User's Guide

Temperature Controller
LDT-5500B Series

Newport®

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Safety and Warranty Information

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

Safety Information and the Manual

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

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

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

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

General Safety Considerations

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

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

If necessary, return the instrument to ILX Lightwave, or authorized local ILX Lightwave distributor, for service or repair to ensure that safety features are maintained (see the contact information on page 6).

All instruments returned to ILX Lightwave are required to have a Return Material Authorization (RMA) number assigned by an official representative of ILX Lightwave Corporation. See “Returning an Instrument” on page 5 for more information.

Safety Symbols

This section describes the safety symbols and classifications.

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

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

Safety Marking Symbols

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

Caution: Refer to manual

Earth Ground Terminal

Alternating Current

Visible and/or invisible laser radiation

Caution: Risk of Electric Shock

Protective Conductor Terminal

Caution: Hot Surface

Frame or Chassis Terminal

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

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

Warranty

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

Limitations

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

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

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

Returning an Instrument

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

1. Obtain a Return Material Authorization number (RMA) from ILX Lightwave Customer Service.
2. Attach a tag to the instrument identifying the owner and indicating the required service or repair. Include the instrument serial number from the rear panel of the instrument.
3. Attach the anti-static protective caps that were shipped with the instrument and place the instrument in a protective anti-static bag.
4. Place the instrument in the original packing container with at least 3 inches (7.5cm) of compressible packaging material. **Shipping damage is not covered by this warranty.**
5. Secure the packing box with fiber reinforced strapping tape or metal bands.
6. Send the instrument, transportation pre-paid, to ILX Lightwave. Clearly write the Return Material Authorization number on the outside of the box and on the shipping paperwork. ILX Lightwave recommends the shipment be insured.

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

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

Claims for Shipping Damage

Upon receiving the instrument, inspect it immediately for any damage or shortages on the packing list. If the instrument is damaged, file a claim with the carrier. The factory will supply a quotation for estimated costs of repair. The customer is responsible for negotiation and settlement with the carrier for the amount of damage.

Comments, Suggestions, and Problems

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

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

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

When contacting ILX Lightwave, please have the following information:

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

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

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

Chapter 1 : Introduction and Specifications

This chapter contains operation and maintenance information for the LDT-5500B Series Temperature Controller:

- ✓ Product Overview
- ✓ Specifications

Product Overview

The LDT-5500B Series Temperature Controller is a microprocessor-based, precision thermoelectric temperature controller designed for temperature control of laser diodes, detectors and other temperature sensitive devices. The LDT- 5500B Series can be used for laser diode testing, laser diode frequency stabilization, IR detector cooling, and the determination of characteristics of electronic devices. The LDT-5500B Series combines high analog stability with the versatility of a microprocessor-based instrument. The internal microprocessor controls the operation of the LDT-5500B Series and performs the non-linear conversion of thermistor resistance to temperature based on user-defined constants.

The LDT-5500B Series can be configured to operate with a wide variety of thermistor temperature sensors and TE modules, as well as AD590 series and LM335 series temperature sensors.

Features of the LDT-5500B Series include:

- Intuitive front panel layout.
- Large and easy-to-read green LED display.
- Display resolution of 0.1 degree Celsius.
- Output current limit control to safely operate TE module based devices.
- Configurable for a variety of thermal sensors.
- LDT-5525B is capable of 4A, 24W; LDT-5545B is capable of 5A, 50W.
- Easy to use remote USB operation.
- Closed-case calibration.

Available Options and Accessories

Options and accessories available for the LDT-5500B Series Temperature Controller include the following:

Table 1.1 Accessories List

DESCRIPTION	MODEL NUMBER
Single Rack Mount Kit, LDX-3500 Series & LDT-5500 Series	RM-134
Dual Rack Mount Kit, LDX-3500 Series & LDT-5500 Series	RM-135
Laser Didoe Mount, 3-pin TO-Can, Temperature Controlled	LDM-4405
Laser Didoe Mount, 3 & 4-pin TO-Can, Temperature Controlled	LDM-4990
Telecommunications Laser Diodes Mounts (For TO-Can, DIL, and Butterfly packages)	LDM-498X
TEC Controller to Unterminated Cable, 5A, DB15 Male to Bare Wire	CC-501S
TEC Controller to Mount Cable, DB15 Male to DB9 Female	CC-505S
Calibrated 10kΩ Thermistor	TS-510
Uncalibrated 10kΩ Thermistor	TS-520
RTD Temperature Sensor Converter	TSC-599
Unipolar Control Adapter	UCA-350

Not a complete list, visit website or contact sales staff for full list.

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

Specifications

Table 1.2 Specifications

	LDT-5525B	LDT-5545B
TEMPERATURE CONTROL		
OUTPUT		
Temperature Control Range[1]	-99°C to 199.9°C	
Temperature Setpoint Resolution	0.1°C	
Temperature Setpoint Accuracy[2]		
Thermistor	±0.2°C	
AD590	±0.2°C	
LM335	±0.2°C	
Short Term Stability (1 hour)[3]	<±0.006°C	
Long Term Stability (24 hours)[3]	<±0.01°C	
Temperature Coefficient		
TEC OUTPUT		
Type	Bipolar current source	
Control Algorithm	Smart Integrator, Hybrid PI	
Compliance Voltage	>6V DC (@ 4A)	>10V DC (@ 5A)
Maximum Output Current	4.0A	5.0A
Maximum Output Power	24W[4]	50W[5]
Current Noise and Ripple[6]	<1 mA rms	
CURRENT LIMIT		
Current Limit Range	0 to 4.04A	0 to 5.05A
Current Limit Set Accuracy	±50 mA	
TEMPERATURE SENSOR		
Thermistor	2-wire NTC	
IC Sensors	AD590/LM335	
RTD Sensor[7]	2-wire RTD 100Ω, 500Ω, or 1 kΩ	
Thermistor Sensing Current	10/100 μA	
IC Sensor Bias	AD590 = 8V LM335 = 0.6 mA	
Usable Thermistor Range	250 to 450,000 Ω	
User Calibration		
Thermistor	Steinhart-Hart, 3 constants	
IC Sensor	Slope and offset, two point	
Analog Output	0 to 5V	
Transfer Function[8]		
10 μA thermistor	10kΩ/V	
100 μA thermistor	10kΩ/V	
AD590	100μA/V	
LM335	1V/V	
TEC MEASUREMENT (DISPLAY)		
Display Type	4 digit green LED	
Temperature Range	-99 °C to 199.9 °C	

Temperature Resolution				
10 μA thermistor	0.1°C			
100 μA thermistor	0.1°C			
AD590	0.1°C			
LM335	0.1°C			
Accuracy[3]	±0.5°C typical			
Thermistor Resistance Range				
10 μA thermistor	2.5 to 450kΩ			
100 μA thermistor	0.25 to 45.0kΩ			
Thermistor Resistance Resolution				
10 μA thermistor	0.1 kΩ			
100 μA thermistor	0.01 kΩ			
Thermistor Resistance Accuracy				
10 μA thermistor	±0.05% of FS			
100 μA thermistor	±0.05% of FS			
TE Current Range	-4.00 to 4.00A		-5.00 to 5.00A	
TE Current Resolution	0.01A			
TE Current Accuracy	±0.03A			
CONNECTIONS				
TEC I/O	15 pin D-sub	Rear Panel		
Analog Output	BNC	Front Panel		
Communications	USB	Rear Panel		
GENERAL				
Power, VAC (50-60 Hz)	VAC ±10%			
Current Draw	100-120VAC 230VAC	0.86A 0.42A	100-120VAC 230VAC	1.16A 0.55A
Size	88mm x 185mm x 304mm 3.5” x 7.3” x 12”			
Weight	3.6 kg (8 pounds)			
Ambient Temperature Range	Operating:	0 to 40 °C		
	Storage:	-40 to 70 °C		
Humidity	<80% relative, non-condensing			
Warm-Up	1 hour to rated accuracy			

1. Actual temperature control range depends primarily on the thermal load, sensor, and TE module used.
2. Accuracy figures are quoted for a typical 10kΩ thermistor and 100 μA current setting. Accuracy figures are relative to the calibration standard. Both resolution and accuracy are dependent upon the user-defined configuration of the instrument.
3. Stability is a strong function of the thermal environment of the temperature sensor and the TE module. Ambient air currents in particular can cause fluctuations of 0.1°C in an exposed mounting configuration.
4. Output power rated into a 1.5Ω load.
5. Output power rated into a 2.0Ω load. @100VAC, Reduced to 40W.
6. Measured with the instrument in ITE mode at half scale output over a bandwidth of 10 Hz to 10 MHz.
7. With use of optional TSC -599 Temperature Sensor Converter.
8. 0 to 5V representing measured temperature.

