodiode current value.

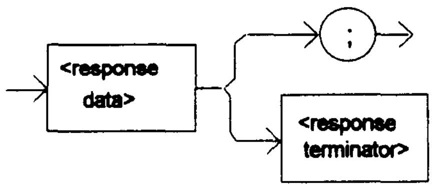
The LASer:COND? query returns the value of the status condition register of the LASER operations.

SYNTAX DIAGRAM




PARAMETERS

None. The response will be in the form:




-where the response is the sum of the following:

| | |
|---|---|
| 1 - LASER Current Limit | 256 - Output is shorted |
| 2 - LASER Voltage Limit | 512 - Output is outside tolerance limit |
| 4 - N/A | 1024 - Output on/off state |
| 8 - Power limit | 2048 - Ready for calibration data state |
| 16 - Interlock disabled | 4096 - Calculation error |
| 32 - N/A | 8192 - Error communicating with LASER board |
| 64 - N/A | 16384 - Software error in LASER control |
| 128 - Open circuit | 32768 - LASER eeprom checksum error |

POINTS OF INTEREST

The LASER conditions which are reported to the status byte are set via the LASer:ENABle:COND command.

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 command is issued.

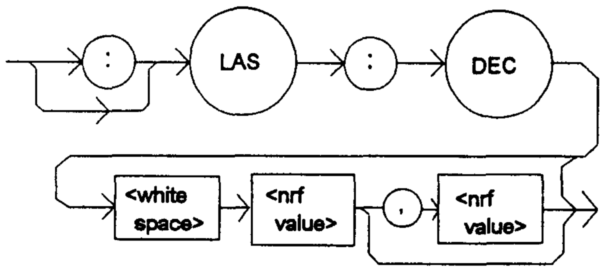
EXAMPLES

"LAS:COND?" -response: 513, means that the LASER limit current and out of tolerance LASER conditions currently exist.

"Radix Hex; Laser:Cond?" -response: #H108, means that the LASER Output shorted and Power limit conditions currently exist.

The LASer:DEC command decrements the selected laser control mode set point by one or more steps. Optional parameters allow multiple steps to be decremented and the time (in milliseconds) between decrements to be set, respectively.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

The decremental default amount is one step. The step size can be edited via the LAS:STEP command. LDC-3712 default values are 0.001/0.002 mA (50/100 mA range), 0.01 mW, or 1 uA (if CALMD = 0), depending on the mode of operation. LDC-3722B default values are 0.01 mA, 0.01 mW, or 1 uA. LDC-3742B default values are 0.1 mA, 0.1 mW, or 1 uA.

If the first optional parameter is used, but not the second, the user may decrement the LASER set point by a multiple of the LAS:STEP size, without changing the LAS:STEP size.

If the both optional parameters are used, the user may create an automated stepping ramp function for the LASER output.

If the first optional parameter is entered as zero, "LAS:DEC 0", the command will do nothing.

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

EXAMPLES

"LAS:MODE:I; LAS:STEP 3; LAS:DEC" -action: The laser source current set point is decremented by 0.3 mA (LDC-3742B), or 0.03 mA (LDC-3722B), or 0.003 mA (LDC-3712 on 50 mA range), or 0.006 mA (LDC-3712 on 100 mA range).

"LAS:MODE:I; LAS:STEP 3; LAS:DEC 3" -action: The laser source current set point is decremented by three times the amount described in the first example.

"LAS:MODE:I; LAS:STEP 3; LAS:DEC 3,5000" -action: The laser source current set point is decremented by the amount described in the first example, three times, with 5 seconds between decremental steps.

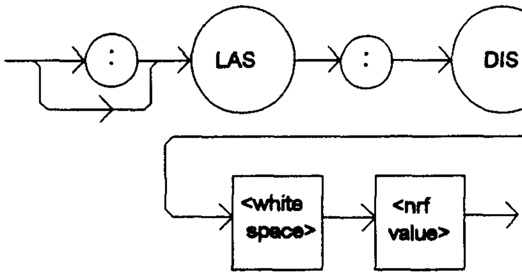
"LAS:STEP 1; LAS:Mode:P; Las:DEC" -action: The power set point is decremented by 0.1 mW (LDC-3742B) or 0.01 mW (LDC-3722B or LDC-3712).

☐ Front Panel
■ Remote

## LASer:DISplay

The LASer:DISplay command enables or disables (turns off) the LASER display and LASER section's indicator LEDs.

SYNTAX DIAGRAM




PARAMETERS An <nrf value>

-where 1 = on, 0 = off.

POINTS OF INTEREST Turning the LASER display and LEDs off means that a message of all blank spaces is sent to the LASER display, and all of the LASER section's indicator LEDs will be turned off.

EXAMPLES "las:dis 1" -action: turns the LASER display on and enables the LASER indicator LEDs.

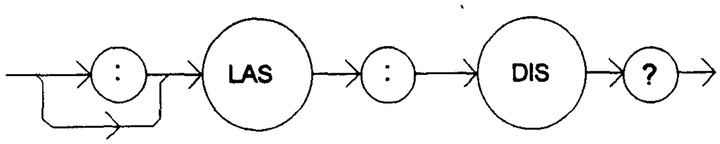
"Laser:dis Off" -action: turns the LASER display and disables the LASER indicator LEDs.

■ Front Panel
■ Remote

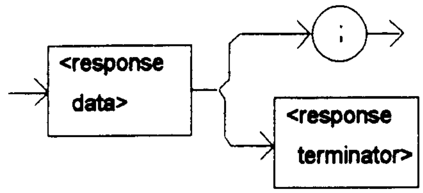
## LAS:DISplay?

The LASer:DISplay? query returns the value shown on the LASER display.

SYNTAX DIAGRAM



PARAMETERS None. The response will be in the form:




POINTS OF INTEREST

Returns the actual (6-character) string from the output buffer to the LASER display. If the display is disabled, it returns "    .".

In local mode, the user would read the LASER display visually.

EXAMPLES

"LAS:DIS?" -response: "- 99.9", means the LASER display shows "- 99.9".

"Laser:DISp?" -response: "  0.6", means the LASER display shows "  0.6".

■ Front Panel
■ Remote

## LASer:DISplay:

The LASer:DISplay: command path is used to get to the LDC-3700 Series Laser Diode Controller's laser display commands.

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

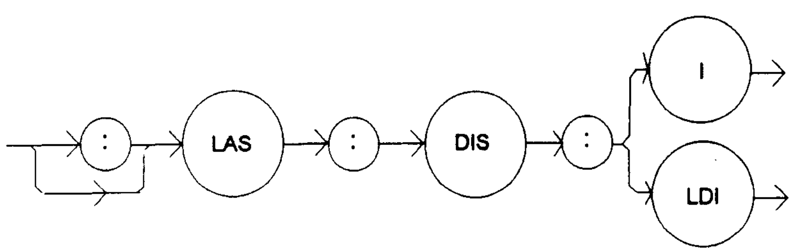
| | | |
|---|---|---|
| LASer:DISplay:LDI | LASer:DISplay:MDI? | LASer:DISplay:PARAM |
| LASer:DISplay:LDI? | LASer:DISplay:MDP | LASer:DISplay:SET |
| LASer:DISplay:MDI | LASer:DISplay:MDP? | LASer:DISplay:SET? |

■ Front Panel
■ Remote

## LASer:DISplay:LDI

The LASer:DISplay:LDI command sets the laser display to show the constant current measurement.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

The actual LASER I display is turned off automatically when another LASER DISPLAY selection is enabled.

In local operation, the LASER I value is displayed by pressing the I switch in the LASER DISPLAY area of the front panel.

EXAMPLES

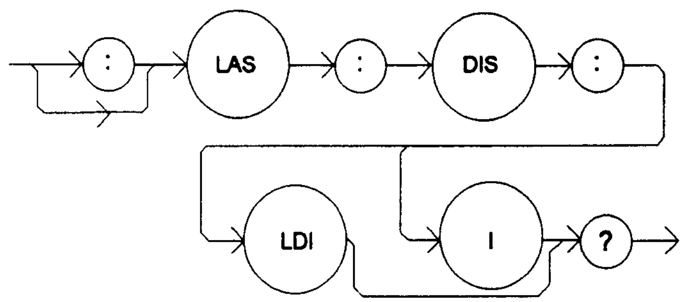
"LAS:DIS:LDI" -action: enables the LASER display for current values.

■ Front Panel
■ Remote

## LASer:DISplay:LDI?

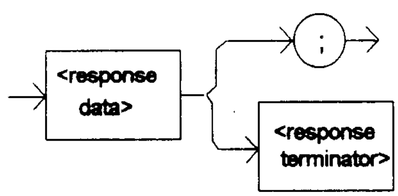
The LASer:DISplay:LDI? query returns the status of the (LAS DISPLAY) I switch.

SYNTAX DIAGRAM




PARAMETERS

None. The response will be in the form:




-where the response of 0 = off, 1 = on.

POINTS OF INTEREST

In local operation, the status of the I switch is determined by visually inspecting the I and SET indicators in the LASER DISPLAY area of the front panel. The status of the I switch is "on" if its indicator is lit and the SET indicator is not lit.

EXAMPLES

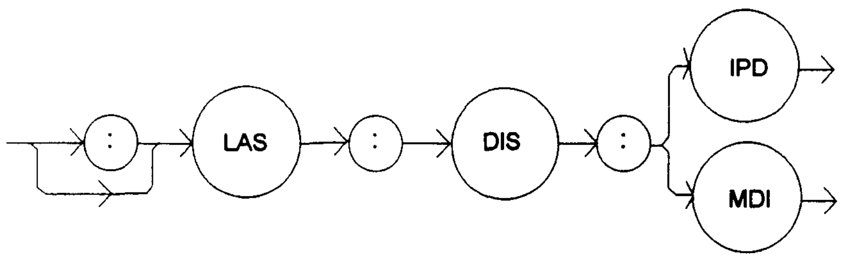
"LAS:DIS:LDI?" -response: 0, means that the (LASER DISPLAY) I switch is not currently active, laser current is not displayed.

"Las:dis:ldI?" -response: 1, means that the (LASER DISPLAY) I switch is currently active, laser current may be displayed.

# LASer:DISplay:MDI

The LASer:DISplay:MDI command sets the laser display to show the monitor photodiode current measurement.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST The actual (LASER DISPLAY) $I_{PD}$ display is turned off automatically when another LASER DISPLAY selection is enabled.

In local operation, the (LASER DISPLAY) $I_{PD}$ value is displayed by pressing the $I_{PD}$ switch in the LASER DISPLAY area of the front panel.

EXAMPLES "LAS:DIS:MDI" -action: enables the LASER display for photodiode current values.

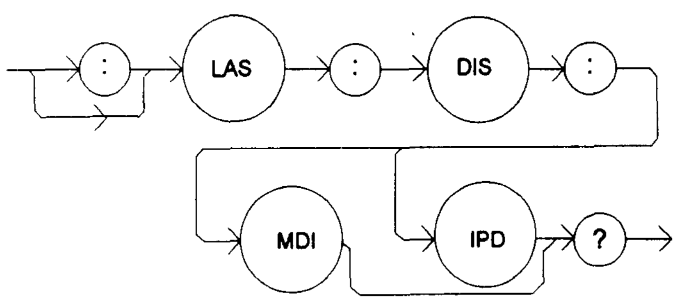
Laser:Disp:Mdi" -action: enables the LASER display for photodiode current values.

■ Front Panel
■ Remote

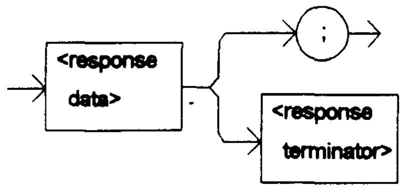
# LASer:DISplay:MDI?

The LASer:DISplay:MDI? query returns the status of the (LASER DISPLAY) $I_{PD}$ switch.

SYNTAX DIAGRAM



PARAMETERS None. The response will be in the form:




-where the response of 0 = off, 1 = on.

POINTS OF INTEREST

In local operation, the status of the $I_{PD}$ switch is determined by visually inspecting the $I_{PD}$ indicator in the LASER DISPLAY area of the front panel. The status of the $I_{PD}$ switch is "on" if its indicator is lit and the SET indicator is not lit (lit = ON).

EXAMPLES

"LAS:DIS:MDI?" -response: 0, means that the (LASER DISPLAY) $I_{PD}$ switch is not currently active, laser photodiode monitor current is not displayed.

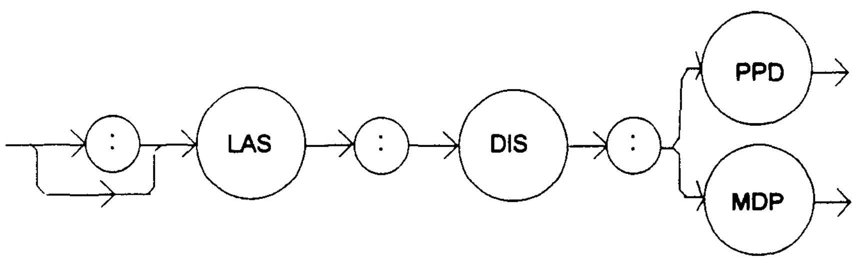
"Las:dis:MDI?" -response: 1, means that the (LASER DISPLAY) $I_{PD}$ switch is currently active, monitor PD current may be displayed.

■ Front Panel
■ Remote

## LASer:DISplay:MDP

The LASer:DISplay:MDP command sets the laser display to show the monitor photodiode power measurement.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

The actual (LASER) $P_{PD}$ display is turned off automatically when another LASER DISPLAY selection is enabled.

In local operation, the (LASER) $P_{PD}$ value is displayed by pressing the $P_{PD}$ switch in the LASER DISPLAY area of the front panel.

EXAMPLES

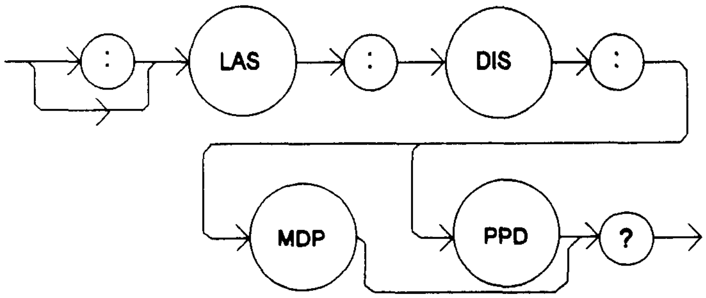
"Las:Display:MDp" -action: enables the LASER display for photodiode power values.

"Laser:Disp:MDP" -action: enables the LASER display for photodiode power values.

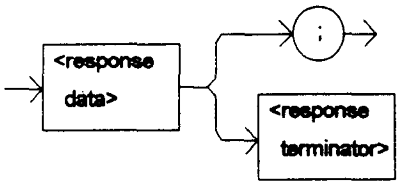
# LASer:DISplay:MDP?

The LASer:DISplay:PPD? query returns the status of the (LASER DISPLAY) $P_{PD}$ switch.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response of 0 = off, 1 = on.

POINTS OF INTEREST In local operation, the status of the $P_{PD}$ switch is determined by visually inspecting the $P_{PD}$ indicator in the LASER DISPLAY area of the front panel. The status of the $P_{PD}$ switch is "on" if its indicator is lit and the SET indicator is not lit.

EXAMPLES "LAS:DISp:MDp?" -response: 0, means that the (LASER DISPLAY) $P_{PD}$ switch is not currently active, laser photodiode monitor power is not displayed.

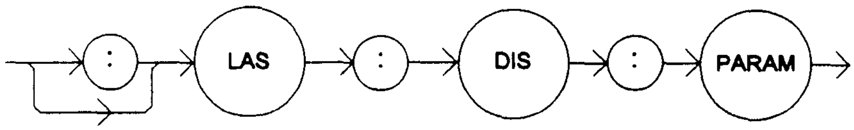
"Las:dis:MDP?" -response: 1, means that the (LASER DISPLAY) $P_{PD}$ switch is currently active, PD power may be displayed.

■ Front Panel
■ Remote

## LASer:DISplay:PARAM

The LASer:DISplay:PARAM command enables the LASer display to show the LASER parameter values.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

This command has the same effect as pressing the (PARAMETER) SELECT switch while in LASER mode. The selected parameter will be displayed for three seconds. The actual LASER PARAM display is turned off automatically when a LASER display selection is enabled.

Each time the command is issued, the next LASER parameter will be selected, see Section 2.13.

In local operation, the LASER PARAMETER is displayed by pressing the SELECT switch in the LASER PARAMETER area of the front panel, while in LASER mode.

EXAMPLES "Laser:Display:Param" -action: selects a LASER parameter and displays its value.

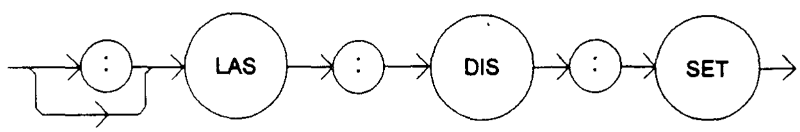
"LAS:DIS:PARAM" -action: selects a LASER parameter and displays a its value.

■ Front Panel
■ Remote

## LASer:DISplay:SET

The LASer:DISplay:SET command sets the laser display to show the set point of the selected LASER DISPLAY mode.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

Using this command has the same effect as physically holding the DIS SET switch down (in).

EXAMPLES "Las:Dis:Set" -action: enables the LASER display for the set point of the selected mode: LDI, MDI ($I_{PD}$) or MDP ($P_{PD}$)

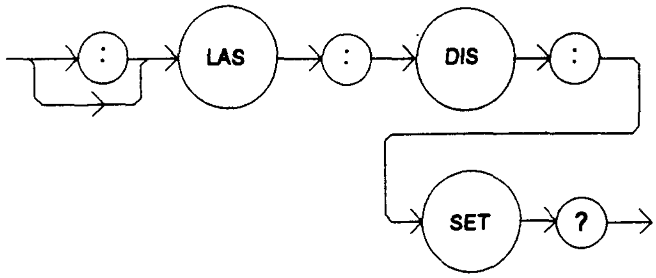
"LAS:Dis:Set" -action: enables the LASER display for the set point of the selected display mode.

■ Front Panel
■ Remote

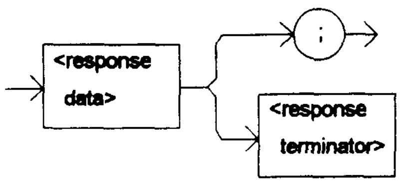
## LASer:DISplay:SET?

The LASer:DISplay:SET? query returns the status of the (LASER DISPLAY) SET switch.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST The set point display will not time out when REMOTE operation is used. (It will be continuously displayed.)

In local operation, the status of the SET switch is determined by visually inspecting the LED on the switch (lit = ON).

EXAMPLES "LAS:DISPLAY:SET?" -response: 0, means the measured value is enabled for the LASER display.

"Las:Dis:Set?" -response: 1, means the set point value is enabled for the LASER display.

# LASer:ENABle:

The LASer:ENABle: command path is used to get to the LDC-3700 Series Laser Diode Controller's laser status enable commands and queries.

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

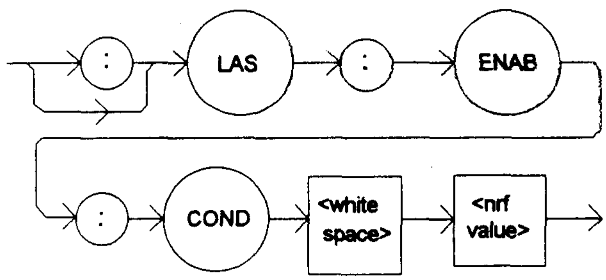
| | |
|---|---|
| LASer:ENABle:COND | LASer:ENABle:EVEnt? |
| LASer:ENABle:COND? | LASer:ENABle:OUTOFF |
| LASer:ENABle:EVEnt | LASer:ENABle:OUTOFF? |

☐ Front Panel
■ Remote

# LASer:ENABle:COND

The LASer:ENABle:COND command sets the condition status enable register of the LASER operations for summary (in bit 3 of the status byte) and generation of service requests.

SYNTAX DIAGRAM




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

| | |
|---|---|
| 1 - LASER Current Limit | 256 - Output is Shorted |
| 2 - LASER Voltage Limit | 512 - Output is Outside Tolerance Limit |
| 4 - N/A | 1024 - Output On/Off State |
| 8 - Power Limit | 2048 - Ready for Calibration Data State |
| 16 - Interlock Disabled | 4096 - Calculation Error |
| 32 - N/A | 8192 - Error Communicating LASER Board |
| 64 - N/A | 16384 - Software Error in LASER Control |
| 128 - Open Circuit | 32768 - LASER Eeprom Checksum Error |

POINTS OF INTEREST

The enabled or disabled LASER conditions can be read by using the LASer:ENABle:COND? query.

The LASER condition status can be monitored by the LASer:COND? query. If any of the enabled LASER conditions are true, bit 3 of the status byte register will be set.

The enable registers normally retain their values at power-up (as they were at power-down) unless the power-on status clear flag is set true (see *PSC, Chapter 3).

EXAMPLES

"LAS:ENAB:COND 129" -action: enables the LASER status condition register so that the Open circuit and LASER current limit conditions will be summarized in the status byte (bit 3).

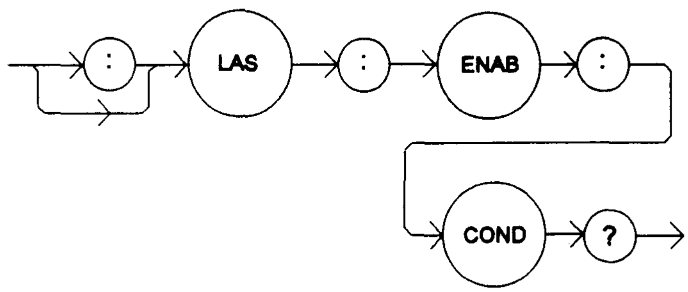
Laser:Enable:Cond #HFF97" - action: enables the LASER status condition register so that any and all of the above conditions will be reported in the status byte register (bit 3).

☐ Front Panel
■ Remote

## LASer:ENABle:COND?

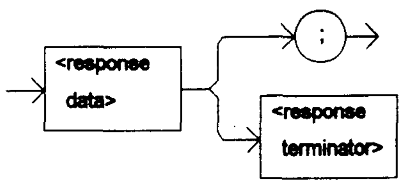
The LASer:ENABle:COND? query returns the value of the status condition enable register of the LASER operations.

SYNTAX DIAGRAM




PARAMETERS

None. The response will be in the form:




-where the response is the sum of the following:

1 - LASER Current Limit
2 - LASER Voltage Limit
4 - N/A
8 - Power Limit
16 - Interlock Disabled
32 - N/A
64 - N/A
128 - Open Circuit

256 - Output is Shorted
512 - Output Changed to be In/Out of Tolerance
1024 - Output On/Off State
2048 - Ready for Calibration Data State
4096 - Calculation Error
8192 - Error Communicating LASER Board
16384 - Software Error in LASER Control
32768 - LASER Eeprom Checksum Error

POINTS OF INTEREST

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

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

EXAMPLES "LAS:ENAB:COND?" -response: 17, means that the Laser Current Limit and Interlock disabled LASER conditions will be reported (in summarized form) to the status byte (bit 3).

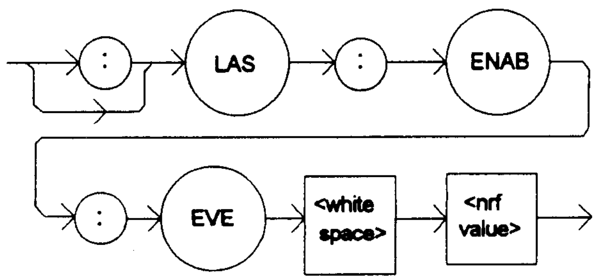
"Radix Hex; Laser:Enable:Cond?" -response: #HFF97, means that all of the above conditions will be reported (in summarized form) to the status byte (bit 3).

☐ Front Panel
■ Remote

## LASer:ENABle:EVEnt

The LASer:ENABle:EVEnt command sets the status event enable register of the LASER operations. These events are summarized in bit 2 of the status byte register.

SYNTAX DIAGRAM




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

| | |
|---|---|
| 1 - LASER Current Limit | 256 - Output is Shorted |
| 2 - LASER Voltage Limit | 512 - Output Changed to be In/Out of Tolerance |
| 4 - N/A | 1024 - Output On/Off State Changed |
| 8 - Power Limit | 2048 - New Measurements Taken |
| 16 - Interlock Changed State | 4096 - Calculation Erro[illegible] |
| 32 - N/A | 8192 - Er[illegible] Communi[illegible]ing LASER Board |
| 64 - N/A | 16384 - [illegible]vare Error in LASER Control |
| 128 - Open Circuit | 32768 - LASER Eeprom Checksum Error |

POINTS OF INTEREST The enabled LASER events can be read by using the LASer:ENABle:EVEnt? query. The LASER event status can be monitored by the LASer:EVEnt? query.

The enable registers normally retain their values at power-up (as they were at power-down) unless the power-on status clear flag is set true (see *PSC, Chapter 3).

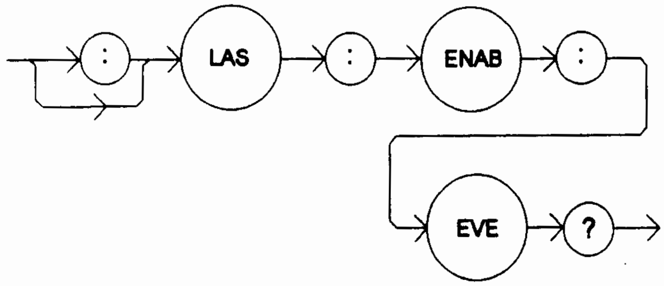
EXAMPLES "LAS:ENAB:EVENT 136" -action: enables the LASER status event register so that the Open circuit and Power limit events will be reported (in summarized form) to the status byte (bit 2).

"Laser:Enable:Event #HFF9B" -action: enables the LASER status event register so all of the above events will be reported (in summarized form) to the status byte (bit 2).

# LASer:ENABle:EVEnt?

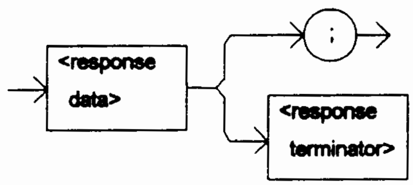
The LASer:ENABle:EVEnt? query returns the value of the status event enable register of the LASER operations.

SYNTAX DIAGRAM




PARAMETERS

None. The response will be in the form:




-where the response is the sum of the following:

| | |
|---|---|
| 1 - LASER Current Limit | 256 - Output is Shorted |
| 2 - LASER Voltage Limit | 512 - Output Changed to be In/Out of Tolerance |
| 4 - N/A | 1024 - Output On/Off State |
| 8 - Power Limit | 2048 - New Measurements Taken |
| 16 - Interlock State Changed | 4096 - Calculation Error |
| 32 - N/A | 8192 - Error Communicating LASER Board |
| 64 - N/A | 16384 - Software Error in LASER Control |
| 128 - Open Circuit | 32768 - LASER Eeprom Checksum Error |

POINTS OF INTEREST

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

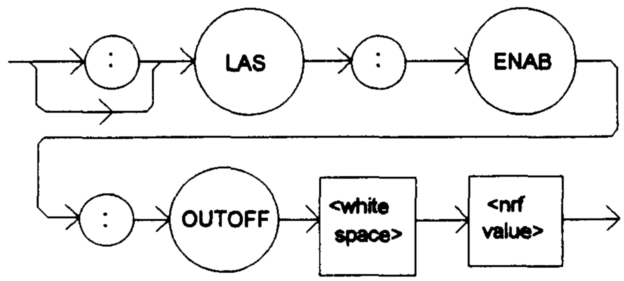
EXAMPLES

"LAS:ENAB:EVE?" -response: 1040, means that the Output on/off state change and Interlock changed LASER events will be reported (in summarized form) to the status byte register (bit 2).

"Radix Hex; Las:Enab:Eve?" -response: #HFF9B, means that all of the above events will be reported (in summarized form) to the status byte register (bit 2).

The LASer:ENABle:OUTOFF command sets the status outoff enable register of the LASER operations (things which will turn the LASER output off).

SYNTAX DIAGRAM




PARAMETERS

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

| | |
|---|---|
| 1 - LASER Current Limit | 256 - N/A |
| 2 - LASER Voltage Limit | 512 - Output is Out of Tolerance* |
| 4 - N/A | 1024 - TEC Output Off |
| 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 |

POINTS OF INTEREST

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

The enable registers normally retain their values at power-up (as they were at power-down) unless the power-on status clear flag is set true (see *PSC, Chapter 3).

The factory default value for this register is #B0000100010001000, or #H888, or 2184 decimal.

EXAMPLES

"LAS:ENAB:OUTOFF 9" -action: enables the LASER status outoff register so that Power limit and LASER current limit conditions will cause the LASER output to be turned off.

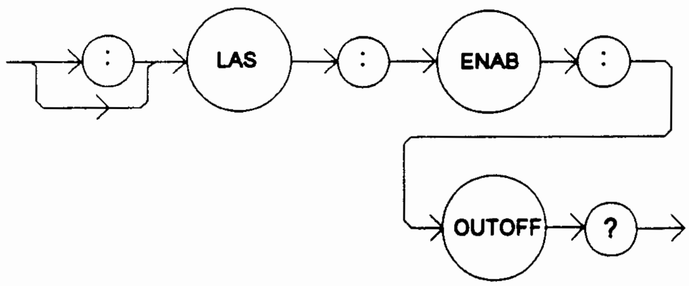
"Las:Enab:Outoff #HE09" -action: enables the LASER status outoff register so that any or all of the above conditions will cause the LASER output to be turned off.

* Warning: If this bit is enabled with the output off, the output may never turn on.

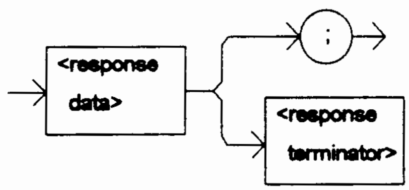
# LASer:ENABle:OUTOFF?

The LASer:ENABle:OUTOFF? query returns the value of the status outoff enable register of the LASER operations.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is the sum of the following:

| | |
|---|---|
| 1 - LASER Current Limit | 256 - N/A |
| 2 - LASER Voltage Limit | 512 - Output is Out of Tolerance |
| 4 - N/A | 1024 - TEC Output Off |
| 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 |

POINTS OF INTEREST The enabled LASER events can be set by using the LASer:ENABle:OUTOFF command. The LASER output status can be monitored by the LASer:EVEnt? query.

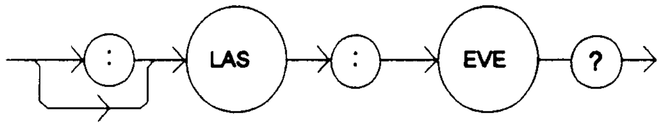
EXAMPLES "LAS:ENAB:OUTOFF?" -response: 2049, means that TEC High Temperature Limit and Current Limit Conditions will cause the LASER output to be turned off.

"Radix Hex; Las:Enab:Eve?" -response: #HE0B, means that all of the above conditions will cause the LASER output to be turned off.

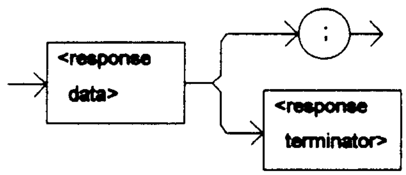
## LASer:EVEnt?

The LASer:EVEnt? query returns the value of the status event register of the LASER operations.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is the sum of the following:

| | |
|---|---|
| 1 - LASER Current Limit | 256 - Output is Shorted |
| 2 - LASER Voltage Limit | 512 - Output Changed to be In/Out of Tolerance |
| 4 - N/A | 1024 - Output On/Off State Changed |
| 8 - Power Limit | 2048 - Ready for Calibration Data State |
| 16 - Interlock Disabled | 4096 - Calculation Error |
| 32 - N/A | 8192 - Error Communicating LASER Board |
| 64 - N/A | 16384 - Software Error in LASER Control |
| 128 - Open Circuit | 32768 - LASER Eeprom Checksum Error |

POINTS OF INTEREST

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

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

EXAMPLES

"LAS:EVE?" -response: 513, means that the LASER output tolerance changed and current limit events have occurred since the last LASer:EVEnt? query.

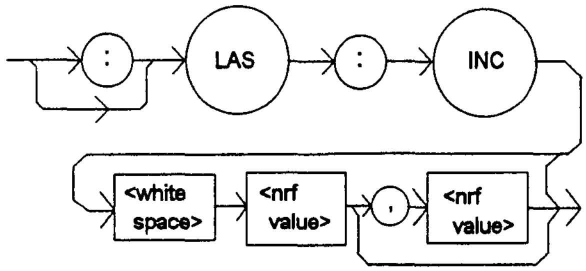
"Radix Hex; Laser:Event?" -response: #H88, means that the LASER Power limit and Open circuit events have occurred since the last LASer:EVEnt? query.

☐ Front Panel
■ Remote

## LASer:INC

The LASer:INC command increments the selected laser control mode set point by one or more steps. Optional parameters allow multiple steps to be incremented and the time (in milliseconds) between increments to be set, respectively.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

The decremental default amount is one step. The step size can be edited via the LAS:STEP command. LDC-3712 default values are 0.001/0.002 mA (50/100 mA range), 0.01 mW, or 1 uA (if CALMD = 0), depending on the mode of operation. LDC-3722B default values are 0.01 mA, 0.01 mW, or 1 uA. LDC-3742B default values are 0.1 mA, 0.1 mW, or 1 uA.

If the first optional parameter is used, but not the second, the LASER set point is incremented by a multiple of the LAS:STEP size, without changing the LAS:STEP size. The second optional parameter is the time, in mSec., between steps.

If both optional parameters are used, the user may create an automated stepping ramp function for the LASER output.

If the first optional parameter is entered as zero, "LAS:INC 0", the command will do nothing.

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

EXAMPLES

"LAS:MODE:I; LAS:STEP 3; LAS:INC" -action: The laser source current set point is incremented by 0.3 mA (LDC-3742B), or 0.03 mA (LDC-3722B), or 0.003 mA (LDC-3712 on 50 mA range), or 0.006 mA (LDC-3712 on 100 mA range).

"LAS:MODE:I; LAS:STEP 3; LAS:INC 3" -action: The laser source current set point is incremented by three times the amount described in the first example.

"LAS:MODE:I; LAS:STEP 3; LAS:INC 3,5000" -action: The laser source current set point is incremented by the amount described in the first example, three times, with 5 seconds between decremental steps.

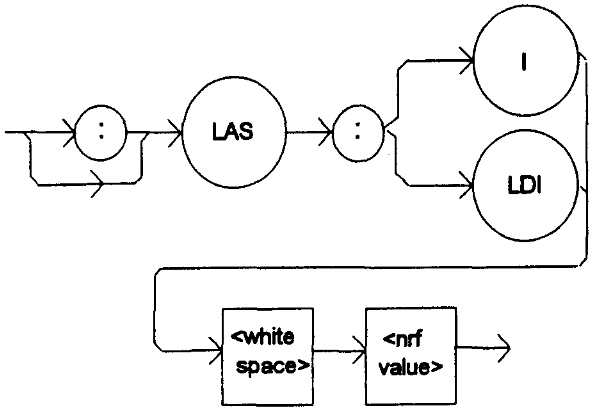
"LAS:STEP 1; LAS:Mode:P; Las:INC" -action: The power set point is incremented by 0.1 mW (LDC-3742B) or 0.01 mW (LDC-3722B or LDC-3712).

■ Front Panel
■ Remote

## LASer:LDI

The LASer:LDI command sets the laser control current.

SYNTAX DIAGRAM




PARAMETERS An <nrf value> which represents the (laser) output current, in mA.

POINTS OF INTEREST Set point is the same for both low and high bandwidth output modes.

In local mode, the LASER I switch in the LASER DISPLAY area of the front panel would be pressed. Then, the desired value would be entered via the ADJUST knob, and the (LASER DISPLAY) SET switch pressed.

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

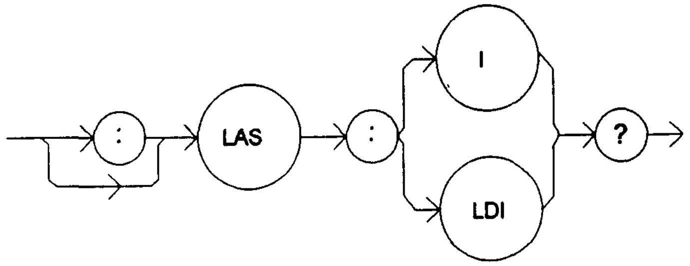
"LAS:ldi 1000" -action: sets the laser output current to 1000.00 mA.

■ Front Panel
■ Remote

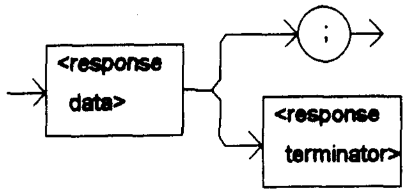
## LASer:LDI?

The LASer:LDI? query returns the value of the measured laser current.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST

Response is the measured laser output current, for either low or high bandwidth modes.

This measurement is updated approximately once every 600 mSec.

In local mode, the measured laser output current would be read by pressing the I switch and visually reading the LASER display.

EXAMPLES

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

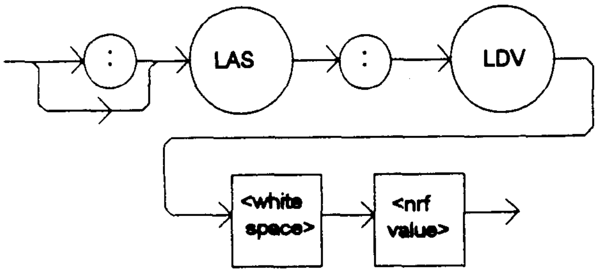
"Laser:LDI?" -response: 100.0, means the measured laser output current is 100.0 mA.

□ Front Panel
■ Remote

## LASer:LDV

The LASer:LDV command sets the laser voltage for calibration of the laser voltage measurement.

SYNTAX DIAGRAM




PARAMETERS

An <nrf value> which represents the (laser) output voltage, in volts.

POINTS OF INTEREST

Set point is the same for both low and high bandwidth output modes.

EXAMPLES

"Las:LDV 4" -action: enters a value of 4.000 volts.

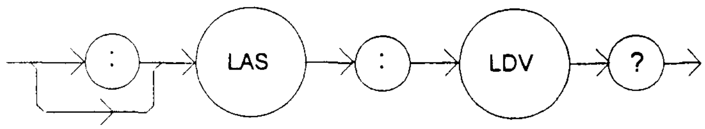
"LAS:ldv 1.025" -action: enters a value of 1.025 volts.

☐ Front Panel
■ Remote

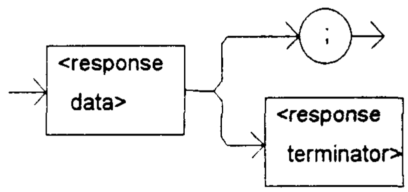
# LASer:LDV?

The LASer:LDV? query returns the value of the measured laser voltage.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST Response is the measured laser output voltage, for either low or high bandwidth modes.

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 1.000 volt.

■ Front Panel
■ Remote

# LASer:LIMit:

The LASer:LIMit: command path is used to get to the LDC-3700 Series Laser Diode Controller's laser limit commands.

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

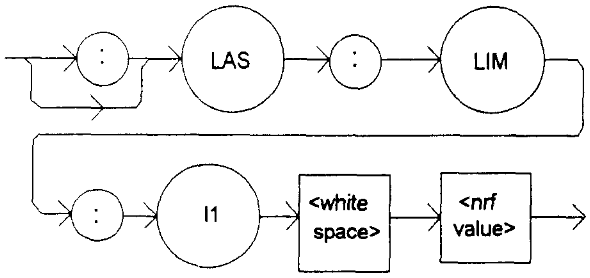
LASer:LIMit:I1 (LDC-3712 and LDC-3742B)
LASer:LIMit:I1? (LDC-3712 and LDC-3742B)
LASer:LIMit:I2 (LDC-3722B)
LASer:LIMit:I2? (LDC-3722B)
LASer:LIMit:I3 (LDC-3742B)
LASer:LIMit:I3? (LDC-3742B)
LASer:LIMit:I5 (LDC-3712 and LDC-3722B)
LASer:LIMit:I5? (LDC-3712 and LDC-3722B)
LASer:LIMit:MDP
LASer:LIMit:MDP?

