User's Guide

LDCM-4371

Laser Diode Controller Mount

PSE TECHNOLOGY
Assisting in the Science of Innovation

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920000001-C

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NOTICES

MANUAL PART NUMBER

920000001-C

EDITION

Second Edition, September 2008

SUBJECT MATER

The information in this document is subject to change without notice.

PSE Technology makes no warranty of any kind with regard to this printed material, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose.

PSE Technology shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material.

PRINTING HISTORY

New editions are complete revisions of the guide reflecting alterations in the functionality of the instrument. Updates are occasionally made to the guide between editions. The part number in the lower right hand corner on the title page changes when an updated guide is published. To find out the current revision of the guide, or to purchase an updated guide, contact your PSE Technology representative.

WARRANTY

This PSE Technology product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, PSE will, at its option, either repair or replace products that prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by PSE. Buyer shall prepay shipping charges to PSE and PSE shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to PSE from another country.

PSE warrants that its software and firmware designated by PSE for use with an instrument will execute its programming instructions when properly installed on that instrument. PSE does not warrant that the operation of the instrument, software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance. No other warranty is expressed or implied. PSE Technology specifically disclaims the implied warranties of Merchantability and Fitness for a Particular Purpose.

EXCLUSIVE REMEDY

The remedies provided herein are Buyer's sole and exclusive remedies. PSE Technology shall not be liable for any direct, indirect, special, incidental or consequential damages whether based on contract, tort, or any other legal theory.

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.

CERTIFICATION

PSE Technology certifies that this product met its published specifications at the time of shipment from the factory.

This product is produced to ISO 9001 international quality system standard as part of our objective of continually increasing customer satisfaction through improved process control.

Customer Service

Comments, Suggestions, and Problem

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

Phone .... (970) 344-4774

Fax .... (970) 344-6012

E-mail .... support@psetech.com

Or mail to:

Customer Support
PSE Technology
1111 Jefferson Drive
Berthoud CO. U.S.A. 80513-2633
www.psetech.com

When you contact us, please have the following information:

Model Number : ______________________

Firmware Version : ______________________

Hardware Version : ______________________

Serial Number : ______________________

End-user Name : ______________________

Company : ______________________

Phone : ______________________

Fax : ______________________

Setup Description :

Problem Description :

We strive to provide the best laser diode instrumentation available anywhere. To achieve this, we would appreciate your ideas and comments on ways we can improve our products. We invite you to contact us at any time with your suggestions. Thanks in advance for helping us improve our products and service. We look forward to serving you even better in the future!

Returning an Instrument for Service

If an instrument is to be shipped to PSE Technology for repair or service, be sure to:
1. Obtain a Return Merchandise Authorization number (RMA) from PSE Customer Service.
2. Attach a tag to the instrument identifying the owner, RMA number, list of all items being returned, short description indicating the required service or repair, and the instrument serial number (located on the rear panel of the instrument).
3. Attach the protective cap(s) that were shipped with the instrument and place the instrument in a protective anti−static bag.
4. Place the instrument in the original packing container with at least 3 inches (7. 5 cm) of compressible packaging material. Shipping damage is not covered by this warranty.
5. Secure the packing box to avoid loss of contents during shipping.
6. Send the instrument to PSE Technology, transportation prepaid. Clearly write the return merchandise authorization number on the outside of the box and on the shipping paperwork. PSE Technology recommends you insure the shipment.

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

Once work is complete, the instrument will be returned transportation prepaid. Repairs are warranted for the remainder of the original warranty or for 90 days, whichever is greater.

Customer Service Philosophy

Every customer service request is an opportunity for us to enhance a vital relationship; we welcome new ideas and feedback, and strive to enhance our services to exceed your needs. We listen, learn and adjust to meet your ever-evolving needs. Our customer service engineers are experienced technical professionals who are completely dedicated to ensuring your satisfaction. This is our commitment to you.

As a leading-edge innovator of products and services, we are committed to deliver advanced instruments that provide greater options than ever before. We are continuously looking for more ways to improve your experience as our customer, and we promise to strive for the highest levels of service.

This is our commitment to you.

SAFETY INFORMATION

INTRODUCTION

The Safety Information section provides details about cautionary symbols used in the manual and safety markings used on the instrument. The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. PSE Technology assumes no liability for the customer's failure to comply with these requirements.