Chapter 2 : Operation

This chapter describes how to install, adjust, and operate the LDT-5500B Series Temperature Controller. It is divided into sections covering installation, familiarization and adjustment, and normal operating procedures. This chapter also includes:

- ✓ Front Panel Features
- ✓ Front Panel Operations
- ✓ Installation Procedures

AC Power Considerations

The LDT-5500B Series Controllers can be configured to operate at nominal line voltages of 100, 120, and 230 VAC (±10%). This can only be done at the factory and need not be changed before operating the instrument. Before operating the instrument, verify that the voltage indicated on the back panel of the instrument matches the power-line voltage used in the operating environment.

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.

Rack Mounting

The LDT-5500B Series Temperature 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 Chapter 1 for applicable rack mount accessory part numbers.

Power Up Sequence

With the LDT-5500B Series Temperature Controller connected to an AC power source, pressing the POWER switch will supply power to the instrument and start the power up sequence.

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

For two seconds, all indicators light up, and all of the 7-segment displays indicate “8”. All lights are then turned off for two seconds. Next, two versions of firmware are displayed on the front panel: first version number displayed is mainboard; the second is the front panel. After this, the sensor positions are displayed for two seconds. After the power-up sequence, the unit is configured to the state it was in when the power was last shut off (except for the display mode which defaults to the control mode).

USB

The LDT-5500B may be controlled by PC using USB. The USB Type B connector is located on the rear panel above the sensor select switch. See the Figure 2.2. The USB drivers (from either the ILX Lightwave website or from the USB Flash Drive/CD) must be installed prior to making USB connection. Please refer to Chapter 3 for more detailed instructions on operating the instrument through USB.

Introduction to the LDT-5500B Series Front Panel

The LDT-5500B Series Temperature Controller's front panel contains displays and controls for the Temperature Controller hardware. Each of the labeled areas on the front panel is described in this chapter.

Refer to Figure 2.1 for the following discussions of the LDT-5500B Series Temperature Controller front panel sections. The key words are in CAPITAL LETTERS for quick identification.

Figure 2.1 LDT-5500B Series Front Panel

Adjustments

The adjustment knob is used for entering values and can be disabled using the ENABLE (adjust enable) button and indicator. In order to make any adjustment, the ENABLE indicator must be lit. Pressing the ENABLE button toggles the ENABLE indicator on or off.

Display

The four digit display is used to show measurements, temperature and output set point, and parameter values. Whenever a set point is being adjusted, the corresponding enunciator will blink. After the set point value is reached, the enunciator will continue to blink for three seconds. After which, the set point will be recorded.

The display SELECT button is used to select the measured current (ITE), sensor resistance, or temperature. The set point type is determined by the MODE selection. Repeatedly pressing the

display SELECT switch will cycle the display from ITE to temperature to resistance (with thermistor sensors only) to set point.

When in ITE mode, the set point will be TE current in Amps.

When in R mode, the set point will be thermistor resistance in kΩ. R mode is not available if the back panel SENSOR SELECT switch is set to LM335 or AD590. R mode operation may offer improved set point resolution (over T mode), depending on the desired temperature set point.

Note: If the control method or sensor current is changed, the set point will be stored.

When in T mode the set point will be temperature in °C.

Parameters

The LDT-5500B Series Temperature Controller allows adjustment of the following parameters, LIM I (TE current limit), LIM T (temperature limit), GAIN (sensor feedback amplifier gain) and CONST (sensor calibration values).

The LDT-5500B Series will limit the ITE output to the LIM I value, regardless of the set point or control mode.

The temperature is limited (via the sensor feedback) to the LIM T value. If the sensor reads a temperature which is greater than LIM T, the output will be disabled.

The GAIN value is used to control the sensor feedback gain, and thus the temperature settling time and overshoot. GAIN values can be adjusted in discrete steps from 1 to 300. If the GAIN is set low, the actual temperature will take longer to reach the temperature set point. If the GAIN is set too high, the actual temperature may oscillate around the set temperature.

The optimum GAIN setting depends on the thermal load, temperature set point, and the type of TE cooler. Set the GAIN to its lowest value and then try increasing it until the temperature oscillates around the set temperature. Then, reduce the GAIN one step.

Parameter Setup

The parameter SELECT button is used to view parameters. Repeatedly pressing the parameter SELECT switch will cycle through the parameters.

When a parameter is selected for viewing, its value will remain on the display for three seconds. The parameter value can be changed by pressing the SET button and turning the adjust knob. The parameter LED will not blink when being adjusted. Three seconds after the parameter value has been reached, the value will be stored and the display will revert to the last measurement mode.

Thermistor Sensor Cal

These are the constants of the Steinhart-Hart equation that the user enters to calibrate the TEC for thermistor temperature conversions. The Steinhart-Hart equation is used to derive temperature from the non-linear resistance of an NTC (Negative Temperature Coefficient) thermistor. For information on setting C_1, C_2, and C_3 for thermistors, see Appendix A. For information on thermistor selection and sensor current selection, see Appendix B.

The range of values for C_1, C_2, and C_3 are -9.99 to +9.99.

To read C_1, C_2 or C_3, press the parameter SELECT button until it sequences to CONST. While on the CONST parameter, the SELECT button cycles through C_1, C_2, and finally C_3. The display will indicate which constant is currently selected, and can be adjusted or viewed by pressing the parameter SET button, and turn the ADJUST knob until the correct value is displayed.

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

IC Sensors

These are the constants entered to calibrate the TEC for AD590 and LM335 temperature conversions.

When a linear sensor device (such as an AD590 or LM335) is used, a linear equation is used. If a linear sensor's calibration is not known, set $C_1 = 0.00$, $C_2 = 1.00$. For more information on linear sensor calibration, see Appendix C.

Appendix C contains information on sensor calibration constants for AD590 and LM335 sensors. Since these devices are used over their linear range, the constants C_1 and C_2 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, C_1 and C_2 must be changed by the user.

Output and Control Mode

The MODE section contains the mode SELECT button, which is used to select the instrument control mode. Repeatedly pressing the mode SELECT button cycles through the current (I TE), sensor reference (R), or temperature (T) control modes. The LED indicators show the selected mode. The MODE section also contains the OUTPUT button and indicator. The ON indicator is lit whenever the output is on. Pressing the OUTPUT button enables the output of the instrument as indicated by the LED indicator. With the output enabled, any thermal load connected to the instrument will be controlled to the mode respective set point.

Conditions Which Will Automatically Disable the OUTPUT

1. Temperature Limit
2. Sensor Open (While Output On)
3. TEC Module Open (While Output On)
4. SENSOR SELECT Switch Moved (While Output On)
5. Operating Mode Changed (While Output On)
6. Short condition or low resistance (LDT-5545B only)

Error Indicators

The ERROR indicators become lit when the corresponding conditions occur. The SENSOR OPEN light comes on whenever the sensor connections are open. The TE OPEN indicator becomes lit whenever an open circuit (or a high impedance condition) occurs on the TE module output when the output is on. When a TE OPEN condition occurs, the output will be shut off and the indicator will remain on until the problem is resolved and the output is turned on again.

The T LIMIT light remains lit whenever the temperature limit is reached. The I LIMIT light will remain lit whenever the I TE current limit is reached.

If a shorting condition occurs or a load which has < 1Ω of resistance is used, the output will be disabled and both the I LIMIT LED and TE OPEN LED will remain lit. This error can only occur on the LDT-5545B due to the minimum load resistance specification.

Analog Output

An analog output signal is available at the ANALOG OUTPUT connector (BNC) on the front panel. This signal is a voltage between 0 - 5.0 volts which is proportional to the measurement. For example, an analog output signal of 2.5 volts (+0.5 volts) would represent a measurement of 50% of full scale.

Figure 2.2 LDT-5500B Series Back Panel

Back Panel Controls and Connections

Refer to Figure 2.2 for the following discussions of back panel controls and connectors. There are no user serviceable parts in the instrument, including the external fuses in the AC power entry module.

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 2.1 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.

Table 2.1 SENSOR SELECT Switch Positions

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

The 10µA and 100µA designations are for the thermistor current source level. 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 C_1 and C_2 are used for a two-point conversion. For more information on setting the constants for use with these sensors, see Appendix C.

TEC Connector

In the lower right hand corner, when facing the back panel, there is a 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 2.3. ILX TEC interconnect cables connect directly to the 15-pin D-connector.