■ Front Panel
■ Remote

## LASer:LIMit:I1

The LASer:LIMit:I1 command sets the LASER current limit value for the 100 mA range on the LDC-3712 and the 1000 mA range on the LDC-3742B. (Not applicable for LDC-3722B).

SYNTAX DIAGRAM




PARAMETERS An <nrf value> which represents the LASER limit current, in mA.

POINTS OF INTEREST The current limit is in effect in all modes of operation of the laser output.

In local operation, the limit current is entered by selecting LIM I parameter, pressing and holding in the (PARAMETER) SET switch, adjusting the ADJUST knob until the desired value is displayed, and then releasing the SET switch.

EXAMPLES "LAS:LIM:I1 80" -action: the LASER current limit is set to 80 mA.

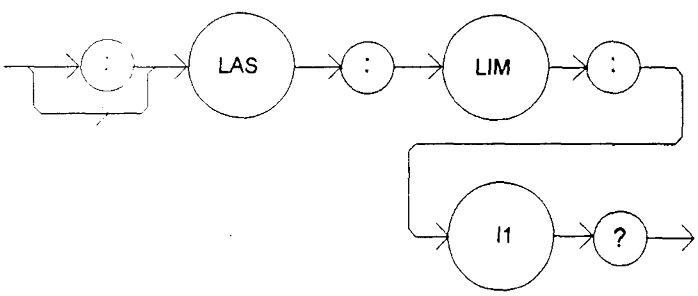
":Laser:Limit:I1 60" -action: the LASER current limit is set to 60 mA.

■ Front Panel
■ Remote

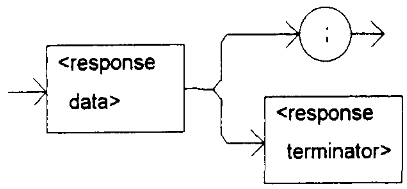
## LASer:LIMit:I1?

The LASer:LIMit:I1? query returns the value of the LASER current limit for the 100 mA range on the LDC-3712 or the 1000 mA range on the LDC-3742B. (Not applicable for LDC-3722B).

SYNTAX DIAGRAM



PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST The current limit is valid for all modes of Laser operation.

In local operation, the limit current value is read by selecting the LIM I parameter, and visually reading the LASER display.

EXAMPLES "LAS:LIM:I1?" -response: 40, means the laser current limit is 40 mA.

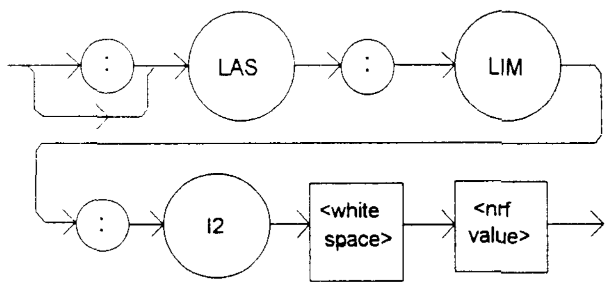
"Laser:LIM:I1?" -response: 500, means the laser current limit is 500 mA (LDC-3742B only).

■ Front Panel
■ Remote

## LASer:LIMit:I2

The LASer:LIMit:I2 command sets the LASER current limit value for the 200 mA range on the LDC-3722B. (Not applicable for LDC-3742B).

SYNTAX DIAGRAM




PARAMETERS An <nrf value> which represents the LASER limit current, in mA.

POINTS OF INTEREST The current limit is in effect in all modes of operation of the laser output.

In local operation, the limit current is entered by selecting LIM I parameter, pressing and holding in the (PARAMETER) SET switch, adjusting the ADJUST knob until the desired value is displayed, and then releasing the SET switch.

EXAMPLES "LAS:LIM:I2 180" -action: the LASER current limit is set to 180 mA.

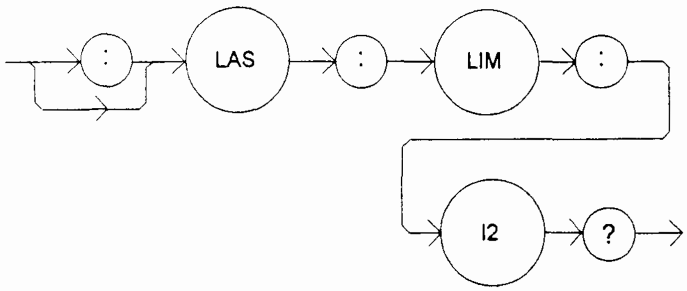
":Laser:Limit:I2 160" -action: the LASER current limit is set to 160 mA.

■ Front Panel
■ Remote

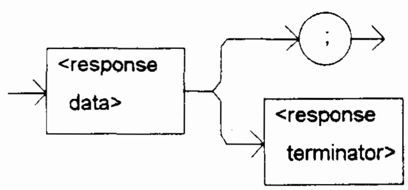
## LASer:LIMit:I2?

The LASer:LIMit:I2? query returns the value of the LASER current limit for the 200 mA range on the LDC-3722B. (Not applicable for LDC-3742B).

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST

The current limit is valid for all modes of Laser operation.

In local operation, the limit current value is read by selecting the LIM I parameter, and visually reading the LASER display.

EXAMPLES

"LAS:LIM:I2?" -response: 40, means the laser current limit is 40 mA (LDC-3722B only).

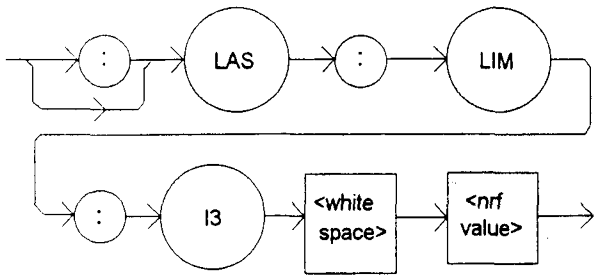
"Laser:LIM:I2?" -response: 150, means the laser current limit is 150 mA (LDC-3722B only).

■ Front Panel
■ Remote

## LASer:LIMit:I3

The LASer:LIMit:I3 command sets the LASER current limit value for the 3000 mA range on the LDC-3742B. (Not applicable for LDC-3722B or LDC-3712).

SYNTAX DIAGRAM




PARAMETERS An <nrf value> which represents the LASER limit current, in mA.

POINTS OF INTEREST The current limit is in effect in all modes of operation of the laser output.

In local operation, the limit current is entered by selecting LIM I parameter, pressing and holding in the (PARAMETER) SET switch, adjusting the ADJUST knob until the desired value is displayed, and then releasing the SET switch.

EXAMPLES "LAS:LIM:I3 800" -action: the LASER current limit is set to 800 mA.

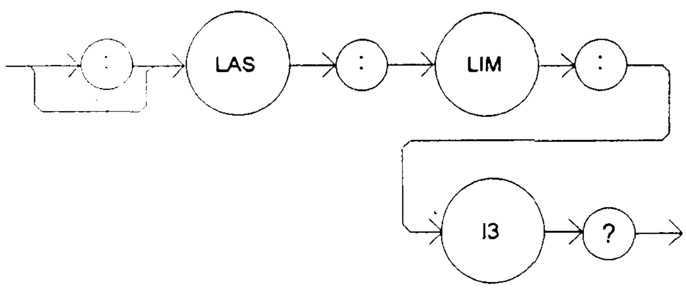
":Laser:Limit:I3 2600" -action: the LASER current limit is set to 2600 mA.

■ Front Panel
■ Remote

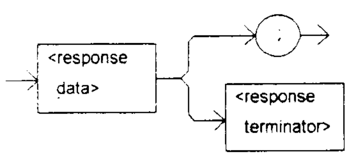
## LASer:LIMit:I3?

The LASer:LIMit:I3? query returns the value of the LASER current limit for the 3000 mA range on the LDC-3742B. (Not applicable for LDC-3722B or LDC-3712).

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST

The current limit is valid for all modes of Laser operation.

In local operation, the limit current value is read by selecting the LIM I parameter, and visually reading the LASER display.

EXAMPLES

"LAS:LIM:I3?" -response: 400, means the laser current limit is 400 mA (LDC-3742B only).

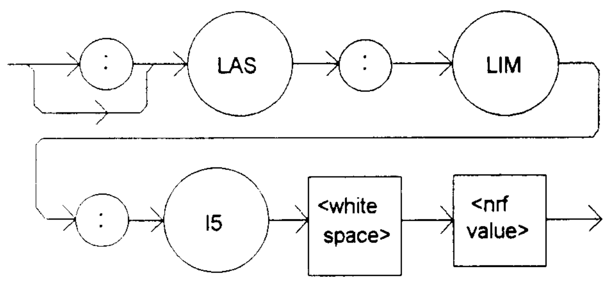
"Laser:LIM:I3?" -response: 1500, means the laser current limit is 1500 mA (LDC-3742B only).

■ Front Panel
■ Remote

## LASer:LIMit:I5

The LASer:LIMit:I5 command sets the LASER current limit value for the 50 mA range on the LDC-3712 and the 500 mA range on the LDC-3722B. (Not applicable for LDC-3742B).

SYNTAX DIAGRAM




PARAMETERS

An <nrf value> which represents the LASER limit current, in mA.

POINTS OF INTEREST

The current limit is in effect in all modes of operation of the laser output.

In local operation, the limit current is entered by selecting LIM I parameter, pressing and holding in the (PARAMETER) SET switch, adjusting the ADJUST knob until the desired value is displayed, and then releasing the SET switch.

EXAMPLES

"LAS:LIM:I5 50" -action: the LASER current limit is set to 50 mA.

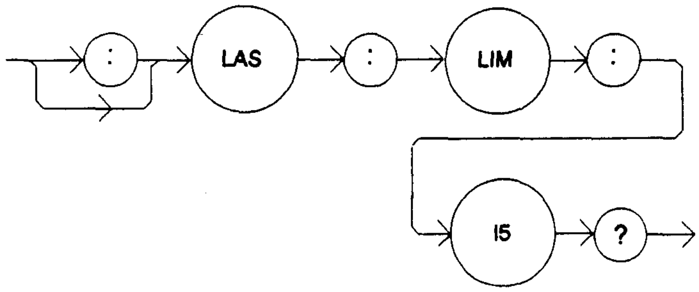
":Laser:Limit:I5 160" -action: the LASER current limit is set to 160 mA (LDC-3722B only).

■ Front Panel
■ Remote

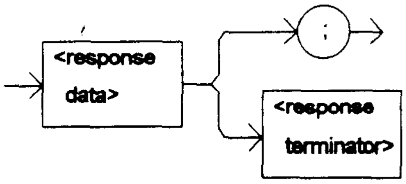
## LASer:LIMit:I5?

The LASer:LIMit:I5? query returns the value of the LASER current limit for the 50 mA range on the LDC-3712 or the 500 mA range on the LDC-3722B. (Not applicable for LDC-3742B).

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST

The current limit is valid for all modes of Laser operation.

In local operation, the limit current value is read by selecting the LIM I parameter, and visually reading the LASER display.

EXAMPLES

"LAS:LIM:I5?" -response: 400, means the laser current limit is 400 mA (LDC-3722B only).

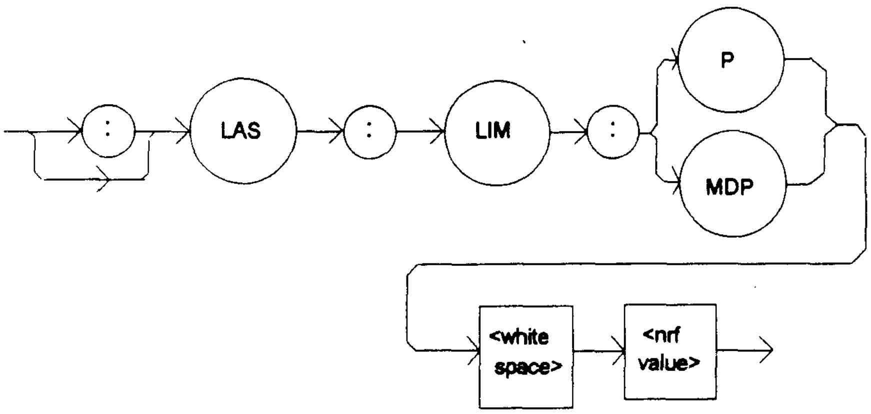
"Laser:LIM:I5?" -response: 50, means the laser current limit is 50 mA.

■ Front Panel
■ Remote

## LASer:LIMit:MDP

The LASer:LIMit:MDP command sets the laser monitor photodiode power limit value.

SYNTAX DIAGRAM



| | |
|---|---|
| PARAMETERS | An <nrf value> which represents the laser monitor photodiode power limit, in mW. |
| POINTS OF INTEREST | When constant MDP mode is used, the output is limited only by the LIM I value. |

The LIM MDP condition may be used to shut the LASER output off, but this requires the use of the LASer:ENABle:OUTOFF command to set bit 3 of the LASER OUTOFF ENABLE register.

In local operation, the limit power is entered by selecting the LIM P parameter, adjusting the ADJUST knob until the desired value is displayed, and then pressing the SET switch in the PARAMETER area of the front panel.

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

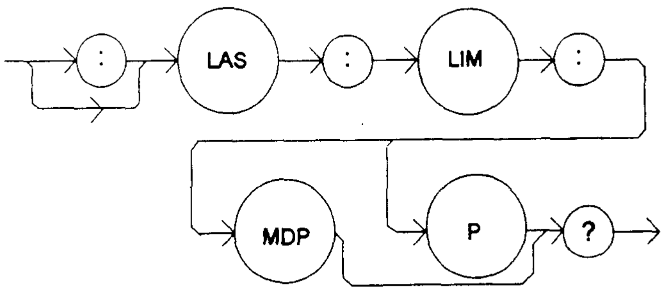
"Las:Limit:MDp 5" -action: sets the laser output power limit to a value which corresponds to producing 5.00 mW of PD feedback (optical) power.

■ Front Panel
■ Remote

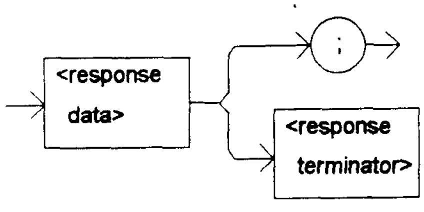
## LASer:LIMit:MDP?

The LASer:LIMit:MDP? query returns the value of the laser monitor PD power limit.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST The (LASER) MDP limit is in effect for both laser output current ranges.

In local operation, the limit power value is read by selecting the LIM P parameter, in the PARAMETER area of the front panel, and visually reading the LASER display.

EXAMPLES "LAS:LIM:MDP?" -response: 3.0, means the monitor PD power limit is set to 3.0 mW.

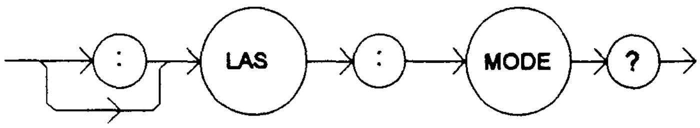
":LAS:Limit:MDP?" -response: 10.0, means the monitor PD power limit is set to 10.0 mW.

■ Front Panel
■ Remote

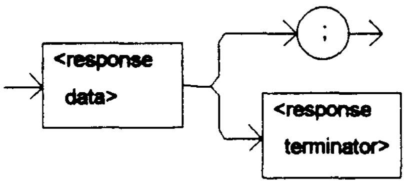
## LASer:MODE?

The LASer:MODE? query returns the selected laser control mode.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is character data.

POINTS OF INTEREST

$I_{HBW}$ mode is the same as I mode (low bandwidth), except that the output low bandpass filter is disabled in $I_{HBW}$ mode.

In local mode, the LASER control mode is indicated by the LED in the LASER MODE area of the front panel. If the P mode LED is lit, the mode is $I_{PD}$ when the CAL PD value is zero, and the mode is $P_{PD}$ when the CAL PD value is non-zero.

EXAMPLES "LAS:MODE?" -response: Ilbw, means that constant I (current) mode is in effect for the laser output.

":Las:Mode?" -response: MDP, means that constant P (power) mode is in effect for the laser output, and CALMD > 0.

"Las:Mode?" -response: MDI, means that constant P (power) mode is in effect for the laser output, and CALMD = 0.

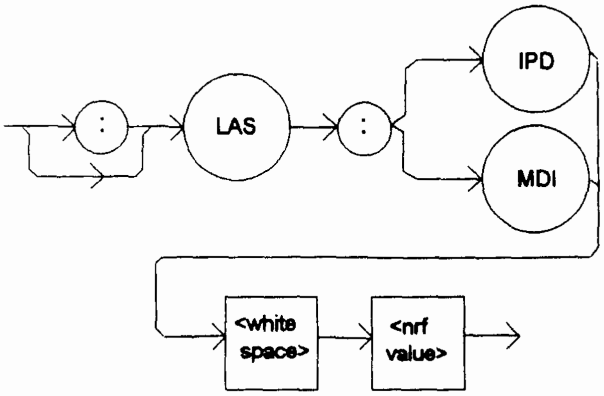
"Laser:MODE?" -response: Ihbw, means that constant $I_{HBW}$ (current, high bandwidth) mode is in effect for the laser output.

■ Front Panel
■ Remote

## LASer:MDI

The LASer:MDI command sets the value of the optical power set point, in uA, if the CALMD (CAL PD) responsivity is 0.

SYNTAX DIAGRAM




PARAMETERS An <nrf value> which represents the photodiode feedback current, in uA.

POINTS OF INTEREST If the CALMD (CAL PD) parameter is not set to 0, the LAS:MDI value will not be used. In this case, the measured MDI would be converted to MDP ($P_{PD}$, by the CAL PD factor), and the MDP ($P_{PD}$) set point would be used.

In local mode, the photodetector current set point would be set by first pressing the (LASER MODE) P switch to enter constant power mode, and then pressing the SET switch, and then turning the ADJUST knob until the desired value appeared on the LASER display.

EXAMPLES "Las:Mdi 40" -action: The LASER output is controlled so that the photodiode feedback current remains constant at 40 uA.

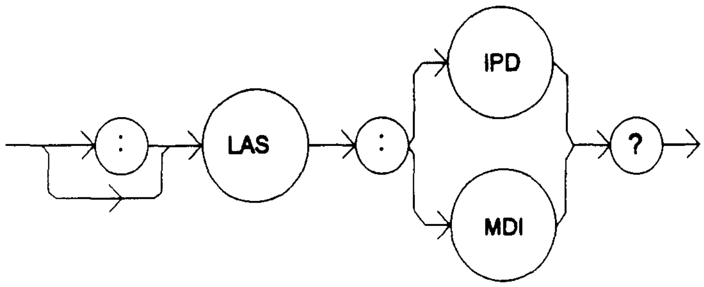
"Laser:MDI 200" -action: The LASER output is controlled so that the photodiode feedback current remains constant at 200 uA.

■ Front Panel
■ Remote

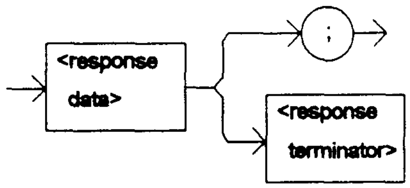
## LASer:MDI?

The LASer:MDI? query returns the value of the laser photodetector current measurement, in uA.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST The response is in uA. The response is valid, even when the unit is not in constant P mode.

This measurement is updated approximately once every 600 mSec.

In local mode, the measured photodetector current would be read by pressing the (LASER DISPLAY) $I_{PD}$ switch and visually reading the LASER display, assuming MDP mode is selected and CALPD is zero.

EXAMPLES "Las:Mode:MDP; Las:Calmd 0; Las:MDi?" -response: 100.0, means 100 uA of photodetector current. This feedback is controlling the laser current output.

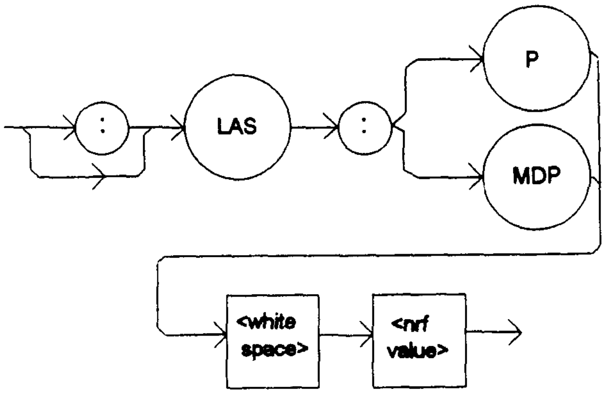
"LAS:MODE:IHBW; LAS:MDI?" -response: 20.0, means 20 uA of photodetector current, but photodiode monitor current is not controlling the laser output current.

■ Front Panel
■ Remote

## LASer:MDP

The LASer:MDP command sets the value of the optical power set point, in mW, if the CALMD (CAL PD) responsivity is greater than 0.

SYNTAX DIAGRAM




PARAMETERS An <nrf value> which represents the photodiode feedback power, in mW.

POINTS OF INTEREST If the CALMD (CAL PD) parameter is set to 0, the LAS:MDP value will not be used. In this case, the measured MDP would be invalid, and the MDI ($I_{PD}$) set point would be used.

In local mode, the photodetector power set point would be set by first pressing the (LASER MODE) P switch to enter constant power mode, and then pressing the SET switch, and then turning the ADJUST knob until the desired value appeared on the LASER display.

EXAMPLES "Las:Mdp 40" -action: The LASER output is controlled so that the photodiode feedback power remains constant at 40 mW.

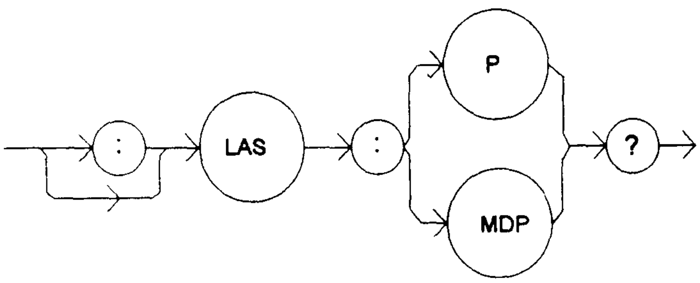
"Laser:MDP 200" -action: The LASER output is controlled so that the photodiode feedback power remains constant at 200 mW.

■ Front Panel
■ Remote

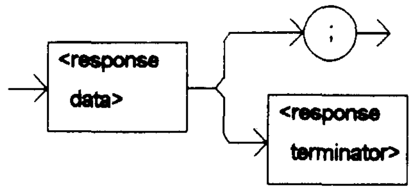
## LASer:MDP?

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

SYNTAX DIAGRAM



PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST 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.

In local mode, the measured photodetector power would be read by pressing the (LASER DISPLAY) $I_{PD}$ switch and visually reading the LASER display, assuming P mode is selected and CALPD is not zero.

EXAMPLES "Las:Mode:MDP; Las:Calmd 460; Las:MDp?" -response: 100.0, means 100 mW of photodetector power. This feedback is controlling the laser current output.

"LAS:MODE:IHBW; LAS:MDP?" -response: 20.0, means 20 mW of photodetector power, but photodiode monitor current is not controlling the laser output current.

■ Front Panel
■ Remote

## LASer:MODE:

The LASer:MODE: command path is used to get to the LDC-3700 Series Laser Diode Controller's laser mode selection commands.

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

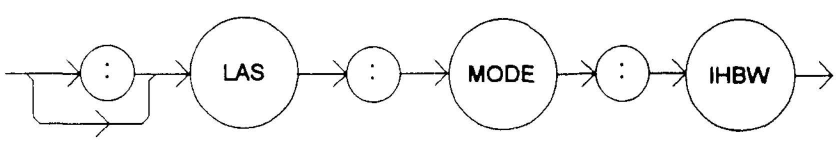
LASer:MODE:IHBW
LASer:MODE:ILBW
LASer:MODE:MDP

■ Front Panel
■ Remote

## LASer:MODE:IHBW

The LASer:MODE:IHBW command selects laser high bandwidth constant current mode.

SYNTAX DIAGRAM



PARAMETERS None.

POINTS OF INTEREST

This mode of operation is constant I mode with the output lowpass filter disabled.

In local operation, the constant I mode is selected by pressing the (LASER MODE) SELECT switch until the $I_{HBW}$ indicator is lit.

EXAMPLES

":las:mode:ihbw" -action: enables the laser high bandwidth constant current mode.

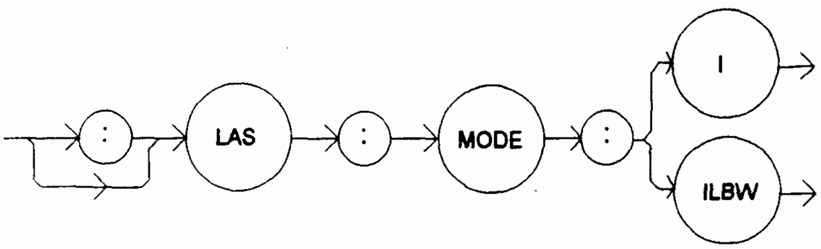
"LAS:Mode:Ihbw" -action: enables the laser high bandwidth constant current mode.

■ Front Panel
■ Remote

## LASer:MODE:ILBW

The LASer:MODE:ILBW command selects laser constant current mode.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

Constant I mode (low bandwidth) enables the output low bandpass filter.

In local operation, the constant I mode is selected by pressing the SELECT switch in the LASER MODE area of the front panel until the I indicator is lit.

EXAMPLES

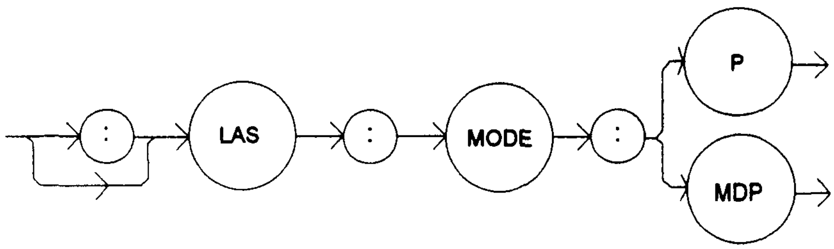
"LAS:MODE:ILBW" -action: sets the laser output for constant I mode (low bandwidth).

"Laser:Mode:ilbw" -action: sets the laser output for constant I mode (low bandwidth).

## LASer:MODE:MDP

The LASer:MODE:MDP command selects laser constant power mode.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

This mode of laser operation requires the laser's monitor PD feedback to maintain constant optical power or constant monitor current.

In this mode, the displayed parameter will be either $I_{PD}$ (if CALMD = 0) in uA, or $P_{PD}$ (if CALMD > 0) in mW.

In local operation, the constant MDP mode is selected by pressing the (LASER MODE) SELECT switch until the P indicator is lit.

EXAMPLES

"LAS:MODE:MDP" -action: sets the laser output mode of operation to constant optical power mode.

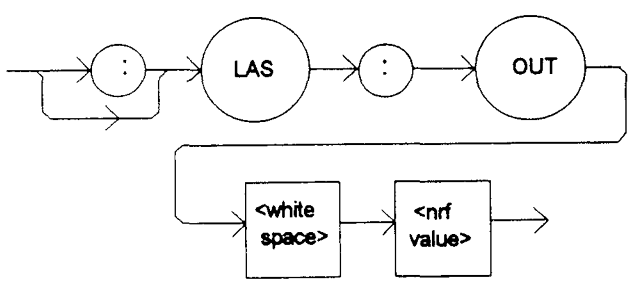
"Laser:Mode:MDp" -action: sets the laser output mode of operation to constant optical power mode.

■ Front Panel
■ Remote

## LASer:OUTput

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

SYNTAX DIAGRAM



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

POINTS OF INTEREST

After the output is turned on, it may be useful to wait until the output is stable (within tolerance) before performing further operations, but it is not necessary. When the LASER output is off, it is safe to connect or disconnect devices to the LASER output terminals.

When the LASER output is off, an internal short is placed across the output terminals. This condition causes the OUTPUT SHORTED light to come on.

In local mode, the LASER output is turned on or off by pressing the ON switch in the LASER MODE area of the front panel.

EXAMPLES "LAS:I 20; LAS:OUT ON" -action: sets the laser output current to 20 mA and then turns the output on.

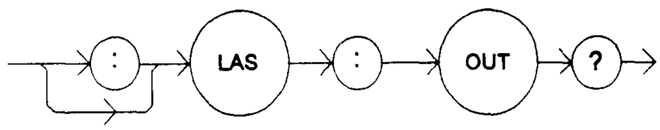
"Las:Out 0" -action: turns the laser output off.

■ Front Panel
■ Remote

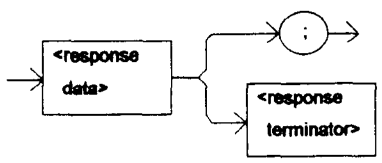
## LASer:OUTput?

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

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST

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

In local mode, the LASER output status is read by visually reading the ON indicator LED in the LASER MODE area of the front panel (lit = on).

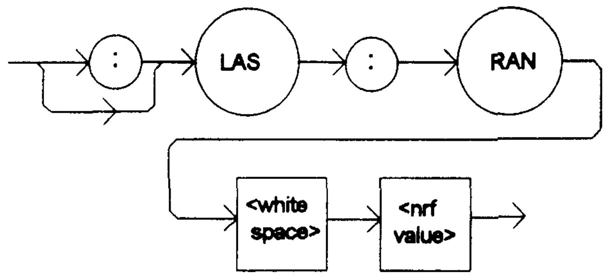
EXAMPLES "Las:OUT?" -response: 0, means that the output switch is disabled, devices may be safely disconnected or connected at the LASER output terminals.

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

## LASer:RANge

The LASer:RANge command selects the laser's drive current output range.

SYNTAX DIAGRAM




PARAMETERS

An <nrf value> which represents the laser current output range.

For LDC-3712: 5 = 50 mA, and 1 = 100 mA range.
For LDC-3722B: 2 = 200 mA, and 5 = 500 mA range.
For LDC-3742B: 1 = 1000 mA, and 3 = 3000 mA range.

POINTS OF INTEREST

This range setting effects the Laser Drive Current output current range only.

The Laser Drive Current output should be "off" when this command is issued. If the Laser Diode Current output is "on" when this command is issued, the LDC-3700 Series Laser Diode Controller will generate error #515, and the range will not be changed.

EXAMPLES

"LAS:RAN 2" -action: sets the laser output drive current range to 200 mA (LDC-3722B only).

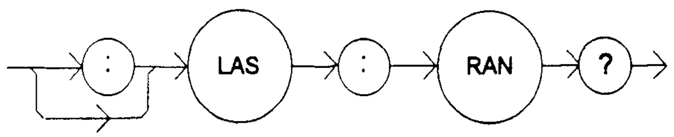
"Laser:range 1" -action: sets the laser output drive current range to 100 mA (LDC-3712 only) or 1000 mA (LDC-3742B only).

■ Front Panel
■ Remote

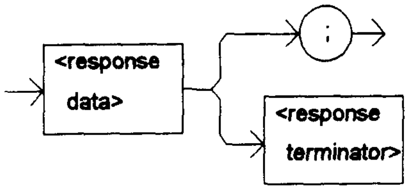
## LASer:RANge?

The LASer:RANge? query returns the value of the Laser Drive Current range.

SYNTAX DIAGRAM



PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>; 1 means 100 mA range (LDC-3712) or 1000 mA range (LDC-3742B), 2 means 200 mA range (LDC-3722B), 3 means 3000 mA range (LDC-3742B), and 5 means 50 mA range (LDC-3712) or 500 mA range (LDC-3722B).

POINTS OF INTEREST The resolution and accuracy of the laser limit current are dependent on the Laser Drive Current output range.

EXAMPLES "LAS:RAN?" -response: 1, means that the Laser Drive Current range is 100 mA (LDC-3712 only) or 1000 mA (LDC-3742B only).

"LAS:range?" -response: 2, means that the Laser Drive Current range is 200 mA (LDC-3722B only).

■ Front Panel
■ Remote

## LASer:SET:

The LASer:SET: command path is used to get to the LDC-3700 Series Laser Diode Controller's laser set point queries.

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

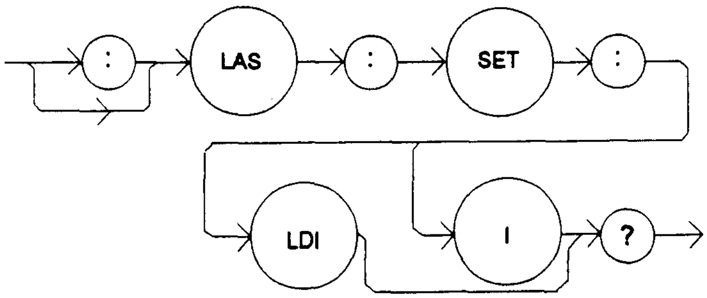
LASer:SET:LDI?
LASer:SET:MDI?
LASer:SET:MDP?

■ Front Panel
■ Remote

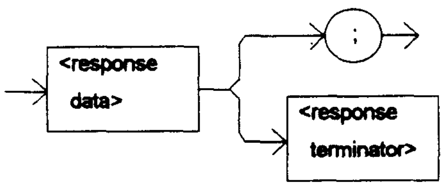
## LASer:SET:LDI?

The LASer:SET:LDI? query returns the constant I value which is used for both output ranges and both bandwidths.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value> which represents the constant I set point value, in mA.

POINTS OF INTEREST In local operation, the constant I set point is read by selecting I or IHBW mode, pressing the SET switch in the LASER DISPLAY area of the front panel, and then visually reading the LASER display.

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

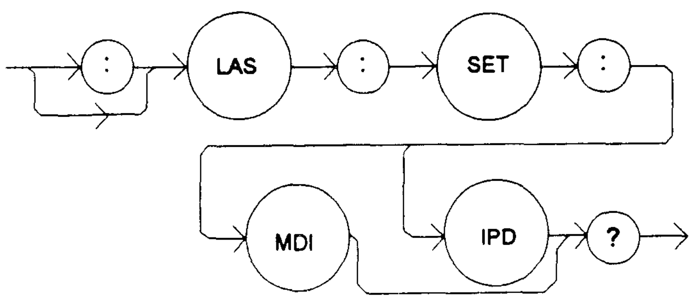
"Laser:set:ldi?" -response: 1200.0 means the laser output current set point value is 1200.0 mA.

■ Front Panel
■ Remote

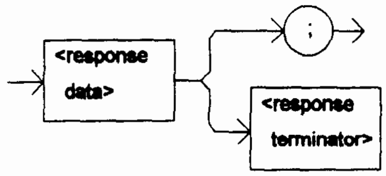
## LASer:SET:MDI?

The LASer:SET:MDI? query returns the laser monitor PD current set point value (when CALPD = 0), in uA.

SYNTAX DIAGRAM



PARAMETERS None. The response will be in the form:




-where the response is an <nrf value> which represents the constant $I_{PD}$ set point value, in uA.

POINTS OF INTEREST

The monitor photodiode current is directly proportional to the laser optical output power. Therefore, the $I_{PD}$ set point may be used to control optical output of the laser.

In local operation, the constant $I_{PD}$ set point is read by selecting P mode (when CAL PD =0), then pressing the SET switch in the LASER DISPLAY area of the front panel, and then visually reading the LASER display.

EXAMPLES

"las:set:mdi?" -response: 30.0, means the laser monitor PD current is set point is 30 uA, for use in constant P mode with CALPD = 0.

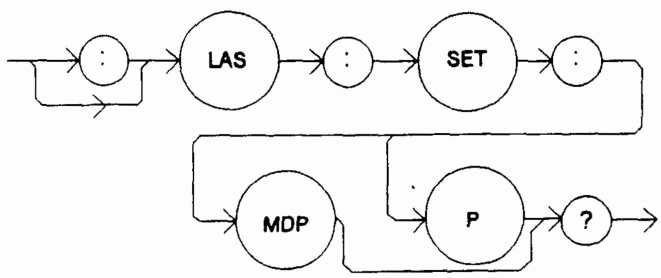
"LAS:Set:MDI?" -response: 100.0 means the laser monitor PD current is set point is 100 uA, for use in constant P mode with CALMD = 0.

■ Front Panel
■ Remote

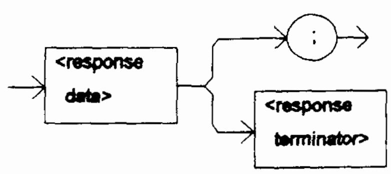
## LASer:SET:MDP?

The LASer:SET:MDP? query returns the laser monitor PD power set point value (when CALMD [CAL PD] is not zero), in mW.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value> which represents the constant $P_{PD}$ set point, in mW.

POINTS OF INTEREST

This set point is used in constant MDP mode only.

In local operation, the constant $P_{PD}$ set point is read by selecting P mode (when CAL PD > 0), then pressing the (LASER DISPLAY) SET switch, and then visually reading the LASER display.

EXAMPLES

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

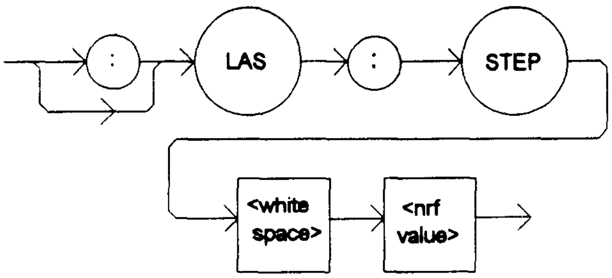
"Laser:Set:MDP?" -response: 25.0, means the laser monitor PD feedback set point is 25.0 mW (CALPD > 0).

☐ Front Panel
■ Remote

## LASer:STEP

The LASer:STEP command is used to increment or decrement the selected laser control mode set point by the given amount, when used with the LASer:INC or LASer:DEC command.

SYNTAX DIAGRAM




PARAMETERS

An integer value of the step amount, in the range 1 to 9999.

POINTS OF INTEREST

The step of 1 corresponds to the smallest incremental change of the mode. For example, a step of 1 means 0.01 mA, 0.01 mW, or 1 uA (if CALPD = 0).

EXAMPLES

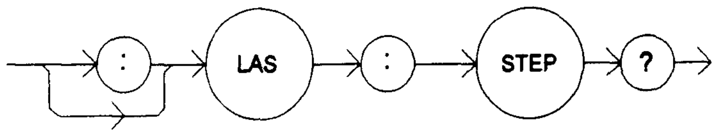
"Las:Mode:i; Las:ldi 20; Las:Step 100; Las:Inc; Las:set:ldi?" -action: sets the step to 1.0 mA, so the Las:set:ldi? query will return a value of 21.0 mA.

"LAS:STEP 1000" -action: sets the step size to 1000; could mean 10.0 mA, 10.0 mW, or 100 uA.

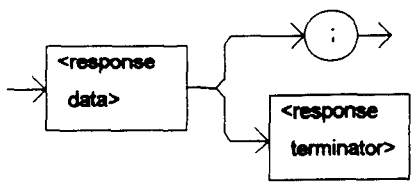
# LASer:STEP?

The LASer:STEP? query is used to read back the LASer STEP value. This value is used to increment or decrement the selected laser control mode set point by the given amount, when used with the LASer:INC or LASer:DEC command.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value> of the step amount.

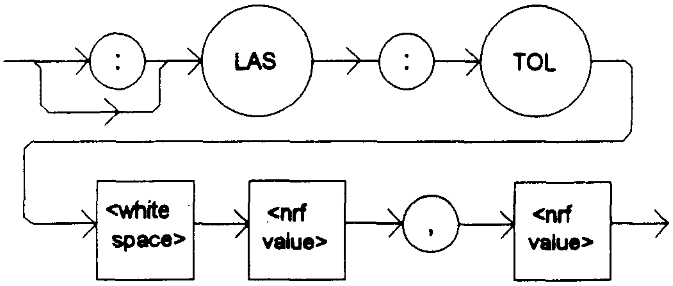
POINTS OF INTEREST The step of 1 corresponds to the smallest incremental change of the mode. For example, a step of 1 means 0.1 mA, 0.01 mW, or 1 uA (if CALPD = 0). A step of 9999 means 999.9 mA, 99.99 mW, or 9999 uA.

EXAMPLES "Las:Mode:LDI; Las:Step?" -response: 1 means the step size is 0.1 mA, since Const I mode is in effect.