Before operation, review the instrument and manual, including the complete Safety Information section, for safety markings and instructions. You must follow these to ensure safe operation and to maintain the instrument in safe operating condition.

SIGNS AND SYMBOLS

Throughout this manual, you will see the following signs and symbols. They indicate potentially dangerous or hazardous situations which, if not avoided, could result in death, serious or minor injury, or damage to the product, and/or Device Under Test (DUT). Specifically:

	The WARNING sign is used throughout the manual to denote a hazard. It calls attention to a procedure, practice or the like, which, if not correctly performed or adhered to, could damage or destroy the instrument or DUT. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.
	The instrument will be marked with this symbol when it is necessary for the user to exercise extra caution in order to protect the product against damage.
	The manual is marked with this symbol when it necessary for the user to exercise caution to avoid visible and/or invisible laser radiation hazard. Avoid direct exposure to beam.
	The manual is marked with this symbol when it is necessary for the user to exercise caution to avoid the risk of electrical shock.
	The manual is marked with this symbol when it is necessary for the user to exercise caution to avoid instrument or DUT damage due to Electrostatic Sensitive Discharge.

GENERAL SAFETY CONSIDERATIONS

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

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

If necessary, return the instrument to PSE Technology, or authorized local PSE distributor, for service or repair to ensure that the safety features are maintained. All instruments returned to PSE Technology are required to have a Return Merchandise Authorization number assigned by an official representative of PSE Technology.

GENERAL CLASSIFICATIONS

Instrument specific 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 PSE Technology 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 over-voltages
- Maximum Relative Humidity: <90% RH, non−condensing
- Operating temperature range of 0 °C to +40 °C
- Storage and transportation temperature of −40 °C to +70 °C
- Maximum altitude: 3000 m (9843 ft)
- This equipment is suitable for continuous operation.

INITIAL INSPECTION

Inspect the shipping container for damage. If there is damage to the container or cushioning, keep them until you have checked the contents of the shipment for completeness and verified the instrument both mechanically and electrically. If the contents are incomplete, mechanical damage or defect is apparent, or if an instrument does not pass the operator's checks, notify the PSE Technology Customer Service.

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, etc.).

ENVIRONMENTAL INFORMATION

This product complies with the WEEE Directive (2002/96/EC) marking requirements. The affixed label indicates that you must not discard this electrical/electronic product in domestic household waste. Product Category: With reference to the equipment types in the WEEE Directive Annex I, this product is classed as a "Monitoring and Control instrumentation" product.

Do not dispose in domestic household waste.

To return unwanted products, contact PSE Technology

CHAPTER 1 – INTRODUCTION

INTRODUCTION

This chapter is intended to familiarize the user with the LDCM-4371 Laser Diode Controller Mount instrument. To avoid possible injury or product damage, the operator should always perform a routine inspection before each use.

WARNING

To avoid possible injury, additional instrument damage, and or DUT damage. Do not use the product if any of the following symptoms exist:

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

Return the instrument for repair by trained service personnel.

PRODUCT OVERVIEW

The highly integrated LDCM-4371 Laser Diode Controller Mount incorporates the industries first precision programmable high-bandwidth modulation laser driver combined with two stages of high power temperature control into a compact laser diode butterfly mount. The instrument includes a multitude of features that have been engineered to ensure absolute wavelength stability and precise sub-picometer control. The LDCM-4371 is the ideal controller to meet the demanding wavelength precision required for Tunable Diode Laser Absorption Spectroscopy (TDLAS) applications.

The new laser driver current source topology uses an innovative, proprietary control loop and incorporates the latest techniques for signal filtering and circuit board shielding while providing up to 250 milliamps (mA) of drive current. These advancements provide unbeatable stability and unparalleled noise performance, ideal for the most demanding applications. This design incorporates adjustable compliance voltage and faster shutoff, helping prevent dangerous “reconnect” transients that occur from intermittent connections between the controller and your laser diode. This new level of protection adds to our proven list of protection features: independent current limits, output shorting circuits and a slow-start turn-on feature.

The laser driver is highly adaptable; to ensure broad support of various applications two independent modes of operation are offered, high-bandwidth constant current and constant power. This new current source design supports modulation bandwidths of up to 1.5 MHz (small signal), achieving the highest direct modulation levels available today. The instrument includes reverse photodiode bias capabilities, especially important for telecom wavelength devices. In addition, the instrument provides precise laser diode forward voltage measurements.