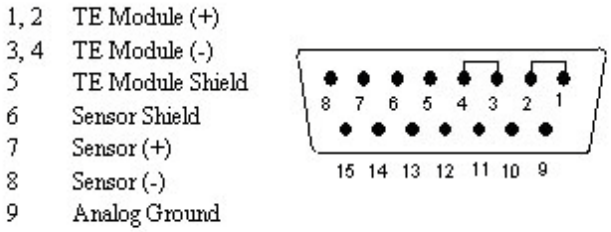

Figure 2.3 Back Panel TEC Connector

USB Connector

The USB Type B connector is located just to the left of center of the back panel. Attach the USB cable to the instrument in the proper orientation. A USB cable is provided in the shipping kit. See Chapter 3 for driver installation information.

TEC Grounding Considerations

The TEC outputs of the LDT-5500B Series are isolated from chassis ground, allowing either output terminal to be grounded at the user's option.

> **Note:** For the TEC connector, if any one terminal pin is grounded, then no other terminal pin should be grounded; damage to thermal load or the temperature controller may occur.

General Operating Procedures

The following sections present some guidelines for operation, as well as some common operating procedures.

Warm-Up and Environmental Considerations

Operate the LDT-5500B Series Temperature 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 LDT-5500B Series Temperature Controller warm up for about 1 hour before use.

Temperature Mode Operation

The LDT-5500B Series Temperature Controller can be operated in several modes, constant current (ITE), constant thermistor resistance (R), or constant temperature (T). This example is for constant temperature (T) mode.

a. Plug the LDT-5500B Series Temperature Controller into an AC power source supplying the correct voltage and frequency for the unit under operation (refer to the back panel for the correct ratings).

b. Turn on the LDT-5500B Series Temperature Controller. The OUTPUT stage will be disabled at power up and the unit will automatically configure its parameters to the state which existed when the power was last shut off.

c. If the ENABLE indicator on the front panel is not lit, press the ENABLE switch so the indicator is lit (adjustment enabled). Press the mode SELECT switch until T mode is selected.

d. Check the setting of the SENSOR SELECT switch for the desired operation (10μA or 100μA). The sensor code will be displayed for two seconds during the power-up sequence.

e. Press the parameter SELECT switch and the values of I LIMIT, T LIMIT, GAIN, and CONST to ensure that they are adequate for the thermal load connected to the controller.

f. Use the ADJUST knob to change the temperature set point until the desired value is displayed.

> **Note:** In some cases, a temperature set point resolution greater than 0.1°C may be attained by using R mode with the appropriate resistance value.

g. Enable the TEC output by pressing the output on switch. 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.

Resistance Mode Operation

a. Plug the LDT-5500B Series Temperature Controller into an AC power source supplying the correct voltage and frequency for the unit under operation (refer to the back panel for the correct ratings).

b. Turn on the LDT-5500B Series Temperature Controller. The OUTPUT stage will be disabled at power up and the unit will automatically configure its parameters to the state which existed when the power was last shut off.

c. If the ENABLE indicator on the front panel is not lit, press the ENABLE switch so the indicator is lit (adjustment enabled). Press the mode SELECT switch until R mode is selected.

d. Check the setting of the SENSOR SELECT switch for the desired operation (10μA or 100μA). The sensor code will be displayed for two seconds during the power-up sequence.

e. Press the parameter SELECT switch and check the values of I LIMIT, T LIMIT, GAIN, and CONST to ensure that they are adequate for the thermal load connected to the controller.

f. Use the ADJUST knob to change the resistance set point until the desired value is displayed.

g. Enable the TEC output by pressing the OUTPUT ON switch. The unit will automatically control the thermal load to the set point resistance.

   If the exact resistance is unknown (to control to a desired temperature), press the DISPLAY switch to view the measured temperature. Readjust the resistance set point and recheck the temperature until the desired result is attained.

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

Chapter 3 : Remote Operation

This chapter details the fundamentals of operating the LDT-5500B Temperature Controller through the USB interface.

- ✓ USB Driver Installation
- ✓ Command Syntax

To begin using the USB port on the LDT-5500B Series Temperature Controller, please install the Virtual Com Port Driver which is available on the companion CD or from our website.
A standard USB A/B cable is necessary to connect the instrument to a PC and is included in the shipping kit. Once connected, the ILX Virtual COM Port driver provides a simple programmable interface to the USB port. The LDT-5500B USB Front Panel software is a simple control software package which allows full control of the instrument.

COM Port Settings
- Baud Rate: 115,200
- Data Bits: 8
- Parity: None
- Stop Bits: 1
- Flow Control: None

USB Driver Installation

Insert the companion USB Flash Drive/CD into the PC. This USB Flash Drive/CD is included with the LDT-5500B Series Temperature controller shipment. The ILX Virtual COM Port Installer should run automatically but if it does not, the executable can be found at [Drive]:\Driver Installation.bat. Follow the instructions of the installer to complete the installation.

Once installation is complete, plug the instrument into the computer with the USB cable. If the Found New Hardware Wizard appears, select “Automatically Install Recommended Software”, click NEXT, and wait for the installation to complete.

Command Syntax

This section details the syntax of the commands as expected by the LDT-5500B.

Letters

Any remote command or query must contain all of the letters of the command. The LDT-5500B does not distinguish between capital and lower case letters.

White Space

Spaces or white space may be used to separate data but may not be used as a separation between command and query question mark. Spaces or white space must be used to separate the command from the first parameter.

Command Termination

Each USB command or query must always be terminated with the new line character: '\n' or 0x0A.

Boolean Parameter Values

Boolean values (0 and 1) are used to represent On/Off or True/False.

Command Timing and Completion

All commands are executed in a sequential manner.

Error Messages

Error messages are reported using the available commands to query for individual errors such as TEMPERATURE LIMIT, SENSOR OPEN, TE CURRENT LIMIT, and TE OPEN. An error query is available to indicate that the output has turned off due to an output short condition or low resistive load. A response of 0 (false) indicates that there is no error. A response of 1 (true) indicates that an error is currently present, or the output was previously disabled due to this error such as a TE OPEN error.

Chapter 4 : Command Reference

This chapter is a guide to all the commands for the LDT-5500B Series Temperature Controller.

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

Table 4.1 shows the format for the device command descriptions in this chapter. The commands that emulate local (front panel) operation are denoted by “FRONT PANEL” in bold text in the upper right hand corner of the command description.

Table 4.1 Remote Command Summary Reference List

Name	Parameters	Function
*IDN?	NONE	Returns the device identification string
*RST	NONE	Used to reset the mode and set point values to factory default values
CURRENT_LIMIT?	NONE	Used to return the status of the ITE limit error
FET_OVER_POWER?	NONE	Used to return the status of the pass elements over powered error. This error and its reporting is reset when the output is enabled.
SENSOR_OPEN?	NONE	Used to return the status of the sensor open error.
TE_OPEN?	NONE	Used to return the status of the sensor open error.
TEC:C1	1	Used to enter temperature sensor constant C_1
TEC:C1?	NONE	Returns the temperature sensor constant C_1
TEC:C2	1	Used to enter temperature sensor constant C_2
TEC:C2?	NONE	Returns the temperature sensor constant C_2
TEC:C3	1	Used to enter temperature sensor constant C_3
TEC:C3?	NONE	Returns the temperature sensor constant C_3
TEC:CAL:ITE	NONE	Used to enter the TEC current source calibration mode
TEC:CAL:SEN	NONE	Used to enter the sensor calibration mode
TEC:GAIN	1	Used to set the TEC control loop gain parameter
TEC:GAIN?	NONE	Returns the TEC control loop gain parameter
TEC:ITE	1	Used to set the TEC current (ITE) set point
TEC:ITE?	NONE	Returns the measured TEC current (ITE) value
TEC:LIM:ITE	1	Used to set the TEC constant current source limit value
TEC:LIM:ITE?	NONE	Used to return the TEC constant current source limit value
TEC:LIM:THI	1	Used to set the TEC temperature limit value
TEC:LIM:THI?	NONE	Returns the TEC temperature limit value
TEC:MODE:ITE	NONE	Sets the mode to constant TEC current mode
TEC:MODE:R	NONE	Sets the mode to constant thermistor resistance mode
TEC:MODE:T	NONE	Sets the TEC mode to constant temperature mode
TEC:MODE?	NONE	Returns the mode, ITE (TEC current), R (sensor) or T
TEC:OUT	1	Used to enable / disable the TEC current output
TEC:OUT?	NONE	Returns the TEC output status

TEC:R	1	Sets the constant sensor resistance; only available in constant R mode
TEC:R?	NONE	Returns the measured temperature sensor value
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 (temperature sensor value) set point
TEC:SET:T?	NONE	Returns the constant T (temperature) set point
TEC:T	1	Used to set the TEC constant T (temperature) set point
TEC:T?	NONE	Returns the TEC measured temperature value
TEMP_LIMIT?	NONE	Used to return the current status of the temperature limit error
MODEL?	NONE	Returns the model of the instrument (5525B or 5545B)

LDT-5500B Series Device-Dependent Commands

The following pages contain a reference for the commands of the LDT-5500B Temperature Controller. This reference contains useful information for both local and remote operation of the LDT-5500B series.