"LAS:MODE:MDP; LAS:CALMD 1; LAS:STEP?" -response: 10 means the step size is 0.1 mW, since Const P mode is in effect.

The LASer:TOLerance command allows the programmer to determine the LASER current tolerance, and time window for it to occur, in order that the operation complete flag be set after a "LASer:OUTput 1" command is issued, or the LASER set point is changed.

SYNTAX DIAGRAM




PARAMETERS Two <nrf values>; the first represents the LASER current tolerance, in mA, with a range of 0.1 to 100.0 mA; and the second represents the time window, in seconds, with a range of 0.001 to 50.000 seconds.

This command may be used in conjunction with the common query *OPC? or common command *WAI to delay further program activities until the LASER current reaches its set point to the specifications of the LASer:TOLerance command.

For example, if the set point is 40.5 mA, tolerance is 1.0 mA for 5 seconds, and the LASER output is turned on, the user may issue the *WAI command to ensure this set point is reached before continuing. In this case, the LDC-3700 Series Laser Diode Controller will wait until its LASER current is within 1.0 mA of 40.5 mA for a period of 5 seconds before the next command is executed.

POINTS OF INTEREST The LDC-3700 Series Laser Diode Controller defaults to a tolerance of 10.0 mA for 5 seconds, unless changed by the LASer:TOLerance command.

If the LDC-3700 Series Laser Diode Controller is operated in P mode, the current tolerance parameter is not used. Instead a fixed value of 50 uA is used for the $I_{PD}$ current, and only the time window parameter may be adjusted.

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

EXAMPLES "Las:Tol 0.5,10" -action: the LDC-3700 Series Laser Diode Controller's LASER current source will be in tolerance when the LASER current is within 0.5 mA for 10.000 seconds.

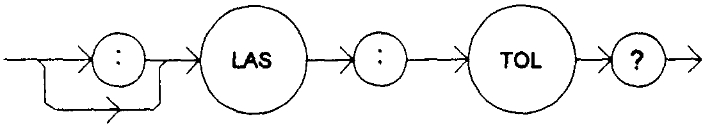
"LAS:TOL 1,1.5;LAS:LDI 30;*WAI;LAS:LDI?" -action: the LDC-3700 Series Laser Diode Controller's LASER current source will return a current measurement after it has reached tolerance where the LASER current is within 1.0 mA of 30.0 mA for 1.500 seconds.

☐ Front Panel
■ Remote

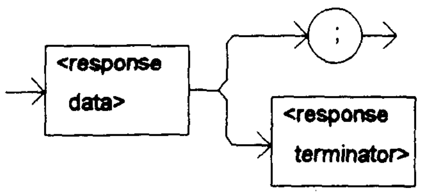
## LASer:TOLerance?

The LASer:TOLerance? query allows the programmer to determine how the LASER current tolerance is set.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response consists of two data units, the first for the current tolerance, in mA; and the second for the time window, in seconds.

POINTS OF INTEREST

The tolerance of the LDC-3700 Series Laser Diode Controller LASER current may be used to delay programming after an "LASer:OUTput 1" command is issued or the set point is changed.

A change of the output into or out of tolerance flag sets a flag in the LASER status event register, and so entering or exiting LASER current tolerance may be used to generate service requests.

EXAMPLES

"Las:Tol?" -response: "0.2,5.0", means the LDC-3700 Series Laser Diode Controller has a LASER current tolerance setting of 0.2 mA with a time window of 5.000 seconds.

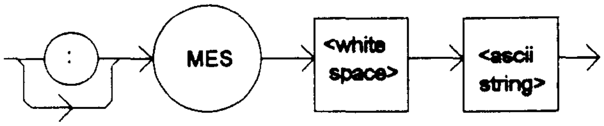
"LASER:TOL?" -response: "1.0,20.0", means the LDC-3700 Series Laser Diode Controller has a LASER current tolerance setting of 1.0 mA with a time window of 20.000 seconds.

☐ Front Panel
■ Remote

## MESsage

The MESsage command allows the user to enter an ASCII string of up to 16 non-zero characters. This command may be useful for storing messages which relate to a test or configuration.

SYNTAX DIAGRAM




PARAMETERS An ASCII string that is 1 - 16 bytes in length.

POINTS OF INTEREST The message may contain any ASCII character, but will be terminated when a NULL terminator character is received. If the message has less than 16 bytes, the software will fill the remaining message space with the space character. After 16 bytes have been entered, the software will null-terminate the string.

EXAMPLES MESSAGE "This is a test." -action: The string, "This is a test. " will be stored in non-volatile memory.

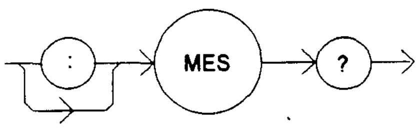
Mes "Test 3" -action: The string, "Test 3           " will be stored in non-volatile memory.

☐ Front Panel
■ Remote

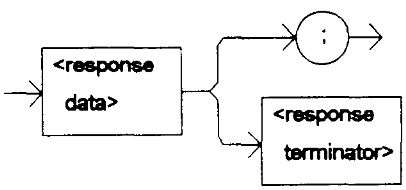
## MESsage?

The MESsage? query returns the previously stored message. This message will always be 16 bytes long and enclosed in quotes. The message is entered via the MESsage command.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the <response data> is a 16-byte long string.

POINTS OF INTEREST

The response data will be a 16-byte long string. If there is no previously stored message, the response will be "                ", all spaces.

EXAMPLES

"MES?" -response: "Test 3          ", means the previously stored message was "Test 3".

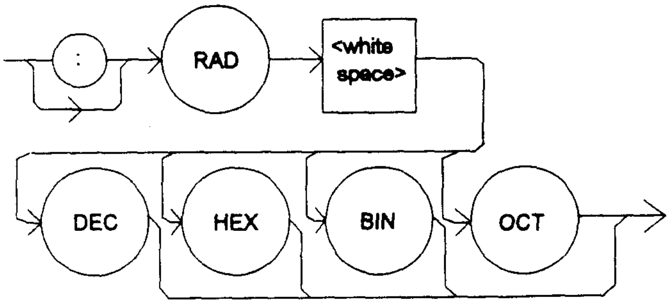
"Message?" -response: "This is a test. ", means the previously stored message was "This is a test."

□Front Panel
■ Remote

## RADix

The RADix command allows the programmer to select the radix type for status, condition, and event query response data. Decimal, binary, hexadecimal, and octal are allowed.

SYNTAX DIAGRAM




PARAMETERS

Character program data is expected, as shown above.

POINTS OF INTEREST

DECimal is the default type. Only the first three letters of the words decimal, hexadecimal, binary, or octal are required.

When the RADIX is selected, all status, condition, and event queries will return values in the new radix.

In the cases where the radix is not DECimal, the flexible numeric type <nrf value> (as shown in the Command Reference diagrams) will be replaced by HEX, BIN, or OCT representation. All of the above radixes may be used to enter program data at any time, without the need for issuing the RADix command. The proper prefix must also be used with Hex (#H), binary (#B), or octal (#O).

This command may be useful for setting up status reporting blocks. The bit-wise status representation may be more easily read in BIN, HEX, or OCT.

EXAMPLES

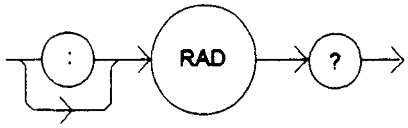
"RAD dec" -action: the decimal radix is selected.

"rad hex; *ESR?" -action: the hexadecimal radix is selected; -response: #H80, means power-on was detected.

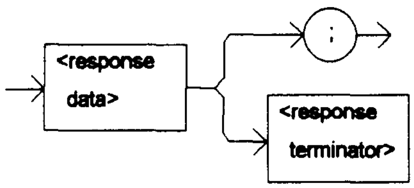
# RADix?

The RADix? query allows the programmer to determine which radix type for status, condition, and event query response data is currently selected. Decimal, binary, octal, and hexadecimal are allowed.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the character response data of DEC means decimal, BIN means binary, HEX means hexadecimal, and OCT means octal.

POINTS OF INTEREST DEC is the default type. The LDC-3700 Series Laser Diode Controller defaults to this radix at power-up.

The RADix command is used to select the desired radix. Once it is changed, the new radix will remain in effect until the power is shut off or a new RADix command is issued.

EXAMPLES "RAD?" -response: Dec, means the selected radix is decimal.

"rad?" -response: Hex, means the selected radix is hexadecimal.

"RADIX?" -response: Oct, means the selected radix is octal.

☐ Front Panel
■ Remote

# SECURE

The SECURE command allows the service technician access to the protected user data command, *PUD, which is a common command. This data is normally changed only at the factory, and therefore the SECURE command is not needed by the user.

■ Front Panel
■ Remote

# TEC:

The TEC: command path is used to get to the LDC-3700 Series Laser Diode Controller's thermoelectric cooler (TEC) source commands.

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

TEC:CAL:
TEC:DISplay:
TEC:ENABle:
TEC:LIMit:
TEC:MODE:
TEC:SET:

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

| | | |
|---|---|---|
| TEC:COND? | TEC:GAIN? | TEC:R? |
| TEC:CONST | TEC:INC | TEC:SENsor? |
| TEC:CONST? | TEC:ITE | TEC:STEP |
| TEC:DEC | TEC:ITE | TEC:STEP? |
| TEC:DISplay? | TEC:MODE? | TEC:T |
| TEC:DISplay? | TEC:OUTput | TEC:T? |
| TEC:EVEnt? | TEC:OUTput? | TEC:TOL |
| TEC:GAIN | TEC:R | TEC:TOL? |

■ Front Panel
■ Remote

# TEC:CAL:

The TEC:CAL: command path is used to get to the LDC-3700 Series Laser Diode Controller's TEC calibration commands.

In local operation, the TEC calibration mode is reached by pressing the (GPIB) LOCAL and (TEC DISPLAY) R or ITE switches at the same time. When sensor calibration mode is selected (with the R switch), the position of the SENSOR SELECT switch will be displayed on the TEC display for two seconds.

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

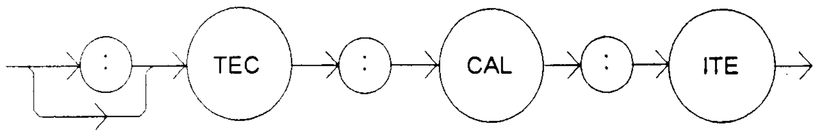
TEC:CAL:ITE
TEC:CAL:ITE?
TEC:CAL:SENsor
TEC:CAL:SENsor?

■ Front Panel
■ Remote

## TEC:CAL:ITE

The TEC:CAL:ITE command is used to enter the TEC's current set point, measurement, and limit calibration mode.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

This is a service related command. When this command is issued, the front panel becomes disabled, and the appropriate adjustments are made to the operating modes. This mode should not be entered unless the user has the proper measurement equipment in place. See Section 6.3.

After this command is issued, the LDC-3700 Series Laser Diode Controller will automatically change to ITE mode, turn the TEC output on, determine its zero current offset, set the ITE limit to 4.0 amps, and drive the output to 1.0 amps. This procedure is outlined in Section 6.3.8.

In remote operation, the TEC:CAL:ITE? query (or bit 11 of the TEC status condition register) may be used to determine if the LDC-3700 Series Laser Diode Controller is ready for the user to enter a value.

In local operation, the TEC ITE calibration mode is entered by pressing the (LOCAL) GPIB and (TEC DISPLAY) ITE swutches at the same time. The LDC-3700 Series Laser Diode Controller will BEEP when it is ready for the user to enter a value (the SET switch is enabled).

EXAMPLES

"Tec:CAL:ITE" -action: the LDC-3700 Series Laser Diode Controller enters calibration mode for current.

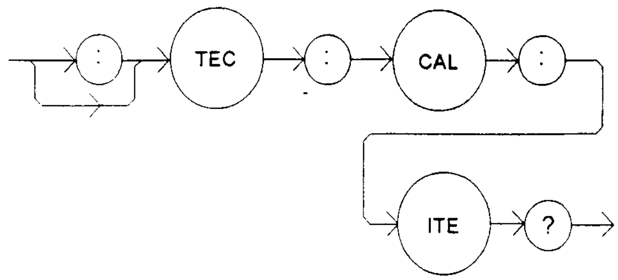
"Tec:Cal:Ite" -action: the LDC-3700 Series Laser Diode Controller enters calibration mode for current.

■ Front Panel
■ Remote

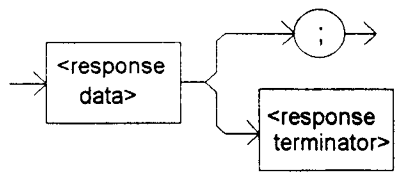
## TEC:CAL:ITE?

The TEC:CAL:ITE? query is used to determine that the LDC-3700 Series Laser Diode Controller is ready for a value to be entered during the calibration cycle of the TEC:CAL:ITE mode.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>; 1 = ready, 0 = not ready.

POINTS OF INTEREST

This query can be used to poll the LDC-3700 Series Laser Diode Controller after the TEC:CAL:ITE command to determine if its waiting for a value. If the response is 1, the LDC-3700 Series Laser Diode Controller is ready to receive a calibration value via the TEC:ITE command (see Section 6.3.8). This query may then be repeated for the second half of the calibration cycle. (A query of the TEC condition status register, bit 11, has the same results.)

In local operation, the ready state during the calibration cycle is indicated by a beep which is issued by the LDC-3700 Series Laser Diode Controller when it is ready for a value to be entered (if the beeper is enabled).

EXAMPLES

"Tec:CAL:ITE?" -response: 1, means the LDC-3700 Series Laser Diode Controller is ready for the user to enter a current value via the TEC:ITE command.

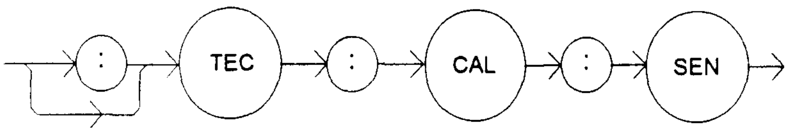
"Tec:Cal:Ite?" -response: 0, means the LDC-3700 Series Laser Diode Controller is not yet ready for the user to enter a current value, or it is not in the TEC current calibration cycle.

■ Front Panel
■ Remote

## TEC:CAL:SENsor

The TEC:CAL:SENsor command sets the TEC's sensor calibration mode for the activated (via the rear panel switch) sensor, and it enters that mode.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

After this command is issued, the front panel is disabled, and the LDC-3700 Series Laser Diode Controller will automatically enter the sensor calibration mode. When the LDC-3700 Series Laser Diode Controller is ready, the SET switch will become enabled, and the user should enter the true measured value. This procedure is outlined in Section 6.3.

In remote operation, the TEC:CAL:SENsor? query may be used to determine if the LDC-3700 Series Laser Diode Controller is ready for the user to enter a value.

In local operation, the LDC-3700 Series Laser Diode Controller will display " --0x", where x is a digit from 1 - 4, to indicate the calibration mode. (This number corresponds to the sensor switch display number). Then it will enable the SET switch and beep when it is ready for the user to enter a value.

EXAMPLES

"Tec:CAL:Sen" -action: the LDC-3700 Series Laser Diode Controller enters calibration mode for the sensor which is selected by the back panel switch.

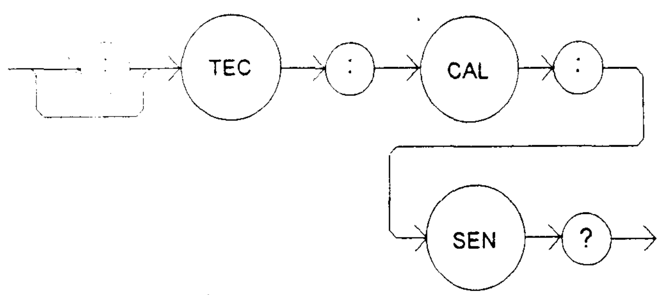
"Tec:Cal:Sensor" -action: the LDC-3700 Series Laser Diode Controller enters calibration mode for the sensor which is selected by the back panel switch.

■ Front Panel
■ Remote

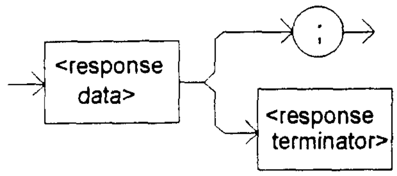
## TEC:CAL:SENsor?

The TEC:CAL:SENsor? query is used to determine that the LDC-3700 Series Laser Diode Controller is ready for a value to be entered during the calibration cycle of the TEC:CAL:SENsor mode.

SYNTAX DIAGRAM



PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>; 1 = ready, 0 = not ready.

POINTS OF INTEREST

This query can be used to poll the LDC-3700 Series Laser Diode Controller after the TEC:CAL:SEN command to determine if it is waiting for a value. If the response is 1, the LDC-3700 Series Laser Diode Controller is ready to receive a calibration value via the TEC:R command (see Section 6.3). (A query of the TEC condition status register, bit 11, has the same results.)

In local operation, the ready state during the calibration cycle is indicated by a beep which is issued by the LDC-3700 Series Laser Diode Controller when it is ready for a value to be entered (if the beeper is enabled).

EXAMPLES

"Tec:CAL:SEN?" -response: 1, means the LDC-3700 Series Laser Diode Controller is ready for the user to enter a resistance value via the TEC:R command.

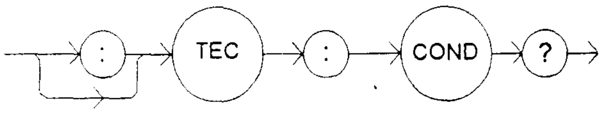
"Tec:Cal:Sensor?" -response: 0, means the LDC-3700 Series Laser Diode Controller is not yet ready for the user to enter a resistance value.

❑ Front Panel
■ Remote

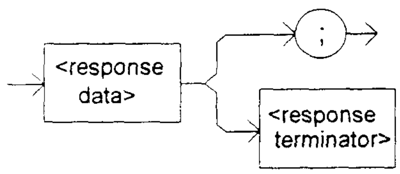
## TEC:COND?

The TEC:COND? query returns the value of the status condition register of the TEC operations.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:



-where the response is the sum of the following:

| | |
|---|---|
| 1 - TE Current Limit | 256 - N/A |
| 2 - Voltage Limit Error | 512 - Output Out of Tolerance |
| 4 - N/A | 1024 - Output On |
| 8 - High Temperature Limit | 2048 - Ready for Calibration Data |
| 16 - TEC Interlock Enable | 4096 - Calculation Error |
| 32 - Booster Enable | 8192 - Internal Communication Error with TEC Board |
| 64 - Sensor Open | 16384 - Software Error |
| 128 - TE Module Open | 32768 - TEC EEPROM Checksum Error |

POINTS OF INTEREST

The enabled TEC conditions can be set by using the TEC:ENABle:COND command.

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

EXAMPLES

"TEC:COND?" -response: 513, means that the Output Out of Tolerance and TE Current Limit TEC conditions currently exist.

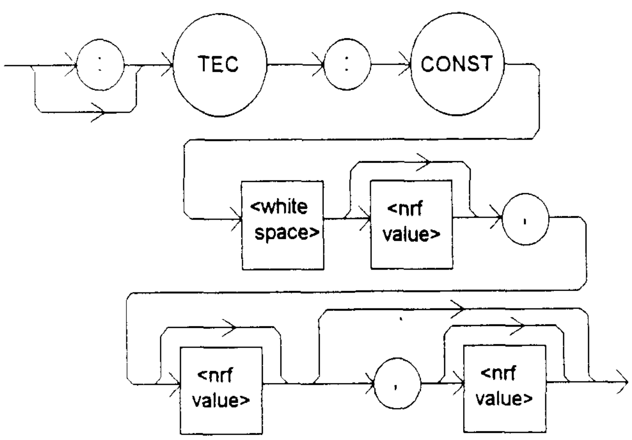
"Radix Hex; TEC:Cond?" -response: #H82, means that the TE Module Open and Voltage Limit TEC conditions currently exist.

■ Front Panel
■ Remote

## TEC:CONST

The TEC:CONST command sets the TEC's Steinhart-Hart equation constants.

SYNTAX DIAGRAM




PARAMETERS

One, two, or three <nrf values>, for the three Steinhart-Hart equation constants or the two linear calibration constants for linear IC sensors. The range of values is -9.999 to +9.999 for all three constants. However, for a thermistor sensor, these values are scaled by the appropriate exponential value for the Steinhart-Hart equation (see Appendix A).

POINTS OF INTEREST

If less than three parameters need to be changed, only the desired change needs to be specified, along with the separating commas (see examples).

When the LM335 or AD590 sensors are selected via the SENSOR SELECT switch, only C1 and C2 are used. Therefore, only two parameters are required in those cases.

In local operation, the constants are entered individually by selecting CONST (C1, C2 or C3 are lit successively by the BAR GRAPH) in the PARAMETER section of the front panel. Then, with the SET switch pressed and held in, the parameter value may be adjusted by turning the ADJUST knob. When the SET switch is released, the value is stored in non-volatile memory.

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 1.4, ," -action: sets C1 to 1.400, C2 and C3 unchanged.

"TEC:Const ,4.5,0.3" -action: sets C2 to 4.500, C3 to 0.300, and C1 is unchanged.

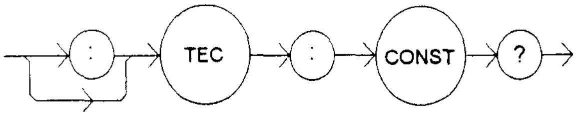
"Tec:CONST 1.4,2.015" -action: sets C1 to 1.400, C2 to 2.015 for two-point calibration of AD590 or LM335 sensors (C3 is unchanged, but not used).

■ Front Panel
■ Remote

## TEC:CONST?

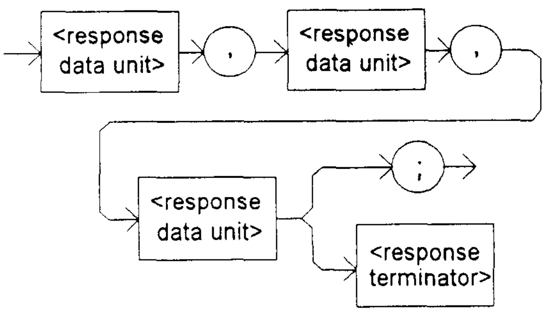
The TEC:CONST? query returns the value of the TEC's Steinhart-Hart constants or the linear sensor conversion constants.

SYNTAX DIAGRAM




PARAMETERS

None. The response will be in the form:




-where the response data represent C1, C2, and C3, respectively.

POINTS OF INTEREST

The response is always in the form: C1,C2,C3.

When the LM335 or AD590 sensors are selected via the SENSOR SELECT switch, only C1 and C2 are used. Therefore, C3 values may be ignored for these cases.

In local operation, the constants may be read by selecting (LED lit) the desired parameter in the PARAMETER section of the front panel and visually reading the value on the TEC display.

Appendices A, B and C contain information on the use of these constants with the various sensor types.

EXAMPLES

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

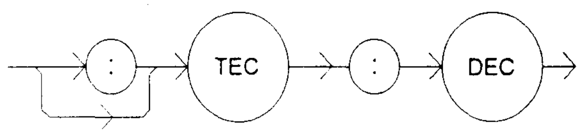
"TEC:Const?" -response: 1.00,2.222,0.07 means C1 = 1.000, C2 = 2.222, and C3 = 0.070.

□ Front Panel
■ Remote

## TEC:DEC

The TEC:DEC command decrements the selected control mode setpoint by one step.

SYNTAX DIAGRAM




PARAMETERS

None.

POINTS OF INTEREST

The decremental amount is one step. The step size can be edited via the STEP command, its default value is 0.1°C, 1 mA (ITE), 1 ohm, 0.01 uA (AD590), or 0.1 mV (LM335), depending on the mode of operation.

EXAMPLES

"TEC:MODE:T; TEC:STEP 2; TEC:DEC" -action: The mode is set for constant temperature and the set point is decremented by 0.2°C.

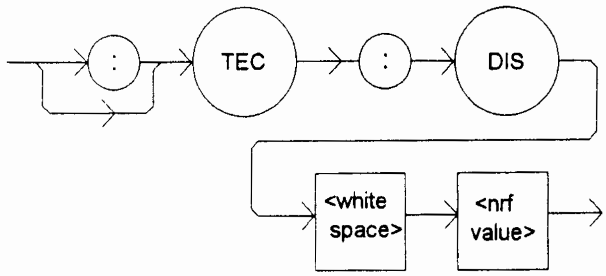
"TEC:Mode:r; Tec:STEP 20; Tec:Dec" -action: The mode is set for constant resistance and the set point is decremented by 20 (0.02 K) ohms, assuming that the SENSOR SELECT switch is in the 100 uA or 10 uA (thermistor current) position.

□ Front Panel
■ Remote

## TEC:DISplay

The TEC:DISplay command enables or disables (turns off) the TEC display and TEC section's indicator LEDs.

SYNTAX DIAGRAM




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

POINTS OF INTEREST Turning the TEC display and LEDs off means that a message of all blank spaces is sent to the TEC display, and all of the TEC section's indicator LEDs will be turned off.

EXAMPLES "TEC:DIS 0" -action: the TEC display will be blanked, and all of the TEC indicator LEDs will be turned off.

"tec:dis 1" -action: the TEC display and LEDs will be enabled.

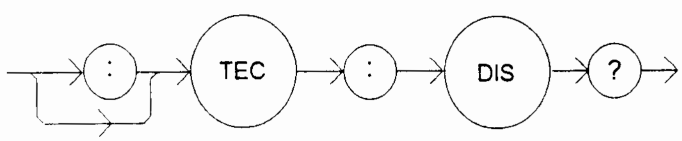
"tec:display on" -action: the TEC display and LEDs will be enabled.

■Front Panel
■ Remote

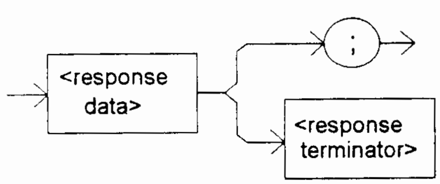
## TEC:DISplay?

The TEC:DISplay? query returns the contents of the TEC display.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is a string.

POINTS OF INTEREST

Returns the actual (6-character) string from the output buffer to the TEC display. If the display is disabled, it returns "    .".

In local operation, the TEC display value is read by visually inspecting the TEC display.

EXAMPLES

"TEC:DIS?" -response: "- 99.9", means "- 99.9" is on the TEC display.

"Tec:DISp?" -response: "  0.6", means "  0.6" is on the TEC display.

■ Front Panel
■ Remote

## TEC:DISplay:

The TEC:DISplay: command path is used to get to the LDC-3700 Series Laser Diode Controller's TEC display commands.

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

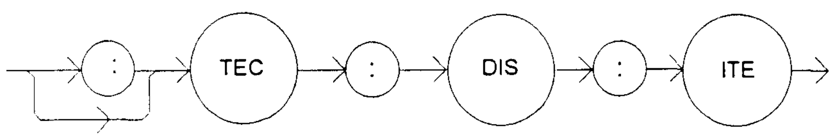
| | |
|---|---|
| TEC:DISplay:ITE | TEC:DISplay:SET |
| TEC:DISplay:ITE? | TEC:DISplay:SET? |
| TEC:DISplay:PARAM | TEC:DISplay:T |
| TEC:DISplay:R | TEC:DISplay:T? |
| TEC:DISplay:R? | |

■ Front Panel
■ Remote

## TEC:DISplay:ITE

The TEC:DISplay:ITE command enables the TEC display to show the TE current measurement.

SYNTAX DIAGRAM




PARAMETERS

None.

POINTS OF INTEREST

The actual TEC ITE display is turned off automatically when another TEC display selection is enabled.

In local operation, the TEC ITE display is enabled by pressing the ITE switch in the TEC DISPLAY area of the front panel.

EXAMPLES

":Tec:Display:Ite" -action: enables the TEC display for measured current values.

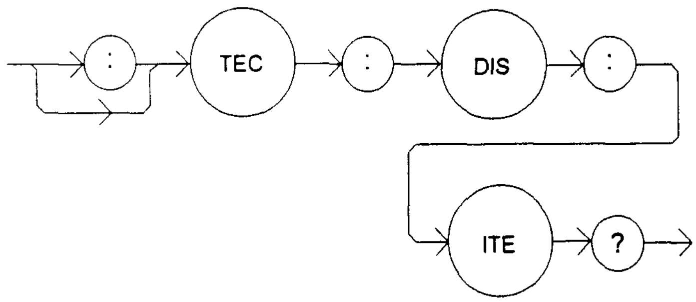
"TEC:DIS:ITE" -action: enables the TEC display for measured current values.

■ Front Panel
■ Remote

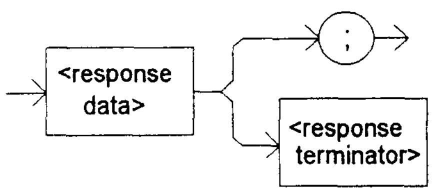
## TEC:DISplay:ITE?

The TEC:DISplay:ITE? query returns the status of the (TEC DISPLAY) ITE switch.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST

The response will be the status of the TEC DIS ITE switch; 1 = on, 0 = off.

In local operation, the status of the TEC ITE display switch is determined by visually inspecting the LED indicator on the (TEC DISPLAY) ITE and SET switches. The ITE measurement will be displayed if the SET indicator is off and the ITE indicator is on (lit = ON).

EXAMPLES

"TEC:DIS:ITE?" -response: " 0", means that the TEC DIS ITE switch is not enabled, TEC output current is not displayed.

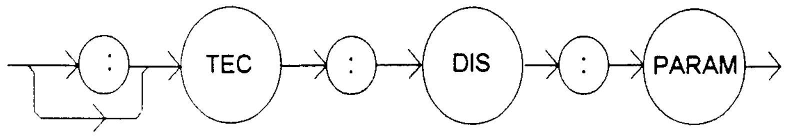
"Tec:DISp:Ite?" -response: "1", means that the TEC DIS ITE switch is enabled, TEC current may be displayed.

■ Front Panel
■ Remote

## TEC:DISplay:PARAM

The TEC:DISplay:PARAM command enables the TEC display to show the parameter values.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

This command has the same effect as pressing the (PARAMETER) SELECT switch while in TEC mode. The selected parameter will be displayed for three seconds. The actual TEC PARAM display is turned off automatically when a TEC display selection is enabled.

Each time the command is issued, the next TEC parameter will be selected, see Section 2.9.

In local operation, the TEC PARAMETER is displayed by pressing the SELECT switch in the TEC PARAMETER area of the front panel, while in TEC mode.

EXAMPLES

":Tec:Display:Param" -action: selects a TEC parameter and displays its value.

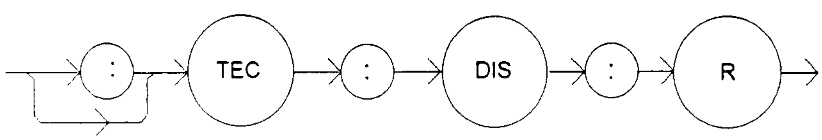
"TEC:DIS:PARAM" -action: selects a TEC parameter and displays its value.

■ Front Panel
■ Remote

## TEC:DISplay:R

The TEC:DISplay:R command sets the TEC display to show the thermistor resistance, AD590 current, or LM335 voltage measurement.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

The actual TEC R display is turned off automatically when another TEC display selection is enabled.

In local operation, the TEC R display is enabled by pressing the R switch in the TEC DISPLAY area of the front panel.

EXAMPLES "TEC:DIS:R" -action: enables the TEC display for measured resistance or linear sensor reference values.

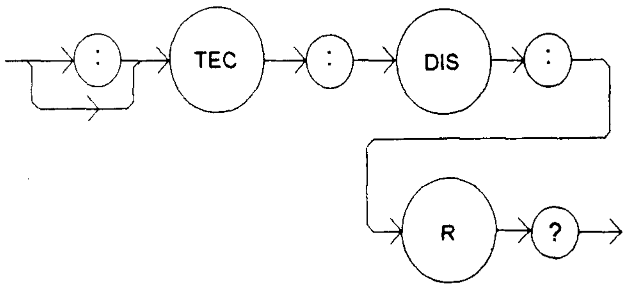
"TEC:Display:R" -action: enables the TEC display for measured resistance or linear sensor reference values.

■ Front Panel
■ Remote

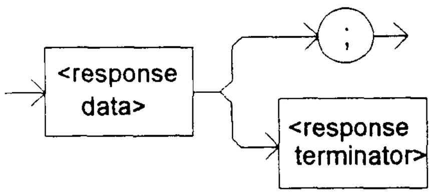
## TEC:DISplay:R?

The TEC:DISplay:R? query returns the status of the (TEC DISPLAY) R switch.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST The response will be the status of the TEC DIS R switch, 1 = on, 0 = off.

In local operation, the status of the TEC R display switch is determined by visually inspecting the LED indicator on the (TEC DISPLAY) R and SET switches. The R measurement will be displayed if the SET indicator is off and the R indicator is on (lit = ON).

EXAMPLES "TEC:Dis:R?" -response: 0, means that the TEC DIS R switch is not active. Therefore, TEC thermistor resistance, or AD590 current, or LM335 voltage is not displayed.

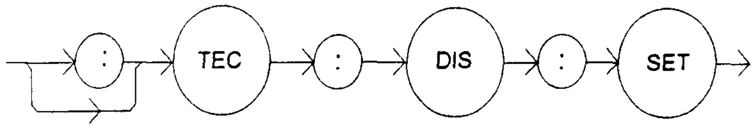
"Tec:dis:R?" -response: 1, means that the TEC DIS R switch is active. Therefore, TEC thermistor resistance, or AD590 current, or LM335 voltage may be displayed.

■ Front Panel
■ Remote

## TEC:DISplay:SET

The TEC:DISplay:SET command sets the TEC display to show the currently selected mode's set point value.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST Using this command has the same effect as physically holding the (TEC DISPLAY) SET switch down (in).

EXAMPLES "Tec:Dis:Set" -action: enables the TEC display for the set point of the selected mode: ITE, R or T.

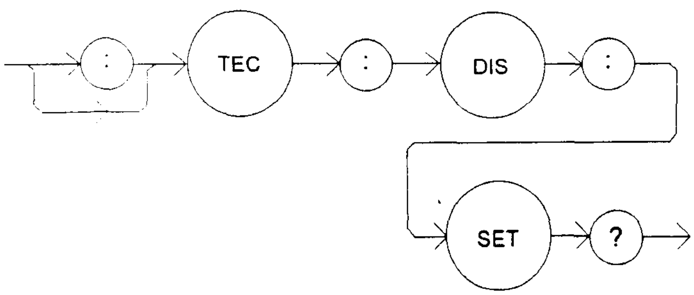
"TEC:Dis:Set" -action: enables the TEC display for the set point of the selected mode: ITE, R or T.

■ Front Panel
■ Remote

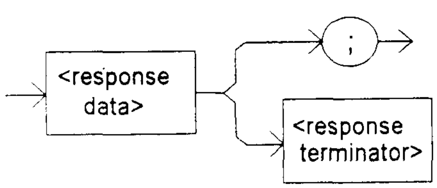
## TEC:DISplay:SET?

The TEC:DISplay:SET? query returns the status of the TEC display set point switch.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:



-where an <nrf> response value of 0 = set point disabled (measured value may be displayed), 1 = set point enabled.

POINTS OF INTEREST

The set point display will not time out when remote operation is used. (It will be continuously displayed.)

In local operation, the status of the (TEC DISPLAY) SET switch is determined by visually inspecting the LED indicator on the switch (lit = ON).

EXAMPLES

"TEC:DISPL:SET?" -response: 0, means the set point value is disabled for the TEC display.

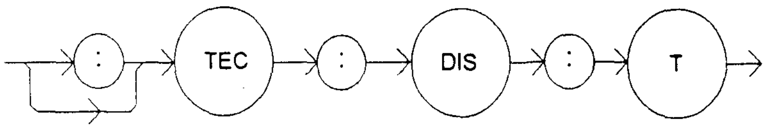
"Tec:Dis:Set?" -response: 1, means the set point value is enabled for the TEC display.

■ Front Panel
■ Remote

## TEC:DISplay:T

The TEC:DISplay:T command enables the TEC display to show the TEC load temperature measurement.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

The actual TEC T display is turned off automatically when another TEC display selection is enabled.

In local operation, the TEC T display is enabled by pressing the T switch in the TEC DISPLAY area of the front panel.

EXAMPLES

"Tec:Dis:T" -action: enables the TEC display for the TEC load's measured temperature.

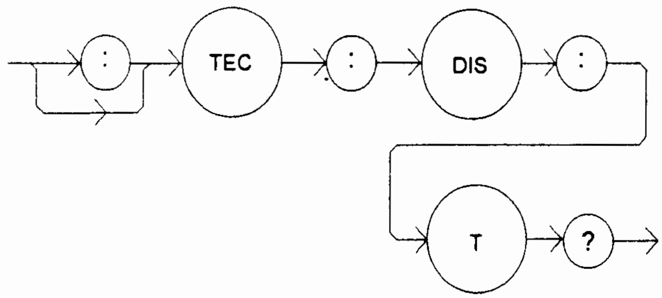
"TEC:DIS:T" -action: enables the TEC display for the TEC load's measured temperature.

■ Front Panel
■ Remote

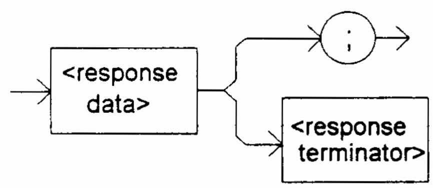
## TEC:DISplay:T?

The TEC:DISplay:T? query returns the status of the (TEC DISPLAY) T switch.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST The response will be the status of the TEC DIS T switch, 1 = on, 0 = off.

In local operation, the status of the TEC T display switch is determined by visually inspecting the LED indicator on the (TEC DISPLAY) T and SET switches. The T measurement will be displayed if the SET indicator is off and the T indicator is on (lit = ON).

EXAMPLES "TEC:Dis:T?" -response: 0, means that the TEC DIS T switch is not enabled, TEC load temperature is not displayed.

"Tec:dis:T?" -response: 1, means that the TEC DIS T switch is enabled, temperature may be displayed.

☐ Front Panel
■ Remote

## TEC:ENABle:

The TEC:ENABle: command path is used to get to the LDC-3700 Series Laser Diode Controller's TEC status enable commands and queries.

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

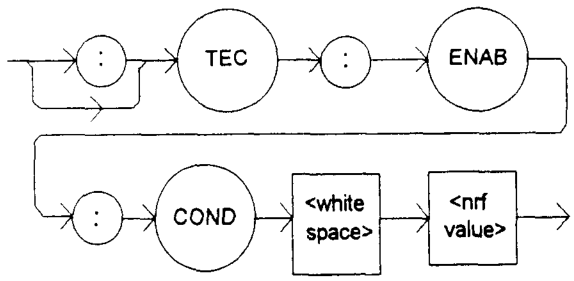
TEC:ENABle:COND
TEC:ENABle:COND?
TEC:ENABle:EVEnt
TEC:ENABle:EVEnt?
TEC:ENABle:OUTOFF
TEC:ENABle:OUTOFF?

◫Front Panel
■ Remote

## TEC:ENABle:COND

The TEC:ENABle:COND command sets the status condition enable register of the TEC operations. These conditions are summarized in bit 1 of the status byte.

SYNTAX DIAGRAM




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

| | |
|---|---|
| 1 - TE Current Limit | 256 - N/A |
| 2 - Voltage Limit Error | 512 - Output Out of Tolerance |
| 4 - N/A | 1024 - Output On |
| 8 - High Temperature Limit | 2048 - Ready for Calibration Data |
| 16 - TEC Interlock Enable | 4096 - Calculation Error |
| 32 - Booster Enable | 8192 - Internal Communication Error with TEC Board |
| 64 - Sensor Open | 16384 - Software Error |
| 128 - TE Module Open | 32768 - TEC EEPROM Checksum Error |

POINTS OF INTEREST

The enabled TEC conditions can be read by using the TEC:ENABle:COND? query.

The TEC condition status can be monitored by the TEC:COND? query. If any of the enabled TEC conditions are true, bit 1 of the status byte register will be set.

The enable registers normally retain their values at power-up (as they were at power-down) unless the power-on status clear flag is set true (see *PSC, Chapter 3).