One of the unique features of this product is the ability to independently attenuate a single modulation signal being delivered to multiple LDCM-4371 instruments. This is crucial in applications such as multiplexed spectroscopy, where multiple lasers are scanned synchronously (from a single function generator). The ability to independently tune the modulation signal ensures that the user can tweak each of the individual laser scan range widths to exactly fit the unique absorption feature of interest.

The two fully-independent low-noise TEC controllers achieve unparalleled temperature stabilities through a matched ratio-metric low-temperature coefficient design topology. Both utilize automatic thermistor current ranging, and a proprietary smart integrator control loop to drive the bi-polar output stage. To help further safeguard your investment each controller contains a programmable precision voltage limit and high-speed temperature fault detection circuit. The TEC controller dedicated to the laser diode’s internal Peltier is equipped with a user programmable gain setting, this provides the flexibility to optimize the settling time for your unique device. In addition, the controller provides measurements of both the Peltier operating voltage and current. The case TEC presents an ultra low-drift precision thermal reference to the laser diode package; this extra level helps ensure unmatched sub-picometer wavelength stability. In addition, the dual stage temperature control provides a cascaded configuration that allows a much wider temperature range, greater than ±60° C from ambient.

INITIAL INSPECTION

When you receive your instrument, inspect it for any shipping damage. The complete shipping kit should be included which contains:

- Laser Diode Controller Mount
- Power Supply
- Instruction Manual
- Calibration Certificate
- Instrument Controller Program CD

To avoid possible injury, additional instrument damage, and or DUT damage. Do not use the product if shipping damage is evident. Return the instrument for repair by trained service personnel.

Note: When unpacking the instrument, be sure to save the packaging and the protective ESD cap(s) on the rear of the instrument in case you have to return the instrument to PSE Technology or ship it elsewhere. Shipping damage is not covered under the standard instrument warranty.

INSTALLATION

This section provides information about the requirements necessary to install the LDCM-4371 Laser Diode Controller Mount and how to begin operating the instrument.

GROUNDING REQUIREMENTS

The LDCM-4371 instrument comes with a three-conductor AC power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adaptor with the grounding wire connected to an electrical ground (safety ground). The LDCM-4371's power jack and supplied power cable meet IEC safety standards.

AC LINE POWER REQUIREMENTS

You can operate the instrument from a single-phase power source delivering nominal line voltages of 100−240 VAC (all values RMS), at 50-60 Hz. The line power voltage can vary ±10%. Maximum power consumption is 22.0 Volt-Amps (20.0 Watts). The instrument's operational voltage is universal and need not be changed before operating the instrument.

Before connecting the instrument to an AC power source, verify that the power source matches the voltage setting printed on the external power supply module. To avoid electrical shock hazard, connect the instrument only to properly earth-grounded, three-prong receptacles. Failure to observe this precaution can result in severe injury or death.

USB CONNECTOR

The USB interface connector (Type "B") is located on the center of the rear panel, next to the power switch. See Figure 1.4. Attach the type "B" connector to the rear of the controller, which is uniquely shaped to ensure proper orientation, and the other end (Type "A") to the USB controlling hub (computer). A total of 127 devices, including the hub devices, may be connected to a single host controller. The maximum length of a standard USB cable is 5 meters (slightly more than 16 feet).

EXTERNAL COMPUTER REQUIREMENTS

Your computer must meet the following minimum requirements, or you may not be able to successfully use the LDCM-4371 Instrument Controller Program.

- Processor operating at 600 MHz or greater
- 256 MB of RAM
- Video graphics card capable of at least 800 x 600 screen resolution and 256 colors
- USB port

- Mouse
- CD ROM Drive
- Windows XP (SP1) operating system or newer

Actual requirements and product functionality may vary based on your hardware, computer system configuration, and other application software.

SOFTWARE INSTALLATION

Use the following steps to install the LDCM-4371 Instrument Controller Program onto your computer.