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.

***IDN?** FRONT PANEL **REMOTE**

Description	Requests the instrument to identify itself.
Parameters	None.
Notes	Returns a comma delimited standard format ASCII identification string, from information stored in the instrument during manufacture.

***RST** FRONT PANEL **REMOTE**

Description	Performs a device reset.
Parameters	None.
Notes	Resets the device to factory default settings (as the unit was received).

CURRENT_LIMIT? FRONT PANEL **REMOTE**

Description	Returns the current status of the ITE current limit error.	
Parameters	None.	
Notes	This error will not disable the output. The ITE current will be clamped at the ITE Limit set point value.	
Examples	Query:	CURRENT_LIMIT?
	Response:	0
		ITE current output is not clamped at set ITE Current Limit.

FET_OVER_POWER? FRONT PANEL **REMOTE**

Description	Returns the current status of the Overpower Pass Elements error.	
Parameters	None.	
Notes	This error will disable the output. This error can indicate that the output has been shorted, allowing too much power to be dissipated across the pass elements. This shorting shutdown feature is built into firmware to prevent any damage occurring to the instrument and any equipment connected. This error can also occur if the resistance of the load is less than 1Ω.	
Examples	Query:	FET_OVER_POWER?
	Response:	0
		Output not disabled due to a shorting or low resistive load.

SENSOR_OPEN? FRONT PANEL **REMOTE**

Description	Returns the status of the sensor open error.	
Parameters	None.	
Notes	This error will disable the output and occurs if the connection for the thermistor or linear temperature sensor is open.	
Examples	Query:	SENSOR_OPEN?
	Response:	0
		Temperature sensing connections are connected.

TE_OPEN? FRONT PANEL **REMOTE**

Description	Returns the current status of the sensor open error.	
Parameters	None.	
Notes	This error will disable the output. The status of this error is reset when the output is enabled.	
Examples	Query:	TE_OPEN?
	Response:	0
		TE is connected correctly and the output is enabled.

TEC:C1 **FRONT PANEL** **REMOTE**
TEC:C1?

Description	Sets/returns the value of constant C_1.	
Parameters	Value between 9.999 and -9.99.	
Examples	Write:	TEC:C1 1.125
	Action:	Sets constant C_1 for presently selected sensor to 1.125.
	Query:	TEC:C1?
	Response:	2.100
		Constant C_1 is set to 2.100.

TEC:C2 **FRONT PANEL** **REMOTE**
TEC:C2?

Description	Sets/returns the value of constant C_2.	
Parameters	Value between 9.999 and -9.99.	
Examples	Write:	TEC:C2 1.125
	Action:	Sets constant C_2 for presently selected sensor to 1.125.
	Query:	TEC:C2?
	Response:	2.100
		Constant C_2 is set to 2.100.

TEC:C3 FRONT PANEL REMOTE
TEC:C3?

Description	Sets/returns the value of constant C_3.	
Parameters	Value between 9.999 and -9.99.	
Notes	When the LM335 or AD590 sensors are selected via the SENSOR SELECT switch, this constant is not used.	
Examples	Write:	TEC:C3 1.125
	Action:	Sets constant C_3 for presently selected sensor to 1.125.
	Query:	TEC:C3?
	Response:	2.100
		Constant C_3 is set to 2.100.

TEC:CAL:ITE FRONT PANEL REMOTE

Description	Starts remote TEC current user calibration mode.	
Parameters	None.	
Notes	Calibration mode can be disabled by sending the “TEC:OUT 1” command or pressing the output on button.	
Examples	Write:	TEC:CAL:ITE
	Action:	Sets the unit into remote TEC current calibration.

TEC:CAL:SEN FRONT PANEL REMOTE

Description	Starts remote SENSOR user calibration mode. Calibration mode is dependent upon which setting the SENSOR SELECT switch is set.	
Parameters	None.	
Notes	Calibration mode can be disabled by sending the “TEC:OUT 1” command or pressing the output on button.	
Examples		SENSOR SELECT switch set to AD590.
	Write:	TEC:CAL:SEN
	Action:	Sets the unit into remote calibration mode for AD590.

TEC:CAL? FRONT PANEL REMOTE

Description	Determines if the LDT-5500B Series Temperature Controller is ready for a value to be entered during the calibration cycle.	
Parameters	None.	
Notes	Query can be used to poll the LDT-5500B Series Temperature Controller after the unit has entered into remote calibration mode. If the response is 1, the LDT-5500B is ready to receive a calibration value.	
Examples	Query:	TEC:CAL?
	Response:	1
		Unit is ready for the user to enter in a measured value.

TEC:GAIN FRONT PANEL REMOTE
TEC:GAIN?

Description	Sets/returns the value of the control loop gain.	
Parameters	1, 3, 10, 30, 100, or 300.	
Notes	If the user enters a gain value which does not equal 1, 3, 10, 30, 100, or 300, the instrument will ignore the command.	
Examples	Write:	TEC:GAIN 10
	Action:	Sets the TEC control loop gain to 10.
	Query:	TEC:GAIN?
	Response:	300
		TEC control loop gain is set to 300.

TEC:ITE FRONT PANEL REMOTE
TEC:ITE?

Description	Sets/returns the TEC control current set point. TEC:ITE is also used to enter the TEC current calibration value.	
Parameters	A value which represents the ITE set point current, in Amps.	
Notes	The TEC:ITE set point command is only used in constant ITE mode. The TEC:ITE? query can be used in all modes of operation. In ITE current calibration mode, the value represents the measured current value in Amps.	
Examples	Write:	TEC:ITE: 2.5
	Action:	Sets TEC current set point to 2.5 Amps in ITE mode.
	Query:	TEC:ITE?
	Response:	1.23
		TEC output current is 1.230 Amps.

TEC:LIM:ITE FRONT PANEL REMOTE
TEC:LIM:ITE?

Description	Sets/returns the TE current limit value.	
Parameters	A value representing the limit value of the TE current, in Amps.	
Notes	ITE limit value is in effect for all modes of TEC operation. The ITE limit will limit the TEC current in both positive and negative current directions.	
Examples	Write:	TEC:LIM:ITE 3.5
	Action:	TEC current limit is set to 3.500 Amps.
	Query:	TEC:LIM:ITE?
	Response:	4.0
		TEC current limit is 4.000 Amps.

TEC:LIM:THI **FRONT PANEL** **REMOTE**
TEC:LIM:THI?

Description	Sets/returns the temperature limit value.	
Parameters	A value which represents the upper bound of the load temperature, in °C.	
Notes	Temperature limit value must be in the range -99.9°C to 199.9°C. This value also becomes the maximum temperature set point. This value will force the TEC output to be shut off if the temperature limit is reached.	
Examples	Write:	TEC:LIM:THI 100.0
	Action:	Sets the temperature limit to 100.0°C.
	Query:	TEC:LIM:THI?
	Response:	35.0 Temperature limit it set to 35°C.

TEC:MODE:ITE **FRONT PANEL** **REMOTE**

Description	Sets constant TE current control mode.	
Parameters	None.	
Notes	This mode keeps the output 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.	
Examples	Write:	TEC:MODE:ITE
	Action:	Sets TEC controller for constant TEC current operation reference operating mode.

TEC:MODE:R **FRONT PANEL** **REMOTE**

Description	Sets constant thermistor resistance reference mode.	
Parameters	None.	
Notes	Since sensor resistance is a function of temperature, this mode also controls the temperature of the thermal load connected to the TEC. This mode bypasses the use of the constants for temperature calculation. This mode also allows for finer control of temperature in cases where the thermistor's temperature / resistance profile is not known. Changing modes cause the output to be forced off, and the new mode's set point value will be displayed.	
Examples	Write:	TEC:MODE:R
	Action:	Sets the TEC controller for constant thermistor resistance reference operating mode.

TEC:MODE:T FRONT PANEL REMOTE

Description	Sets constant temperature control mode.	
Parameters	None.	
Notes	Since the load temperature is derived from sensor resistance, constant R and T modes are related. In T mode, the set point is converted to a resistance for 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.	
Examples	Write:	TEC:MODE:T
	Action:	Sets the TEC controller for constant load temperature operating mode.