EXAMPLES

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

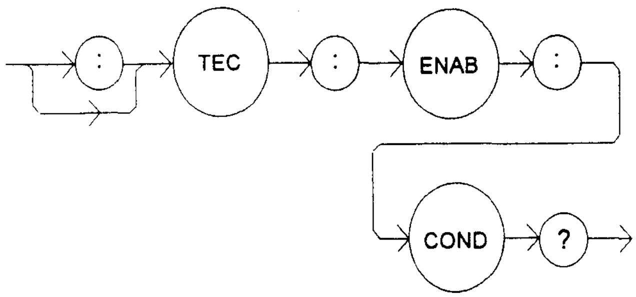
"Tec:Enable:Cond #HFDFB" -action: enables the TEC status condition register so that any and all of the above conditions will be reported in the status byte register.

◫Front Panel
■ Remote

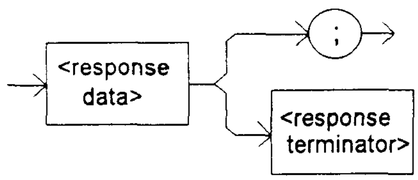
## TEC:ENABle:COND?

The TEC:ENABle:COND? query returns the value of the status condition enable register of the TEC operations.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is the sum of the following:

| | |
|---|---|
| 1 - TE Current Limit | 256 - N/A |
| 2 - Voltage Limit Error | 512 - Output Out of Tolerance |
| 4 - N/A | 1024 - Output On |
| 8 - High Temperature Limit | 2048 - Ready for Calibration Data |
| 16 - TEC Interlock Enable | 4096 - Calculation Error |
| 32 - Booster Enable | 8192 - Internal Communication Error with TEC Board |
| 64 - Sensor Open | 16384 - Software Error |
| 128 - TE Module Open | 32768 - TEC EEPROM Checksum Error |

POINTS OF INTEREST

The enabled TEC conditions can be set by using the TEC:ENABle:COND command.

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

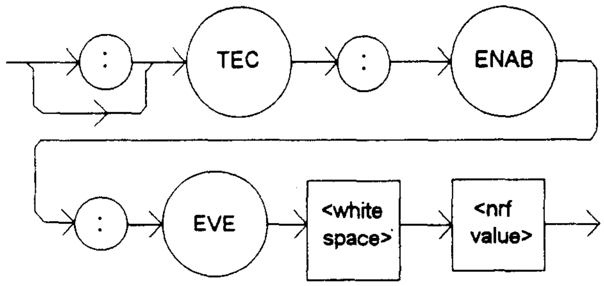
EXAMPLES

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

"Radix Hex; TEC:Enable:Cond?" -response: #HFDFB, means that any and all of the above conditions will be reported in the status byte register.

The TEC:ENABle:EVEnt command sets the status event enable register of the TEC operations. These events are summarized in bit 0 of the status byte register.

SYNTAX DIAGRAM




PARAMETERS

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

| | |
|---|---|
| 1 - TE Current Limit | 256 - N/A |
| 2 - Voltage Limit Error | 512 - Output Changed to be In/Out of Tolerance |
| 4 - N/A | 1024 - Output On/Off Changed |
| 8 - High Temperature Limit | 2048 - New Measurements Taken |
| 16 - TEC Interlock Disabled | 4096 - Calculation Error |
| 32 - Booster Enable | 8192 - Internal Communication Error with TEC Board |
| 64 - Sensor Open | 16384 - Software Error |
| 128 - TE Module Open | 32768 - TEC EEPROM Checksum Error |

POINTS OF INTEREST

The enabled TEC events can be read by using the TEC:ENABle:EVEnt? query.

The enabled TEC event status can be monitored by the TEC:EVEnt? query.

The enable registers normally retain their values at power-up (as they were at power-down) unless the power-on status clear flag is set true (see *PSC, Chapter 3).

EXAMPLES

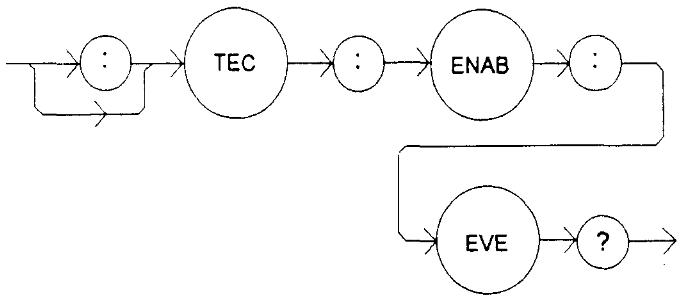
"Tec:Enab:EVENT 160" -action: enables the TEC status event register so that the TE Module Open and Booster Changed conditions will be reported (in summarized form) to the status byte register (bit 1).

"Tec:Enable:EVEnt #HFFFB" -action: enables the TEC status event register so that any and all of the above events will be reported (in summarized form) to the status byte register (bit 1).

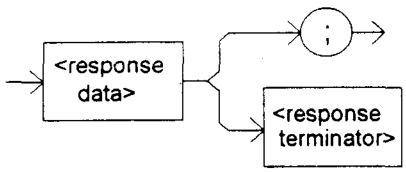
# TEC:ENABle:EVEnt?

The TEC:ENABle:EVEnt? query returns the value of the status event enable register of the TEC operations.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is the sum of the following:

| | |
|---|---|
| 1 - TE Current Limit | 256 - N/A |
| 2 - Voltage Limit Error | 512 - Output Changed to be In/Out of Tolerance |
| 4 - N/A | 1024 - Output On/Off Changed |
| 8 - High Temperature Limit | 2048 - New Measurements Taken |
| 16 - TEC Interlock Disabled | 4096 - Calculation Error |
| 32 - Booster Enable | 8192 - Internal Communication Error with TEC Board |
| 64 - Sensor Open | 16384 - Software Error |
| 128 - TE Module Open | 32768 - TEC EEPROM Checksum Error |

POINTS OF INTEREST

The enabled TEC events can be set by using the TEC:ENABle:EVEnt command.

The TEC event status can be read and reset by issuing the TEC:EVEnt? query.

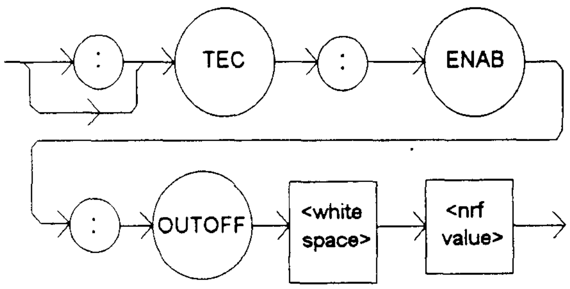
EXAMPLES

"TEC:ENAB:EVE?" -response: 520, means that the High Temperature Limit and Output Out of Tolerance TEC events will be reported (in summarized form) to the status byte register (bit 0).

"Radix Hex; TEC:Enab:Eve?" -response: #HFFFB, means that all of the above events will be reported (in summarized form) to the status byte register (bit 0).

The TEC:ENABle:OUTOFF command sets the status outoff enable register of the TEC operations (things which will turn the TEC output off).

SYNTAX DIAGRAM




PARAMETERS

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

1 - TE Current Limit Condition
2 - Voltage Limit Condition
4 - N/A
8 - High Temperature Limit Condition
16 - TEC Interlock Changed Condition
32 - Booster Changed (While Output On) Event
64 - Sensor Open (While Output On) Condition
128 - Module Open (While Output On) Condition
256 - Sensor Type Change (While Output On) Event
512 - Output Out of Tolerance Condition
1024 - Sensor Shorted (While Output On) Condition
2048 - N/A
4096 - Software Error Condition
8192 - N/A
16384 - N/A
32768 - N/A

POINTS OF INTEREST

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

The value of the TEC outoff enable register is stored in non-volatile memory and is retained at power-up.

The factory default setting for this register is #H5E8, or 1512 decimal.

The High Temperature Limit Condition, Sensor Open (While Output On) Condition, and Sensor Type Change (While Output On) Event bits will not be in effect and will not cause the TEC output to be shut off, if the LDC-3700 Series Laser Diode Controller is in ITE mode.

WARNING: If the Outout Out of Tolerance Change Event bit is set when the power is off, the TEC output will not be able to be turned on until this bit is reset.

EXAMPLES "TEC:ENAB:OUTOFF 9" -action: enables the TEC status outoff register so that a High Temperature Limit Condition or a TE Current Limit Condition will cause the TEC output to be turned off.

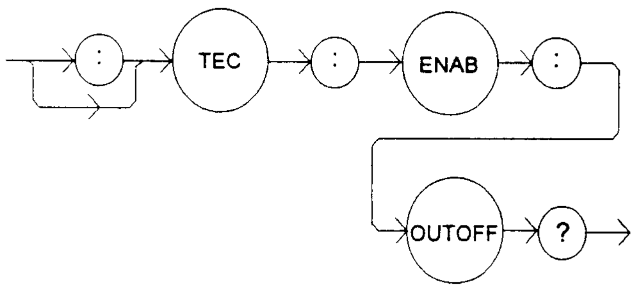
"Tec:Enab:Outoff #H17EB" -action: enables the TEC status outoff register so that any and all of the above conditions will cause the TEC output to be turned off.

☐ Front Panel
■ Remote

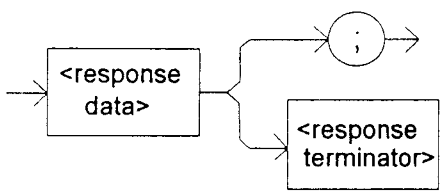
## TEC:ENABle:OUTOFF?

The TEC:ENABle:OUTOFF? query returns the value of the status outoff enable register of the TEC operations (things which will turn the TEC output off).

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is the sum of the following:

1 - TE Current Limit Condition

2 - Voltage Limit Condition

4 - N/A

8 - High Temperature Limit Condition
16 - TEC Interlock Changed Condition
32 - Booster Changed (While Output On) Event
64 - Sensor Open (While Output On) Condition
128 - Module Open (While Output On) Condition

256 - Sensor Type Change (While Output On) Event
512 - Output Out of Tolerance Condition
1024 - Sensor Shorted (While Output On) Condition
2048 - N/A
4096 - Software Error Condition
8192 - N/A
16384 - N/A
32768 - N/A

POINTS OF INTEREST

The enabled TEC outoff events and conditions (which can turn the TEC output off) can be set by using the TEC:ENABle:OUTOFF command.

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.

"Radix Hex; TEC:Enab:Outoff?" -response: #H17EB, means that all of the above conditions will cause the TEC output to be turned off.

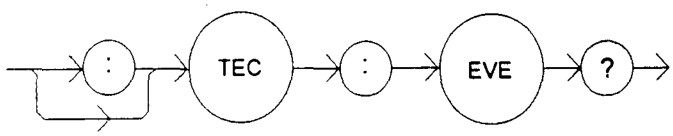
"Radix Bin; TEC:Enab:Outoff?" -response: #B1001, means that the High Temperature Limit and TE Current Limit conditions will cause the TEC output to be turned off.

□ Front Panel
■ Remote

## TEC:EVEnt?

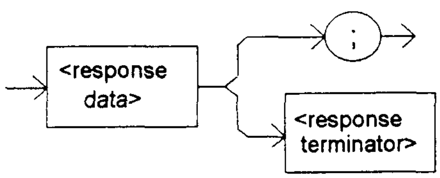
The TEC:EVEnt? query returns the value of the status event register of the TEC operations.

SYNTAX DIAGRAM




PARAMETERS

None. The response will be in the form:




-where the response is the sum of the following:

| | |
|---|---|
| 1 - TE Current Limit | 256 - Sensor Type Changed |
| 2 - TE Voltage Limit | 512 - Output Changed to be In or Out of Tolerance |
| 4 - N/A | 1024 - Output On/Off Changed |
| 8 - High Temperature Limit | 2048 - New Measurements Taken |
| 16 - TEC Interlock Disabled | 4096 - Calculation Error |
| 32 - Booster Changed | 8192 - Internal TEC Control Communication Error |
| 64 - Sensor Open | 16384 - Software Error in TEC Control |
| 128 - TE Module Open | 32768 - TEC EEPROM Checksum Error |

POINTS OF INTEREST

The TEC conditions which are reported to the status byte are set via the TEC:ENABle:EVEnt command.

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

EXAMPLES

"TEC:EVE?" -response: 513, means that the Output went In or Out of Tolerance and the TE Current Limit events have occured since the last TEC:EVEnt? query.

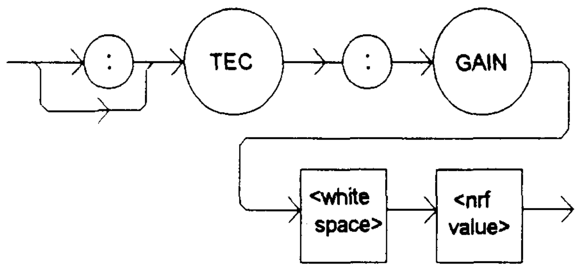
"Radix Hex; TEC:Event?" -response: #H82, means that the Voltage Limit and TE Module Open events have occured since the last TEC:EVEnt? query.

■ Front Panel
■ Remote

## TEC:GAIN

The TEC:GAIN command sets the TEC control loop gain.

SYNTAX DIAGRAM




PARAMETERS

An <nrf value> between 1 - 300, the value will be stored to the nearest of: 1, 3, 10, 30, 100, or 300.

POINTS OF INTEREST

If the user enters a gain value which is greater than 300, a value of 300 will be stored. If the user enters a gain value which is less than 1, a value of 1 will be stored.

If the user enters a value which is not legal, the LDC-3700 Series Laser Diode Controller will round that value to the nearest legal value, if possible.

In local operation, the gain is entered by selecting the GAIN parameter, pressing and holding in the SET switch, and entering the desired value by adjusting the front panel knob. When the SET switch is released, the gain value is stored in non-volatile memory.

EXAMPLES

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

"Tec:gain 3" -action: the TEC control loop gain is set to 3.

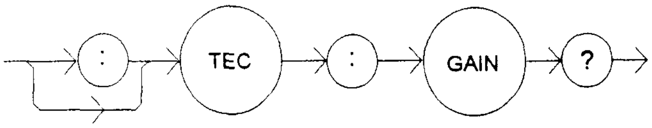
"TEC:Gain 200" -action: the TEC control loop gain is set to 100 (the LDC-3700 Series Laser Diode Controller rounds 200 to the nearest valid number).

■ Front Panel
■ Remote

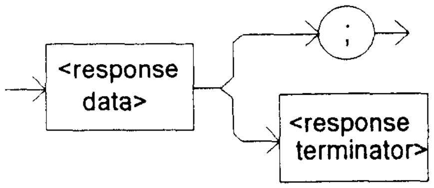
## TEC:GAIN?

The TEC:GAIN? query returns the value of the control loop gain.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response value is one of the following integers: 1, 3, 10, 30, 100, or 300.

POINTS OF INTEREST

If a value other than 1, 3, 10, 30, 100, or 300 is entered via the GAIN command, the nearest valid value will be stored.

In local operation, the gain value is queried by selecting the GAIN parameter and visually reading the display.

EXAMPLES

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

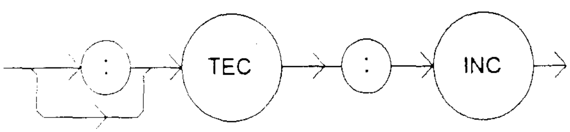
"Tec:GAIN?" -response: 100.0, means the control loop gain is set to 100.

❑ Front Panel
■ Remote

## TEC:INC

The TEC:INC command increments the selected control mode set point by one step.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

The incremental amount is one step. The step size can be edited via the STEP command, its default value is 0.1°C, 1 mA (ITE), 1 ohm, 0.01 uA (AD590), or 0.1 mV (LM335), depending on the mode of operation.

EXAMPLES

"TEC:MODE:T; TEC:STEP 2; TEC:INC" -action: The mode is set for constant temperature and the set temperature is incremented by 0.2°C.

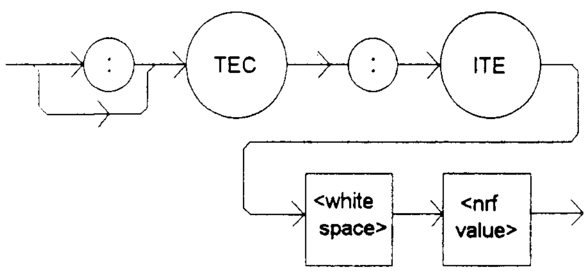
"TEC:Mode:r; Tec:STEP 20; Tec:inc" -action: The mode is set for constant resistance and the set point is incremented by 20 (0.02 K) ohms, assuming that the SENSOR SELECT switch is in the 100 uA or 10 uA (thermistor current) position.

■ Front Panel
■ Remote

## TEC:ITE

The TEC:ITE command sets the TEC control current set point. It is also used to enter the TEC current calibration value.

SYNTAX DIAGRAM




PARAMETERS

An <nrf value> which represents the ITE set point current, in Amps. In ITE current calibration mode, the <nrf value> represents the measured current value in Amps.

POINTS OF INTEREST

This set point is used by the TEC's constant ITE mode only.

In local operation, the ITE set point is entered by selecting (ADJUST) TEC and ITE modes, pressing the (TEC DISPLAY) SET switch, adjusting the ADJUST knob (within 3 seconds), and then releasing the SET switch when the desired value is shown on the TEC display.

EXAMPLES

"TEC:ITE 1" -action: sets the TEC output current set point to 1.000 Amps.

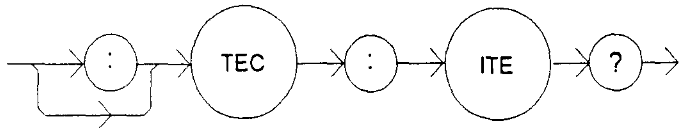
"TEC:MODE:ITE; Tec:Ite 3.5" -action: sets the TEC output current set point to 3.500 Amps and the output is controlled to that value.

■ Front Panel
■ Remote

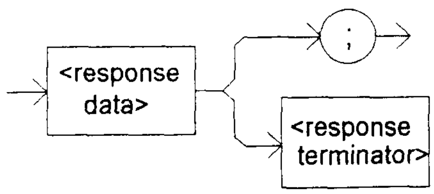
## TEC:ITE?

The TEC:ITE? query returns the value of the measured TEC output current.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response value represents the measured ITE current, in Amps.

POINTS OF INTEREST

The TEC load current is constantly measured and updated, regardless of the TEC mode of operation.

This measurement is updated approximately once every 400 mSec.

If an external booster is used, the ITE measurement will remain zero, as the internal output section is disabled in that case.

In local operation, the ITE measured value is determined by pressing the ITE switch in the TEC DISPLAY area of the front panel, and visually reading the value on the TEC display.

EXAMPLES "TEC:ITE?" -response: 2.43, means the measured TEC output current is 2.430 Amps.

"Tec:Ite?" -response: -3.27, means the measured TEC output current is -3.270 Amps.

■ Front Panel
■ Remote

## TEC:LIMit:

The TEC:LIMit: command path is used to get to the LDC-3700 Series Laser Diode Controller's TEC limit commands.

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

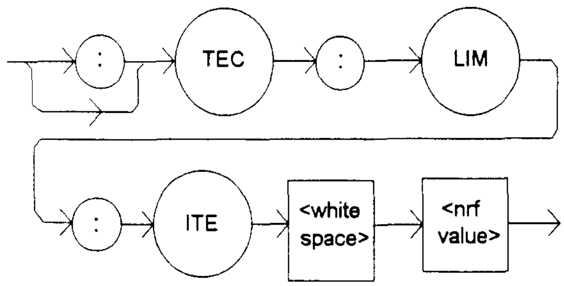
TEC:LIMit:ITE
TEC:LIMit:ITE?
TEC:LIMit:THI
TEC:LIMit:THI?

■ Front Panel
■ Remote

## TEC:LIMit:ITE

The TEC:LIMit:ITE command sets the TEC TE current limit value.

SYNTAX DIAGRAM




PARAMETERS An <nrf value> representing the limit value of the TE current, in Amps.

POINTS OF INTEREST

This value also limits the TEC booster output signal voltage to a value which is proportional to the TEC limit current (approximately 1 V/A).

In local operation, the ITE limit is set by selecting the LIM $I_{TE}$ parameter, pressing the (PARAMETER) SET switch, adjusting the ADJUST knob until the desired value appears on the TEC display, and then releasing the SET switch.

EXAMPLES

"TEC:LIM:ITE 3.5" -action: the TEC current limit is set to 3.500 amps.

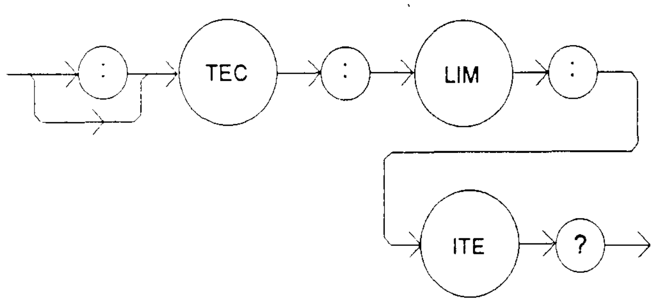
"Tec:Limit:Ite 4.0" -action: the TEC current limit is set to 4.000 amps.

■ Front Panel
■ Remote

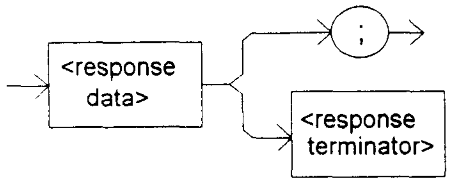
## TEC:LIMit:ITE?

The TEC:LIMit:ITE? query returns the value of the TEC's TE current limit.

SYNTAX DIAGRAM



PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST The response value is in amps.

In local operation, the ITE limit value is read by pressing the (TEC PARAMETER) SELECT switch until the LIM $I_{TE}$ indicator is lit, and reading the value on the TEC display.

EXAMPLES "TEC:LIM:ITE?" -response: 3.5, means the TEC output current limit is 3.500 amps.

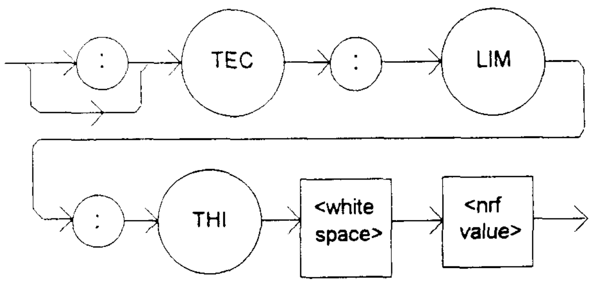
"Tec:Limit:Ite? -response: 4.0, means the TEC output current limit is 4.000 amps.

■ Front Panel
■ Remote

## TEC:LIMit:THI

The TEC:LIMit:THI command sets the TEC high temperature limit value.

SYNTAX DIAGRAM




PARAMETERS An <nrf value> which represents the upper bound of the TEC load temperature, in °C.

POINTS OF INTEREST The THI limit value must be in the range 0 - 199.9 °C.

In local operation, the THI limit is set by selecting the LIM $T_{HI}$ parameter, pressing the (PARAMETER) SET switch, adjusting the ADJUST knob until the desired value appears on the TEC display, and then releasing the SET switch.

The default setting of the TEC outoff enable register forces the TEC output to be shut off if the high temperature limit is reached. (See the TEC:ENABle:OUTOFF command.)

EXAMPLES "TEC:LIM:THI 100" -action: sets the TEC load temperature limit to 100.0°C.

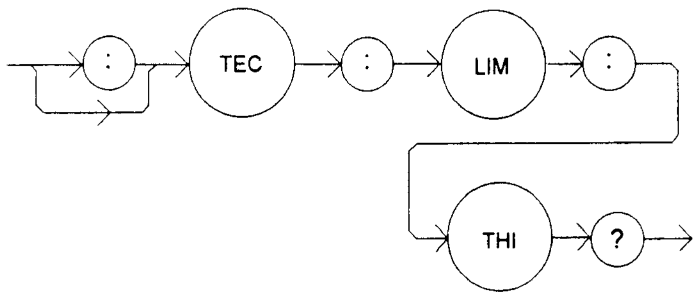
"Tec:Lim:thi 30.3" -action: sets the TEC load temperature limit to 30.3°C.

■ Front Panel
■ Remote

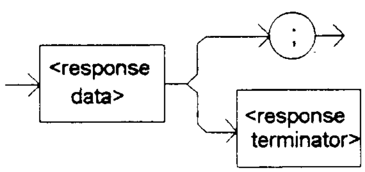
## TEC:LIMit:THI?

The TEC:LIMit:THI? query returns the value of the TEC load's high temperature limit.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST

The temperature limit is valid for R and T modes of TEC output operation.

In local operation, the THI limit value is read by pressing the (TEC PARAMETER) SELECT switch until the LIM $T_{HI}$ indicator is lit, and reading the value on the TEC display.

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 also used to turn the TEC output off (see TEC:ENABle:OUTOFF).

EXAMPLES "TEC:LIM:Thi?" -response: 30.5, means the TEC load's high temperature limit is 30.5°C.

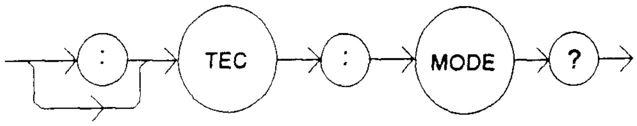
"Tec:Limit:THI? -response: 184.7, means the TEC load's high temperature limit is 184.7°C.

■ Front Panel
■ Remote

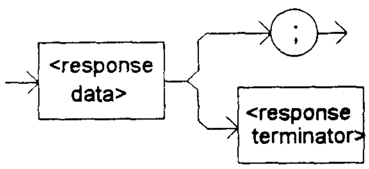
# TEC:MODE?

The TEC:MODE? query returns the selected TEC control mode.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is a character response.

POINTS OF INTEREST

The TEC mode is also the parameter which is controlled. The TEC output is kept at the set point.

In local operation, the mode is of operation is determined by visually inspecting the LED indicators in the TEC MODE area of the front panel (lit = ON).

EXAMPLES

"Tec:MODE?" -response: ITE, means that constant ITE (current) mode is in effect for the TEC output.

":TEC:Mode?" -response: R, means that constant R (resistance/reference) mode is in effect for the TEC output.

"Tec:Mode?" -response: T, means that constant T (temperature) mode is in effect for the TEC output.

■ Front Panel
■ Remote

# TEC:MODE:

The TEC:MODE: command path is used to get to the LDC-3700 Series Laser Diode Controller's TEC mode selection commands.

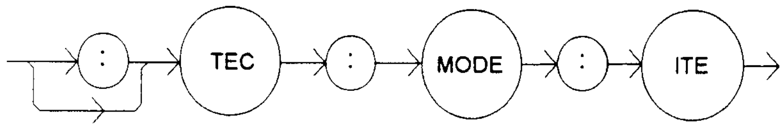
The following commands may be reached directly from the TEC:MODE: command path.

TEC:MODE:ITE
TEC:MODE:R
TEC:MODE:T

## TEC:MODE:ITE

The TEC:MODE:ITE command selects TEC constant TE current mode.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

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

Changing modes causes the output to be forced off, and the new mode's set point value will be displayed.

In local operation, the TEC control mode is set by pressing the (TEC MODE) SELECT switch until the desired mode is indicated by corresponding LED (lit = ON).

EXAMPLES

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

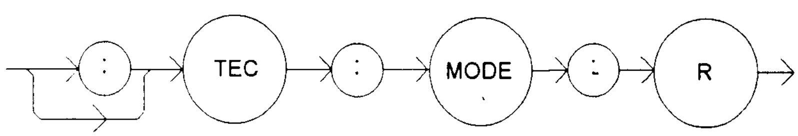
"Tec:Mode:Ite" -action: sets the TEC controller for constant TEC current operation.



## TEC:MODE:R

The TEC:MODE:R command selects TEC constant thermistor resistance/linear sensor reference mode.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST

Since sensor resistance (or linear sensor reference) is a function of temperature, this mode also controls the TEC output load temperature, but it bypasses 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 output to be forced off, and the new mode's set point value will be displayed.

In local operation, the TEC control mode is set by pressing the (TEC MODE) SELECT switch until the desired mode is indicated by corresponding LED (lit = ON).

EXAMPLES "TEC:MODE:R" -action: sets the TEC controller for constant thermistor resistance/linear sensor reference operating mode.

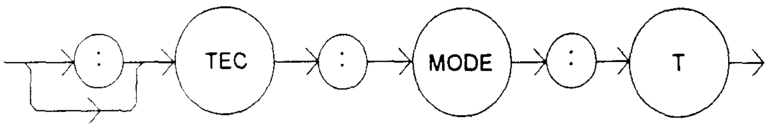
"Tec:Mode:R" -action: sets the TEC controller for constant thermistor resistance/linear sensor reference operating mode.

■ Front Panel
■ Remote

## TEC:MODE:T

The TEC:MODE:T command selects TEC constant temperature mode.

SYNTAX DIAGRAM




PARAMETERS None.

POINTS OF INTEREST Since TEC load temperature is derived from sensor resistance/reference, constant R and T modes are related. In T mode the set point is converted to resistance or reference using the appropriate constants and conversion model.

Changing modes causes the output to be forced off, and the new mode's set point value will be displayed.

In local operation, the TEC control mode is set by pressing the (TEC MODE) SELECT switch until the desired mode is indicated by corresponding LED (lit = ON).

EXAMPLES "TEC:MODE:T" -action: sets the TEC controller for constant load temperature operating mode.

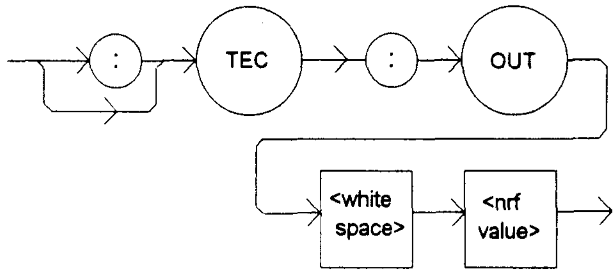
":tec:mode:T" -action: sets the TEC controller for constant load temperature operating mode.

■ Front Panel
■ Remote

## TEC:OUTput

The TEC:OUTput command turns the TEC output on or off.

SYNTAX DIAGRAM




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

POINTS OF INTEREST

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

In local operation, the TEC output is toggled off and on by pressing the ON switch in the TEC MODE area of the front panel.

EXAMPLES

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

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

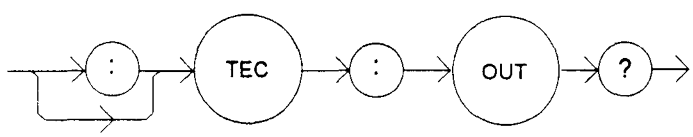
"Tec:Out OFF" -action: turns the TEC output off.

■ Front Panel
■ Remote

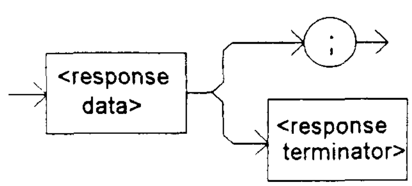
## TEC:OUTput?

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

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST

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

In local operation, the status of the TEC output is determined by visually inspecting the indicator LED of the ON switch in the TEC MODE area of the front panel (lit = ON).

EXAMPLES

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

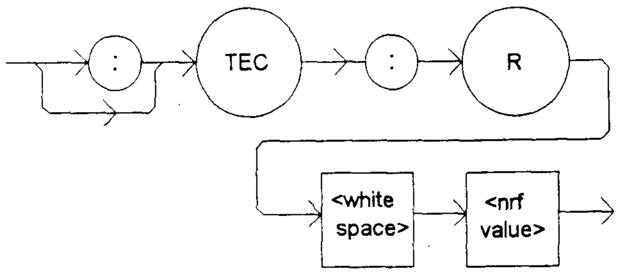
"TEC:OUT?" -response: 1, means the TEC output switch is on, TEC output is on.

■ Front Panel
■ Remote

## TEC:R

The TEC:R command sets the TEC's constant thermistor resistance or linear sensor reference set point.

SYNTAX DIAGRAM




PARAMETERS

An <nrf value> which represents the thermistor resistance set point value, in Kohms; the AD590 current set point, in uA; or the LM335 voltage set point, in mV, depending on the selected sensor type.

POINTS OF INTEREST

The R set point is used to control the TEC output in R mode only. Using the R mode, the user may also monitor the temperature of the TEC load via a remote algorithm of his/her own design.

In local operation, the R set point is entered by selecting (ADJUST) TEC and R modes, pressing the (TEC DISPLAY) SET switch, adjusting the ADJUST knob (within 3 seconds), and then releasing the SET switch when the desired value is shown on the TEC display.

EXAMPLES

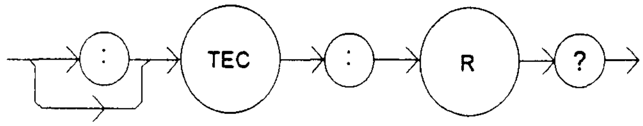
"TEC:R 20.5" -action: sets the set point thermistor resistance to 20.5 Kohms, or sets the AD590 current to 20.5 uA, or sets the LM335 voltage to 20.5 mV.

"TEC:Mode:R; TEC:R 10" -action: sets the set point thermistor resistance to 10.0 Kohms, or the AD590 current to 10.0 uA, or the LM335 voltage to 10.0 mV. The TEC output sensor is controlled to that value, if the output is on.

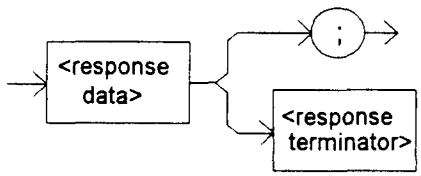
# TEC:R?

The TEC:R? query returns the value of the TEC thermistor resistance, or AD590 current, or LM335 voltage measurement.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the <nrf> response value is the measured TEC thermistor resistance, in Kohms, or AD590 current in uA, or the measured LM335 voltage in mV.

POINTS OF INTEREST

TEC load temperature is derived from the thermistor resistance or linear sensor reference measurement.

This measurement is updated approximately once every 400 mSec.

In local operation, the R measured value is determined by pressing the R switch in the TEC DISPLAY area of the front panel, and visually reading the value on the TEC display.

EXAMPLES

"TEC:R?" -response: 10.543, means the measured TEC thermistor resistance is 10.543 Kohms, or the measured AD590 current is 10.543 uA, or the measured LM335 voltage is 10.543 mV, depending on the SENSOR SELECT switch position.

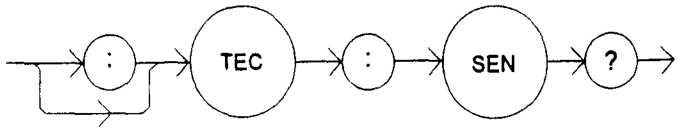
"Tec:R?" -response: 0.728, means the measured TEC thermistor resistance is 728 ohms, or the measured AD590 current is 0.728 uA, or the measured LM335 voltage is 0.728 mV, depending on the SENSOR SELECT switch position.

□ Front Panel
■ Remote

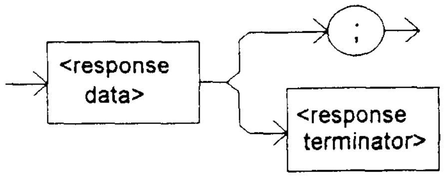
# TEC:SENsor?

The TEC:SENsor? query is used to read back the SENSOR SELECT switch position value. This value is a coded representation of the sensor type/thermistor sensor current.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response of 1 = thermistor, at 100 uA; 2 = thermistor, at 10 uA; 3 = LM335 sensor; 4 = AD590 sensor.

POINTS OF INTEREST

The sensor code is displayed on the TEC display, and bit 8 of the TEC event register is set, whenever the back panel SENSOR SELECT switch position is changed.

The sensor selection must be made locally at the back panel SENSOR SELECT switch.

In local operation, the setting of the SENSOR SELECT switch may be read by visually inspecting the back panel SENSOR SELECT switch.

If the response is 0, the sensor type is undetermined and a hardware error must exist.

EXAMPLES

"TEC:Sensor?" -response: 1, means the SENSOR SELECT switch is in the 100 uA thermistor position.

"Tec:SEN?" -response: 3, means the LM335 sensor is selected by the back panel SENSOR SELECT switch.

■ Front Panel
■ Remote

## TEC:SET:

The TEC:SET: command path is used to get to the LDC-3700 Series Laser Diode Controller's TEC set point queries.

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

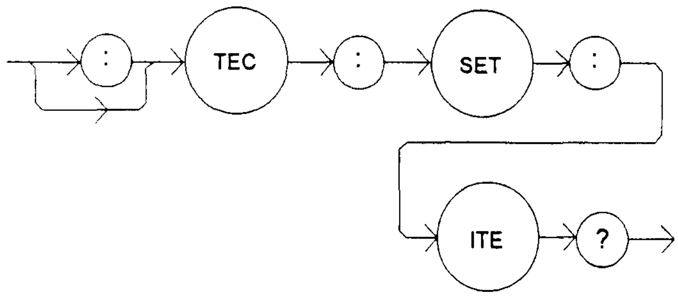
TEC:SET:ITE?
TEC:SET:R?
TEC:SET:T?

■ Front Panel
■ Remote

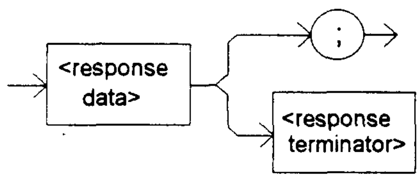
# TEC:SET:ITE?

The TEC:SET:ITE? query returns the TEC constant TE current set point value.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response <nrf value> represents the ITE set point, in amps.

POINTS OF INTEREST

The TEC output is controlled to this set point value only when constant ITE mode is in effect.

In local operation, the ITE set point value is read by pressing the (TEC DISPLAY) SET switch while in ITE mode, and visually reading the TEC display.

EXAMPLES

"TEC:SET:ITE?" -response: 3.0, means the ITE set point is 3.000 amps.

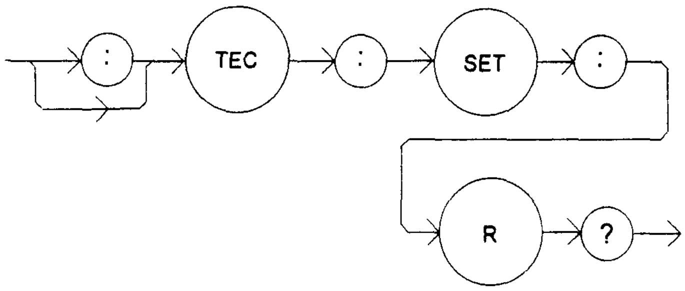
"Tec:Set:Ite?" -response: 4.0, means the ITE set point is 4.000 amps.

■ Front Panel
■ Remote

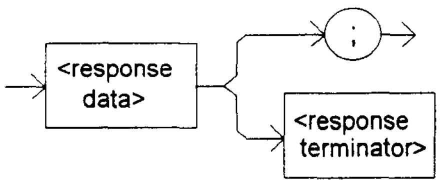
# TEC:SET:R?

The TEC:SET:R? query returns the TEC's constant thermistor resistance or linear sensor reference set point value.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response <nrf value> represents the set point thermistor resistance value, in Kohms; or the AD590 set point current, in uA; or the LM335 set point voltage, in mV.

POINTS OF INTEREST The TEC output is controlled to this set point value only when constant R mode is in effect.

In local operation, the R set point value is read by pressing the (TEC DISPLAY) SET switch while in R mode, and visually reading the TEC display.

EXAMPLES "TEC:SET:R?" -response: 3.4, means the R set point is 3.400 Kohms, or 3.40 uA, or 3.4 mV, depending on the SENSOR SELECT switch position.

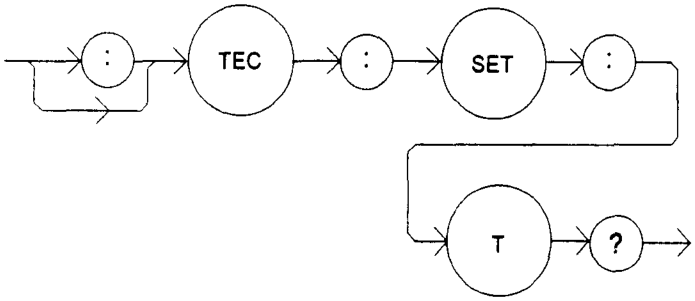
"Tec:Set:R?" -response: 4.0, means the R set point is 4.000 Kohms, or 4.00 uA, or 4.0 mV, depending on the SENSOR SELECT switch position.