- Insert the Instrument Controller Program CD into the computer's CD ROM drive
- Once the CD is in the drive it should automatically begin the installation process. If your computer is configured to block automatic installations, you can begin the process by double-clicking on the setup.exe file on the CD.
- The installation will automatically install all the program and driver files needed to use the LDCM-4371 Laser Diode Controller Mount.
- Once the software installation process is complete, connect the instrument to a spare USB port on your PC. The computer will detect the instrument and launch the Windows Operating System - Found New Hardware Wizard.
- Follow the standard windows prompts to allow windows to automatically install and register the driver for the LDCM-4371 instrument.
- Note that if Windows is configured to warn when unsigned (non-WHQL certified) drivers are about to be installed, the screen shown in Figure 1.1 will be displayed. Click on "Continue Anyway" to continue with the installation. If Windows is configured to ignore file signature warnings, no message will appear.

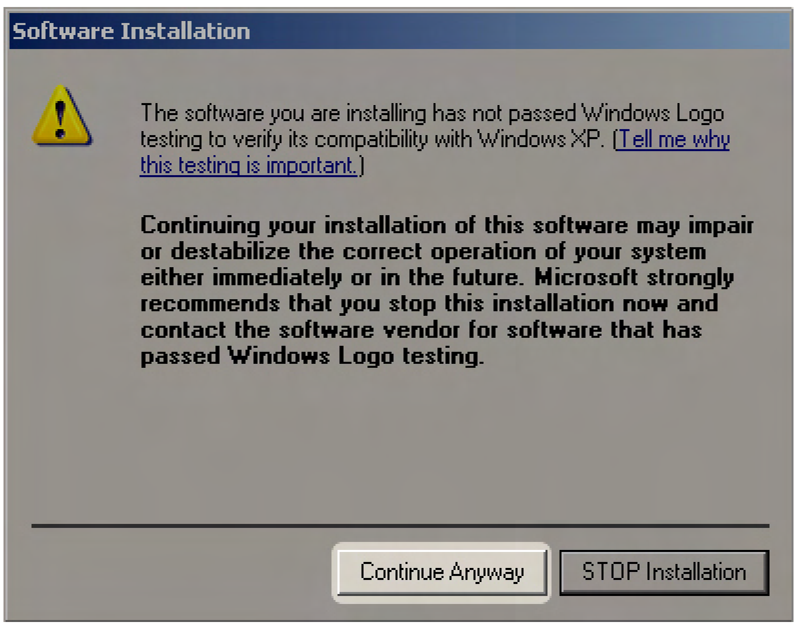


Figure 1.1: Instrument Driver Installation non-WHQL Warning Screen

LDCM-4371 ORIENTATION

Now that the basics for LDCM-4371 Laser Diode Controller Mount operation have been explained, you are prepared to learn about its operation. Figure 1.2 and Figure 1.4 show front and rear views of the instrument respectively. The figures identify such items as functional keypad groupings, connectors, and switches. Use these figures to familiarize yourself with your new controller. Please refer to Chapter 2, Basic Operations for operating fundamentals of your integrated controller mount.

LDCM-4371 Front Panel

Figure 1.2: LDCM-4371Laser Diode Controller Mount Front Panel View

❖ **Laser Output ON/OFF Pushbutton**

When the switch is not illuminated, the laser output is off. The pushbutton switch has a toggling action, pressing the switch with the laser in the off state will initiate the laser on sequence. The laser on sequence consists of a 5 second laser safety delay before actually enabling the laser output, during this period the button will flash green. This safety delay is required to meet the CDRH US21 1040.10 laser safety requirement. After the safety delay has expired, the laser output is enabled and the button is illuminated solid green. When the instrument detects an error condition or a user configured output off limit condition, the output will be disabled and the button will be illuminated solid red. Clearing the condition that forced the laser output to automatically turn off and turning the laser back on will clear the solid red error indicator. The user can configure the instrument to flash the button red when a limit condition is detected but not configured to disable the output. It is important to note that the laser output can only be switched on when the laser enable key switch is in the on (I) position.

❖ **TEC Output ON/OFF Pushbutton**

When the button is not illuminated, the TEC output is off. The pushbutton switch has a toggling action, pressing the switch with the TEC in the off state will enable the output. When the TEC output is enabled the button is illuminated solid green. When the instrument detects an error condition or a user configured output off limit condition, the output will be disabled and the button will be illuminated solid red. Clearing the condition that forced the output to automatically turn off and turning the TEC back on will clear the solid red error indicator. The user can configure the instrument to flash the button red when a limit condition is detected but not configured to disable the output. When toggling the TEC Output button, both the internal TEC and the case TEC are linked, both TECs will be either On or Off at the same time.