TEC:MODE? FRONT PANEL REMOTE

Description	Returns the selected TEC control mode.	
Parameters	None.	
Notes	The TEC mode is also the parameter which is controlled. The TEC output is kept at the set point..	
Examples	Query:	TEC:MODE?
	Response:	R
		TEC is in constant (thermistor) resistance mode.

TEC:OUT FRONT PANEL REMOTE
TEC:OUT?

Description	Sets/returns the status of the TEC output.	
Parameters	1 = on, 0 = off	
Notes	After the output is enabled, it may be useful to wait until the output is stable (within tolerance) before performing further operations, but it is not necessary.	
Examples	Write:	TEC:OUT 1
	Action:	Enables the TEC output
	Query:	TEC:OUT?
	Response:	1
		TEC output is enabled.

TEC:R FRONT PANEL REMOTE
TEC:R?

Command	Sets/returns the constant thermistor resistance set point.	
Parameters	A value which represents the thermistor resistance set point value, in kΩ.	
Notes	The R set point is used to control the TEC output in R mode only. TEC load temperature is derived from the thermistor resistance.	
Examples	Write:	TEC:R 25.2
	Action:	Sets the set point thermistor resistance to 25.2 kΩ.
	Query:	TEC:R?
	Response:	10.534
		Measured TEC thermistor resistance is 10.534 kΩ.

TEC:SEN? FRONT PANEL REMOTE

Description	Returns the position of the SENSOR SELECT switch. 1 = 100μA thermistor; 2 = 10μA thermistor; 3 = LM335; 4 = AD590.
Parameters	None.
Notes	The sensor code is displayed on the TEC display whenever the back panel SENSOR SELECT switch position is changed. The sensor selection must be made locally at the back panel SENSOR SELECT switch. If the response is 0, the sensor type is undetermined and a hardware error exists. TEC load temperature is derived from the thermistor resistance.
Examples	Query: TEC:SENS? Response: 1 SENSOR SELECT switch is set to 100μA thermistor.

TEC:SET:ITE? FRONT PANEL REMOTE

Description	Returns the constant TE current set point value.
Parameters	None.
Notes	The TEC output is controlled to this set point value only when the TEC is in constant ITE mode.
Examples	Query: TEC:SET:ITE? Response: 3.0 ITE set point is 3.000 Amps.

TEC:SET:R? FRONT PANEL REMOTE

Description	Returns the constant (thermistor) resistance set point value.
Parameters	None.
Notes	The TEC output is controlled to this set point value only when the TEC is in constant R mode.
Examples	Query: TEC:SET:R? Response: 3.4 R set point is 3.400kΩ.

TEC:SET:T? FRONT PANEL REMOTE

Description	Returns the constant temperature set point value, in °C.
Parameters	None.
Notes	The TEC output is controlled to this set point value only when the TEC is in constant T mode.
Examples	Query: TEC:SET:T? Response: 22.0 Temperature set point is 22.0°C.

TEC:T FRONT PANEL REMOTE
TEC:T?

Description	Sets/returns the TECs constant temperature set point.	
Parameters	A value which represents the temperature set point, in °C.	
Notes	The TEC temperature is controlled to this set point only when the TEC is operated in T mode. If the maximum temperature limit is set (see TEC:LIM:T), this limit becomes the maximum set point value as well.	
Examples	Write:	TEC:T 15.0
	Action:	Sets the TEC temperature set point to 15.0°C.
	Query:	TEC:T?
	Response:	29.2
		Measured load temperature is 29.2°C.

TEMP_LIMIT? FRONT PANEL REMOTE

Description	Returns the current status of the temperature limit error.	
Parameters	None.	
Notes	This error is always updated. This means if the output was disabled because of a temperature limit, the user may not know if this query is performed AFTER the actual temperature is below the temperature limit set point.	
Examples	Query:	TEMP_LIMIT?
	Response:	0
		Measured temperature is below the set temperature limit.

MODEL? FRONT PANEL REMOTE

Description	Returns the instrument model number.	
Response	Returns an ASCII identification string of the model number.	
Examples	Query:	MODEL?
	Response:	5545B
		Instrument is an LDT-5545B.

Chapter 5 : Maintenance and Troubleshooting

This chapter describes how to maintain and troubleshoot the LDT-5500B Series Temperature Controller.

- ✓ Calibration
- ✓ Disassembly
- ✓ Troubleshooting

WARNING

The service procedures described in this chapter are for use by qualified personnel. Potentially lethal voltages exist within the LDT-5500B Series Temperature Controller. To avoid electric shock, the user should not perform any of the procedures described in this chapter unless qualified to do so.

CAUTION

High voltages are present on and around the printed circuit boards of the LDT-5500B Series Temperature Controller.

Calibration Overview

The LDT-5500B Series Temperature 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.

Recommended Equipment

Recommended test equipment for calibrating the LDT-5500B Series Temperature Controller is listed in Table 5.1. Equipment other than that shown in the table may be used if the specifications meet or exceed those listed.

Table 5.1 Recommended Calibration Equipment List

DESCRIPTION	MFG / MODEL	SPECIFICATION
DMM	HP 3457A	DC Amps (@ 1.0A): ±0.02% Resistance (@ 10Ω): 0.02% 0.1 μA or 0.1 mW resolution
Resistors	Metal Film	15 kΩ (for ITE calibration) 4 kΩ and 40 kΩ (for 100 μA calibration) 4 kΩ and 400 kΩ (for 10 μA calibration) 4 kΩ and 10 kΩ (for LM335 calibration) 10 kΩ and 20 kΩ (for AD590 calibration)
	High Power	1Ω, 20W, low TCR (for 5525B ITE calibration) 1.5Ω, 50W, low TCR (for 5545B ITE calibration)

Environmental Conditions

Calibrate this instrument under laboratory conditions. Recommended calibration temperature is at 23°C ± 1.0°C. When necessary, however, the LDT-5500B Series Temperature Controller may be calibrated at its intended use temperature if this is within the specified operating temperature range of 0 to 40°C.

Warm Up

The LDT-5500B Series Temperature Controller should be allowed to warm up for at least 1 hour before calibration.

Calibration Adjustments

There are two calibration adjustments that need to be made for the LDT-5500B Series Temperature Controller. They are calibration of sensor measurement and calibration of the ITE current measurement and limit circuits.

If a problem arises during calibration which prevents its normal completion, the calibration may be aborted with no ill effects by simply pressing the OUTPUT switch. This is possible because the calibration values are not saved to non-volatile memory until the last step of each calibration procedure.

Thermistor Calibration

The following procedure is for calibrating the 100μA and 10μA constant current sources so that the thermistor resistance measurements for these ranges will be accurate. This procedure calibrates the resistance measurements of the thermistor. This procedure does not calculate C1, C2, and C3. For information on calibrating the thermistor sensor, see Appendix A. Calibration may be aborted by pressing the OUTPUT switch.

a. Set the SENSOR SELECT switch (back panel) to the 100 μA position. Set C1 to 0.99, C2 to 2.57, and C3 to 0.855.

b. Measure and record the exact resistance of the 4kΩ, 40kΩ, and 400kΩ metal film resistors. A 4-point probe resistance measurement is recommended.

c. Connect the 4kΩ (for 100μA) or 40kΩ (for 10μA) metal film resistor to the sensor input of the LDT-5500B Series Temperature Controller (pins 7 and 8).

d. Enter the sensor calibration mode by pushing the parameter SET and display SELECT buttons at the same time. After this, the display will indicate the sensor resistance in kΩ. Allow the measurement to settle for about three seconds.

e. Press and hold in the ENABLE button and turn the ADJUST knob until the display indicates the same resistance recorded for the 4kΩ metal film resistor.

f. Release the ENABLE switch and wait for the 7-segment display to flash off and then back on. Replace the 4kΩ resistor with the 40kΩ metal film resistor (for 100μA) or 400kΩ metal film resistor (for 10μA). After three seconds, repeat Step e with this resistor.

   Once the final sensor measurement is entered, the display will go blank. During this step, the sensor temperature set point calibration is taking place internally. Allow the instrument to self-calibrate. Once completed, the calibration constants will be stored to non-volatile memory, and the display will return to its previous state.

g. Switch the SENSOR SELECT switch to the 10μA position and repeat steps c - f.

h. After calibration, the I LIMIT will be automatically set to 2.00 Amps. Reset the I LIMIT to the desired value.