■ Front Panel
■ Remote

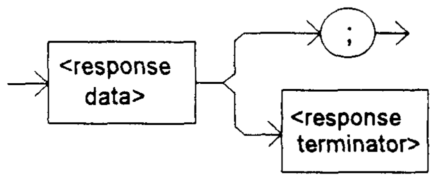
## TEC:SET:T?

The TEC:SET:T? query returns the TEC constant temperature set point value, in °C.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response <nrf value> represents the set point temperature, in °C.

POINTS OF INTEREST

The TEC output is controlled to this set point value only when constant T mode is in effect.

In local operation, the T set point value is read by pressing the (TEC DISPLAY) SET switch while in T mode, and visually reading the TEC display.

EXAMPLES

"TEC:SET:T?" -response: 33.4, means the constant T set point is 33.4°C.

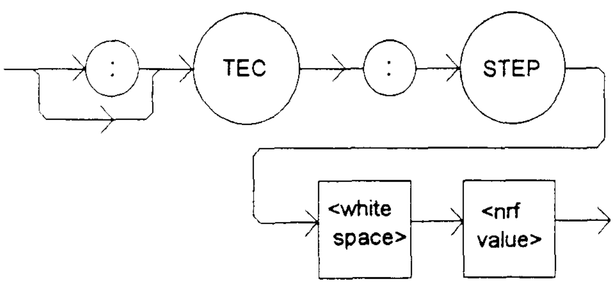
"Tec:Set:t?" -response: -4.0, means the constant T set point is -4.0 °C.

☐ Front Panel
■ Remote

## TEC:STEP

The TEC:STEP command is used to increment or decrement the selected TEC control mode set point by the given amount, when used with the TEC:INC or TEC:DEC command.

SYNTAX DIAGRAM



PARAMETERS An integer value of the step amount, in the range 1 - 9999.

POINTS OF INTEREST The step of 1 corresponds to the smallest incremental change of the mode. For example, a step of 1 means 0.1°C, 1 ohm, 0.01 uA (AD590), 0.1 mV (LM335), or 1 mA (ITE mode).

EXAMPLES "TEC:Mode:t; TEC:t 20; TEC:Step 10; TEC:Inc; TEC:Set:t?" -sets the step to 1°C, so the TEC:Set:t? query will return a value of 21 mA.

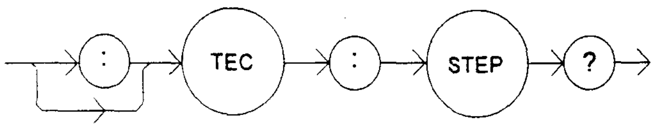
"Tec:Step 100" -sets the step size to 100; could mean 10.0°C, 100 ohms, 1 uA (AD590), 10 mV (LM335), or 100 mA (ITE mode).

☐ Front Panel
■ Remote

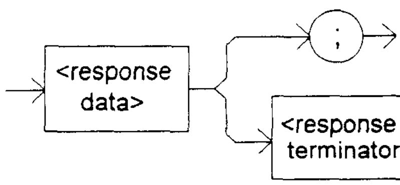
## TEC:STEP?

The TEC:STEP? query is used to read back the TEC STEP value. This value is used to increment or decrement the selected TEC control mode set point by the given amount, when used with the TEC:INC or TEC:DEC command.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST The step of 1 corresponds to the smallest incremental change of the mode. For example, a step of 1 means 0.1 °C, 0.001 Kohm, 0.01 uA (AD590), 0.1 mV (LM335), or 1 mA.

EXAMPLES "TEC:Mode:T; TEC:Step?" -response: 2, means the step size is 0.2°C. This value is in tenths of a degree C, since Const T mode is in effect.

"Tec:MODE:R; TEC:STEP?" -response: 40, means the step size is 40 ohms, assuming the SENSOR SELECT switch is in the 100 or 10 uA position. This value is in ohms, since Const R mode is in effect and a thermistor sensor is selected.

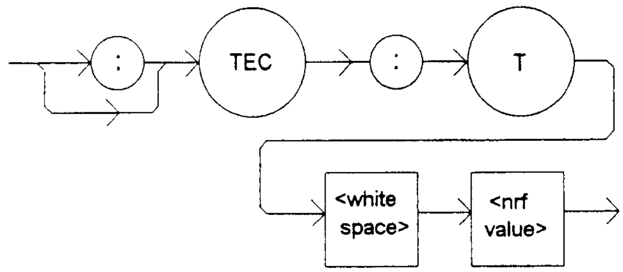
"Tec:MODE:ITE; Tec:STEP?" -response: 20, means the step size is 20 mA. This value is in mA, since Const ITE mode is in effect.

■ Front Panel
■ Remote

## TEC:T

The TEC:T command sets the TEC's constant temperature setpoint.

SYNTAX DIAGRAM




PARAMETERS — An <nrf value> which represents the TEC temperature, in °C.

POINTS OF INTEREST — The TEC temperature will be controlled to this set point only when the TEC is operated in T mode.

In local operation, the R set point is entered by selecting (ADJUST) TEC and R modes, pressing the (TEC DISPLAY) SET switch, adjusting the ADJUST knob (within 3 seconds), and then releasing the SET switch when the desired value is shown on the TEC display.

EXAMPLES — "Tec:T 20" -action: sets the TEC temperature set point to 20.0°C.

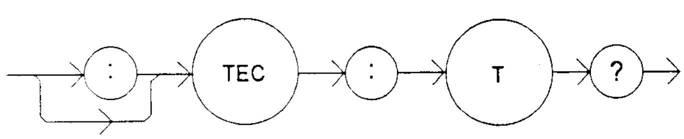
"TEC:MODE:T; TEC:T 25.3" -action: sets the TEC temperature set point to 25.3°C. The output is controlled to this value, if the output is on.

■ Front Panel
■ Remote

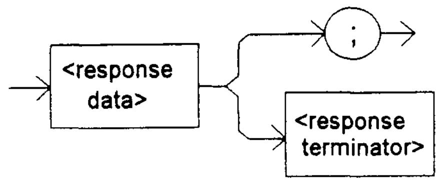
## TEC:T?

The TEC:T? query returns the value of the TEC temperature measurement.

SYNTAX DIAGRAM



PARAMETERS None. The response will be in the form:




-where the response is an <nrf value>.

POINTS OF INTEREST

The measured TEC temperature is valid for all modes of TEC operation. Temperature is continually updated.

This measurement is updated approximately once every 400 mSec.

In remote operation, the response value has 6 digits of precision.

In local operation, the T measured value is determined by pressing the T switch in the TEC DISPLAY area of the front panel, and visually reading the value on the TEC display.

EXAMPLES

"TEC:T?" -response: 10.4231, means the measured TEC load temperature is 10.4231°C.

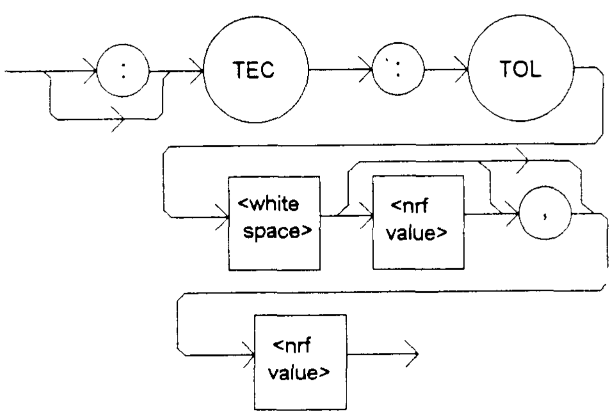
"Tec:Mode:R; Tec:T?" -response: -3.0778, means the measured TEC load temperature is -3.07780°C.

☐ Front Panel
■ Remote

## TEC:TOLerance

The TEC:TOLerance command allows the programmer to determine the TEC temperature tolerance, and time window for it to occur, in order that the operation complete flag be set after a "TEC:OUTput 1" command is issued or the set point is changed.

SYNTAX DIAGRAM



PARAMETERS One or two <nrf values>; the first represents the temperature tolerance, in °C, with a range of 0.1°C to 10.0°C; and the second represents the time window, in seconds, with a range of 0.001 to 50.0 seconds.

This command may be used in conjunction with the TEC:COND? to test for and delay further program activities until the TEC temperature reaches its set point to the specifications of the TEC:TOLerance command.

For example, if the set point is 10°C, tolerance is 0.2°C for 5 seconds, and the TEC output is turned on, the user may issue the TEC:COND? query and read back the response to ensure this set point is reached before continuing. In this case, the TEC will not set bit 9 of the TEC condition register until its TEC load temperature is within 0.2°C of 10°C for a period of 5 seconds.

POINTS OF INTEREST The LDC-3700 Series Laser Diode Controller defaults to a tolerance of 0.2°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, and the Operation-Complete flag (see *OPC, Chapter 3) may never be set.

In R mode the temperature and time parameters are both in effect, as in T mode.

In ITE mode, the temperature parameter is not used. A fixed value of 10 mA is used instead of the temperature parameter, and only the time window may be adjusted.

EXAMPLES "Tol 0.5,10" -action: the LDC-3700 Series Laser Diode Controller's TEC controller will be in tolerance when the temperature is within 0.5°C for a period of 10.000 seconds.

"TOLer 0.1,1.05" -action: the LDC-3700 Series Laser Diode Controller's TEC controller will be in tolerance when the temperature is within 0.1°C for a period of 1.050 seconds.

"TEC:MODE:ITE; TOLer ,10" -action: the LDC-3700 Series Laser Diode Controller's TEC controller is set for ITE mode, and will be in tolerance when the ITE current is within 10 mA for a period of 10.000 seconds.

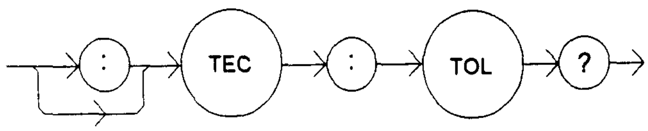
"Tec:Mode:R; TOLer 0.1,2.5" -action: the LDC-3700 Series Laser Diode Controller's TEC controller will be in tolerance when the temperature is within 0.1°C for a period of 2.500 seconds.

## TEC:TOLerance?

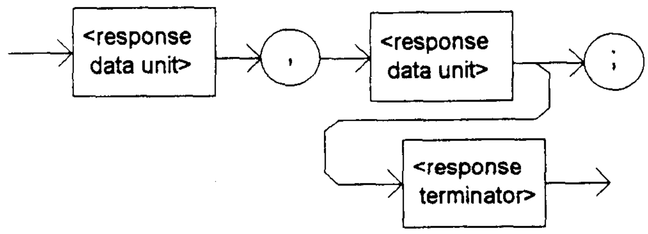
☐ Front Panel
■ Remote

The TEC:TOLerance? query allows the programmer to determine how the TEC temperature tolerance is set.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response consists of two data units, the first represents the temperature tolerance, in °C, and the second represents the time window, in seconds.

POINTS OF INTEREST

The tolerance of the LDC-3700 Series Laser Diode Controller temperature controller may be used to delay programming after an "TEC:OUTput 1" command is issued or the set point is changed.

The TEC tolerance specification is also used in the TEC status event and condition registers, and so entering or exiting TEC temperature tolerance may be used to generate service requests.

EXAMPLES

"Tec:Tol?" -response: "0.2,5", means the LDC-3700 Series Laser Diode Controller has a TEC tolerance setting of 0.2°C with a time window of 5.000 seconds.

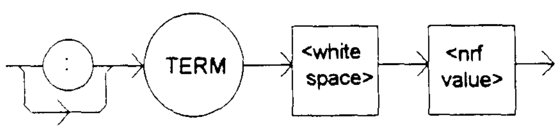
"TEC:TOL?" -response: "1.0,20", means the LDC-3700 Series Laser Diode Controller has a TEC tolerance setting of 1.0°C with a time window of 20.000 seconds.

☐ Front Panel
■ Remote

# TERM

The TERM command allows the programmer to select the message terminator type for GPIB messages. <CR> (carriage return), <CR><NL> (new line), <CR><^END> (EOI), <CR><NL><^END>, <NL><^END>, <NL>, and <^END> are allowed.

SYNTAX DIAGRAM



PARAMETERS

An <nrf value>, where

0 = <CR><NL><^END>,
1 = <CR><NL>,
2 = <CR><^END>,
3 = <CR>,
4 = <NL><^END>,
5 = <NL>,
6 = <^END>, and
7 = N/A

POINTS OF INTEREST

<CR><NL><^END> (number 0) is the default type. This does not strictly comply with the IEEE-488.2 specification. However, the <CR> is ignored (treated as white space), so this terminator may be used with other IEEE-488.2 compliant instruments.

Use of any terminator other than number 4 removes the LDC-3700 Series Laser Diode Controller from strict compliance with the IEEE-488.2 standard. The other options are provided to allow compatibility with GPIB drivers that do not meet the IEEE-488.2 standard.

Although the <CR> is recognized as <white space> by the IEEE-488.2 specification, it is used as a possible terminator in order to be compatible with GPIB products that do not comply with the IEEE-488.2 standard.

Use of terminator number 3 is especially risky with other devices that comply with the IEEE-488.2 specification. This is because the <CR> character is treated as white space by such a device. Therefore, if terminator number 3 is used, other IEEE-488.2 devices may indefinitely for a message termination and "hang" the bus.

EXAMPLES

"TERM 5" -action: the <NL> (new line) terminator is selected. The LDC-3700 Series Laser Diode Controller will terminate a message with the <NL> character.

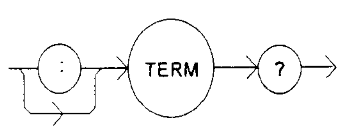
"Term 4" -action: the <NL> (new line) <^END> (EOI) terminator is selected. The LDC-3700 Series Laser Diode Controller will terminate a message with the <NL><^END> characters, in succession, and in that order.

☐ Front Panel
■ Remote

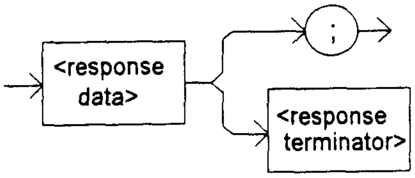
## TERM?

The TERM? query allows the programmer to determine which program message terminator is currently selected. <CR> (carriage return), <CR><NL> (new line), <CR><^END> (EOI), <CR><NL><^END>, <NL><^END>, <NL>, and <^END> are allowed.

SYNTAX DIAGRAM



PARAMETERS None. The response will be in the form:




-where

0 = <CR><NL><^END>,
1 = <CR><NL>,
2 = <CR><^END>,
3 = <CR>,
4 = <NL><^END>,
5 = <NL>,
6 = <^END>, and
7 =N/A.

POINTS OF INTEREST <CR><NL><^END> (0) is the default type.

EXAMPLES "Term?" -response: 0, means the selected program message terminator is the <CR><NL><^END> characters, in succession, in that order.

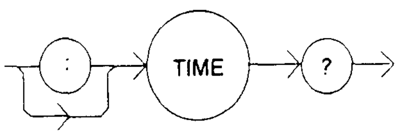
"TERM?" -response: 2, means the selected program message terminator is the <CR><^END> characters, in succession, and in that order.

☐ Front Panel
■ Remote

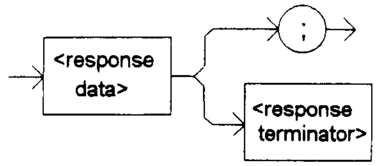
## TIME?

The TIME? query allows the programmer to determine how much time has passed since the LDC-3700 Series Laser Diode Controller was last powered up.

SYNTAX DIAGRAM



PARAMETERS None. The response will be in the form:




-where the response is character data in the form: hours:minutes:seconds.

POINTS OF INTEREST The TIME clock is independent of the TIMER clock.

EXAMPLES "Time?" -response: 1:02.36, means that 1 minute and 2.36 seconds have passed since the LDC-3700 Series Laser Diode Controller was powered up.

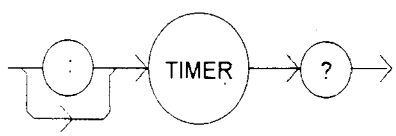
"TIME?" -response: 32:00:76, means that 32 minutes and 0.76 seconds have passed since the LDC-3700 Series Laser Diode Controller was powered up.

❑ Front Panel
■ Remote

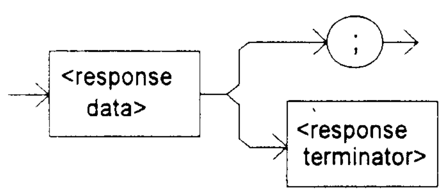
## TIMER?

The TIMER? query allows the programmer to determine how much time has passed since the last TIMER? query was issued.

SYNTAX DIAGRAM




PARAMETERS None. The response will be in the form:




-where the response is character data which represents hours:minutes:seconds.

POINTS OF INTEREST Each time the TIMER? query is issued, the timer is reset to 0 and the elapsed time since the last TIMER? query is returned.

The timer counter is initially set at power-up, the same as the TIME? counter. So the first time the TIMER? is issued its response will be the same as if a TIME? query's response.

EXAMPLES "Timer?" -response: 00:02:00.31, means the LDC-3700 Series Laser Diode Controller has been on for 2 minutes and 0.31 seconds since the last TIMER? query was issued.

"TIMER?" -response: 00:00:12.03, means the LDC-3700 Series Laser Diode Controller has been on for 12.03 seconds since the last TIMER? query was issued.

## 4.5 Error Messages

Error messages may appear on the TEC or LASER displays when error conditions occur in the respective functions of the LDC-3700 Series Laser Diode Controller. For example, a current limit error in the TEC side of the LDC-3700 Series Laser Diode Controller will be displayed on the TEC display.

In most cases, the error message will appear for three seconds and then the display will revert to its former state. In the case of multiple error messages, the LDC-3700 Series Laser Diode Controller will show each message as soon as it is discovered.

In remote operation, the current error list can be read by issuing the "ERR?" query. When this is done, a string will be returned containing the previously unread error messages (up to 10) which are currently in the error message queue.

Appendix D contains an explanation of the error messages which may be reported by the LDC-3700 Series Laser Diode Controller on the displays or via remote operation.

## 4.6 LDC-3700 Series Laser Diode Controller Programming Examples

This section is intended as a simple example of programming the LDC-3700 Series Laser Diode Controller over the GPIB. The first short examples contain sections of a BASIC program. These examples are not complete programs, and therefore cannot be used by themselves. However, they illustrate the simplicity of programming the LDC-3700 Series Laser Diode Controller, and show some possible uses of its features, but the initialization of variable and files has been omitted for simplicity. The last example contains a complete BASIC program which uses both the TEC and LASER controller of the LDC-3700 Series Laser Diode Controller to gather L/I data at varying temperatures.

The following BASIC programming example, Example Program 4.1, exercises the TEC controller of the LDC-3700 Series Laser Diode Controller, and it demonstrates the DELAY, and TEC:STEP commands.

This example assumes that the LDC-3700 Series Laser Diode Controller's LASER controller is set up for measuring laser light power. It also assumes the use of a subroutine for talking to the LDC-3700 Series Laser Diode Controller over the GPIB. This subroutine is shown in Example Program 4.3.

```
200 CMD$ = "Tec:Const 1.125,2.347,0.855" : GOSUB 1000          'Set constants for typical 10K thermistor
210 CMD$ = "Tec:Gain 10" : GOSUB 1000                          'Set control loop gain
220 CMD$ = "Tec:Step 100; Tec:Mode:T" : GOSUB 1000             'Temperature mode, with 10°C step
230 CMD$ = "Tec:T 0; Output ON" : GOSUB 1000                   'Start laser temperature at 0°C
240 FOR X=1 TO 10                                              'Step temperature from 0 to 100 °C
250   CMD$ = "Delay 20000; Las:MDP?; Tec:Inc" : GOSUB 1000     'Wait 20 seconds for temperature to
260   INPUT#2,P$                                               'stabilize, measure laser light power,
270                                                            'and increment laser temp. by 10°C
280 NEXT X                                                     '
```

**Example Program 4.1 TEC Step and Delay**

The following BASIC programming example, Example Program 4.2, exercises the LASER controller of the LDC-3700 Series Laser Diode Controller, and it demonstrates the use of the LAS:CALPD, LAS:MODE:P, and LAS:P? commands for working in constant optical power mode.

This program example assumes that a laser and a monitor photodiode detector are properly installed, and the detector responsivity is known to be 1.2 uA/mW. It also assumes the use of a subroutine for talking to the LDC-3700 Series Laser Diode Controller over the GPIB. This subroutine is shown in Example Program 4.3.

```
300 CMD$ = "Las:Calmd 1.2" : GOSUB 1000                        'Set the detector responsivity to 1.2 uA/mW
310 CMD$ = "Las:Output OFF; Las:Mode:MDP" : GOSUB 1000         'Output off; set to constant power mode
320 CMD$ = "Las:Lim:I1 1000" : GOSUB 1000                      'Set limit to 1000 mA (LDC-3742B)
330 CMD$ = "Las:Output ON" : GOSUB 1000                        'Turn LASER output on
340 FOR X=1 TO 50                                              'Take 50 measurements
350   CMD$ = "Delay 1000; Las:MDP?" : GOSUB 1000               'Wait 1 second between readings
360   INPUT#2,P$                                               'Input is monitor photodiode power, in mW
370 NEXT X                                                     '
```

**Example Program 4.2 LASER Constant Optical Power Measurement**

The following example program, Example Program 4.3, is a BASIC program for use with the LDC-3700 Series Laser Diode Controller. It may be used to gather L/I data (laser output vs. drive current) at several different stabilized temperatures.

```
10  '              * * *  L/I vs TEMP  * * *
20  '
30  'This program measures laser light output vs. drive current over several temperatures.
40  'It is intended for use with an LDC-3700 Series Laser Diode Controller, an IBM PC/XT or compatible using an IOTech
50  'GP488 controller card and PERSONAL488 software (IOTech, P.O.Box 21204, Cleveland,
60  'OH 44121). This program assumes that the GPIB address of the LDC-3700 Series Laser Diode Controller is "01".
70  '
80  'This program was written in GWBASIC (Microsoft Corp.)
90  '
100 '------------------- INITIALIZE PROGRAM PARAMETERS ------------------------------
110 '
120 'AD$ = "01"                                   'Set GPIB address for LDC-3700 Series Laser Diode
Controller
130 'OUT$ = "OUTPUT"                              'Used in output subroutine
140 '
200 '------------------ INITIALIZE THE GPIB DEVICE DRIVERS ---------------------------
210 '
220 OPEN "\DEV\IEEEOUT" FOR OUTPUT AS #1
230 OPEN "\DEV\IEEEIN" FOR INPUT AS #2
240 IOCTL#1,"BREAK"                             'Clear driver
250 PRINT#1,"RESET"
260 CMD$ = "*RST" : GOSUB 1000                 'Reset the LDC-3700 Series Laser Diode Controller to default
values
270 '
300 '------------------- INITIALIZE THE OUTPUT/PRINT HEADER ---------------------------
310 '
320 CLS                                          'Clear the screen
330 '
340 PRINT " * * *  LASER OUTPUT vs. DRIVE CURRENT at 10 DEGREE C STEPS  * * *"
350 PRINT
360 PRINT " Temperature    Drive Current    Output"
370 PRINT "     (C)            (mA)          (mW)"
380 PRINT " ========   ========  ====="
390 '
400 '-------------------- INITIALIZE LDC-3700 Series Laser Diode Controller ----------------------------------------
410 '
420 CMD$ = "Tec:Tol 0.5,0.5" : GOSUB 1000                 'Set the tolerance to 0.5°C for 0.5 seconds
430 CMD$ = "Tec:Gain 100" : GOSUB 1000                    'Set control loop gain
440 CMD$ = "Tec:Step 100; Tec:Mode:T" : GOSUB 1000        'Temperature mode, with 10°C step
450 CMD$ = "Tec:T 30; Output ON" : GOSUB 1000             'Start laser temperature at 30°C
460 CMD$ = "Las:Tol 1,0.4" : GOSUB 1000
470 CMD$ = "Las:Lim:I2 100" : GOSUB 1000                  'Set output current limit to 100 mA (LDC-3722B)
480 CMD$ = "Las:Step 0.5; Las:Output ON" : GOSUB 1000     'Turn LASER output on, and set 0.5 mA step
```

**Example Program 4.3 L/I vs Temperature**

```
490 '
500 '------------------------ TAKE DATA ------------------------------------------------------------
510 '
520 FOR X=1 TO 3                                                'Gather data over 3 temperatures
530  '
540  CMD$ = "Las:LDI 0; *WAI" : GOSUB 1000                      'Reset output to 0 mA; wait for temperature
550                                                             'and current to reach tolerance levels
560  FOR Y=1 TO 100                                             'Step drive current from 0 to 50 mA
570   '
580   CMD$ = "Las:Inc; *WAI" : GOSUB 1000                       'Wait until drive current is within tolerance
590   CMD$ = "Las:MDI?" : GOSUB 1000                            'Take the monitor photodiode current measurement
600   INPUT#2,L$                                                'Input the value
610   CMD$ = "Las:LDI?" : GOSUB 1000                            'Take the drive current measurement
620   INPUT#2,I$                                                'Input the value
630   CMD$ = "Tec:T?" : GOSUB 1000                              'Take the temperature measurement
640   INPUT#2,T$                                                'Input the value
650   '
700   '------------------------ PRINT OUT RESULTS -------------------------------
710   '
720   T = VAL(T$) : I = VAL(I$) : L = VAL(L$)                   'Convert data types
720   IMAGE$ = "  ###.#    ###.##       ###.##"
730   PRINT USING IMAGE$;T,I,L
740   '
750  NEXT Y
760  '
770  CMD$ = "Tec:Inc" : GOSUB 1000                              'Increment the temperature
780  '
790 NEXT X
800 '
810 '------------------------------------- DONE --------------------------------
820 '
830 CMD$ = "Las:Output OFF; Tec:Output OFF"                      'Turn off outputs
840 END
850 '
1000 '------------------------------ OUTPUT SUBROUTINE -----------------------
1010 '
1020 PRINT#1,OUT$;AD$;CMD$ : RETURN                              'Output the command; and return
```

**Example Program 4.3 L/I vs Temperature (Cont.)**

# Chapter 5

# THEORY OF OPERATION

## 5.1 Introduction

There are six electronic circuit boards inside the LDC-3700 Series Laser Diode Controller. They are the Power Supply Board, the Main Board which contains the microprocessor, the Front Panel Display Board and the Front Panel Driver Board, the TEC Board, and the LASER Board.

A functional block diagram of the LDC-3700 Series Laser Diode Controller circuit boards is shown in Figure 5.1. In each of the following sections there are functional block diagrams for the various circuit boards of the LDC-3700 Series Laser Diode Controller. You may also refer to the schematics in Chapter 7 for greater detail.

When the Model 1231 IEEE-488.2/GPIB interface is installed, it is incorporated into the Main microprocessor Board.

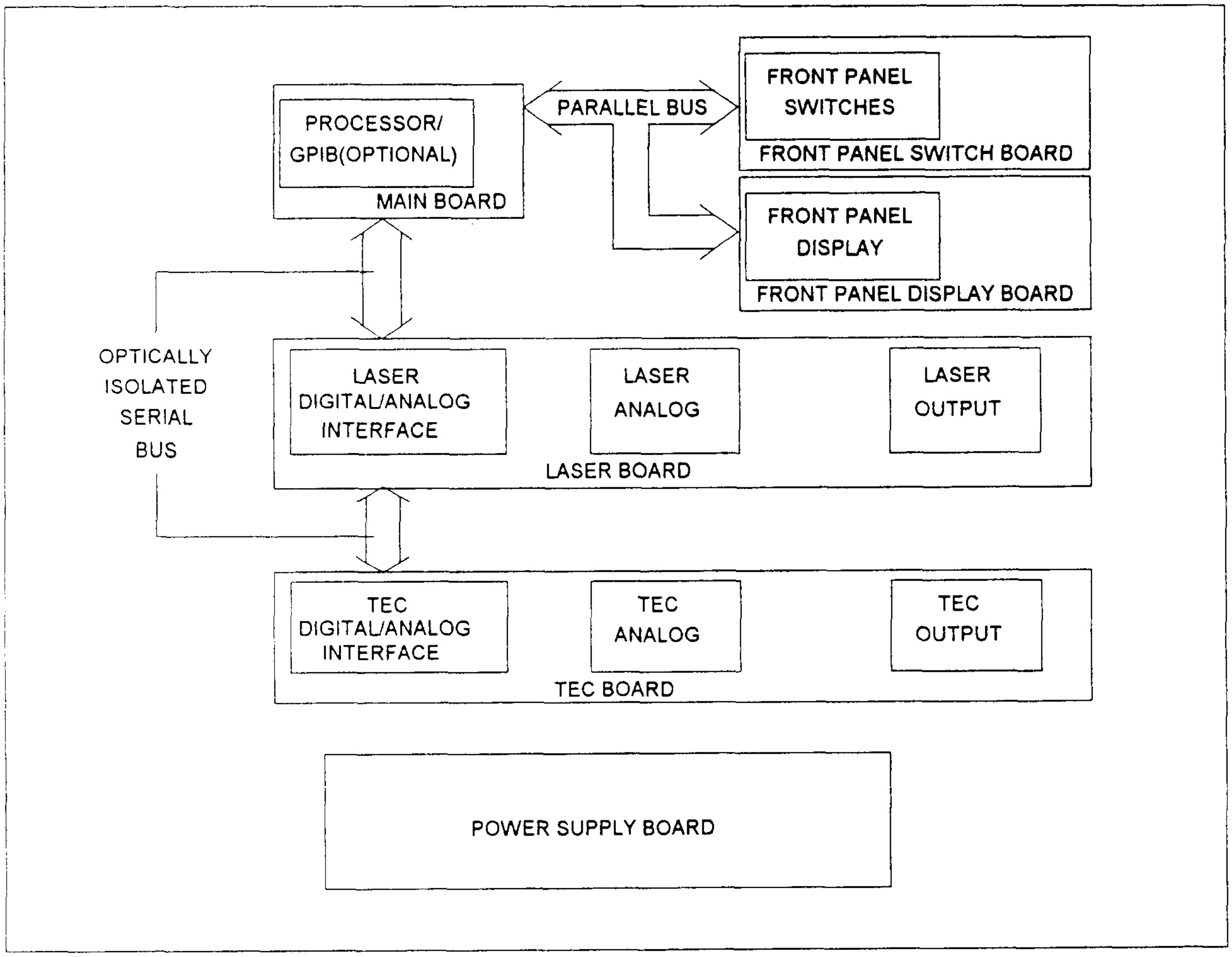



**Figure 5.1 LDC-3700 Series Laser Diode Controller Block Diagram**

This chapter explains the general function of each board and each circuit in the block diagram. The TEC theory of operation is explained in Section 5.2, the LASER side is explained in Section 5.3, and the theory of operation of the Main Processor board, which is common to both TEC and LASER operation, is explained in Section 5.4. The Front Panel Display and Switch Boards are discussed in Section 5.5, while the Power Supply Board is discussed in Section 5.6.

## 5.2 TEC Board Theory of Operation

The TEC Board is mounted on its side, directly behind the TEC display section of the front panel. Figure 5.2 shows the functionality of the TEC Board. The following sections detail the theory of operation for each of the blocks in Figure 5.2.

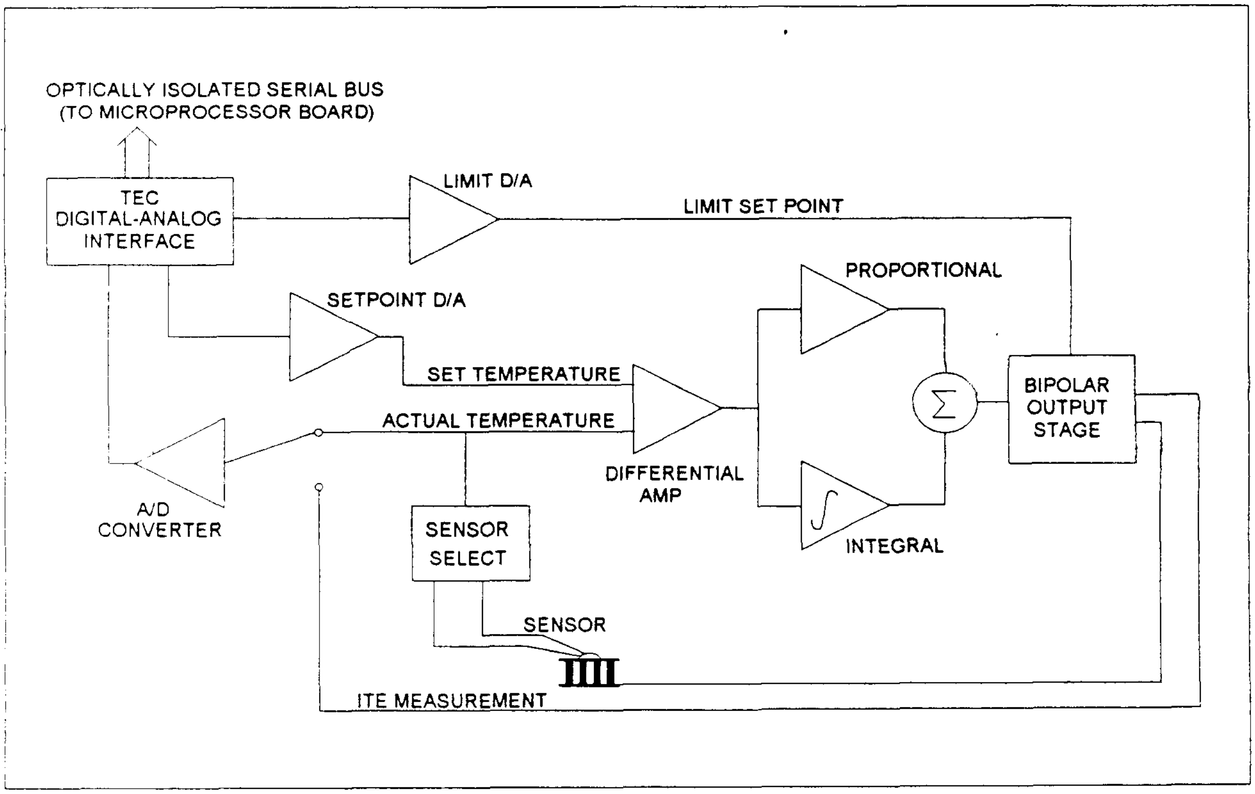



**Figure 5.2 TEC Board Block Diagram**

### 5.2.1 TEC Digital-Analog Interface

The TEC interface provides optically isolated serial communications between the TEC board and the microprocessor. Control signals are passed to the TEC board to set the TEC board status, current limit, and temperature set points. Instructions and data are sent over the serial interface to the optical barrier, U207 - U213 (see Figure 7.19). Status and analog TEC control data are serially passed back to the microprocessor via U206 and U207.

### 5.2.2 Limit D/A

The Limit D/A converts a digital limit signal from the microprocessor to a voltage which becomes the limit voltage for the Bipolar Output Stage.

The ITE current limit D/A converter is made up of U215 and U201:B (see Figure 7.18). The microprocessor loads the digitally stored current limit value into the 12-bit D/A (U215) which converts it to a voltage at the output of U201:B.

The current limit value is updated at power-up, at a "bin" recall, and whenever the LIM ITE value is changed.

### 5.2.3 Set Point D/A

The Set Point D/A converts a digital set point signal from the microprocessor to a voltage which becomes the set temperature input to the PI control loop.

The Set Point D/A converter is made up of U214 and U201:C (see Figure 7.18). The microprocessor loads the digitally stored current set point value into the 12-bit D/A (U214) which converts it to a voltage at the output of U201:C.

The TEC current set point value is updated at power-up, at a "bin" recall, and whenever a TEC set point value is changed.

### 5.2.4 A/D Converter

The 16-bit A/D converter, U205 (see Figure 7.18), measures the actual temperature voltage and the current output of the bipolar output stage. The value of actual temperature measurement is used by the microprocessor in the calculation of temperature or thermistor resistance for display on the front panel. The ITE measurement is used to drive the LED bar graph and the ITE measurement display mode on the front panel.

### 5.2.5 Sensor Select

Sensor selection is accomplished in the Sensor Select block of the TEC board. Precision 100 μA and 10 μA current sources (U225 and Q200) may be selected for thermistor control (see Figure 7.20). LM335 and AD590 IC temperature sensors may also be selected. Sensor selection is accomplished via the back panel SENSOR SELECT switch, S201. The AD590 has a +8 VDC bias voltage and the LM335 has a 1 mA bias current. These biases are provided by U226.

The output of the Sensor Select block of the TEC board is a voltage which is proportional to the actual temperature. This voltage is fed to the A/D converter which provides a digital measurement to the microprocessor and to the PI control loop to close the feedback loop when temperature is being controlled.

### 5.2.6 Difference Amplifier

Differential amp U233 (see Figure 7.16) provides a proportional difference signal to the PI control. This signal is the difference between set temperature and actual temperature voltages.

### 5.2.7 Proportional Amplifier

The Proportional amplifier, U231:D (see Figure 7.16), is part of a digitally controlled gain stage consists of the analog switches U229:D, U230, and the associated resistors. The analog switches vary the ratio of resistance in the feedback circuit to change the gain to 1, 3, 10, 30, 100 or 300. The gain setting determines how fast the LDC-3700 Series Laser Diode Controller reaches the set point temperature and how quickly it settles to this temperature.

### 5.2.8 Integrator

The signal from the difference amplifier, U233 (see Figure 7.16), is sent to an integrator, U231:C, which reduces the difference between the set point temperature and the actual temperature to zero, regardless of the gain setting. This "smart" integrator is controlled by the microprocessor, and is only switched on via U227:A when needed. An analog switch, U227:C, discharges the integrating capacitor whenever integration is not required to prevent unnecessary difference signal integration.

### 5.2.9 Bipolar Output Stage

The Bipolar Output Stage consists of circuits which limit the TEC output, sense the TEC output, sense voltage and current limit conditions, as well as supply the bipolar TEC output. The following sections discuss these functions of the Bipolar Output Stage.

#### 5.2.9.1 Current Limiting

The output of the proportional amplifier and integrator together form the control signal. Output current limiting is effected by bounding the control signal so that it is always less than the limit current. The limit current is set with the front panel controls or through the GPIB interface bus.

The bipolar current limit levels are established by the output of the current Limit D/A and the unity gain invertor U201:B. Q201, U235:B, U235:C (see Figure 7.17), and the associated circuitry provide the necessary control signal bounding.

#### 5.2.9.2 Current Limit Condition Sensing

Comparators U237:A and U237:B (see Figure 7.17) sense the output of U235:A to determine when output current limiting is occurring. When this condition occurs, the I Limit signal is sent to the microprocessor via U206 and U207 (see Figure 7.19). The microprocessor responds by flashing the front panel TE CURRENT LIMIT LED at approximately 1 Hz, and then it updates its internal error status register.

#### 5.2.9.3 Voltage Controlled Current Source

The bounded output control signal is applied to U235:D. This amplifier along with Q202, Q203, and the current sensing amplifier U236 form the output voltage controlled current source (see Figure 7.17). The output of this stage directly drives the externally connected TE cooler module. A one-tenth volt signal at the input to this stage causes a one amp output.

#### 5.2.9.4 Voltage Limit Condition Sensing

Comparators U237:D and U237:C (see Figure 7.17) sense the output of U235:D to determine when TEC output compliance voltage limiting is occurring. This condition occurs whenever the LDC-3700 Series Laser Diode Controller back panel TEC output is open or connected to a high resistance. If this condition occurs, the V Limit error signal is passed to the microprocessor via U206 and U207 (see Figure 7.19). The microprocessor responds by flashing the front panel TE MODULE OPEN LED at approximately 1 Hz, and it updates its internal error status register.

### 5.2.10 TEC Control Modes

The LDC-3700 Series Laser Diode Controller provides three control modes for operation, constant T (temperature), constant R (thermistor resistance/linear sensor reference), and constant ITE (current) modes. Each of these modes is discussed in the following sections.