❖ **Protective Conductor Jack**

The protective conductor jack provides a convenient connection for a personal grounding strap. Electro-Static Discharge (ESD) does damage laser diodes, they are extremely sensitive devices! Whenever installing a laser into, or removing a laser from, the LDCM-4371 Laser Diode Controller Mount insert a personal grounding strap into the grounding jack to protect the laser diode from potential ESD damage. The instrument does not need to be plugged in for this to be effective at protecting your device. The handling precautions outlined by the laser diode manufacturers are not overstated.

Always use a personal grounding strap when opening the instrument. Failure to do so may result in internal instrument damage that is not covered under the warranty.

❖ **Interlock Jack**

The instrument contains a laser current source that has an external remote interlock capability. This allows you to connect the interlock circuit to an external switch for safety. As shipped from the factory, unless specially requested, the external interlock option is disabled. When using the external interlock feature, the user must connect a +5V source to the jack. The optically isolated input will allow laser operation when the +5V source is present, and will disable the laser output when the source is not present. Use the following steps to enable the external interlock option:

a. Shut down the instrument.

b. Unplug both the USB cable and external power cable.

c. Ground yourself to the instrument with a wrist strap inserted into the protective conductor jack so that you are assured of being at the same potential.

Always use a personal grounding strap when opening the instrument. Failure to do so may result in internal instrument damage that is not covered under the warranty.

d. Remove the four 4-40 hex socket cap screws connecting the recessed bumpers (non-skid feet) on the bottom of the instrument. This will allow the removal of the bottom cover plate.

e. Locate the dual DIP switch (SW2) labeled in white silkscreen text as CONFIG. It is located towards the center rear of the instrument, as highlighted in the photo below.