Remote Thermistor Calibration

a. Set the SENSOR SELECT switch (back panel) to the 100μA position. Set C_1 to 0.99, C_2 to 2.57, and C_3 to 0.855.

b. Measure and record the exact resistance of the 4kΩ, 40kΩ, and 400kΩ metal film resistors. A 4-point probe resistance measurement is recommended.

c. Connect the 4kΩ (for 100μA) or 40kΩ (for 10μA) metal film resistor to the sensor input of the LDT-5500B Series Temperature Controller (pins 7 and 8).

d. Enter the sensor calibration mode by sending the command TEC:CAL:SEN. After this, the display will indicate the sensor resistance in kΩ. Allow the measurement to settle for about three seconds.

e. Send the command “TEC:R VALUE”, where VALUE indicates the resistance in kΩ measured in Step b for the 4kΩ resistor.

f. Wait for the 7-segment display to flash off and then back on. Replace the 4kΩ resistor with the 40kΩ metal film resistor (for 100μA) or 400kΩ metal film resistor (for 10μA). After three seconds, repeat Step e with this resistor.

   Once the final sensor measurement is entered, the display will go blank. During this step, the sensor temperature set point calibration is taking place internally. Allow the instrument to self-calibrate. Once completed, the calibration constants will be stored to non-volatile memory and the display will return to its previous state.

g. Switch the SENSOR SELECT switch to the 10μA position and repeat steps c - f.

h. After calibration, the I LIMIT will be automatically set to 2.00 Amps. Reset the I LIMIT to the desired value.

AD590 Sensor Calibration

The following procedure is for calibrating the AD590 sensor measurement so that the temperature measurement will be accurate. This procedure calibrates the current measurement of the AD590. This procedure does not calibrate C_1 and C_2. For information on calibrating the AD590 sensor, see Appendix C.

Calibration may be aborted by pressing the OUTPUT switch.

a. Set the SENSOR SELECT switch (back panel) to the AD590 position. Set C_1 to 0.00, C_2 to 1.00.

b. Connect a precision 20kΩ metal film resistor and a precision ammeter in series at the sensor input of the LDT-5500B Series Temperature Controller (pins 7 and 8).

c. Enter the sensor calibration mode by pushing the display SELECT and parameter SET buttons at the same time. After this, the TEC display will indicate sensor reference current in μA. Wait for three seconds for the measurement to settle. The kΩ enunciator is used to indicate sensor calibration.

d. Press and hold in the ENABLE button and turn the ADJUST knob until the display indicates the same current as shown on the precision ammeter.

e. Release the ENABLE button and wait for the 7-segment display to flash off and then back on. Replace the 20kΩ resistor with a 10kΩ metal film resistor. Wait for three seconds and repeat Step d using the 10kΩ resistor.

   Once the final sensor measurement is entered, the display will go blank. During this step, the sensor temperature set point calibration is taking place internally. Allow the instrument to self-calibrate. Once completed, the calibration constants will be stored to non-volatile memory, and the display will return to its previous state.

f. After calibration, I LIMIT will be automatically set to 2.00 Amps. Reset the I LIMIT to the desired value.

Remote AD590 Sensor Calibration

a. Set the SENSOR SELECT switch (back panel) to the AD590 position. Set C_1 to 0.00, C_2 to 1.00.

b. Connect a precision 20kΩ metal film resistor and a precision ammeter in series at the sensor input of the LDT-5500B Series Temperature Controller (pins 7 and 8).

c. Enter the sensor calibration mode by sending the command “TEC:CAL:SEN”. After this, the TEC display will indicate sensor reference current in μA. Wait for three seconds for the measurement to settle.

d. Send the command “TEC:R VALUE”, where VALUE indicates in μA, the current measured by the precision ammeter.

e. Wait for the 7-segment display to flash off and then back on. Replace the 20kΩ resistor with a 10kΩ metal film resistor. Wait for three seconds, then repeat Step d using the 10kΩ resistor.

   Once the final sensor measurement is entered, the display will go blank. During this step, the sensor temperature set point calibration is taking place internally. Allow the instrument to self-calibrate. Once completed, the calibration constants will be stored to non-volatile memory, and the display will return to its previous state.

f. After calibration, I LIMIT will be automatically set to 2.00 Amps. Reset the I LIMIT to the desired value.

LM335 Sensor Calibration

The following procedure is for calibrating the LM335 sensor measurement so that the temperature measurement will be accurate. This procedure calibrates the voltage measurement of the LM335. This procedure does not calibrate C_1 and C_2. For information on calibrating the LM335 sensor, see Appendix C.

Calibration may be aborted by pressing the OUTPUT switch.

a. Set the SENSOR SELECT switch (back panel) to the LM335 position. Set C_1 to 0.00, C_2 to 1.00.

b. Connect a precision 4kΩ metal film resistor and a precision voltmeter in parallel at the sensor input of the LDT-5500B Series Temperature Controller (pins 7 and 8).

c. Enter the sensor calibration mode by pushing the display SELECT and parameter SET buttons at the same time. After this, the display will indicate sensor reference voltage in 100's of mV. Wait for three seconds for the measurement to settle. The kΩ enunciator is used to indicate sensor calibration.

d. Press and hold in the ENABLE button and turn the ADJUST knob until the display indicates the same voltage as shown on the precision voltmeter multiplied by 10. For example, if the voltage across the resistor is 1.9871 Volts, turn the ADJUST knob until the display reads 19.87.

e. Release the ENABLE button and wait for the 7-segment display to flash off and then back on. Replace the 4kΩ resistor with a 10kΩ metal film resistor. After three seconds, repeat Step d with the 10kΩ resistor.

   Once the final sensor measurement is entered, the display will go blank. During this step, the sensor temperature set point calibration is taking place internally. Allow the instrument to self-calibrate. Once completed, the calibration constants will be stored to non-volatile memory, and the display will return to its previous state.

f. After calibration, I LIMIT will be automatically set to 2.00 Amps. Reset the I LIMIT to the desired value.

Remote LM335 Sensor Calibration

a. Set the SENSOR SELECT switch (back panel) to the LM335 position. Set C_1 to 0.00, C_2 to 1.00.

b. Connect a precision 4kΩ metal film resistor and a precision voltmeter in parallel at the sensor input of the LDT-5500B Series Temperature Controller (pins 7 and 8).

c. Enter the sensor calibration mode by sending the command “TEC:CAL:SEN”. After this, the TEC display will indicate sensor reference current in mV. Wait for three seconds for the measurement to settle.

d. Send the command “TEC:R VALUE”, where VALUE indicates the value measured by the precision voltmeter multiplied by 10. For example, if the voltage across the resistor is 1.9871 Volts, send the command “TEC:R 19.87”.

e. Wait for the 7-segment display to flash off and then back on. Replace to 20kΩ resistor with a 10 kΩ metal film resistor. Wait for three seconds, then repeat step d using the 10kΩ resistor.

   Once the final sensor measurement is entered, the display will go blank. During this step, the sensor temperature set point calibration is taking place internally. Allow the instrument to self-calibrate. Once completed, the calibration constants will be stored to non-volatile memory, and the display will return to its previous state.

f. After calibration, I LIMIT will be automatically set to 2.00 Amps. Reset the I LIMIT to the desired value.

ITE Current Calibration

The following procedure is for calibrating the ITE constant current source for both polarities of current. During this procedure the ITE current is driven to a series of pre-determined values. 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 LDT-5500B Series Temperature Controller then automatically calibrates the TEC current source and limits.

Calibration may be aborted by pressing the OUTPUT switch.

a. For the LDT-5525B, connect a 1Ω, 20W resistor across the TEC output terminals (pins 1 and 3). For the LDT-5545B, connect a 1.5Ω, 50W resistor. Use a calibrated DMM to measure the voltage across the resistor. Calculate the current in the following steps by using Ohm's Law:

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

where V is the accurately measured voltage across the resistor, and R is the accurately measured load resistance. A 4-point probe resistance measurement is recommended.

b. Enter the calibration mode by pushing the display SELECT and mode SELECT buttons. This will put the LDT-5500B Series into ITE calibration mode. Wait for three seconds for the output to settle to about 3 Amps (LDT-5525B); 4 Amps (LDT-5545B).

c. Press and hold in the ENABLE button and turn the ADJUST knob until the display shows the correct value (absolute value of the ITE measurement, as calculated from Step a.)

d. Release the ENABLE button. Wait three seconds to allow the ITE current to settle at the new set point.

e. Repeat steps c and d for all six set points, once for each of the (automatically adjusted) set points. For the LDT-5525B, the set points are: 3A, -3A, 3A, 1A, -1A, and -3A. For the LDT-5545B, the set points are: 4A, -4A, 4A, 1A, -1A, and -4A.