#### 5.2.10.1 T Mode

In constant T mode the TEC load is driven to the set point temperature. This temperature is monitored by the sensor at the load. In the case of a thermistor sensor, the thermistor's resistance is used to determine load temperature by using the Steinhart-Hart conversion equation. The resistance is determined by measuring the voltage across the thermistor (with a known current of 10 or 100 μA) at U232 (see Figure 7.16). The resistance measurement is saved, and the converted temperature value is also saved. The ITE current is also measured and saved. The TE output current is dropped across R277 (see Figure 7.17), and the voltage at U236 is converted to an ITE current value.

When an LM335 sensor is used, a two-point conversion equation is used to determine the temperature (see Appendix C). Its reference voltage is measured at U232. This value is saved, the ITE current value is measured and saved, and the converted temperature is also saved.

When an AD590 sensor is used, another two-point conversion equation is used to determine the temperature (see Appendix C). Its reference current is dropped across R227, and this voltage is measured by U232 (see Figure 7.16). The reference voltage is converted back to current and saved, and the converted temperature is also saved. The ITE current is also measured and saved.

#### 5.2.10.2 R Mode

In constant R mode, the TEC load is driven to the set point resistance (with thermisors) or reference (with linear sensors). This resistance or reference is measured (as described in Section 5.2.10.1) and converted to a temperature. Both of these values are saved as well as the ITE current value, just as in consant T mode, but the load is controlled at the R set point instead of the T set point.

#### 5.2.10.3 ITE Mode

In constant ITE mode, the TEC load is driven with a constant current, at the ITE set point value. The ITE current is dropped across R227, and the voltage at U232 (see Figure 7.16) is converted to ITE current. This value is saved. In this mode, the temperature and resistance/reference values are also measured and saved, although the output is controlled to the ITE set point.

### 5.3 LASER Board Theory of Operation

The LASER Board is mounted on its side, directly behind the LASER display section of the front panel. Figure 5.3 shows the functionality of the LASER Board. Due to the proprietary nature of the LASER board circuits, the LASER board schematic diagrams and theory of operation are withheld. For more information regarding the LASER board, contact ILX Lightwave.

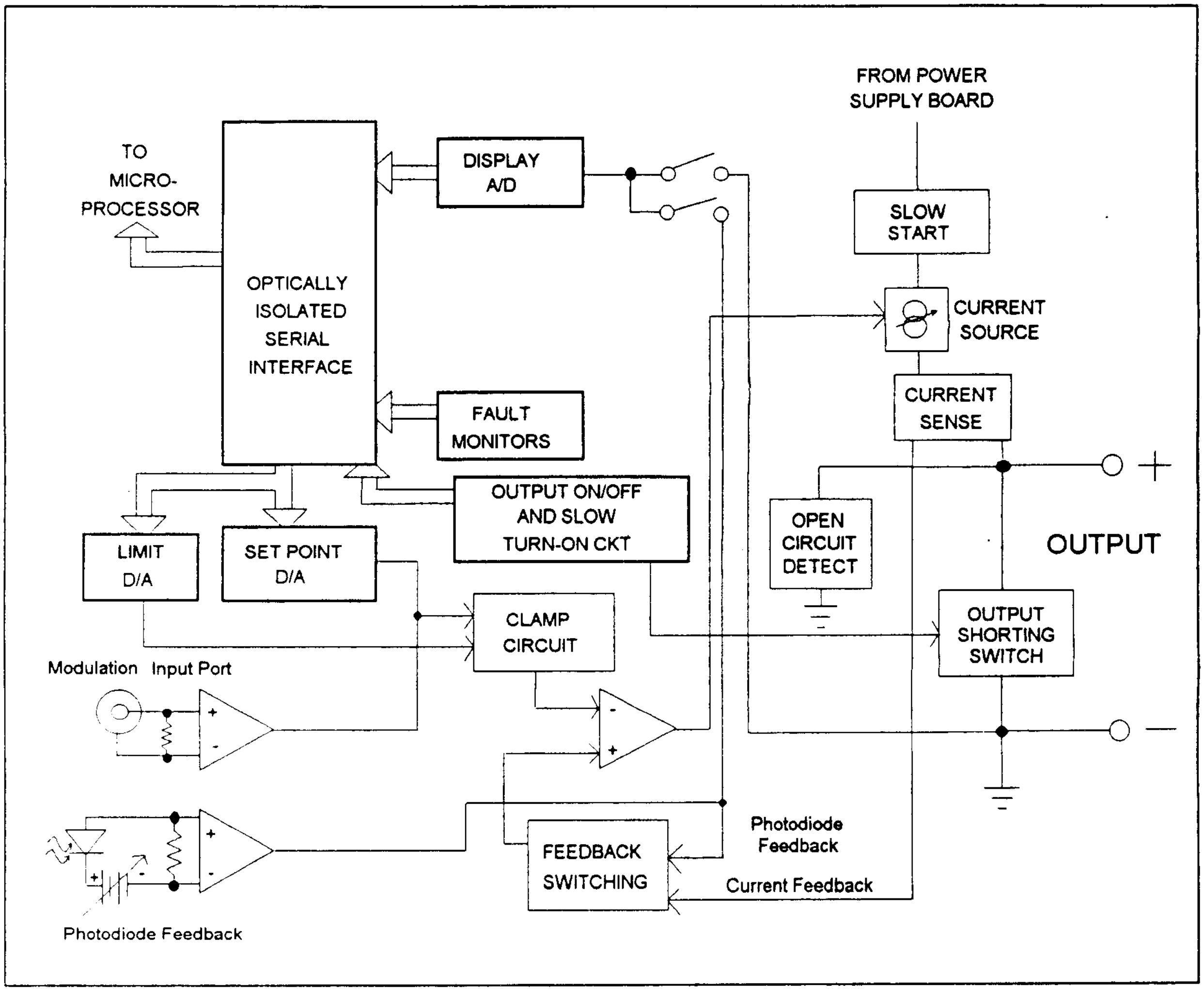



**Figure 5.3 LASER Board Block Diagram**

## 5.4 Main Microprocessor Board

The Main Microprocessor Board contains the microprocessor, memory, the serial interface to the TEC and LASER boards, front panel interface, and the GPIB interface (when that option is installed). It also contains circuitry which monitors the AC line voltage and saves the state of the LDC-3700 Series Laser Diode Controller at power down. The block diagram of the Main Microprocessor Board is shown in Figure 5.4.

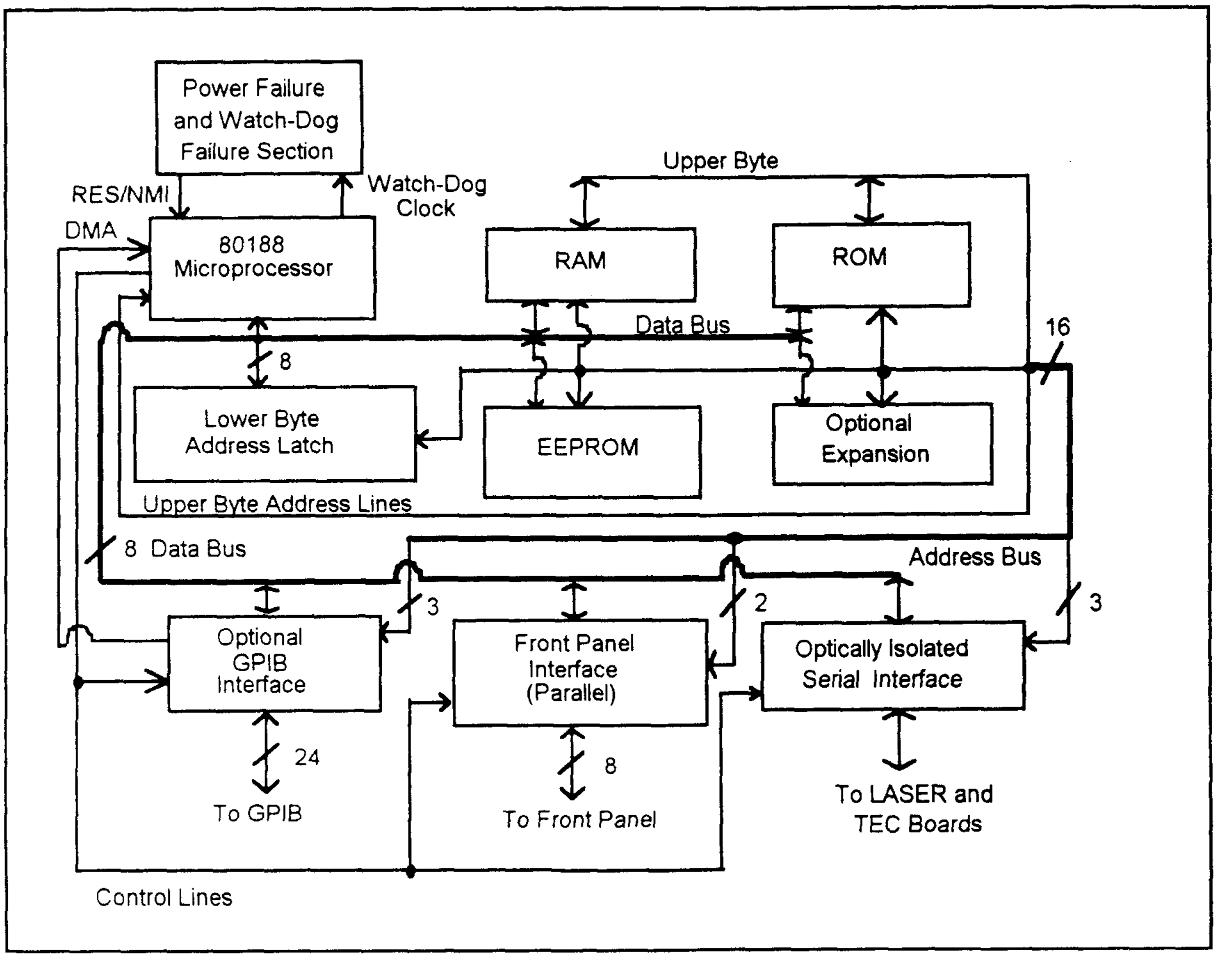



**Figure 5.4 Main Processor Board Block Diagram**

### 5.4.1 Microprocessor

The LDC-3700 Series Laser Diode Controller uses a CMOS 80188 microprocessor, U401, to control its internal operations (see Figure 7.6). The upper address bits select either the RAM, ROM, or EEPROM that the 80188 can access.

The LDC-3700 Series Laser Diode Controller's microcode provides a fail-safe countdown which generates a reset in the event of a malfunction. A 1 Hz watch-dog pulse is normally present at PCS6 (pin 32 of U401). If for any reason this clock pulse fails to appear at pin 6 of U417, it will generate a non-maskable interrupt to reset the LDC-3700 Series Laser Diode Controller.

Since the lower eight address lines in the 80188 architecture are also used as data lines, an address latch, U402, holds necessary address information when data is loaded onto the bus. This latch is enabled by the ALE signal from the 80188.

### 5.4.2 Memory

The LDC-3700 Series Laser Diode Controller uses three types of memory. RAM memory, U404 (see Figure 7.6), is retained only while power is applied to the unit. ROM memory, U403, contains the internal instructions that make the LDC-3700 Series Laser Diode Controller function. The third type of memory is electrically erasable programable memory, EEPROM, U405. U406 is reserved for ROM expansion or other optional future uses.

EEPROM stores calibration constants and other data which must be retained even when power is removed from the unit. Examples of data stored in this memory include the TEC and LASER parameters and calibration constants.

EEPROM may be reprogrammed at least 10,000 times, providing ample capacity for most applications.

### 5.4.3 Optically Isolated Serial Interface

The 80188, in the LDC-3700 Series Laser Diode Controller, communicates with external TEC and LASER controllers through a serial interface. Parallel data from the microprocessor is converted to a bi-directional serial signal at the asynchronous serial interface which is comprised of U419 - U422 (see Figure 7.7).

### 5.4.4 Front Panel Interface

The front panel interface (see Figure 7.6) is a latched parallel I/O port which consists of U407 (data lines) and U424 (address lines). This I/O port is used for communicating with the front panel displays, LEDs, and switches.

### 5.4.5 Optional GPIB Interface

The 1231 IEEE-488.2/GPIB interface, shown in Figure 7.8, uses the 9914 interface chip, U412, to control its operations. The interface latches GPIB data through U413 and control information through U414. The clock for the 9914 is provided by the 80188 (U401) CLKOUT line.

### 5.4.6 Data Protection at Power-Down

If the AC line voltage begins to fail, this condition is detected and U417 (see Figure 7.6) generates an interrupt of the microprocessor. If the voltage at pin 4 of U417 falls below 1.3 volts, U417 will trigger a non-maskable interrupt. This interrupt is used to save all of the critical data which has not yet been saved in non-volatile memory.

## 5.5 Front Panel Display and Switch Boards

The Front Panel Display and Switch Boards are piggy-backed so that all of the associated front panel circuitry is located together. The block diagram of the Front Panel Display Board is shown in Figure 5.5. The block diagram of the Front Panel Switch Board is shown in Figure 5.6.

The Front Panel Display Board contains the TEC and LASER displays and drivers, the error indicator LEDs, and the ADJUST knob softpot.

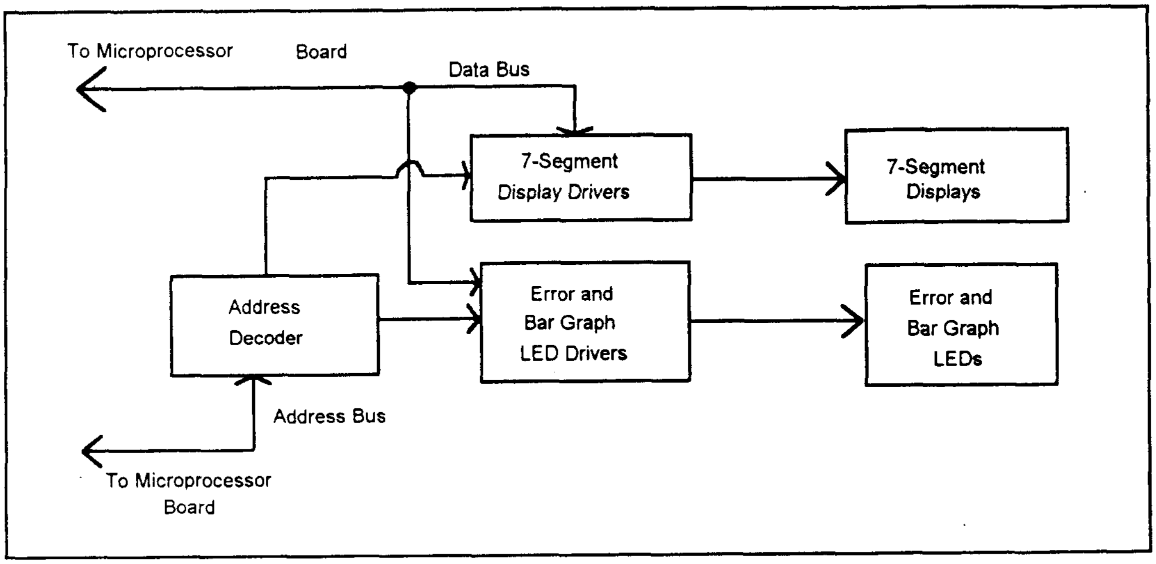



**Figure 5.5 Front Panel Display Board Block Diagram**

The Front Panel Switch board contains the switches, their associated LEDs, and the parameter indicator LEDs.

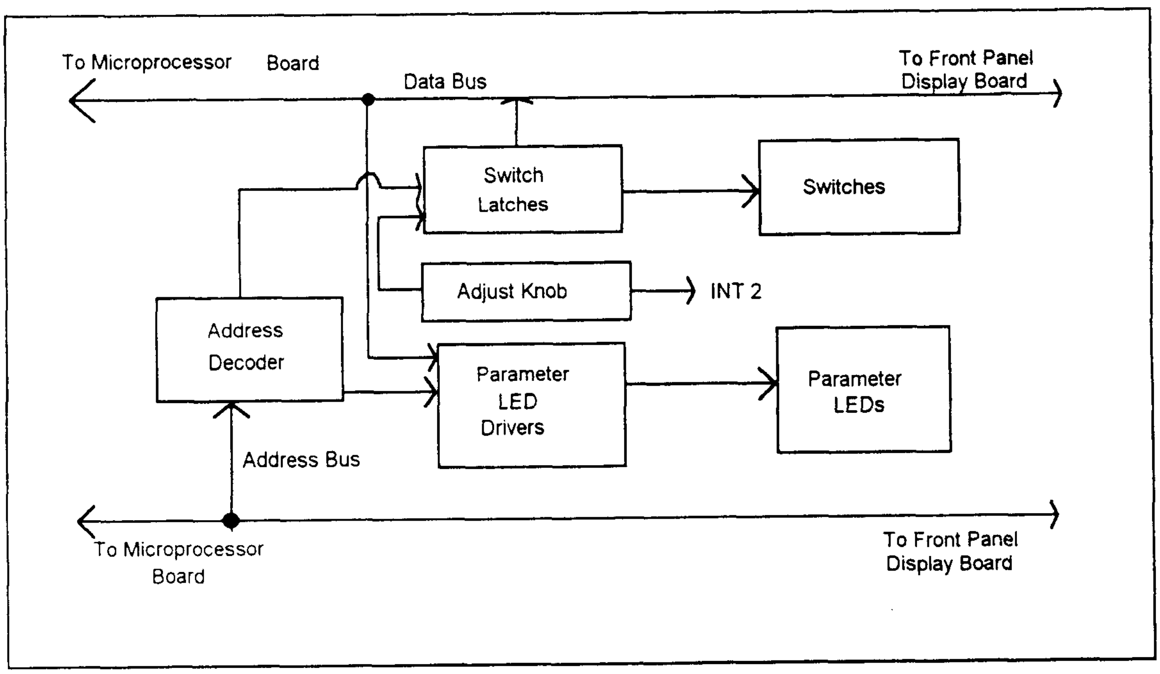



**Figure 5.6 Front Panel Switch Board Block Diagram**

### 5.5.1 Display Drivers

The display drivers (U601 - U603) are specialized output ports that require two I/O address lines (see Figure 7.13). Each address corresponds to one of four display digits or group of decimal points. Three display select lines are used to select the three display drivers. The display selection is made by decoding address lines A2 - A4 at U604 (see FIgure 7.14). The lower four data lines are written to these drivers, decoded, and the data appears on the LDC-3700 Series Laser Diode Controller front panel displays.

### 5.5.2 Switches

The LDC-3700 Series Laser Diode Controller switches are latched to the data bus via U308 - U310 (see Figure 7.10). When one of these latches is enabled, it is used to sample the front panel input switches. The latches are selected via the address decoder, U301 (see Figure 7.11), which decodes address lines A2 - A4.

### 5.5.3 LED Drivers

Latches U303 - U306, and U311 (see Figure 7.11) provide the output current sinking capability necessary to drive the front panel switch and parameter indicator LEDs. The latches are selected via the U301 decoder of address lines A2 - A4.

Latches U605 - U608 (see Figure 7.14) drive the error indicator LEDs and the bar graph LEDs. The latches are selected via the U604 decoder of address lines A2 - A4.

### 5.5.4 ADJUST Knob

The ADJUST knob is a digital encoder, or softpot, U307 (see Figure 7.10). When ADJUST knob movement is detected, an interrupt is generated in the microprocessor. The direction of the knob movement is determined by the quadrature output of the softpot, which is buffered by U302:C and U302:D. This information is used to generate a microprocessor interrupt via the INT2 line. The direction information is latched onto the data bus via U308.

### 5.6 Power Supply Board

The Power Supply Board contains regulated and unregulated power supplies for the TEC, LASER, Main Processor, and Front Panel Boards. It also contains a zero crossing reference for the microprocessor, power for the fan, and power for biasing a photodiode detector. Figure 5.7 shows the Power Supply Board Block Diagram.

Power is supplied through the rear panel mounted entry module which provides in-line transient protection and RF filtering (see Figure 7.2). The back panel also houses the in line fuse Z602. The main power switch S601 is located on the Front Panel Display Board. Jumpers located on the power supply subassembly select series or parallel connection of the transformer primaries for operation from 100 VAC, 120 VAC, 220 VAC, or 240 VAC.

### 5.6.1 TEC Power Supplies

The TEC Power Supplies include a +15 VDC supply which is regulated by U501 (see Figure 7.3), a -15 VDC supply which is regulated by U502, and an unregulated $\pm$12 volt supply for the TEC current source.

### 5.6.2 LASER Power Supplies

The LASER Power Supplies include a +15 VDC supply which is regulated by U511, a -15 VDC supply which is regulated by U510 (see Figure 7.4), an unregulated +22 volt supply for the LASER output, a 33 VAC supply, and a regulated 5 volt supply for the photodiode detector.

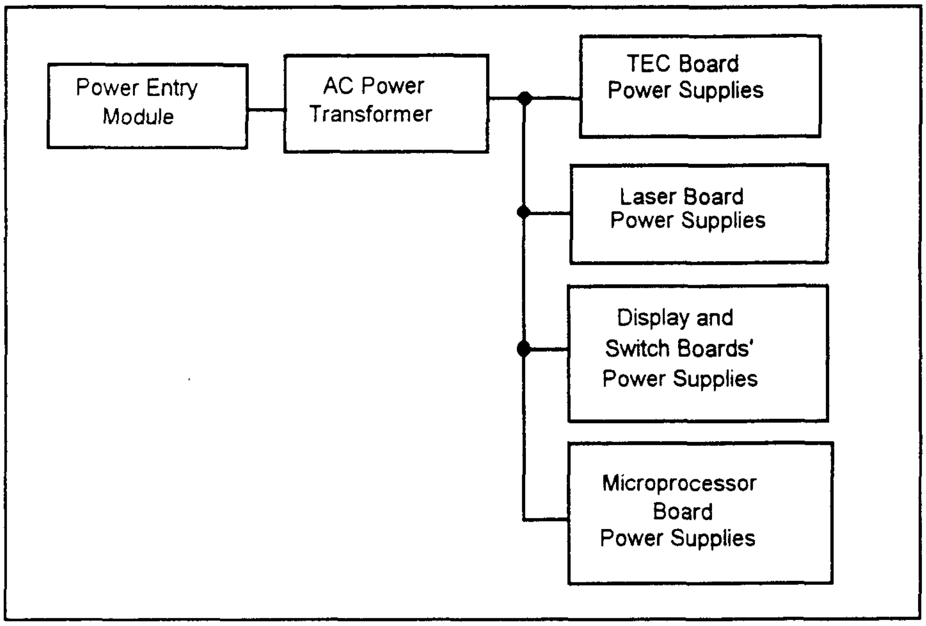



**Figure 5.7 Power Supply Board Block Diagram**

### 5.6.3 Main Processor Board Power Supplies

The Main Processor Board Power Supplies include a +5 VDC supply which is regulated by U505 (see Figure 7.3), an unregulated +7 to +12 volt supply for the power-down checking circuit, and a zero-crossing reference for line frequency checking.

### 5.6.4 Front Panel Boards Power Supplies

The Front Panel Display and Switch Boards are supplied +5 VDC which is regulated by U506 (see Figure 7.3).

## 5.7 Interlock Operation

The back panel LASER Input/Output connector has interlock connections which must be connected before the LASER output will be enabled. The TEC Input/Output connector may also be used as an interlock, but with reverse logic (normally not connected), as explained below.

### 5.7.1 LASER Interlock

On the LASER Input/Output connector, pins 1 and 2 form the interlock path. If there is not a current path between these pins the LASER output will not be enabled. When this path is broken, the LASER Interlock Error condition/event will be reported in the LASER Condition Status Register and the LASER Event Status Register.

This interlock is a safety feature for laser protection. It requires that the connecting cable at the LASER connector be secure before the LASER output is enabled. A secure connection significantly reduces the possibility of an intermittent open circuit to the laser drive current.

### 5.7.2 TEC Interlock

On the TEC Input/Output connector, J204, pins 13 (TEMP LIMIT) and 15 (DIGITAL GND) form another type of interlock (see Figure 7.17). These two pins are normally not connected (open circuit), and must remain open for the TEC output to be on. If there is a short circuit between these pins the TEC output will be disabled. When this short circuit is present, the TEC Interlock Error condition/event will be reported in the TEC Event Status Register and the TEC Condition Status Register.

This circuit is useful for remote monitoring of temperature, and therefore is labeled TEMP LIMIT on the back panel connector, J204. This interlock is intended for use with an external current booster. A switch or control circuit of the user's own design is required. It is left as an option which the user may or may not employ.

## 5.8 Booster Operation

The LDC-3700 Series Laser Diode Controller may be used to control a booster current source which accepts a control signal of up to ±10.0 volts. A booster current source may be required if the LDC-3700 Series Laser Diode Controller's ±4 A, 16 W output is not adequate to control a thermal load.

Whenever a connection is present between the BOOSTER PRESENT (pin 14) and DIGITAL GROUND (pin 15) of the back panel TEC Input/Output connector, J204 (Figure 7.17), analog switch U229:B (Figure 7.17) will open and the TEC OUTPUT will be disabled. In this case, the BOOST CONTROL signal voltage will be available for controlling a booster current source.

The Booster Enabled conditon is reported in the TEC Condition Status register. When the GPIB option is implemented, this condition may be used to trigger a service request.

The booster current source should use the control voltage which is available between the BOOST CONTROL (pin 10) and AGND (pin 9) of the back panel TEC Auxiliary Input/Output connector, J204.

When the BOOSTER PRESENT signal is connected to DIGITAL GROUND, the LIM I value may be increased above the normal operation maximum of 4.0 Amps, to a maximum of 10.0 Amps. This is permitted for operation with a booster current source so that the CONTROL SIGNAL voltage may be ±10.0 volts. The CONTROL SIGNAL voltage is linearly proportional to the control current, which is limited by the LIM I parameter.
Whether or not a booster current source is used, the LDC-3700 Series Laser Diode Controller uses a sensor for controlling the temperature. The feedback loop GAIN may require adjustment when a booster current source is used. This is because a booster current source may be used with different thermal loads than those found with normal LDC-3700 Series Laser Diode Controller operation, and those loads may require larger or smaller GAIN values in order to settle to the set temperatures in a desirable fashion. See Section 2.9.6 for setting the GAIN value.

During operation, if the status of the connection between the BOOSTER PRESENT and DIGITAL GROUND changes, this event will be reported in the TEC Event Status Register. When the GPIB option is implemented, this event may be used to trigger a service request.

# Chapter 6

# MAINTENANCE

## 6.1 Introduction

This chapter describes how to maintain the LDC-3700 Series Laser Diode Controller. Included are sections covering calibration, fuse replacement, line voltage selection, and disassembly.

**WARNING**

**THE SERVICE PROCEDURES DESCRIBED IN THIS CHAPTER ARE FOR USE BY QUALIFIED PERSONNEL. POTENTIALLY LETHAL VOLTAGES EXIST WITHIN THE LDC-3700 SERIES LASER DIODE CONTROLLER. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY OF THE PROCEDURES DESCRIBED IN THIS CHAPTER UNLESS YOU ARE QUALIFIED TO DO SO.**

**QUALIFIED SERVICE PERSONNEL ARE REQUIRED TO WEAR PROTECTIVE EYEGLASSES AND ANTI-STATIC WRIST BANDS WHILE WORKING ON THE LDC-3700 SERIES LASER DIODE CONTROLLER CIRCUIT BOARDS.**

**CAUTION! HIGH VOLTAGES ARE PRESENT ON AND AROUND THE PRINTED CIRCUIT BOARDS OF THE LDC-3700 SERIES LASER DIODE CONTROLLER.**

## 6.2 Calibration Overview

The LDC-3700 Series Laser Diode Controller should be calibrated every 12 months or whenever performance verification indicates that calibration is necessary.

All calibrations can be done with the case closed. The instrument is calibrated by changing the internally stored digital calibration constants.

### 6.2.1 Recommended Equipment

Recommended test equipment for calibrating the LDC-3700 Series Laser Diode Controller is listed in Table 6.1. Equipment other than that shown in the table may be used if the specifications meet or exceed those listed. If your LDC-3700 Series Laser Diode Controller is equipped with the model 1231 GPIB/IEEE-488.2 interface you may refer to sections 6.3.2, 6.3.4, 6.4.2, 6.4.4, and 6.4.5 for calibration procedures using the GPIB, if desired.

**RECOMMENDED TEST EQUIPMENT**

| Description | Mfg./Model | Specification |
|---|---|---|
| DMM | HP 3457A | DC Amps (@ 1.0 A): ±0.02 %<br>Resistance (@ 10 Ω): 0.02 %<br>0.1 μA or 0.1 mV resolution |
| Resistors | Metal Film | 10 KΩ for 100 μA calibration<br>100 KΩ for 10 μA calibration<br>6.8 KΩ for LM335 sensor calibration<br>16.8 KΩ for AD590 sensor calibration |
| | High-Power | 1 Ω, 20 W, low TCR, for current calibration<br>100 Ω, 2 W, low TCR, (3712) for voltage cal..<br>25 Ω, 5 W, low TCR, (3722B or 3742B) for voltage cal. |
| $I_{PD}$ Calibration Resistors | Metal Film | 49 Ω, 100 Ω, and 1.0 MΩ, 1%, 1/4 W |
| | High-power | 49 Ω, 1/2 W, low TCR (LDC-3712);<br>11 Ω, 1 W, low TCR (LDC-3722B);<br>1 Ω, 10 W, low TCR (LDC-3742B) |
| Optical Isolator | TIL117 | or equivalent, 6-pin |
| Connector | D-sub | 9-pin male |

**Table 6.1 Recommended Test Equipment**

### 6.2.2 Environmental Conditions

Calibrate this instrument under laboratory conditions. We recommend calibration at 23°C ± 1.0°C. When necessary, however, the LDC-3700 Series Laser Diode Controller may be calibrated at its intended use temperature if this is within the specified operating temperature range of 0 to 50°C.

### 6.2.3 Warm-Up

The LDC-3700 Series Laser Diode Controller should be allowed to warm up for at least 1 hour before calibration.

## 6.3 TEC Controller Calibration Adjustments

There are only three calibration adjustments that need to be made for the TEC side of the LDC-3700 Series Laser Diode Controller, for use with thermistors. They are calibration of the resistance at the 10 μA and the 100 μA source current settings, and calibration of the ITE current limits.

If linear temperature sensors are used, they should be calibrated as outlined in Sections 6.3.3 - 6.3.6. If you have the optional Model 1231 IEEE-488.2/GPIB interface you may follow the procedure in sections 6.3.2, 6.3.4, 6.3.6, and 6.3.8 to calibrate the LDC-3700 Series Laser Diode Controller remotely.

### 6.3.1 Local Operation Thermistor Calibration

The following procedure is for calibrating the 100 μA and 10 μA constant current sources so that the thermistor resistances for these ranges will be as accurate as possible. This procedure is for local (front panel) operation. See Section 6.3.2 for remote calibration of the sensors.

a. Set the SENSOR SELECT switch (back panel) to the 100 μA position.

b. Measure and record the exact resistance of your metal film resistors. (A 4-point probe resistance measurement is recommended.)

c. Connect the correct metal film resistor to the thermistor input of the LDC-3700 Series Laser Diode Controller. Use nominal values of 10 KΩ for the 100 μA setting and 100 KΩ for the 10 μA setting.

d. Enter the TEC sensor calibration mode by pushing the (GPIB) LOCAL and (TEC DISPLAY) R switches at the same time. The sensor code (SENSOR SELECT switch position) value will be displayed for 2 seconds. After this, the TEC display will indicate sensor resistance in KΩ. The LDC-3700 Series Laser Diode Controller will beep when it is ready to accept a new calibration value.

e. Press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the TEC display indicates the same resistance you recorded for the metal film resistor.

f. Release the (PARAMETER) SET switch to store the new value into non-volatile memory. After the (PARAMETER) SET switch is released, the LDC-3700 Series Laser Diode Controller will beep and return to its former state (before calibration).

g. Switch the SENSOR SELECT switch (back panel) to the 10 μA position and repeat this procedure with the 100 KΩ resistor.

### 6.3.2 Remote Operation Thermistor Calibration

The following procedure is for calibrating the 100 μA and 10 μA constant current sources so that the thermistor resistances for these ranges will be as accurate as possible. This procedure is for remote (GPIB) operation. See Section 6.3.1 for local calibration of the sensors.

a. Set the SENSOR SELECT switch (back panel) to the 100 μA position.

b. Measure and record the exact resistance of your metal film resistors. (A 4-point probe resistance measurement is recommended.)

c. Connect the correct metal film resistor to the LDC-3700 Series Laser Diode Controller's thermistor input. Use nominal values of 10 KΩ for the 100 μA setting and 100 KΩ for the 10 μA setting.

d. Enter the "TEC:CAL:SENsor" command over the GPIB. The TEC display will show the resistance value, and will then expect the actual value to be entered, in KΩ.

   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-3700 Series Laser Diode Controller is ready to receive it.

The LDC-3700 Series Laser Diode Controller will be ready to receive the actual (measured) resistance value when, after a "TEC:CAL:SEN?" query is sent, the response from the LDC-3700 Series Laser Diode Controller is "1".

After the "TEC:R" value is entered, the "*OPC?" query may be used to determine when the calibration sequence is done. However, the "*OPC", or "*WAI" command, or "*OPC?" query should not be issued until after the expected resistance value is entered, or the system will "hang". This happens because the LDC-3700 Series Laser Diode Controller will wait indefinitely for an input, yet not allow any input until the calibration is finished.

f. Once the "TEC:R" value is sent, the LDC-3700 Series Laser Diode Controller will beep and return to its former state (before calibration). The "OPC?" query may be used (after the "TEC:R" value is sent) to determine when the calibration is completed.

   The operation complete flag (bit 0 of the Standard Event Status Register) may be used to trigger a service request. This type of interrupt is enabled by setting bit 0 of the Service Request Enable register (via the *ESE command) and bit 5 of the Service Request Enable register (via the *SRE command). Service request (SRQ) handling depends on your GPIB hardware. Refer to your GPIB user's manual for details.

g. Switch the SENSOR SELECT switch (back panel) to the 10 μA position and repeat this procedure with the 100 KΩ resistor.

### 6.3.3 Local Operation AD590 Sensor Calibration

The following procedure is for calibrating the AD590 sensor so that the temperature measurement will be as accurate as possible. This procedure is for local (front panel) operation. See Section 6.3.4 for remote calibration of the AD590 sensor.

a. Set the SENSOR SELECT switch (back panel) to the AD590 position.

b. Connect a precision 16.8 KΩ (metal film) resistor and a precision ammeter in series at the sensor input of the LDC-3700 Series Laser Diode Controller.

c. Enter the TEC sensor calibration mode by pushing the (GPIB) LOCAL and (TEC DISPLAY) R switches at the same time. The TEC display will become blank for 2 seconds, then the sensor code (SENSOR SELECT switch position) value will be displayed for 2 seconds. After this, the TEC display will indicate sensor reference current in μA. The LDC-3700 Series Laser Diode Controller will beep when it is ready to accept a new calibration value.

d. Press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the TEC display indicates the same current as shown on the precision ammeter.

e. Release the (PARAMETER) SET switch to store the new value into non-volatile memory. After the SET switch is released, the LDC-3700 Series Laser Diode Controller will beep and return to its former state (before calibration).

### 6.3.4 Remote Operation AD590 Sensor Calibration

The following procedure is for calibrating the AD590 sensor so that the measured temperature will be as accurate as possible. This procedure is for remote (GPIB) operation. See Section 6.3.3 for local calibration of the AD590 sensor.

a. Set the SENSOR SELECT switch (back panel) to the AD590 position.

b. Connect a precision 16.8 KΩ (metal film) resistor and a precision ammeter in series at the sensor input of the LDC-3700 Series Laser Diode Controller.

c. Enter the "TEC:CAL:SENsor" command over the GPIB. The TEC display will show the current value in μA. The LDC-3700 Series Laser Diode Controller will beep when it is ready to accept a new calibration value.

d. Input the actual current measured by the external ammeter (as an <nrf value>) via the "TEC:R <nrf value>" command.

   If this value is to be measured and entered remotely via a GPIB controlled DMM, for example, the measured value of the current should not be entered until the LDC-3700 Series Laser Diode Controller is ready to receive it.

   The LDC-3700 Series Laser Diode Controller will be ready to receive the current value when, after a "TEC:CAL:SEN?" query is sent, the response from the LDC-3700 Series Laser Diode Controller is "1".

   After the "TEC:R" value is entered, the "*OPC?" query may be used to determine when the calibration sequence is done. However, the "*OPC", or "*WAI" command, or "*OPC?" query should not be issued until after the expected "TEC:R" value is entered, or the system will "hang". This happens because the LDC-3700 Series Laser Diode Controller will wait indefinitely for an input, yet not allow any input until the calibration is finished.

e. Once the "TEC:R" value is sent, the LDC-3700 Series Laser Diode Controller will beep and return to its former state (before calibration). The "OPC?" query may be used (after the "TEC:R" value is sent) to determine when the calibration is completed.

   The operation complete flag (bit 0 of the Standard Event Status Register) may be used to trigger a service request. This type of interrupt is enabled by setting bit 0 of the Service Request Enable register (via the *ESE command) and bit 5 of the Service Request Enable register (via the *SRE command). Service request (SRQ) handling depends on your GPIB hardware. Refer to your GPIB user's manual for details.

### 6.3.5 Local Operation LM335 Sensor Calibration

The following procedure is for calibrating the LM335 sensor so that the temperature measurement will be as accurate as possible. This procedure is for local (front panel) operation. See Section 6.3.4 for remote calibration of the LM335 sensor.

a. Set the SENSOR SELECT switch (back panel) to the LM335 position.

b. Connect a precision 6.8 KΩ (metal film) resistor and a precision voltmeter in parallel at the sensor input of the LDC-3700 Series Laser Diode Controller.

c. Enter the TEC sensor calibration mode by pushing the (GPIB) LOCAL and (TEC DISPLAY) R switches at the same time. The sensor code (SENSOR SELECT switch position) value will be displayed for two seconds. After this, the TEC display will indicate sensor reference voltage in mV. The LDC-3700 Series Laser Diode Controller will beep when it is ready to accept a new calibration value.

d. Press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the TEC display indicates the same voltage as shown on the precision voltmeter.

e. Release the (PARAMETER) SET switch to store the new value into non-volatile memory. After the SET switch is released, the LDC-3700 Series Laser Diode Controller will beep and return to its former state (before calibration).

### 6.3.6 Remote Operation LM335 Sensor Calibration

The following procedure is for calibrating the LM335 sensor so that the measured temperature will be as accurate as possible. This procedure is for remote (GPIB) operation. See Section 6.3.5 for local calibration of the LM335 sensor.

a. Set the SENSOR SELECT switch (back panel) to the LM335 position.

b. Connect a precision 6.8 KΩ (metal film) resistor and a precision voltmeter in parallel at the sensor input of the LDC-3700 Series Laser Diode Controller.

c. Enter the "TEC:CAL:SENsor" command over the GPIB. The TEC display will show the voltage in mV. The LDC-3700 Series Laser Diode Controller will beep when it is ready to accept a new calibration value.

d. Input the actual voltage measured by the external voltmeter (as an <nrf value>) via the "TEC:R <nrf value>" command.

   If this value is to be measured and entered remotely via a GPIB controlled DMM, for example, the measured value of the current should not be entered until the LDC-3700 Series Laser Diode Controller is ready to receive it.

   The LDC-3700 Series Laser Diode Controller will be ready to receive the voltage value when, after a "TEC:CAL:SEN?" query is sent, the response from the LDC-3700 Series Laser Diode Controller is "1".

   After the "TEC:R" value is entered, the "*OPC?" query may be used to determine when the calibration sequence is done. However, the "*OPC", or "*WAI" command, or "*OPC?" query should not be issued until after the expected "TEC:R" value is entered, or the system will "hang". This happens because the LDC-3700 Series Laser Diode Controller will wait indefinitely for an input, yet not allow any input until the calibration is finished.

e. Once the "TEC:R" value is sent, the LDC-3700 Series Laser Diode Controller will beep and return to its former state (before calibration). The "OPC?" query may be used (after the "TEC:R" value is sent) to determine when the calibration is completed.

   The operation complete flag (bit 0 of the Standard Event Status Register) may be used to trigger a service request. This type of interrupt is enabled by setting bit 0 of the Service Request Enable register (via the *ESE command) and bit 5 of the Service Request Enable register (via the *SRE command). Service request (SRQ) handling depends on your GPIB hardware. Refer to your GPIB user's manual for details.