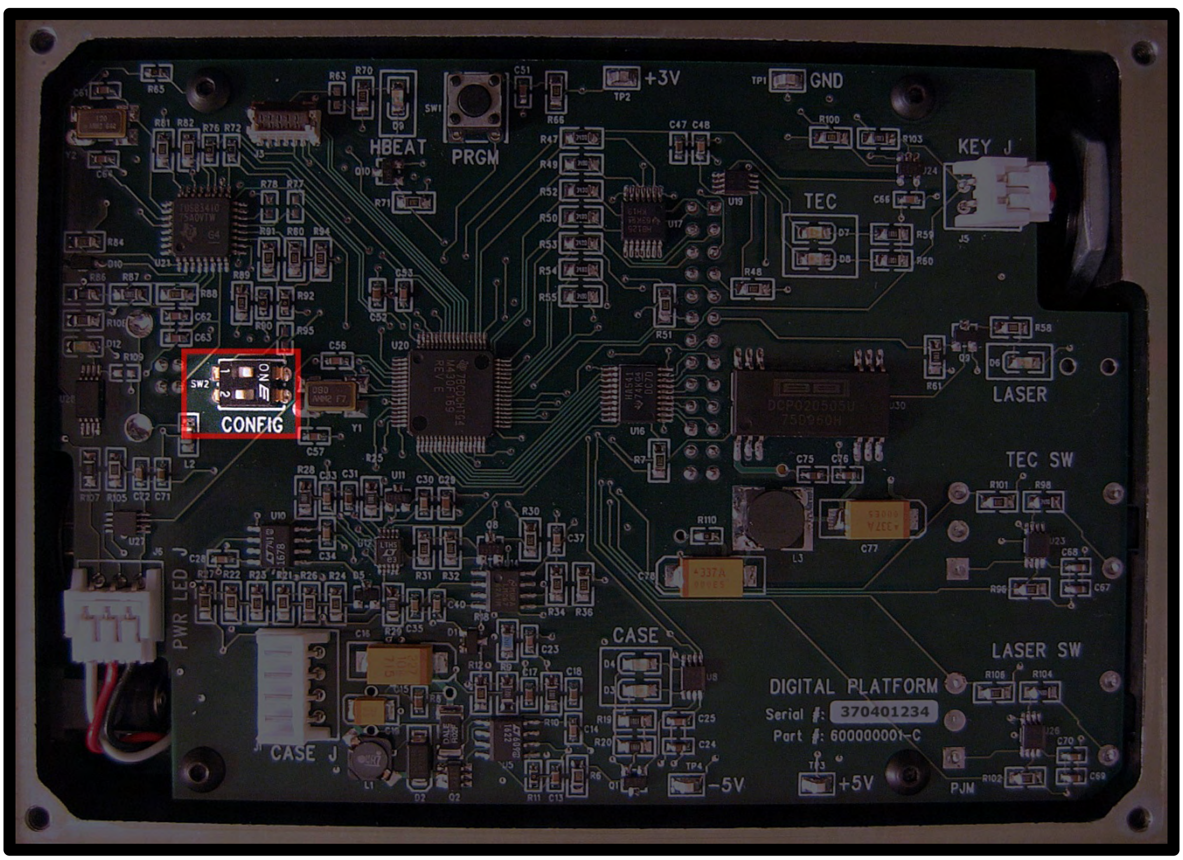


Figure 1.3: External Interlock Configuration Dip Switch

f. Slide the second switch (labeled 2 on the component) to the position labeled ON.

g. Replace the bottom cover plate, non-skid feet, and four 4-40 hex socket cap screws.

- **Laser Key Switch**

  The laser key switch enables the laser current only when the key is inserted and in the ON (I) position. Note that the key can only be removed from the instrument when in the OFF (O) position. This feature is required to meet the CDRH US21 1040.10 laser safety requirements.

LDCM-4371 Rear Panel

Figure 1.4: LDCM-4371 Laser Diode Controller Mount Rear Panel View

- **Modulation Input Jack**

  The LDCM-4371 Laser Diode Controller Mount allows a modulated signal to be superimposed on the laser control current. Specific details of the programmable modulation transfer function (voltage-to-current) can be found in Chapter 3: Laser Driver Setup>Modulation Attenuation Setpoint, Chapter 4: Set Modulation.

- **USB Receptacle**

  The instrument is equipped with a USB (Universal Serial Bus) interface. USB was designed to allow peripheral devices to be connected using a single standardized interface socket and to improve plug-and-play capabilities by allowing devices to be connected and disconnected without rebooting the computer (hot swapping). An additional convenient feature includes providing power to the instrument while configuring operation through a computer. USB is intended to help retire all legacy varieties of serial and parallel ports. For modern instrumentation USB has become the standard connection method.

- **External Power ON/OFF Rocker Switch**

  The instrument can operate in two different powered modes:

  - External Power Mode - Relies upon the external AC adapter to provide power for the instrument. In this mode, the higher power consumption laser diode controller is available. When the external source is connected to the power input jack and the rocker switch is in the up position I (ON), the external power is applied to the instrument. When the instrument is in this state the rocker switch is illuminated green. When the external power is connected to the power input jack and the rocker switch is in the down O (OFF) position, the external power is removed from the instrument. When the instrument is in this state, the rocker switch is not illuminated or illuminated red when the instrument is connected to a powered USB port.
  - USB Bus Power Mode – When the instrument is operating on USB bus-power, the external AC adapter is disconnected. This feature allows the user to configure the instrument through a computer without the need to attach the external power source. In this mode the high power consumption laser diode controller is disabled. When operating on USB bus-power, the On/Off rocker switch is illuminated red, and the position of the switch is irrelevant.

- **Power Input Jack**

  When the instrument is being used for laser diode control, the higher power consumption requires the external AC power adapter to be plugged into the power input jack.

MAINTENANCE

RECOMMENDED CALIBRATION FREQUENCY

No user maintenance procedures are required for this instrument other than an occasional cleaning, as needed, to remove any accumulated dust or dirt from the external surfaces. Leaving the contact arms in the down position (closed) will help in maintaining contact reliability and minimize accumulation of dust in the socket contacts. Finally, always store the mount with the laser cover installed.

It is recommended that the modulation SMA connector be covered with the supplied protective cap when not in use.

The recommended calibration frequency for this instrument is yearly to ensure performance to the published specifications. PSE factory calibrations employ NIST traceable measurement instruments, and our calibration engineers use automated test equipment to accurately and efficiently capture and record the calibration data. An original certificate of calibration authenticity is provided with all instrument calibrations, and a detailed report showing pre-calibration out-of-tolerance conditions is available upon request. We understand our customer's time is valuable therefore we endeavor to achieve calibration turn times within five business days or less.