After the last set point is entered, the LDT-5500B Series Temperature Controller's front panel will go blank while the instrument calibrates the ITE set point and current limits. Allow the instrument to self-calibrate. Once completed, the calibration constants will be stored to non-volatile memory, and the display will return to its previous state.

f. After calibration, the I LIMIT will be automatically set to 2.00 Amps. Reset the I LIMIT to the desired value.

Remote ITE Current Calibration

a. For the LDT-5525B, connect a 1Ω, 20W resistor across the TEC output terminals (pins 1 and 3). For the LDT-5545B, connect a 1.5Ω, 50W resistor. Use a calibrated DMM to measure the voltage across the resistor. Calculate the current in the following steps by using Ohm's Law:

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

where V is the accurately measured voltage across the resistor, and R is the accurately measured load resistance. A 4-point probe resistance measurement is recommended.

b. Enter into remote ITE current calibration mode by sending the command “TEC:CAL:ITE”. After this, the TEC display will indicate ITE current in Amps.

c. Remotely send the current value measured and calculated using step a using the command TEC:ITE <value>

d. Wait three seconds to allow the ITE current to settle at the new set point.

e. Repeat Steps c and d for all six set points; once for each of the (automatically set) set points. For the LDT-5525B, the set points are 3A, -3A, 3A, 1A, -1A and -3A. For the LDT-5545B, the set points are 4A, -4A, 4A, 1A, -1A and -4A.

After the last set point is entered, the LDT-5500B Series Temperature Controller’s front panel will go blank while the instrument calibrates the ITE set point and current limits. Allow the instrument to self-calibrate. Once completed, the calibration constants will be stored in non-volatile memory, and the display will return to its previous state.

f. After calibration, the I LIMIT will be automatically set to 2.00 Amps. Reset the I LIMIT to the desired state.

Troubleshooting

This section is a guide to troubleshooting the LDT-5500B Series Temperature Controller. Some of the more common symptoms are listed here, and the appropriate troubleshooting actions are given. It is recommended that the user start at the beginning of this guide. Read the symptom descriptions, and follow the steps for the corrective actions which apply. If problems are encountered which are beyond the scope of this guide, contact an ILX Lightwave representative.

Table 5.2 Troubleshooting Reference List

Symptom	Causes and Corrective Actions
LDT-5500B Series unit will not power up	Check AC power line voltage and power cord connections.
Power on, but display is frozen and switches don't work	This may occur if the unit loses power (AC line) briefly. Turn the power switch off and on again to restart.
Power on, but no TE current output	If TE OPEN indicator is lit, check the load connections and then try again. If SENSOR OPEN or TEMP LIMIT indicators are lit, check the temperature sensor connections and then try again.
Power on, but measured ITE current is always about 0.0A	Check to ensure that the I LIMIT parameter is not set to 0.0A. If SENSOR OPEN indicator is lit, check the sensor connections and then try again. Check that the back panel SENSOR SWITCH position is set to the proper sensor type. Check that the sensor's temperature calibration constants (C_1, C_2, and C_3) are correct values for the sensor type.
Power on, but temperature is not controlled	Check that the GAIN setting is not too low and that the I LIMIT value is not too low for the thermal load. Check the adjust ENABLE switch; the indicator must be lit for any adjustments to be made.
Unable to adjust output or parameter	Check the MODE or DISPLAY switch; if they do not respond, the unit may be in measurement calibration mode (see Chapter 3); press the OUTPUT switch to abort this mode.
Unable to switch DISPLAY, MODE, SENSOR CAL or PARAMETER modes	The unit may be in measurement calibration mode (see Chapter 3); press the OUTPUT switch to abort this mode. Check that the AC power cord connection is secure; power line drop outs may reset the unit and when the power is restored, the output will be off.
Output goes off intermittently	Check the TE module connections; a high impedance on the TE load may cause the output to exceed the compliance voltage momentarily, thus shutting the output off.
R Mode set point is not saved	The R mode set point value is not independent from the T mode set point value; if the control mode is changed from R mode to T mode, the R set value will change to a value which corresponds to the temperature, based on C1, C2, and C3.

Appendix A: Steinhart-Hart Equation

Reference the ILX Lightwave Application Note “Thermistor Calibration and the Steinhart-Hart Equation” for information on this equation.

Appendix B: Sensing Current and Thermistor Selection

Choosing the right sensing current depends on the range of temperature that needs to be measured and the resolution required at the highest measured temperature. To correctly select the proper sensing current, two aspects must be understood: how the thermistor and the LDT-5500B Series Temperature 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. At high temperatures, the thermistor resistance changes less for an equivalent temperature change at lower temperatures (the thermistor becomes less sensitive). Consider the temperature and sensitivity figures in Table B.1 below for a 10kΩ thermistor.

Table B.1 Thermistor Sensitivity

TEMPERATURE	SENSITIVITY
-20°C	5600Ω / °C
25°C	439Ω / °C
50°C	137Ω / °C

In the LDT-5500B Series Temperature 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 input voltage of the LDT-5500B Series Temperature Controller.

Thermistor resistance and voltage are related through Ohms Law (V = IR). The LDT-5500B Series Temperature Controller supplies current to the thermistor, either 10μA or 100μA. As the thermistor resistance changes, a changing voltage signal is available to the thermistor inputs of the LDT-5500B Series. The LDT- 5500B Series' measurement system 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 10kΩ thermistor. (A 10kΩ thermistor has a resistance of 10kΩ at 25°C). The practical temperature ranges for a typical 10kΩ thermistor with the LDT-5500B Series are given in Table B.2, below. These temperature ranges may vary from thermistor to thermistor, even though both thermistors are nominally 10kΩ. This is due to manufacturing tolerances in the thermistor, and is compensated for by determining C_1, C_2, and C_3 (calibrating the thermistor). The practical temperature ranges for a 10kΩ thermistor are also shown as solid bars at the bottom of Figure B.1.

Table B.2 10kΩ Thermistor Temperature Range

SENSING CURRENT	TEMPERATURE RANGE
10μA	-30 to 30°C
100μA	10 to 70°C

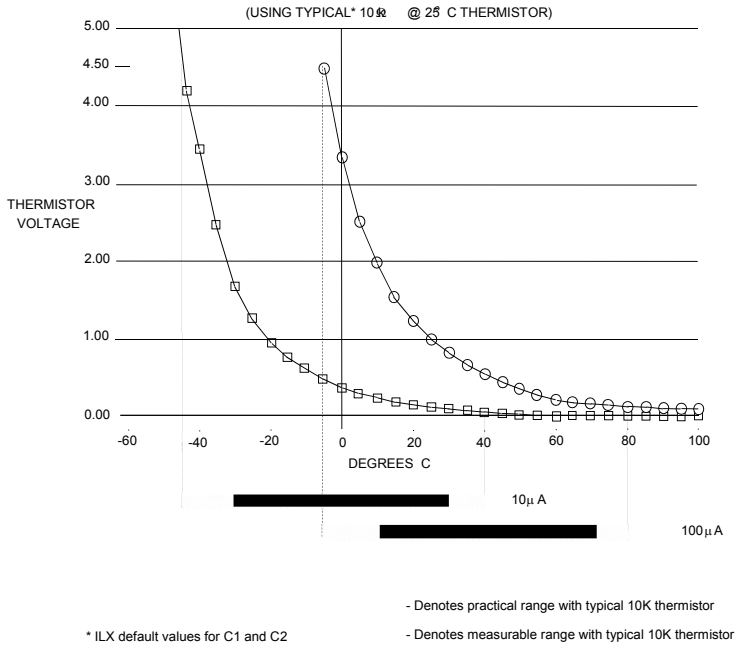

Figure B.1 Thermistor Temperature Range

Temperature Resolution

Measurement resolution must also be considered since the measurement resolution decreases as the thermistor temperature increases. A temperature controller (such as the LDT-5500B Series) has a limited measurement resolution. A temperature change of one degree centigrade will be represented by a greater resistance increase at a lower temperature than at a higher temperature because of the non-linear resistance of the thermistor. Resolution figures for a typical 10kΩ thermistor are given in Table B.3, below.