### 6.3.7 Local Operation ITE Current Calibration

The following procedure is for calibrating the ITE constant current source for both polarities of current. This procedure calibrates the zero current set point automatically, then it automatically drives the TE current output to internally set limits of $\pm 1$ amp. When each of these values is reached and is stable, the user enters the actual value of the current, as measured by an external DMM. The LDC-3700 Series Laser Diode Controller then automatically calibrates the TEC current source and limits.

This procedure is for local (front panel) operation. See Section 6.3.8 for remote calibration of the ITE current.

a. With the output off, connect a 1 Ω, 20 W, resistor across the TEC output terminals and use a calibrated DMM to measure the voltage across the resistor. Calculate the current in the following steps by 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.)

b. Press the (GPIB) LOCAL and (TEC DISPLAY) ITE switches at the same time to place the LDC-3700 Series Laser Diode Controller in its TEC Current Calibration mode. The TEC output must be off in order to enter the ITE calibration mode.

   The TEC display will show a value of about zero amps as the LDC-3700 Series Laser Diode Controller calibrates itself for a zero current level. After about 20 seconds the LDC-3700 Series Laser Diode Controller will beep and the TEC display will begin to change to show about 1 amp (the limit calibration value).

c. After the value on the TEC display is stable (has not changed by more than one digit for several seconds) the LDC-3700 Series Laser Diode Controller is ready for the actual I value to be entered.

   Press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the TEC display shows the correct value (absolute value of the ITE measurement), as calculated from Step a.

d. Release the (PARAMETER) SET switch to store the new calibration value into non-volatile memory. The LDC-3700 Series Laser Diode Controller will then beep to indicate that it is ready for the user to enter the limit calibration value for its negative polarity output.

e. Repeat Steps c and d for the negative polarity of the TEC output current. After the value for the negative polarity of the TEC output is entered, the LDC-3700 Series Laser Diode Controller will automatically calibrate its current limits and set points. After a few seconds, the LDC-3700 Series Laser Diode Controller will return to its former state (before calibration). The LDC-3700 Series Laser Diode Controller will beep when it has finished storing all of the new calibration values.

### 6.3.8 Remote Operation ITE Current Calibration

The following procedure is for calibrating the ITE constant current source for both polarities of current. This procedure calibrates the zero current set point automatically, then it automatically drives the TE current output to internally set limits of $\pm 1$ amp. When each of these values is reached and is stable, the user enters the actual value of the current, as measured by an external DMM. The LDC-3700 Series Laser Diode Controller then automatically calibrates the TEC current source and limits.

This procedure is for remote (GPIB) operation. See Section 6.3.7 for local (front panel) calibration of the ITE current.

a. With the output off, connect a 1 Ω, 20 W, resistor across the TEC output terminals and use a calibrated DMM to measure the voltage across the resistor. Calculate the current in the following steps by 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.)

b. Enter the "TEC:OUTPUT OFF" command. The TEC output must be off in order to enter the ITE calibration mode.

Enter the "TEC:CAL:ITE" command over the GPIB to place the LDC-3700 Series Laser Diode Controller in its TEC Current Calibration mode. The LDC-3700 Series Laser Diode Controller will automatically calibrate its zero output current. The zero-point calibration may take about 20 seconds.

c. When the LDC-3700 Series Laser Diode Controller is ready for the actual ITE value to be entered, a remote query of "TEC:CAL:ITE?" will return a response of "1".

When the measured value (actual I) is stable and the LDC-3700 Series Laser Diode Controller is ready to proceed, enter the value by issuing the "TEC:ITE <nrf value>" command, where the (absolute value of the) actual ITE value is the <nrf value>.

To ensure measurement stability of the actual ITE value when the measurement is taken as a part of an automated test, the DMM measurement should be polled in a loop. When the measured value is consistent within one digit for 5 seconds (for example), the actual ITE value could be considered stable.

d. Once the actual ITE value is entered via the "TEC:ITE" command, the new calibration value is stored into non-volatile memory. The LDC-3700 Series Laser Diode Controller will then be ready for the user to enter the limit calibration value for its negative polarity output.

e. Repeat Steps c and d for the negative polarity of the TEC output current. After the value for the negative polarity of the TEC output is entered, the LDC-3700 Series Laser Diode Controller will automatically calibrate its current limits and set points. After a few seconds, the LDC-3700 Series Laser Diode Controller will return to its former state (before calibration). The LDC-3700 Series Laser Diode Controller will beep when it has finished storing all of the new calibration values.

After the last "TEC:ITE" value is entered, the "*OPC?" query may be used to determine when the calibration sequence is done. However, the "*OPC", or "*WAI" command, or "*OPC?" query should not be issued until after the last "TEC:ITE" value is entered, or the system will "hang". This happens because the LDC-3700 Series Laser Diode Controller will wait indefinitely for an input, yet not allow any input until the calibration is finished.

If the "*OPC?" query is issued during ITE calibration, the time out period of the GPIB driver should be at least 1 minute to prevent the GPIB driver from timing out and "hanging" the system. Refer to your GPIB driver instruction manual for information on setting the GPIB driver time out period.

The operation complete flag (bit 0 of the Standard Event Status Register) may be used to trigger a service request. This type of interrupt is enabled by setting bit 0 of the Service Request Enable register (via the *ESE command) and bit 5 of the Service Request Enable register (via the *SRE command). Service request (SRQ) handling depends on your GPIB hardware. Refer to your GPIB user's manual for details.

### 6.4 LASER Controller Calibration Adjustments

There are three calibration adjustments that need to be made for the LASER side of the LDC-3700 Series Laser Diode Controller. They are calibration of the constant current source for both bandwidths and ranges, calibration of the laser voltage measurement, and calibration of the constant light power ($I_{PD}$) feedback circuits.

The LDC-3700 Series Laser Diode Controller implements a two-point calibration for the Laser current source. Two currents are applied to a load, and the resulting measured currents are fed back (by the user) to the LDC-3700 Series Laser Diode Controller. The LDC-3700 Series Laser Diode Controller calibration program uses the two sets of data to calculate calibration constants that it will thereafter use to set current.

If you have the optional Model 1231 IEEE-488.2/GPIB interface you may follow the procedure in sections 6.4.2, 6.4.4 and 6.4.5 to calibrate the LDC-3700 Series Laser Diode Controller remotely.

#### 6.4.1 Local Operation Current Source Calibration

The following procedure is for local (front panel) operation. See Section 6.4.2 for remote calibration of the current source.

45ma for 50ma 3712

a. Set the LASER current limit (LIM I) to 90% of full scale (e.g., 900 mA for 1000 mA range on the LDC-3742B), set the mode to I (low bandwidth), set the output range as desired, and current set point to 80% of full scale (i. e. 800 mA for 1000 mA range on LDC-3742B).

   Disconnect any laser from the LASER output. Connect a 1 Ω, 20 W, resistor across the LASER output terminals and use a calibrated DMM to measure the voltage across the resistor. Calculate the current in the following steps by 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.)

   OR - (with LDC-3722B or LDC-3712) Connect a calibrated DMM across the LASER output terminals and measure the current directly.

b. Press the (LASER MODE) ON switch to turn the LASER output on. The LASER output must be on in order to enter the LASER I calibration mode.

c. Enter the LASER I calibration mode by pushing the (GPIB) LOCAL and (LASER DISPLAY) I switches at the same time. The LASER display will indicate output current in mA. The LDC-3700 Series Laser Diode Controller will beep when it is ready to accept a new calibration value.

d. Press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the LASER display indicates the same current as calculated in Step a.

e. Release the (PARAMETER) SET switch to accept the first calibration point. After the (PARAMETER) SET switch is released, the LDC-3700 Series Laser Diode Controller will beep. It will then apply the second calibration current, approximately one-fourth of the original current. (For example, if the first calibration set point was 800 mA, the second set point will be about 200 mA.)

f. Calculate the second current as in Step a.

g. The LDC-3700 Series Laser Diode Controller will beep when it is ready to accept the second calibration value. When it does, press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the LASER display indicates the same current as calculated in Step f.

h. Release the (PARAMETER) SET switch to accept the second calibration point. After the (PARAMETER) SET switch is released, the LDC-3700 Series Laser Diode Controller will calculate the calibration constants, store them to nonvolatile memory. In low bandwidth calibration mode, the LDC-3700 Series Laser Diode Controller will also perform current limit calibrations for I and P modes. Then it will beep, and return to its former (before calibration) state.

i. Repeat this procedure with the high bandwidth, and then repeat it all with other range (four combinations are possible).

### 6.4.2 Remote Operation Current Source Calibration

The following procedure is for remote (GPIB) operation. See Section 6.4.1 for local calibration of the current source.

a. Set the LASER current range via the "LAS:RAN x" command, and set the limit to 90% of full scale via the "LAS:LIM:Ix" commands (where x = 1, 2, 3, or 5, depending on the model and range desired --see LAS:LIM commands, Chapter 4). Set the output bandwidth to low bandwidth via the "LAS:MODE:ILBW" command, and current set point to 80% of full scale via the "LAS:LDI" command.

   Disconnect any laser from the LASER output. Connect a 1 Ω, 20 W, resistor across the LASER output terminals and use a calibrated DMM to measure the voltage across the resistor. Calculate the current in the following steps by 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.)

   OR - (with LDC-3722B or LDC-3712) Connect a calibrated DMM across the LASER output terminals and measure the current directly.

b. Enter the "LAS:OUTPUT ON" command to turn the LASER output on. The LASER output must be on in order to enter the LASER I calibration mode.

c. Enter the LASER I calibration mode by issuing the "LAS:CAL:LDI" command.

d. Input the first actual (measured) LASER output current (as an <nrf value>) via the "LAS:LDI <nrf value>" command.

   If this value is to be measured and entered remotely via a GPIB controlled DMM, for example, the measured value of the current should not be entered until the LDC-3700 Series Laser Diode Controller is ready to receive it:

   The LDC-3700 Series Laser Diode Controller will be ready to receive the current value when, after a "LAS:CAL:LDI?" query is sent, the response from the LDC-3700 Series Laser Diode Controller is "1".

e. Once the actual I value is entered via the "LAS:LDI" command, the LDC-3700 Series Laser Diode Controller will beep and will apply a new current equal to approximately one-fourth (1/4) the previous set current.

f. Input the second actual (measured) LASER output current (as an <nrf value>) as in Step d.

g. Once the second actual I value is entered via the "LAS:LDI" command, the new calibration constants will be calculated and stored into non-volatile memory. In low bandwidth calibration mode, the LDC-3700 Series Laser Diode Controller will also perform current limit calibrations for I and P modes. The "OPC?" query may be used (after the "LAS:LDI" value is sent) to determine when the calibration is completed.

   The operation complete flag (bit 0 of the Standard Event Status Register) may be used to trigger a service request. This type of interrupt is enabled by setting bit 0 of the Service Request Enable register (via the *ESE command) and bit 5 of the Service Request Enable register (via the *SRE command). Service request (SRQ) handling depends on your GPIB hardware. Refer to your GPIB user's manual for details.

h. Repeat this procedure with the high bandwidth, and then repeat it all with the other range (four combinations are possible).

### 6.4.3 Local Operation $I_{PD}$ Current Calibration

The following procedure is for calibrating the LASER $I_{PD}$ constant current source. This procedure calibrates the feedback circuits for constant $I_{PD}$ and constant $P_{PD}$ modes. When these values are reached and are stable, the user enters the actual value of the current, as measured by an external DMM. The LDC-3700 Series Laser Diode Controller then automatically calibrates the LASER feedback circuits.

This procedure is for local (front panel) operation. See Section 6.4.4 for remote calibration of the $I_{PD}$ current.

a. With the LASER output off, connect a calibrated ammeter to the PD Anode output of the LDC-3700 Series Laser Diode Controller, and connect the circuit of Figure 6.1 to the LASER and PD outputs (R3 = 1 Ω, LDC-3742B; 11 Ω, LDC-3722B; or 49 Ω, LDC-3712).

If a calibrated ammeter (with 0.1 μA resolution) is not available, use a zero-Ohm jumper in place of the ammeter. Then, place a calibrated DMM (with 0.1 mV resolution) to measure the voltage across the resistor, R1, as shown in Figure 6.1. Calculate the current in the following steps by using Ohm's Law:

$$I = E / R$$

-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.)

b. Set the LASER current limit (LIM I) as desired. Set the $I_{PD}$ set point to 4000 μA (LDC- 3722B or LDC-3712) or 8000 μA (LDC-3742B), and set the CAL PD parameter to zero. This puts the LDC-3700 Series Laser Diode Controller into a constant $I_{PD}$ mode.

c. Press the (LASER MODE) ON switch to turn the LASER output on. Verify proper operation, i.e., the $I_{PD}$ set point should be close, and the unit should not be in current limit.

d. Press the (GPIB) LOCAL and (LASER DISPLAY) $I_{PD}$ switches at the same time to place the LDC-3700 Series Laser Diode Controller in its LASER Current Calibration mode.

After a few seconds the LDC-3700 Series Laser Diode Controller will beep and the LASER display will show the $I_{PD}$ set point value.

e. After the value on the LASER display is stable (has not changed by more than one digit for several seconds) the LDC-3700 Series Laser Diode Controller is ready for the actual $I_{PD}$ value to be entered.

Press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the LASER display shows the correct value, as shown on the calibrated ammeter (or the calculated $I_{PD}$ value from Step a).

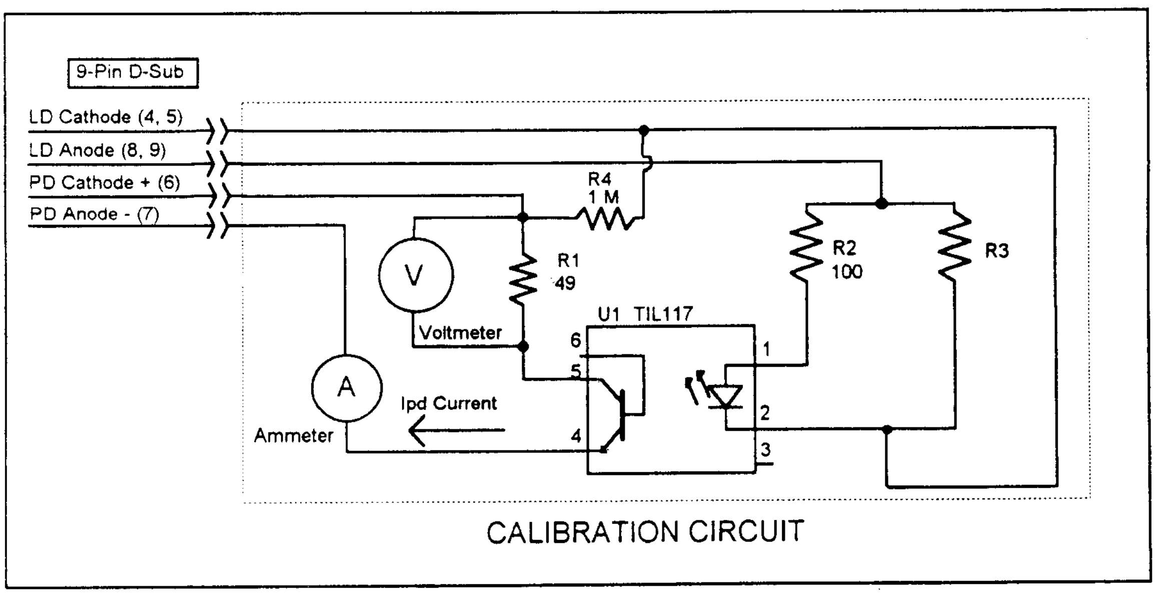



**Figure 6.1 $I_{PD}$ Calibration Circuit**

f. Release the (PARAMETER) SET switch to store the first calibration value into non-volatile memory. It will then set the second calibration current, approximately one-fourth of the original current. (For example, if the first calibration set point was 4000 μA, the second set point will be about 1000 μA.) Calculate the second current as in Step a.

g. The LDC-3700 Series Laser Diode Controller will beep when it is ready to accept the second calibration value. When it does, press and hold in the (PARAMETER) SET switch and turn the ADJUST knob until the LASER display indicates the same current as calculated in Step f.

h. Release the (PARAMETER) SET switch to accept the second calibration point. After the (PARAMETER) SET switch is released, the LDC-3700 Series Laser Diode Controller will calculate the calibration constants, store them to nonvolatile memory, beep, and return to its former (before calibration) state.

### 6.4.4 Remote Operation $I_{PD}$ Current Calibration

The following procedure is for calibrating the LASER $I_{PD}$ constant current source. This procedure calibrates the feedback circuits for constant $I_{PD}$ and constant $P_{PD}$ modes. When these values are reached and are stable, the user enters the actual value of the current, as measured by an external DMM. The LDC-3700 Series Laser Diode Controller then automatically calibrates the LASER feedback circuits.

This procedure is for remote (GPIB) operation. See Section 6.4.3 for local calibration of the $I_{PD}$ current.

a. With the LASER output off, connect a calibrated ammeter to the PD Anode output of the LDC-3700 Series Laser Diode Controller, and connect the circuit of Figure 6.1 to the LASER and PD outputs (R3 = 1 Ω, LDC-3742B; 11 Ω, LDC-3722B; or 49 Ω, LDC-3712).

   If a calibrated ammeter (with 0.1 μA resolution) is not available, use a zero-Ohm jumper in place of the ammeter. Then, place a calibrated DMM (with 0.1 mV resolution) to measure the voltage across the resistor, R1, as shown in Figure 6.1. Calculate the current in the following steps by using Ohm's Law:

$$I = E / R$$

   -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.)

b. Set the LASER current limit via the "LAS:LIM:Ix" (where x = 1, 2, 3, or 5, depending on the model and range --see LAS:LIM commands, Chapter 4) command as desired. Set the $I_{PD}$ set point to 4000 μA via the "LAS:MDI 4000" command. Set the CAL PD parameter to zero via the "LAS:CALMD 0" command. This puts the LDC-3700 Series Laser Diode Controller into a constant $I_{PD}$ (MDI) mode.

c. Enter the "LAS:OUT ON" command to turn the LASER output on. Verify proper operation, i.e., the $I_{PD}$ output should be close to the set point (read it via the "LAS:MDI?" query), and the unit should not be in current limit (read the limit status via the "LAS:COND?" query, bit 0).

d. Enter the "LAS:CAL:MDI" command to place the LDC-3700 Series Laser Diode Controller in its LASER Current Calibration mode.

e. After a few seconds, the LDC-3700 Series Laser Diode Controller will be ready for the actual $I_{PD}$ current to be entered via the "LAS:MDI" command. The measured value of the current should not be entered until the LDC-3700 Series Laser Diode Controller is ready to receive it.

The LDC-3700 Series Laser Diode Controller will be ready to receive the current value when, after a "LAS:CAL:MDI?" query is sent, the response from the LDC-3700 Series Laser Diode Controller is "1".

f. Once the actual $I_{PD}$ value is entered via the "LAS:MDI" command, the LDC-3700 Series Laser Diode Controller will beep and the new calibration value will be stored into non-volatile memory. It will then set the output to approximately one-fourth of the original current. (For example, if the first calibration set point was 4000 μA, the second set point will be about 1000 μA.) Then, it will be ready to receive the second calibration value. Calculate the second current value as in Step a.

g. Input the second actual (measured) monitor diode current (as an <nrf value>) as in Step d.

h. Once the second actual $I_{PD}$ value is entered via the "LAS:MDI" command, the new calibration constants will be calculated and stored into non-volatile memory. The "OPC?" query may be used (after the "LAS:MDI" value is sent) to determine when the calibration is completed.

The operation complete flag (bit 0 of the Standard Event Status Register) may be used to trigger a service request. This type of interrupt is enabled by setting bit 0 of the Service Request Enable register (via the *ESE command) and bit 5 of the Service Request Enable register (via the *SRE command). Service request (SRQ) handling depends on your GPIB hardware. Refer to your GPIB user's manual for details.

### 6.4.5 Remote Operation Laser Voltage Measurement Calibration

The following procedure is for calibrating the LASER voltage measurement. This procedure can only be performed remotely (over GPIB).

a. With the LASER output off, connect a calibrated voltmeter, in parallel with a resistor (100 Ω, 2 Watt for the LDC-3712; 15 Ω, 5 Watt for the LDC-3722B or LDC-3742B), to the LASER output of the LDC-3700 Series Laser Diode Controller.

b. Set the range (100 mA for the LDC-3712, 500 mA range for the LDC-3722B, or 1000 mA for the LDC-3742B), via the "LAS:RAN x" (where x = 1 for LDC-3742B, 5 for LDC-3722B, or 1 for LDC-3712).

Set the LASER current limit via the "LAS:LIM:Ix" (where x = 1 for LDC-3742B, 5 for LDC-3722B, or 1 for LDC-3712) command to full scale for the selected range.

Set the I set point via the "LAS:LDI nnn" command. (where nnn = 60 for the LDC-3712, 400 for the LDC-3722B or LDC-3742B)

c. Enter the "LAS:OUT ON" command to turn the LASER output on. The LASER output must be on in order to enter the LDV calibration mode.

d. Enter the "LAS:CAL:LDV" command to place the LDC-3700 Series Laser Diode Controller in its LASER Voltage Calibration mode.

e. After a few seconds, the LDC-3700 Series Laser Diode Controller will be ready for the actual laser voltage to be entered (in volts) via the "LAS:LDV" command. The measured value of the voltage should not be entered until the LDC-3700 Series Laser Diode Controller is ready to receive it. The LDC-3700 Series Laser Diode Controller will beep when it is ready to accept a new calibration value.

   The LDC-3700 Series Laser Diode Controller will be ready to receive the voltage value when, after a "LAS:CAL:LDV?" query is sent, the response from the LDC-3700 Series Laser Diode Controller is "1".

f. Once the actual voltage value is entered via the "LAS:LDV" command, the LDC-3700 Series Laser Diode Controller will set the current to approximately one-fourth of the original value. It will then expect the second calibration voltage point, approximately one-fourth of the original voltage. (For example, if the first calibration set point was 6.0000 V, the second set point will be about 1.5000 V.)

g. Input the second actual (measured) LASER output current (as an <nrf value>) as in Step d.

h. Once the second actual voltage value is entered via the "LAS:LDV" command, the LDC-3700 Series Laser Diode Controller will beep and the new calibration constants will be calculated and stored into non-volatile memory.

   The operation complete flag (bit 0 of the Standard Event Status Register) may be used to trigger a service request. This type of interrupt is enabled by setting bit 0 of the Service Request Enable register (via the *ESE command) and bit 5 of the Service Request Enable register (via the *SRE command). Service request (SRQ) handling depends on your GPIB hardware. Refer to your GPIB user's manual for details.

## 6.5 Fuse Replacement

The fuses are accessible from the back panel of the LDC-3700 Series Laser Diode Controller. Before replacing the fuses, turn power off and disconnect the line cord. Use only the fuses indicated below in Table 6.2.

**FUSE REPLACEMENT**

| Line voltage | Fuse Replacement |
|---|---|
| 90 - 110 VAC | 3 Amp, 3AG, Slow Blow |
| 110 - 130 VAC | 3 Amp, 3AG, Slow Blow |
| 210 - 230 VAC | 1.5 Amp, 3AG, Slow Blow |
| 230 - 250 VAC | 1.5 Amp, 3AG, Slow Blow |

**Table 6.2 Fuse Replacement**

## 6.6 Line Voltage Selection

Line voltage selection is made by installing jumpers according to Figure 6.2. Normally these jumpers are set at the factory. When necessary, however, they may be moved to accommodate new line voltage conditions. You must remove the LDC-3700 Series Laser Diode Controller's bottom cover to access the jumpers on the power supply.

Carefully remove the jumpers and then install them in the new position, as shown in Figure 6.2.

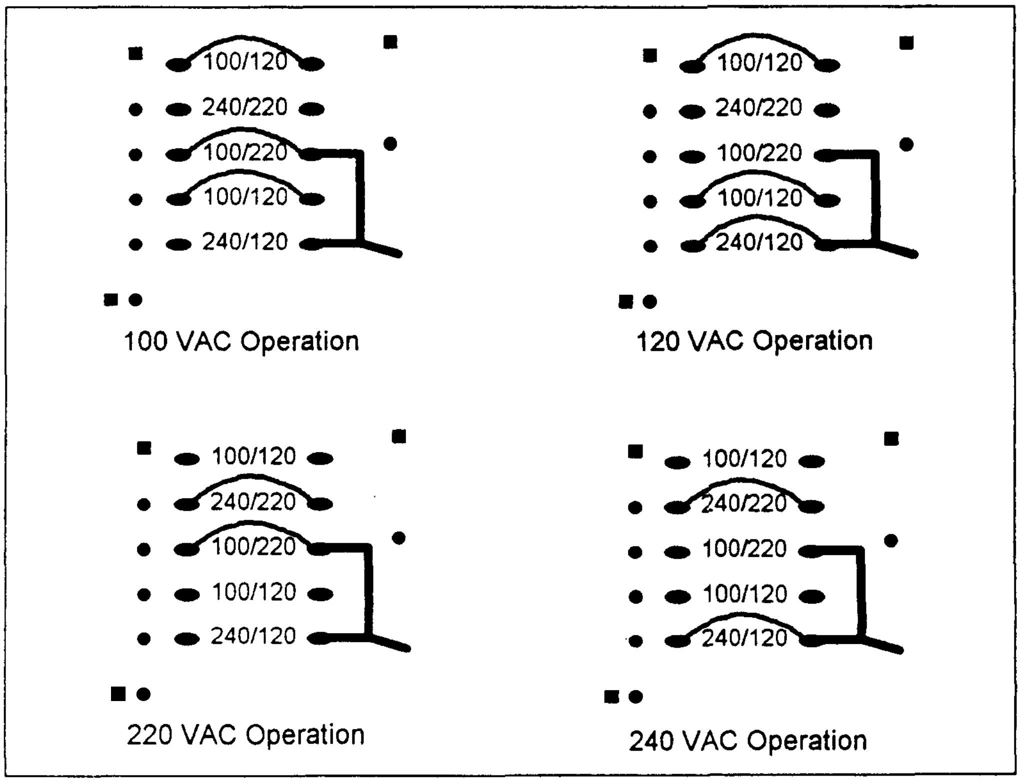



**Figure 6.2 Power Line Voltage Selection**

## 6.7 Disassembly

The top and bottom covers of the LDC-3700 Series Laser Diode Controller may be removed by extracting the countersunk screws on the sides of the instrument near the back panel. After these screws are out, slide either cover towards the rear of the instrument and then pull it up and off.

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# Index (continued)

# Index (continued)

# Appendix A

## The Steinhart-Hart Equation

Two-terminal thermistors have a nonlinear relationship between temperature and resistance. The resistance verses temperature characteristics for a family of similar thermistors is shown in Figure A.1. It has been found empirically that the resistance verses temperature relationship for most common negative temperature coefficient (NTC) thermistors can be accurately modeled by a polynomial expansion relating the logarithm of resistance to inverse temperature. The Steinhart-Hart equation is one such expression and is given as follows:

$1/T = A + B(\text{Ln } R) + C(\text{Ln } R)^3$ Equation 1

Where T is is expressed in KELVIN.

Once the three constants A, B, and C are accurately determined, Equation 1 introduces small errors in the calculation of temperature over wide temperature ranges. Table A.1 shows the results of using equation 1 to fit the resistance verses temperature characteristic of a common 10K ohm (at room temperature) thermistor. Equation 1 will produce temperature calculation errors of less than 0.01 °C over the range -20 C to 50 °C.

**CURVE-FITTING EQUATION COMAPARISON**

| | | Error T (°C) | Error T (°C) |
|---|---|---|---|
| R[1] | T Actual | First Order Fit Eq 2[2] | Third Order Fit Eq 1[3] |
| 97072 | -20.00 | -0.00 | -0.32 |
| 55326 | -10.00 | 0.00 | -0.06 |
| 32650 | 0.00 | -0.00 | 0.09 |
| 19899 | 10.00 | -0.00 | 0.15 |
| 12492 | 20.00 | -0.00 | 0.13 |
| 10000 | 25.00 | 0.00 | 0.08 |
| 8057 | 30.00 | 0.00 | 0.01 |
| 5326 | 40.00 | 0.00 | -0.20 |
| 3602 | 50.00 | -0.00 | -0.50 |

**Table A.1 Comparison of Curve Fitting Equations**

[1] Resistance of a 10 kΩ, Fenwal UUA41J1 thermistor.

[2] Constants $A' = 0.963 * 10^{-3}$, $B' = 2.598 * 10^{-4}$.

[3] Constants
$A = 1.125 * 10^{-3}$ (C1 = 1.125)
$B = 2.347 * 10^{-4}$ (C2 = 2.347)
$C = 0.855 * 10^{-7}$ (C3 = 0.855)

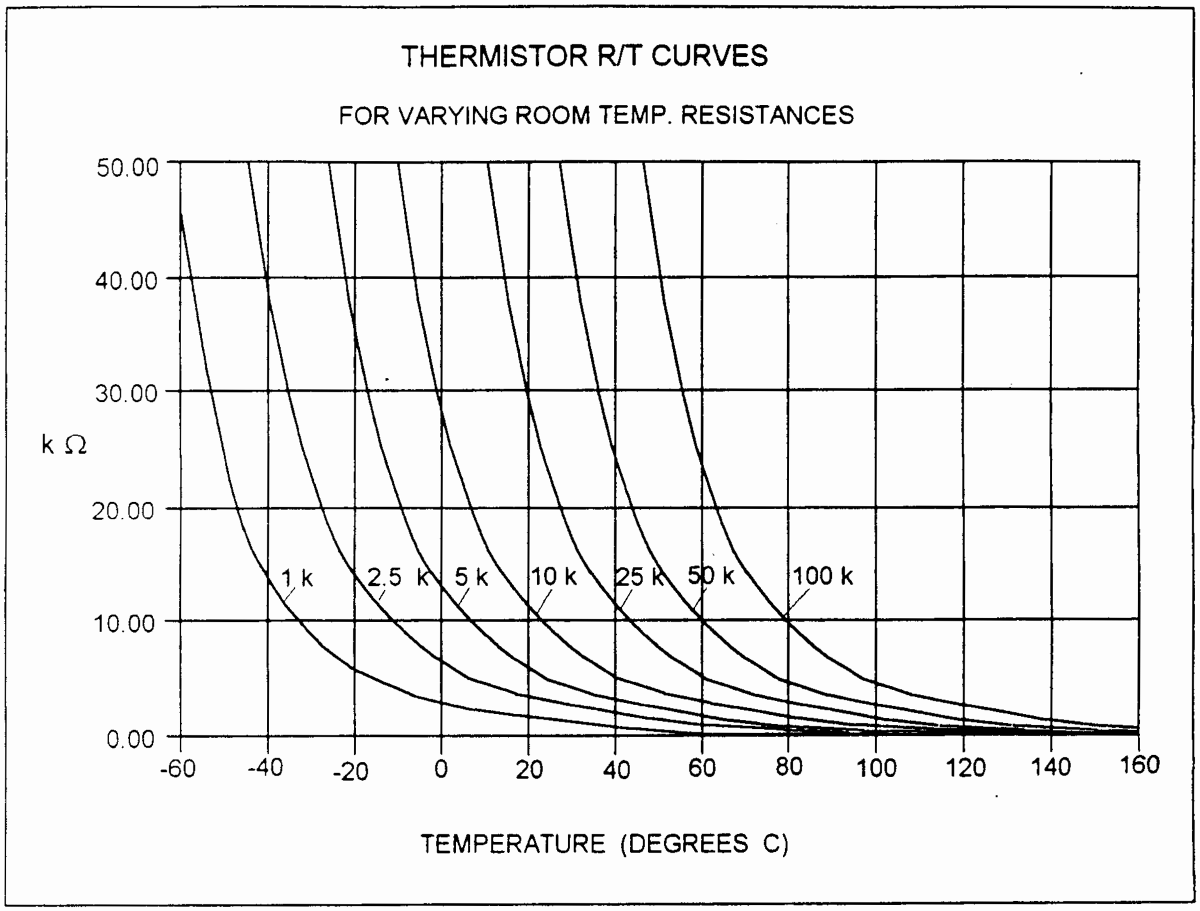


**Figure A.1 Thermistor Resistance Versus Temperature**

In practice we have found that the constants A, B and C for virtually all common thermistors lie within a narrow range. Consequently, we have defined the constants C1, C2, C3 as follows:

$$C1 = A * 10^{+3}$$
$$C2 = B * 10^{+4}$$
$$C3 = C * 10^{+7}$$

The constants C1, C2, And C3 may all be expressed in the form n.nnn simplifying entry into the LDC-3700 Series Laser Diode Controller.

If high accuracy is not required, the Steinhart-Hart equation may be simplified to a first order polynomial:

$1/T = A' + B' * \ln R$ Equation 2

This equation is easier to solve and often provides adequate results. Table A.1 also shows that the use of Equation 2 introduces temperature errors of less than 0.5°C over the range -20 C to 50°C. Once the constants A' and B' are determined, the LDC-3700 Series Laser Diode Controller is programmed with the following values of C1, C2 and C3:

$$C1 = A' * 10^{+3}$$
$$C2 = B' * 10^{+4}$$
$$C3 = 0.000$$

Table of Constants

We have tested or reviewed many thermistors and include the appropriate calibration constants for the temperature range -20 C to 50 C in most cases. Please contact ILX Lightwave Corporation if you require more information about these constants or would like other constants computed for you.

**THERMISTOR CONSTANTS**

| Manufacturer | Type | | | C1 | C2 | C3 |
|---|---|---|---|---|---|---|
| Fenwal | 3K | @25C | Curve 1 | 1.557 | 2.162 | 1.259 |
| Fenwal | 5K | @25C | Curve 1 | 1.448 | 2.152 | 1.165 |
| Fenwal | 10K | @25C | Curve 1 | 1.302 | 2.137 | 1.058 |
| Fenwal | 3K | @25C | Curve 10A | 1.089 | 2.712 | 1.812 |
| Fenwal | 5K | @25C | Curve 10A | 0.957 | 2.690 | 1.707 |
| Fenwal | 10K | @25C | Curve 10A | 0.780 | 2.660 | 1.582 |
| Fenwal | 3K | @25C | Curve 16 | 1.405 | 2.369 | 1.006 |
| Fenwal | 5K | @25C | Curve 16 | 1.286 | 2.360 | 0.939 |
| Fenwal | 10K | @25C | Curve 16 | 1.126 | 2.346 | 0.861 |
| Fenwal | 3K | @25C | Curve 17 | 0.999 | 2.807 | 2.091 |
| Fenwal | 5K | @25C | Curve 17 | 0.864 | 2.780 | 1.977 |
| Fenwal | 10K | @25C | Curve 17 | 0.685 | 2.742 | 1.840 |
| Fenwal | 3K | @25C | Curve 18 | 1.436 | 2.289 | 1.657 |
| Fenwal | 5K | @25C | Curve 18 | 1.324 | 2.271 | 1.553 |
| Fenwal | 10K | @25C | Curve 18 | 1.174 | 2.246 | 1.432 |
| Dale | 2K | @25C | Curve 1 | 1.500 | 2.377 | 1.067 |
| Dale | 3K | @25C | Curve 1 | 1.405 | 2.369 | 1.006 |
| Dale | 4K | @25C | Curve 1 | 1.338 | 2.364 | 0.968 |
| Dale | 5K | @25C | Curve 1 | 1.286 | 2.360 | 0.939 |
| Dale | 6K | @25C | Curve 1 | 1.244 | 2.356 | 0.918 |
| Dale | 7K | @25C | Curve 1 | 1.208 | 2.353 | 0.900 |
| Dale | 8K | @25C | Curve 1 | 1.177 | 2.351 | 0.885 |
| Dale | 9K | @25C | Curve 1 | 1.150 | 2.348 | 0.872 |
| Dale | 10K | @25C | Curve 1 | 1.126 | 2.346 | 0.861 |
| Dale | 2K | @25C | Curve 2 | 1.259 | 2.669 | 1.509 |
| Dale | 5K | @25C | Curve 2 | 1.024 | 2.638 | 1.349 |
| Dale | 10K | @25C | Curve 2 | 0.848 | 2.615 | 1.248 |
| Dale | 10K | @25C | Curve 9 | 1.031 | 2.388 | 1.576 |
| Dale | 2.252K | @25C | Curve 1 | 1.472 | 2.375 | 1.048 |
| Spectra Diode Labs Modules | | | | 0.848 | 2.615 | 1.248 |
| Lasertron Modules | | | | 1.126 | 2.346 | 0.861 |
| General Optronics Modules | | | | 1.126 | 2.346 | 0.861 |

**Table A.2 Thermistor Constants**

**Computer programs**

We have included two computer programs that use a least squares curve fitting routine to determine the values of C1, C2 and C3. The programs, called STEIN3 and STEIN1, are written in IBM's advanced BASICA. STEIN3 calculates the values the coefficients C1, C2 and C3 using equation 1. STEIN1 calculates C1 and C2 using equation 2. Type one of these program into your computer.

Next you must create a data file for your thermistor that describes the resistance at various temperatures. The temperature verses resistance calibration data can be obtained from the thermistor manufacturer. Enter the resistance at various temperatures as data points into an ASCII file. You can write the data file on a word processor, but you must use non-document mode so special word processing characters are not inserted into the data file. Format the data with one temperature-resistance pair per line and at least one space separating the two numbers. Temperatures should be in centigrade and resistances in ohms. We recommend that you use at least twenty data points, uniformly spread over the intended range of use, for an accurate determination of the coefficients. Enter a -1 to signify the end of the resistance data and temperature data.