Potentially lethal voltages exist within the instrument. To avoid electric shock, do not perform any maintenance on the instrument unless you are qualified to do so. Qualified service personnel are required to wear protective eyewear and anti-static wrist bands while working on or near the circuit boards.

METROLOGY

Metrology ensures that your calibrated instruments deliver accurate results with provable validity. The mission of metrology is to maintain measurement standards, to develop effective new methods, and to ensure that measurements are accepted uniformly around the world.

Your instruments need to be calibrated against known standards so their results can be trusted to have a universally accepted meaning. Metrology is the science that supports this trust—in both the "meaning" and the measurements:

- Metrology defines calibration and ensures predictable performance from your measurement tools.
- Metrology is the discipline that defines standards and codifies accreditation and traceability.
- Metrology expertise is at the heart of our reputation for accuracy, precision, and performance.

Without metrology and its standards, acceptance of products and measurements between nations and customers would be significantly more difficult. At PSE Technology, metrology professionals guide calibration policies and procedures at accredited calibration facilities around the world.

When you choose PSE Technology as your service provider, you get the benefit of an experienced metrology staff plus seasoned technicians applying deep product-specific knowledge. The result is services guaranteed to be of the highest quality in the industry.

WHY CALIBRATE

Calibration is all about confidence in the measurement results you're getting. Calibration assures you that your measurements are accurate within the specification limits that led you to select the instrument in the first place.

Every new PSE Technology instrument arrives freshly calibrated and adjusted, with a Certificate of Traceable Calibration. Dig a little deeper into the documentation and you will find details about recommended calibration intervals. These routine calibrations are your prescription for the continued health and performance of the instrument.

- In production test, you may encounter false passes or (equally undesirable) false failures. False passes can send inferior products to your customers, ruining your reputation for quality. False failures end up in the reject bin, ruining yields and prompting costly rework or discards.
- In the engineering lab, inaccurate measurements can distort your findings about the behavior of an emerging design. Imagine going through an unnecessary design turn because your instrument wrongly measured an optical power!

- Globally agreed standards of weights and measures. Is your wavelength the same as your customer's wavelength? Is your nanosecond the same as their nanosecond? Only traceable calibration can ensure adherence to these standards.
- Contractual requirements stipulating a regular calibration regimen. The penalty for non-compliance could be fines, loss of business, or worse.
- Cost. Sometimes a calibration procedure reveals an underlying problem that could evolve into a costly failure if left unattended.

Today's digital instruments are not exempt from regular calibrations. Even though they inherently are more stable than their predecessors, the new tolerances are much narrower than in the past. And even the latest digitizing instruments have analog circuitry—preamplifiers, buffers, etc.—whose performance can change over time.

A regular schedule of calibrations will keep your instrument in optimal condition to support your design, troubleshooting, and manufacturing work

LDCM-4371 INSTRUMENT SPECIFICATIONS

LASER DRIVER SPECIFICATIONS

LASER CURRENT DRIVE[1]

Output Range:	0 to 250 mA
Setpoint Resolution:	4 μA
Setpoint Accuracy:	±0.05% of full scale
Compliance Voltage:	3.5 V Maximum
Temperature Coefficient:	≤10 ppm/°C
Short-term Stability:[2]	≤ 3 ppm
Long-term Stability:[3]	≤ 8 ppm
Noise and Ripple (rms):[4]	5 μA
Transients	
Operational:[5]	< 1mA
1 kV EFT:[6]	< 2mA
Surge:	< 3mA

LASER LIMIT SETTINGS

Current Limit	
Range:	0 to 250 mA
Resolution:	4 μA
Accuracy:	± 0.7 mA
Voltage	
Range:	0 to 3.75 V
Resolution:	0.53 μV
Accuracy:	± 0.2 V

PHOTODIODE FEEDBACK

Type:	Integrated Back Facet Monitor
Reverse Bias Voltage:	0 or 5 V
PD Current Range:	250 to 50,000μA
Stability:[7]	± 0.01%
Output Accuracy:	± 0.05%

[1] All values measured after a 1-hour warm-up period
[2] Over any 1-hour period, output set at full scale
[3] Over any 24-hour period, output set at full scale
[4] Measured optically, evaluating noise intensity of a laser diode into a photodetector with 150 kHz bandwidth
[5] Maximum output current transient resulting from normal and accidental power upsets
[6] Maximum output current transient resulting from 1 kV power line transient spike
[7] Maximum monitor photodiode drift over any 30 minute period (Assumes zero photodiode responsivity drift)