Table B.3 10kΩ Thermistor Voltage vs. Resolution

TEMPERATURE	VOLTAGE AT 10 μA	RESOLUTION
-20°C	56mV / °C	0.018°C / mV
25°C	4.4mV / °C	0.23°C / mV
50°C	1.4mV / °C	0.70°C / mV

For a typical 10kΩ thermistor, a temperature change from -20°C to -19°C will be represented by a measurement change of about 56mV (if supplied with 10μA). The same thermistor measurement will only change about 1.4mV from 49 to 50°C. For that case, with the LDT-5500B Series, the temperature measurement resolution would be reduced to about 0.2°C. If the 100μA setting were used instead, the thermistor measurement would change by 14mV from 49 to 50°C, providing the maximum resolution of 0.1°C (with the LDT-5500B Series).

Therefore, the sensor current chosen may impact the temperature measurement resolution as well as the set point control accuracy.

Selecting the Sensing Current

To select the current setting for a typical 10kΩ thermistor, determine the lowest temperature needed to sample and set the SENSOR SELECT switch according to the range limits in Table B.2. If the temperature of interest is below 10°C, the switch will likely need to be set to the 10μA setting.

If the required temperatures are between 10°C and 30°C, either SENSOR SELECT setting (100μA or 10μA) will work with a 10kΩ thermistor. However, the 100μA setting provides greater measurement resolution, and therefore better control.

> **Note:** Generally, it is best to use the 100μA SENSOR SELECT setting for all measurements of 10°C or greater with a typical 10kΩ thermistor.

Selecting and Using Thermistors

The type of thermistor chosen 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 it can be seen that 10kΩ thermistors are generally a good choice for most laser diode applications where high stability is required near room temperatures. Similarly, 10kΩ thermistors are often a good choice for detector cooling applications where operating temperatures are from -30°C to room temperature.

If a different temperature range is required or the required accuracy 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 specific applications.

Appendix C: AD590 and LM335 Sensor Calibration

The LDT-5500B Series Temperature Controller uses two constants (C_1 and C_2) for calibrating linear thermal sensing devices, such as the AD590, and the LM335. C_1 is used as the linear or zero offset value, and C_2 is used as the slope or gain adjustment. Therefore, C_1 should be set to a nominal value of 0, and C_2 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^{o}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:

$$i = \frac{1\mu A}{K}$$

where i is the nominal current produced by the AD590, and K is in Kelvin.

The LDT-5500B Series Temperature Controller uses i to determine the nominal temperature, T_n, by the formula:

$$T_n = \frac{i}{\frac{1\mu A}{K}} - 273.15$$

where T_n is in °C.

The temperature, T_d, which is displayed by the LDT-5500B Series Temperature Controller, is first calibrated as follows:

$$T_d = C_1 + (C_2 * T_n)$$

where C_1 and C_2 are the constants stored by the user in the LDT-5500B Series Temperature Controller for the AD590.

The AD590 measurement is calibrated, at the factory, with C_2 = 1 and C_1 = 0 (nominal values). The AD590 grades of tolerance vary, but typically this means that without adjusting C_1 or C_2, the temperature accuracy is ±1°C over its rated operating range. If C_1 and C_2 are also calibrated, the temperature accuracy is ±0.2°C over its rated operating range. However, the AD590 is not perfectly linear, and even with C_1 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 C_1 is assumed to be zero.

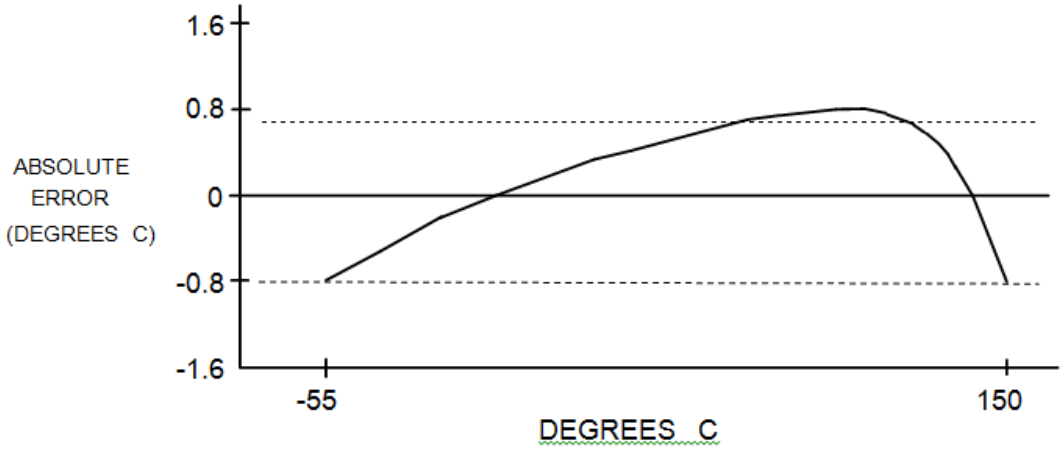

Figure C.1 AD590 Nonlinearity

If a maximum absolute error of 0.8°C is tolerable (over the entire temperature range), the one point calibration of C_1 should be used (see page 54). If C_1 is calibrated at 25°C, and the intended operating range is 0 to 50°C, a maximum error of about ±0.2°C may be expected over

that operating range. If a greater accuracy is desired, the two point method of determining C_1 and C_2 should used (see page 49). Note however, the absolute error curve is non-linear; therefore the constant C_2 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:

$$V = \frac{10mV}{K}$$

where V is the nominal voltage produced by the LM335 and K is in Kelvin.

The LDT-5500B Series Temperature Controller uses V to determine the nominal temperature, T_n, by the formula:

$$T_n = \frac{V}{\frac{1mV}{K}} - 273.15$$

where T_n is in °C.

The temperature, T_d, which is displayed by the LDT-5500B Series Temperature Controller, is first calibrated as follows:

$$T_d = C_1 + (C_2 * T_n)$$

where C_1 and C_2 are the constants stored by the user in the LDT-5500B Series Temperature Controller for the LM335.

When the LDT-5500B Series is shipped from the factory, the LM335 measurement system is calibrated, but the sensor (C_1 and C_2) is not. Nominally, C_1 = 0, and C_2 = 1. In that case, the temperature accuracy is typically ±1°C over the rated operating range. With C_1 and C_2 calibrated also, the temperature accuracy is typically ±0.3°C over the rated operating range. The temperature accuracy may be improved over a narrow temperature range by a two-point calibration of C_1 and C_2. However, the LM335 is not perfectly linear, and even with C_1 accurately known (and C_2 uncalibrated) there is a non-linear absolute temperature error associated with the device. This non-linearity caused error is typically ±0.3°C, with the error associated with C_1 assumed to be zero.

If a maximum absolute error of ±1°C is tolerable, no calibration of C_1 or C_2 is required, just set C_1 = 0, C_2 = 1. If a maximum absolute error of ±0.5°C is tolerable, the one point calibration of C_1 may be used (see page 48). If a greater accuracy is desired, the two point method of determining C_1 and C_2 should used (see page 49). Note however, the absolute error associated with the constant C_2 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 LDT-5500B Series Temperature 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 C_1 parameter. Read and record the value of C_1.

3. Place the sensor at an accurately known and stable temperature, Ta. Connect the sensor to pins 7 and 8 of the LDT-5500B Series' 15-pin connector. Set the LDT-5500B Series for normal constant temperature (T mode) operation. Allow the LDT-5500B Series Temperature Controller to stabilize at the known temperature, T_a and read the displayed temperature, T_d.

4. Determine the new value of C_1, C_{1n}, from the formula:

$$C_{1n} = C_1 + T_a - T_d$$

and replace C_1 with C_{1n} by selecting the C_1 parameter and entering the new C_{1n} 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 LDT-5500B Series Temperature 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 C_1 parameter. Read and record the value of C_1. Select the C_2 parameter. Read and record the value of C_2.

3. Place the sensor at an accurately known and stable temperature, T_{a1}. Connect the sensor to pins 7 and 8 of the LDT-5500B Series's 15-pin connector. Set the LDT-5500B Series for normal constant temperature (T mode) operation. Allow the LDT-5500B Series Temperature 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. The smaller the intended operating range, the better the calibration over that same range.

5. Determine the new value of C_1 (C_{1n}) and C_2 (C_{2n}) from the following calculations.

   First determine the intermediate values U and V, where

   $$V = \frac{(T_{a1} - T_{a2})}{(T_{d1} - T_{d2})} \quad \text{and} \quad U = T_{a1} - (T_{d1} * V)$$

   Then C_{1n} and C_{2n} can be determined by the following:

   $$C_{1n} = U + (V * C_1) \quad \text{and} \quad C_{2n} = V * C_2$$

6. Replace C_1 with C_{1n} by selecting the C_1 parameter and entering the new C_{1n} value. Replace C_2 with C_{2n} by selecting the C_2 parameter and entering the new C_{2n} value.