A small sample data file is included below as an example of the data format and end-of-data marker (R = -1).

| Temperature | Resistance |
|---|---|
| -20 | 97072 |
| -10 | 55326 |
| 0 | 32650 |
| 10 | 19899 |
| 20 | 12492 |
| 25 | 10000 |
| 30 | 8056.8 |
| 40 | 5326.4 |
| 50 | 3602.3 |
| -1 | -1 |

Run the STEIN3 or STEIN1 program. The best curve fitting values for C1, C2 and C3 will be displayed. Key these numbers into the LDC-3700 Series Laser Diode Controller. If the computer program supplies negative values for constants C2 or C3 then the temperature verses resistance data was bad or incorrectly entered.

```
80 REM ************** STEIN1 ****************
90 REM
92 REM    Rev: 3-11-87
94 REM    T is expressed in Kelvins.
100 REM   Least squares fit program to find the thermistor coefficients
110 REM   C1 and C2 in the following equation:
120 REM
130 REM          1/T = C1 + C2 * (ln R)
140 REM
200 REM
210 REM  Variables:
220 REM
230 REM   T[i], R[i]     temperature and resistance data values.
240 REM
250 REM   Y[i] = 1/T[i]  the dependent variable (depends on R[i])
260 REM              in the Steinhart - Hart equation (above).
270 REM
280 REM   X[i] = ln(R[I])  the value of the ith function of the independent
290 REM              variable ln(R) (natural log of resistance)
330 REM
1000 DEFDBL A-Z
1010 DEFINT I, J, K, L
1020 DIM R[400], T[400], Y[400], X[400]
1025 C[3]=0
1030 PRINT "What is the data file name"; : INPUT D$
1040 OPEN "i", 1, D$
1050 REM    **** read and echo T(i), R(i) from the data file ****
1060 REM           (terminate read on R=-1)
1070 I=0
1080 PRINT "Data:"
1090 G$="Point    Temperature (Celsius)   Resistance (ohms)"
1100 H$=" ###        #####.##          ########.##"
1110 PRINT G$
1120 PRINT
1130 I=I+1
1140 INPUT #1, T(I), R(I)
1150 IF R(I)<0 THEN GOTO 1180
1155 X(I)=LOG(R(I)) : Y(I)=1/(T(I)+273.15)
1160 PRINT USING H$; I, T(I), R(I)
1170 GOTO 1130
1180 N=I-1
1190 CLOSE
1200 REM         **** accumulate sums ****
1205 SX=0 : SY=0 : SXY=0 : SXX=0
1210 FOR I = 1 TO N
1220 SX=SX+X(I)
1230 SY=SY+Y(I)
1240 SXY=SXY+X(I)*Y(I)
1250 SXX=SXX+X(I)*X(I)
1260 NEXT I
```

(Continued on next page)

(Program "STEIN1",continued from previous page)

```
1300 REM        **** print out results ****
1310 C[2]=(N*SXY-SX*SY)/(N*SXX-SX*SX)
1320 C[1] = (SY-C[2]*SX)/N
1620 PRINT
1630 G$="Key in:    C1       C2       C3"
1640 P$="       #.###     #.###     #.###"
1650 PRINT G$
1660 PRINT USING P$; C[1]*1000!, C[2]*10000!,C[3]
1700 '
1702 C1=INT(C[1]*1000000!)/1000000!
1704 C2=INT(C[2]*1E+07)/1E+07
1706 C3=0
1710 PRINT
1712 PRINT "          T        T          T"
1714 PRINT "   R      ACTUAL     CALC       ERROR"
1716 PRINT " ======== ========= ========== ========="
1718 P$=  " #######    ####.##    ####.##     ####.##"
1720 FOR L=1 TO N
1730 X=LOG(R(L))
1740 TCALC=1/(C1+C2*X+C3*X*X*X)-273.15
1760 PRINT USING P$;R(L),T(L),TCALC,T(L)-TCALC
1780 NEXT L
```

```
80 REM ************** STEIN3 ****************
90 REM
92 REM    Rev: 3-11-87
94 REM
100 REM   Least squares fit program to find the thermistor coefficients
110 REM   C1, C2 and C3 in the Steinhart-Hart equation:
120 REM
130 REM           1/T = C1 + C2 * (ln R) + C3 * (ln R)**3
140 REM
150 REM  Reference:
160 REM
170 REM   "Data Reduction and Error Analysis for the Physical Sciences"
180 REM        Philip R. Bevington (McGraw-Hill, New York, 1969)
190 REM            Library call no.: QA 278 B48
200 REM
210 REM  Variables:
220 REM
230 REM  T[i], R[i]    temperature and resistance data values.
240 REM
250 REM  Y[i] = 1/T[i]  the dependent variable (depends on R[i])
260 REM            in the Steinhart - Hart equation (above).
270 REM
280 REM  X[n,i]        the value of the nth function of the independent
290 REM            variable R (resistance) evaluated at the ith
300 REM            data point R[i]
310 REM
320 REM      X[1,i] = 1 ;  X[2,i] = ln(R[i])  ;  X[3,i] = ln(R[i]) ** 3
330 REM
340 REM  c[j]          the value of the jth coefficient to be solved for
350 REM            in the expansion
360 REM
370 REM      Y[i] = c[1] * X[1,i] + c[2] * X[2,i] + c(3) * X[3,i]
380 REM
390 REM            which becomes the Steinhart - Hart equation
395 REM            which is the inverse of the alpha matrix
400 REM            with the above substitutions for Y[i] and X[n,i].
410 REM            c[j] corresponds to Bevington's a[j] vector
420 REM            in his eqn 8-26.
430 REM
440 REM  A[j,k]        Bevington's alpha matrix (j,k=1,2,3)
450 REM            and beta vector (j=4, k=1,2,3) (Bevington eqn 8-23).
460 REM
470 REM  E[j,k]        Bevington's epsilon (error) matrix (eqns 8-28, 8-30)
480 REM            and contains the uncertainties in the estimates
490 REM            of the c[j] coefficients. These uncertainties are
500 REM            the consequence of the scatter (errors) in the
510 REM            input temperature verses resistance data.
```

(Continued on next page)

(Program STEIN3, continued from previous page)

```
1000 DEFDBL A-Z
1010 DEFINT I, J, K, L
1020 DIM R[400], T[400], Y[400], X[4,400], A[4,3], B[3,3], E[3,3], C[3]
1030 PRINT "What is the data file name"; : INPUT D$
1040 OPEN "i", 1, D$
1050 REM    **** read and echo T(i), R(i) from the data file ****
1060 REM          (terminate read on R=-1)
1070 I=0
1080 PRINT "Data:"
1090 G$="Point    Temperature (Celsius)   Resistance (ohms)"
1100 H$=" ###        #####.##          ########.##"
1110 PRINT G$
1120 PRINT
1130 I=I+1
1140 INPUT #1, T(I), R(I)
1150 IF R(I)<0 THEN GOTO 1180
1160 PRINT USING H$; I, T(I), R(I)
1170 GOTO 1130
1180 N=I-1
1190 CLOSE
1200 REM         **** calculate 4 x 3 matrix ****
1210 FOR I = 1 TO N
1220 H=LOG(R(I))
1230 X(1,I)=1
1240 X(2,I)=H
1250 X(3,I)=H*H*H
1260 REM      (subscript 4 corresponds to y[i] = X[4,i])
1270 X(4,I)=1/(T(I)+273.15)
1280 NEXT I
1290 REM   **** Calculate alpha (i=1 to 3) and beta (i=4) ****
1300 REM           (Bevington eqns 8-23)
1310 FOR I=1 TO 4 : FOR J=1 TO 3 : A(I,J)=0 : NEXT J : NEXT I
1320 FOR I=1 TO N : FOR J=1 TO 4 : FOR K=1 TO 3
1330 A(J,K)=A(J,K)+X(J,I)*X(K,I)
1340 NEXT K : NEXT J : NEXT I
1350 REM   **** Error matrix "E" = inverse of alpha (3x3 part of A) ****
1360 GOSUB 2010
1370 REM    **** Coefficients = beta (fourth column of A) x E ****
1380 REM             (eqn 8-26 of Bevington)
1390 FOR I=1 TO 3 : C(I)=0 : FOR J=1 TO 3
1400 C(I)=C(I)+E(I,J)*A(4,J)
1410 NEXT J : NEXT I
1420 SIGMA=0
1430 FOR I=1 TO N
1440 H=X(4,I)-C(1)*X(1,I)-C(2)*X(2,I)-C(3)*X(3,I)
1450 SIGMA=SIGMA+H*H
1460 NEXT I
```

(Continued on next page)

(Program STEIN3, continued from previous page)

```
1470 REM        **** sigma = mean square deviation ****
1480 REM              (Bevington eqn 8-29)
1490 SIGMA=SQR(SIGMA/(N-3))
1500 REM     **** print coefficients and estimated errors ****
1510 REM           (eqns 8-26 and 8-30 of Bevington)
1520 F$="##.####^^^^  +/- ##.##^^^^ )"
1530 PRINT
1540 PRINT "1/T = (";
1550 PRINT USING F$; C(1), SIGMA*SQR(E(1,1))
1560 PRINT "    + (";
1570 PRINT USING F$; C(2), SIGMA*SQR(E(2,2));
1580 PRINT " * ln (R)"
1590 PRINT "    + (";
1600 PRINT USING F$; C(3), SIGMA*SQR(E(3,3));
1610 PRINT " * ln (R) ** 3"
1620 PRINT
1630 G$="Key in:    C1        C2        C3"
1640 P$="       #.###     #.###      #.###"
1650 PRINT G$
1660 PRINT USING P$; C[1]*1000!, C[2]*10000!, C[3]*1E+07
1700 '
1710 PRINT
1712 PRINT "             T        T         T"
1714 PRINT "    R      ACTUAL     CALC       ERROR"
1716 PRINT " ========  =========  ==========  ========="
1718 P$=  " #######    ####.##    ####.##     ####.##"
1720 FOR L=1 TO N
1730 X=LOG(R(L))
1740 TCALC=1/(C(1)+C(2)*X+C(3)*X*X*X)-273.15
1760 PRINT USING P$;R(L),T(L),TCALC,T(L)-TCALC
1780 NEXT L
1890 REM   ******************* program end ************************
1892 END
2000 REM      ************* Begin Subroutines ****************
2010 REM       **** Invert 3 x 3 matrix "A" by cofactors ****
2020 GOSUB 2160 : GOSUB 2120
2030 DET=SUM
2040 FOR K=1 TO 3 : FOR L=1 TO 3
2050 GOSUB 2160
2060 FOR J=1 TO 3 : B(J,L)=0 : B(K,J)=0 : NEXT J : B(K,L)=1
2070 GOSUB 2120
2080 REM       **** "E" = inverse = transpose of cofactor ****
2090 E(L,K)=SUM/DET
2100 NEXT L : NEXT K
2110 RETURN
```

(Continued on next page)

(Program STEIN3, continued from previous page)

```
2120 REM        **** 3 x 3 determinant routine ****
2130 SUM = B[1,1]*B[2,2]*B[3,3]+B[1,2]*B[2,3]*B[3,1]+B[1,3]*B[2,1]*B[3,2]
2140 SUM = SUM-B[1,1]*B[2,3]*B[3,2]-B[1,2]*B[2,1]*B[3,3]-B[1,3]*B[2,2]*B[3,1]
2150 RETURN
2160 REM     **** Copy matrix A onto "scratch" matrix B ****
2170 FOR I=1 TO 3 : FOR J=1 TO 3 : B(I,J)=A(I,J) : NEXT J : NEXT I
2180 RETURN
```

Once the constants, C1, C2, and C3 have been determined (using this program or other means), temperature can be calculated from resistance, or resistance calculated from temperature using the RandT.BAS program below.

For more information on using the S-H equation, refer to ILX Lightwave Application Note #4.

Using the S-H Equation to Find Resistance or Temperature

The program below, RandT.BAS, will calculate the thermistor resistance for a given temperature, or the temperature given the resistance, using the S-H equation above. The accuracy of this conversion depends on the accuracy of the S-H constants.

```
5 '**************** RandT.BAS *****************
10 CLS
20 '
30 'Program is in GWBASIC 3.2 for IBM or compatible computers.
40 'Enter the S-H constants in the form: C1, C2, C3
50 'This program calculates resistance or temperature, given the S-H
60 'constants and one known parameter.
70 'T is in degrees C, and R in ohms.
80 '
90 INPUT "C1, C2, C3"; C1!, C2!, C3!        'input S-H constants
100 '
110 PRINT "Enter R to find resistance, T to find temperature,"
120 PRINT "or Q to quit."
130 '
140 A$ = INKEY$                    'input selection
150 IF A$ = "R" GOTO 190
160 IF A$ = "T" GOTO 290
170 IF A$ = "Q" GOTO 330 : ELSE GOTO 140
180 '
```

(Continued on next page)

(Program RandT.bas, continued from previous page)

```
190 INPUT "T"; T!                    'find resistance given temperature
200 K! = T + 273.15                      'convert to Kelvin
210 U! = C2! / (3! * C3!)                'intermediate steps
220 V! = ((1! / K!) - C1!) / (2! * C3!)
230 W! = SQR((V! * V!) + (U! * U! * U!))
240 X! = (V! + W!)^(1! / 3!)
250 Y! = (W! - V!)^(1! / 3!)
260 R! = EXP(X! - Y!)
270 PRINT " Resistance in ohms = "; R! : PRINT : GOTO 140
280 '
290 INPUT "R"; R!                    'find temperature given resistance
300 T! = (1! / (C1! + C2! * LOG(R!) + C3! * (LOG(R!)^3))) - 273.15
310 PRINT " Temperature in C = "; T! : PRINT : GOTO 140
320 '
330 END
```

# Appendix B

## Sensing Current and Thermistor Selection

### Introduction

Choosing the right sensing current depends on the range of temperature you want to measure and the resolution you require at the highest measured temperature. To correctly set the SENSOR SELECT switch you must understand how the thermistor and the LDC-3700 Series Laser Diode Controller interact, and how temperature range and resolution values are inherent in the nature of thermistors.

### Thermistor Range

Thermistors can span a wide temperature range, but their practical range is limited by their non-linear resistance properties. As the sensed temperature increases, the resistance of the thermistor decreases significantly and the thermistor resistance changes less for an equivalent temperature change -the thermistor becomes less sensitive. Consider the temperature and sensitivity figures in Table B.1 below.

**Thermistor Sensitivity at Various Temperatures**

| Temperature | Sensitivity |
|---|---|
| -20°C | 5600 ohms/°C |
| 25°C | 439 ohms/°C |
| 50°C | 137 ohms/°C |

**Table B.1 Thermistor Sensitivity**

In the LDC-3700 Series Laser Diode Controller, the practical upper temperature limit is the temperature at which the thermistor becomes insensitive to temperature changes. The lower end of the temperature range is limited by the maximum A/D input voltage of the LDC-3700 Series Laser Diode Controller. Thermistor resistance and voltage are related through Ohms Law (V = I x R). The LDC-3700 Series Laser Diode Controller supplies current to the thermistor, either 10 μA or 100 μA, and as the resistance changes a changing voltage signal is available to the thermistor inputs of the LDC-3700 Series Laser Diode Controller's TEC I/O connector. The LDC-3700 Series Laser Diode Controller's A/D will over-range when the input voltage exceeds about 4.5 volts. Figure B.1 graphically shows the lower temperature and upper voltage limits for a typical 10 kΩ thermistor. The practical temperature ranges for a typical 10 K thermistor (a 10 K thermistor has a resistance of 10 kΩ at 25 °C) with the LDC-3700 Series Laser Diode Controller are given in Table B.2, below. These temperature ranges may vary from thermistor to thermistor, even though booth thermistors are nominally 10 K. This is due to manufacturing tolerances in the thermistor, and is compensated for by determining C1, C2, and C3 (calibrating the thermistor). The practical temperature ranges for a 10K thermistor are also shown as solid bars at the bottom of Figure B.1.

**10K Thermistor Practical Temperature Range**

| Sensing Current | Temperature Range |
|---|---|
| 10 μA | -30 to 30 °C |
| 100 μA | 10 to 70 °C |

**Table B.2 10K Thermistor Temperature Ranges**

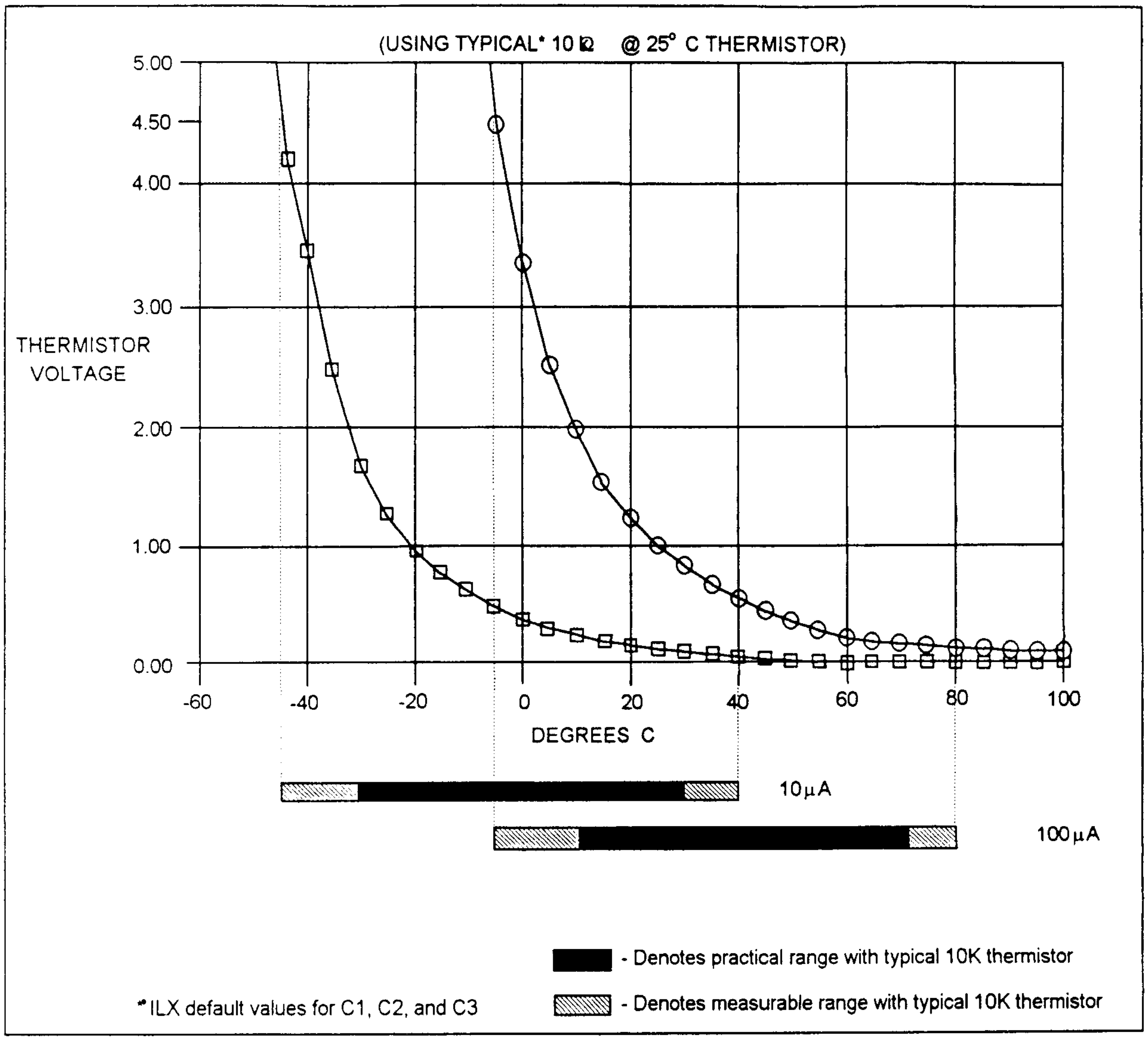


**Figure B.1 Thermistor Temperature Range**

## Temperature Resolution

You must also consider measurement resolution since the resolution decreases as the thermistor temperature increases. The LDC-3700 Series Laser Diode Controller uses an A/D converter that has a maximum resolution of about 76 uV/step. The microprocessor converts this digital number to resitance, stores this resistance, then converts it to a temperature using the Steinhart-Hart equation, and stores this temperature. A temperature change of one degree centigrade will be represented by a greater resistance increase (and therefore more A/D steps) at a lower temperature than at a higher temperature because of the non-linear resistance of the thermistor. Resolution figures for a typical 10 kΩ thermistor are given in Table B.3, below.

**Thermsitor Voltage vs. Resolution for Various Temperatures**

| Temperature | Voltage at 10 μA | Resolution |
|---|---|---|
| -20°C | 56 mV/°C | 0.018°C/mV |
| 25°C | 4.4 mV/°C | 0.23°C/mV |
| 50°C | 1.4 mV/°C | 0.70°C/mV |

**Table B.3 10K Thermsitor Voltage vs. Resolution**

For this thermistor, a temperature change from -20 to -19°C will be represented by 737 A/D steps (if supplied with 10 μA). The same thermistor will only change about 18 A/D steps from 49 to 50°C!

The resolution you choose will impact the temperature displayed on the LDC-3700 Series Laser Diode Controller. If you want to read a certain temperature with 0.2°C accuracy, you must set the LDC-3700 Series Laser Diode Controller SENSOR SELECT switch for that resolution. Since the thermistor is non-linear the resolution will also decrease as the temperature increases. The high temperature limit occurs when the temperature resolution drops below an acceptable level.

### Selecting the Sensing Current

To select the current setting for a typical 10K thermistor, determine the lowest temperature you will need to sample and set the SENSOR SELECT switch according to the range limits in Table B.2. If the temperature you want to sample is below 10 °C you will probably need to set the switch to the 10 μA setting.

With the SENSOR SELECT switch set to 10 μA, the best resolution you will see will be a 0.1°C temperature change. If, for example, the lower limit is 10°C you can choose either SENSOR SELECT setting, but there is a tradeoff in terms of resolution. If you need better than 0.1°C measurement resolution you will have to change the setting of the SENSOR SELECT switch to 100 μA. If the lower limit of the desired temperature range is less than 10 °C, and you require resolution better than 0.1 °C, try a 100K thermistor on the 10 μA setting.

If you require temperatures of 10 °C to 30 °C, either SENSOR SELECT setting (100 μA or 10 μA) will work with a 10K thermistor. However, the 100 μA setting provides greater measurement resolution, and therefore better control.

**NOTE - Generally, it is best to use the 100 μA SENSOR SELECT setting for all measurements of 10 °C or greater with a typical 10 K thermistor.**

### Selecting and Using Thermistors

The type of thermistor you choose will depend primarily on the operating temperature range. These guidelines for selecting the range and resolution will apply to any thermistor. From Figure B.1 you can see that 10 K thermistors are generally a good choice for most laser diode applications where high stability is required near room temperatures. Similarly, 10 K thermistors are often a good choice for detector cooling applications where you want to operate at temperatures from -40°C to room temperature.

If you require a different temperature range or the accuracy you need can't be achieved with either switch setting, select another thermistor. Thermistor temperature curves, supplied by the manufacture, show the resistance verses temperature range for many other thermistors. ILX Lightwave Corporation will also offer help for your specific application.

# Appendix C

# AD590 and LM335 Sensor Calibration

### Introduction

The LDC-3700 Series Laser Diode Controller Modular Laser Diode Controller uses two constants (C1 and C2) for calibrating linear thermal sensing devices, such as the AD590, and the LM335. C1 is used as the linear or zero offset value, and C2 is used as the slope or gain adjustment. Therefore, C1 should be set to a nominal value of 0, and C2 should be set to a nominal value of 1, when the SENSOR SELECT switch is in the AD590, or LM335 positions.

In order to calibrate a linear sensor device, the sensor must be operated at an accurately known, stable temperature. For example, the sensor may be calibrated at 0°C if the sensor is placed in ice water until its temperature is stable. A highly accurate temperature probe, thermometer, environmental chamber, etc., may also be used to determine the known temperature for calibration. This appendix contains one and two point calibration methods for linear sensor devices. These methods will work for either type of device.

### AD590 Sensor

The AD590 is a linear thermal sensor which acts as a constant current source. It produces a current, i, which is directly proportional to absolute temperature, over its useful range (-50°C to +150°C). This nominal value can be expressed as:

$$i = 1uA / K$$

-where i is the nominal current produced by the AD590, and K is in Kelvin.

The LDC-3700 Series Laser Diode Controller uses i to determine the nominal temperature, $T_n$, by the formula:

$$T_n = ( i / ( 1uA / K ) ) - 273.15$$

-where $T_n$ is in °C.

The temperature, $T_d$, which is displayed by the LDC-3700 Series Laser Diode Controller is first calibrated as follows:

$$T_d = C1 + ( C2 * T_n )$$

-where C1 and C2 are the constants stored by the user in the LDC-3700 Series Laser Diode Controller for the AD590.

The AD590 measurement is calibrated, at the factory, with C2 = 1 and C1 = 0 (nominal values). The AD590 grades of tolerance vary, but typically this means that without adjusting C1 or C2, the temperature accuracy is $\pm$1 °C over its rated operating range. If C1 and C2 are also calibrated, the temperature accuracy of $\pm$0.2 °C over its rated operating range.

However, the AD590 is not perfectly linear, and even with C1 accurately known there is a non-linear absolute temperature error associated with the device. This non-linearity is shown in Figure C.1, reprinted from Analog Devices specifications, where the error associated with C1 is assumed to be zero.

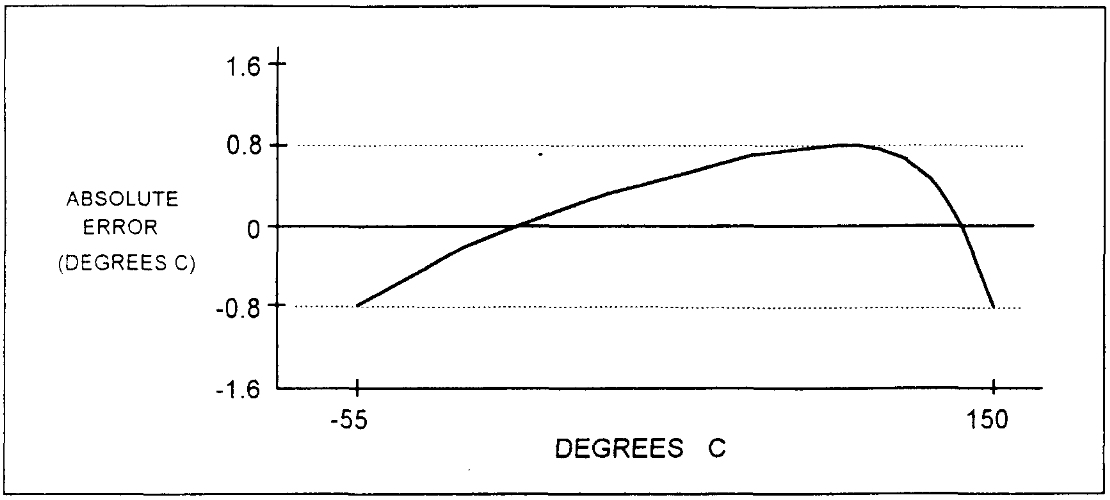


**Figure C.1 AD590 Nonlinearity**

If a maximum absolute error of 0.8 °C is tolerable (over the entire temperature range), the one point calibration of C1 should be used. If C1 is calibrated at 25 °C, and the intended operating range is 0 to 50 °C, a maximum error of about $\pm$0.2 °C may be expected over that operating range. If a greater accuracy is desired, the two point method of determining C1 and C2 should used. Note however, the absolute error curve is non-linear, therefore the constant C2 will vary over different temperature ranges.

**LM335 Sensor**

The LM335 is a linear thermal sensor which acts as a constant voltage source. It produces a voltage, v, which is directly proportional to absolute temperature, over its useful range (-40°C to +100°C). This nominal value can be expressed as:

$$v = 10mV / K$$

-where v is the nominal voltage produced by the LM335 and K is in Kelvin.

The LDC-3700 Series Laser Diode Controller uses v to determine the nominal temperature, $T_n$, by the formula:

$$T_n = ( v / ( 10mV / K ) ) - 273.15$$

-where $T_n$ is in °C.

The temperature, $T_d$, which is displayed by the LDC-3700 Series Laser Diode Controller, is first calibrated as follows:

$$T_d = C1 + ( C2 * T_n )$$

-where C1 and C2 are the constants stored by the user in the LDC-3700 Series Laser Diode Controller for the LM335.

When the LM335 measurement is calibrated, C1 and C2 uncalibrated, and the temperature accuracy is typically $\pm 0.5$ °C over the rated operating range. With C1 and C2 calibrated also, the temperature accuracy is typically $\pm 0.2$ °C over the rated operating range. The temperature accuracy may be improved over a narrow temperature range by a two-point calibration of C1 and C2.

However, the LM335 is not perfectly linear, and even with C1 accurately known (and C2 uncalibrated) there is a non-linear absolute temperature error associated with the device. This non-linearity caused error is typically $\pm 0.3$ °C, with the error associated with C1 assumed to be zero.

If a maximum absolute error of $\pm 0.5$ °C is tolerable, no calibration of C1 or C2 is required, just set C1 = 0, C2 = 1. If a maximum absolute error of $\pm 0.3$ °C is tolerable, the one point calibration of C1 should be used. If a greater accuracy is desired, the two point method of determining C1 and C2 should used. Note however, the absolute error associated with the constant C2 may vary over different temperature ranges.

### One Point Calibration Method

This procedure will work for any linear temperature sensor. The accuracy of this procedure depends on the accuracy of the known temperature, externally measured. It is used to determine the zero offset of the device, and it assumes that the gain offset (slope) is known and is correct.

1. Allow the LDC-3700 Series Laser Diode Controller to warm up for at least one hour. Set the SENSOR SELECT switch for the desired sensor type, and RECALL the constants for the particular device to be calibrated.

2. Select the C1 parameter. Read and record the value of C1.

3. Place the sensor at an accurately known and stable temperature, $T_a$. Connect the sensor to the TEC module of the LDC-3700 Series Laser Diode Controller for normal Constant temperature operation. Allow the LDC-3700 Series Laser Diode Controller to stabilize at the known temperature, $T_a$ and read the displayed temperature, $T_d$.

4. Determine the new value of C1, $C1_n$, from the formula:

$$C1_n = C1 + T_a - T_d$$

and replace C1 with $C1_n$ by selecting the C1 parameter and entering the new $C1_n$ value.

**Two Point Calibration Method**

This procedure will work for any linear temperature sensor. The accuracy of this procedure depends on the accuracy of the known temperatures, externally measured. It is used to determine the zero offset of the device and the gain offset (slope).

1. Allow the LDC-3700 Series Laser Diode Controller to warm up for at least one hour. Set the SENSOR SELECT switch for the desired sensor type, and RECALL the constants for the particular device to be calibrated.

2. Select the C1 parameter. Read and record the value of C1. Select the C2 parameter. Read and record the value of C2.

3. Place the sensor at an accurately known and stable temperature, $T_{a1}$. Connect the sensor to the TEC module of the LDC-3700 Series Laser Diode Controller for normal Constant temperature operation. Allow the LDC-3700 Series Laser Diode Controller to stabilize at the known temperature, $T_{a1}$ and read the displayed temperature, $T_{d1}$. Record these values.

4. Repeat Step 3 for another known temperature, $T_{a2}$, and the corresponding displayed temperature, $T_{d2}$.

   The two known temperatures should at the bounds of the intended operating range. For best results, make the range between $T_{a1}$ and $T_{a2}$ as narrow as possible.

5. Determine the new value of C1 ($C1_n$) and C2 ($C2_n$) from the following calculations.

   First determine the intermediate values U and V, where

   $$V = (T_{a1} - T_{a2}) / (T_{d1} - T_{d2}), \text{ and}$$
   $$U = T_{a1} - (T_{d1} * V)$$

   Then $C1_n$ and $C2_n$ can be determined by the following:

   $$C1_n = U + (V * C1)$$
   $$C2_n = V * C2$$

6. Replace C1 with $C1_n$ by selecting the C1 parameter and entering the new $C1_n$ value. Replace C2 with $C2_n$ by selecting the C2 parameter and entering the new $C2_n$ value.

# Appendix D

# LDC-3700 Series Laser Diode Controller Error Messages

### Introduction

Error messages may appear on the TEC or LASER displays when error conditions occur in the respective functions of the LDC-3700 Series Laser Diode Controller. For example, a current limit error in the TEC side of the LDC-LDC-3700 Series Laser Diode Controller will be displayed on the TEC display.

In most cases, the error message will appear for three seconds and then the display will revert to its former state. In the case of multiple error messages, the LDC-3700 Series Laser Diode Controller will show each message for three seconds in succession.

In remote operation, the current error list can be read by issuing the "ERR?" query. When this is done, a string will be returned containing all of the error messages which are currently in the error message queue.

Table D.2 contains all of the error messages which may be generated by the LDC-3700 Series Laser Diode Controller. Not all of these messages may appear on the front panel displays. Some refer to GPIB activities only, for example.

The errors codes are numerically divided into areas of operation. Errors which pertain to the following areas are listed in the ranges shown in Table D.1.

ERROR CODE CLASSIFICATIONS

| Error Code Range | Area of Operation |
|---|---|
| E-001 to E-099 | Internal Program Errors |
| E-100 to E-199 | Parser Errors |
| E-200 to E-299 | Execution Control Errors |
| E-300 to E-399 | GPIB Errors |
| E-400 to E-499 | TEC Control Errors |
| E-500 to E-599 | LASER Control Errors |

**Table D.1 Error Code Classifications**

LDC-3700 Series Laser Diode Controller ERROR MESSAGES

| Error Code | Explanation |
|---|---|
| E-001 | Memory allocation failure. |
| E-101 | <program mnemonic> is too long. |
| E-102 | <PROGRAM MESSAGE UNIT> is too long. |
| E-103 | <DEFINITE LENGTH ARBITRARY BLOCK PROGRAM DATA> length too long. |
| E-104 | <NON-DECIMAL NUMERIC PROGRAM DATA> type not defined. |
| E-105 | <DECIMAL PROGRAM DATA> exponent not valid. |
| E-106 | <DECIMAL PROGRAM DATA> digit expected. |
| E-107 | <DECIMAL PROGRAM DATA> digit not expected. |
| E-108 | <DECIMAL PROGRAM DATA> more than one decimal point. |
| E-109 | <DECIMAL PROGRAM DATA> more than one exponential indicator (E). |
| E-110 | <SUFFIX PROGRAM DATA> must have digit following sign. |
| E-111 | <SUFFIX PROGRAM DATA> must have alpha character following operator. |
| E-113 | <ARBITRARY BLOCK PROGRAM DATA> length less than digit count. |
| E-114 | <DEFINITE LENGTH BLOCK PROGRAM DATA> premature end of data. |
| E-115 | <PLACEHOLDER PROGRAM DATA> identifier not valid. |
| E-116 | Parser syntax error, character was not expected. |
| E-120 | <program mnemonic> Lookup, word as part of a header path, has no commands. |
| E-121 | <program mnemonic> Lookup, word as part of a header path, is not found. |
| E-122 | <program mnemonic> Lookup, cannot find a null entry. |
| E-123 | <program mnemonic> Lookup, word within context of current path, is not found. |
| E-124 | <program mnemonic> Lookup, failed because query/command type match failed. |
| E-125 | <program mnemonic> Lookup, word within context of common command path, is not found. |
| E-126 | Too few or too many program data elements. |
| E-201 | <PROGRAM DATA> value out of range. |
| E-202 | <PROGRAM DATA> will not convert to valid type. |
| E-203 | Security violation, command is not available without clearance. |
| E-204 | <PROGRAM DATA> suffix type is not valid. |
| E-205 | <PROGRAM DATA> is not a boolean value or word. |
| E-206 | <PROGRAM DATA> will not convert to a signed 16-bit value. |
| E-207 | <PROGRAM DATA> will not convert to an unsigned 16-bit value. |
| E-208 | <PROGRAM DATA> will not convert to a signed 32-bit value. |
| E-209 | <PROGRAM DATA> will not convert to an unsigned 32-bit value. |
| E-210 | <PROGRAM DATA> will not convert to a floating point value. |
| E-211 | <PROGRAM DATA> will not convert to a character value. |
| E-212 | <PROGRAM DATA> will not convert to a byte array pointer. |
| E-213 | <PROGRAM DATA> is incorrect block data length. |
| E-214 | <PROGRAM DATA> length exceeds maximum. |

**Table D.2 LDC-3700 Series Laser Diode Controller Error Message Codes**

LDC-3700 Series Laser Diode Controller ERROR MESSAGES (continued)

| Error Code | Explanation |
|---|---|
| E-301 | A <RESPONSE MESSAGE> was ready, but controller failed to read it. (Query error). |
| E-302 | Device was addressed to talk, but controller failed to read all of the <RESPONSE MESSAGE>. (Query error) |
| E-401 | TEC (Temp Limit) interlock disabled output. |
| E-402 | Sensor open disabled output. |
| E-403 | TEC module open disabled output. |
| E-404 | TEC Current limit disabled output. |
| E-405 | TEC Voltage limit disabled output. |
| E-407 | TEC high temperature limit disabled output. |
| E-408 | Booster change disabled output. |
| E-409 | Sensor change disabled output. |
| E-410 | TEC out of tolerance disabled output. |
| E-411 | TEC control error disabled output. |
| E-412 | Analog section status is all 1's or all 0's (power down). |
| E-413 | Serial EEPROM checksum error. |
| E-415 | Sensor short disabled output. |
| E-416 | Incorrect Configuration for Calibration Sequence to start. |
| E-501 | LASER interlock disabled output. |
| E-503 | LASER open circuit disabled output. |
| E-504 | LASER current limit disabled output. |
| E-507 | LASER Power limit disabled output. |
| E-508 | TEC output is off condition. |
| E-509 | TEC High Temperature Limit condition. |
| E-510 | LASER out of tolerance disabled output. |
| E-511 | LASER control error disabled output. |
| E-512 | Analog section status is all 1's or all 0's (power down). |
| E-513 | Serial EEPROM checksum error. |
| E-515 | Laser Output must be off to change ranges. |
| E-516 | Incorrect Configuration for Calibration Sequence to start. |
| E-517 | Calibration for Laser Diode current must have the output on to start. |
| E-518 | Calibration for the Monitor Diode must have the output on and the responsivity set to zero to start. |
| E-519 | Setting a measurement is only valid during the calibration phase for that measurement. User has tried to calibrate a measurement without first entering the required calibration mode. |
| E-520 | User cannot change the Laser Current set point while operating in a calibration mode for another measurement. |

**Table D.2 LDC-3700 Series Laser Diode Controller Error Message Codes (Cont.)**

Appendix F

# N. I. GPIB Configuration

## Introduction

This appendix guides the user through the configuration of a National Instruments GPIB controller for use with the LDC-3700 Series Laser Diode Controller.

## Setup

Before using the LDC-3700 Series Laser Diode Controller with the National Instruments GPIB controller, run IBCONF.EXE (found in your National Instruments driver subdirectory) and configure the LDC-3700 Series Laser Diode Controller (as a GPIB device) as follows (some of the device setting labels may be slightly different, depending on the version of IBCONF):

Select an unused device, i. e. DEV1. Then edit the setup (press F6) as follows.

| | |
|---|---|
| Primary Address: | Any Valid Value |
| Secondary Address: | None |
| Timeout Setting: | T10s |
| EOS Byte: | 00H |
| Terminate Read on EOS: | no |
| Set EOI with EOS on Write: | yes |
| Type of Compare on EOS: | 7-bit |
| Set EOI with last Byte of Write: | yes |
| Repeat Addressing: | yes |

Save these changes when prompted by the IBCONF program.

# ATTENTION!

## THE FOLLOWING PAGES CONTAIN

## INFORMATION FOR GETTING YOUR

## LDC-3700 SERIES LASER DIODE CONTROLLER UP AND RUNNING QUICKLY.

Place this section (Appendix E) in the back of this manual, LDC-3700 Series Laser Diode Controller Instruction Manual.

# Appendix E

# QUICK START

## Introduction

This appendix guides the user through the minimal steps necessary to run the LDC-3700 Series Laser Diode Controller safely with a laser diode.

## Setup

Turn the LDC-3700 Series Laser Diode Controller power on by turning the front panel key switch to the "ON" position. If you are going to use the TEC controller in addition to the LASER controller, follow the TEC setup instructions. Otherwise, skip the TEC Setup.

## TEC Setup

Press the "TEC" switch in the "ADJUST" section to enter TEC adjustment mode. Then, press the "SELECT" switch in the "PARAMETER" section. The "LIM ITE" indicator will light up and the TEC current limit will be displayed on the "TEC" digital display. Adjust this limit (if needed) by pressing and holding in the "SET" switch in the "PARAMETER" section and turning the "ADJUST" knob.

When the TEC current limit has been set, press the "SET" switch in the "PARAMETER" section again until the "LIM THI" indicator is lit. Adjust the temperature limit as desired, in the same manner as the TEC current limit.

Press the "SET" switch in the "TEC DISPLAY" section and adjust the temperature to the desired operating point.

## LASER Setup

The default current range is the lower output range (50 mA for the LDC-3712, 200 mA for the LDC-3722B, or 1000 mA for the LDC-3742B). If you require the higher current range, press the "PRESS TWICE" switch in the "RANGE" section twice (within 1 second) to change ranges.

Press the "LAS" switch in the "ADJUST" section to enter LASER adjustment mode. Then, press the "SELECT" switch in the "PARAMETER" section. The "LIM I" (blue) indicator will light up and the Laser Current limit will be displayed on the "LASER" digital display. If you have selected to use the higher current range, press the "SELECT" switch again until the "LIM I" (black) indicator is lit. Adjust this limit (to a value which is just greater than the recommended operating current for your laser) by pressing and holding in the "SET" switch in the "PARAMETER" section and turning the "ADJUST" knob. .

Press the "SET " switch in the "LASER DISPLAY" section and adjust the output current to 0.0 mA (via the "ADJUST" knob).

## Connecting Your Laser

WARNING - Refer to Chapter 2 of the LDC-3700 Series Laser Diode Controller Instruction Manual for laser grounding configurations and handling BEFORE connecting lasers to the unit.

Refer to the LDC-3700 Series Laser Diode Controller back panel for the following connections.

Connect the laser to the "LD I/O" connector, and connect the temperature control module (if one exists) to the "TEC I/O" connector. Set the "SENSOR SELECT" switch to the proper sensor type (use 100 uA if you have a thermistor).

## Operation

Once the laser and TEC module are connected properly, and the limits and set points have been set (as described above), press the "ON" switch in the "TEC MODE" section (if temperature control is to be used) and press the "ON" switch in the "LASER MODE" section to turn on the current output. When the outputs are on, the indicators int eh "ON" switches will be lit.

Press the "LASER" switch in the "ADJUST" section and turn the knob to adjust the laser drive current to the desired level.

## More Information

The default modes of operation are "T" (temperature) mode for the TEC control, and "I" (constant current, low bandwidth) mode for the laser current source. See Chapter 2 of the LDC-3700 Series Laser Diode Controller Instruction Manual for greater detail on using the unit with these and other modes.

Chapter 6 has information on calibration and maintenance.