LASER DRIVER SPECIFICATIONS (CONTINUED)

MODULATION

Input:	0 to ±15 V, 50 Ω terminated inside instrument
Transfer Function:[8]	1 µA/V to 200 mA/V, digitally adjustable
Bandwidth (3dB):[9]	1.5 MHz

LASER DRIVER MEASUREMENT

Laser Drive Current	
Range:	0 to 250mA
Resolution:	4 µA
Accuracy:	± 0.05% of full scale
Photodiode Current	
Range:	15000 µA
Resolution:	0.1 µA
Accuracy:	± 2 µA
Photodiode Responsivity	
Range:[10]	2.50 to 500.00 µA/mW
Resolution:	0.008 µA/mW
Optical Power	
Range:	0.00 to 100.00 mW
Resolution:	2.0 µW
Forward Voltage	
Range:	0 to 3.5 V
Resolution:	53 µV
Accuracy:[11]	± 7 mV

Table 1.1: Laser Driver Specifications

[8] 125 mA setpoint, with 50 mA modulation current into 1 Ω load
[9] 50% modulation depth at mid-scale output into 1 Ω load
[10] Responsivity value is user defined and is used to calculate the optical power
[11] Voltage measurement made with mid-scale output into 1 Ω load

TEC CONTROLLER SPECIFICATIONS

TEMPERATURE CONTROL[12]

Control Range:[13]	-100.0 °C to +100.0 °C
Resolution:	0.01 °C
Accuracy:	± 0.1 °C
Temperature Coefficient:	< 5 ppm/°C
Output Type:	Bi-polar current source
Control Type:	Ziegler/Nichols Optimized PID
Maximum Voltage:	5.0 V
Maximum Power:	7.5 Watts
Voltage Limit	
Range	0 to 5.0 Volts
Resolution:	80 µV
Accuracy	±0.05 Volts
Short-term Stability:[14]	< ±0.003 °C
Long-term Stability:[15]	< ±0.004 °C
Current Noise and Ripple:[16]	< 0.5 mA rms

TEMPERATURE SENSOR

Type:	Thermistor (2-wire NTC)
Useable Thermistor Range:	25 to 450kΩ typical
User Calibration:	Steinhart-Hart, 3 constants

TEC MEASUREMENT

Temperature	
Range:[17]	-100.0 °C to +100.0 °C
Resolution:	0.01 °C
Accuracy:	± 0.5 °C
Voltage	
Range:	5 Volts
Resolution:	61 µV
Accuracy:[18]	± 10 mV
Current	
Range:	1.5 Amps
Resolution:	23 µA
Accuracy:	± 0.01 Amps

Table 1.2: TEC Controller Specifications

[12] All values measured after 1-hour warm-up period
[13] Software is limiting to this range, it is unlikely this full range will be useable, the actual range will depend on the load, thermistor, and TE module
[14] Over any 1-hour period set at 25 °C
[15] Over any 24-hour period set at 25 °C
[16] Measured at 1 Amp output over 10 Hz − 10 MHz
[17] Range limits are bounded through software
[18] Voltage measurement accuracy is load dependant (calibrated resistive load used for specification)

GENERAL INSTRUMENT SPECIFICATIONS

CONNECTORS	
External Modulation Input:	SMA, 50Ω Input Impedance
Computer Communication:	Type “B” USB, USB 2.0 full speed
Protective Conductor Jack:	For standard 0.175” Banana Plug
Interlock:	2.5 mm Mono Audio
Power Input Jack:	2.1 mm Center Conductor +5V @ 4A
USB:	Type B Receptacle
GENERAL	
Size (H x W x D):	1.25” x 4.0” x 5.5” (31.8mm x 102mm x 140mm)
Weight:	1.4 pounds (0.64 kg)
Power Requirements:	120 VAC at 60Hz, 220 VAC at 50/60 Hz, 230−240 VAC at 50/60Hz
Temperature:	0 to +40 °C operating; −40 to +70 °C storage
Humidity:	< 90% relative humidity, non-condensing.

Table 1.3: General Instrument Specifications

MINIMUM CONTROLLING COMPUTER REQUIREMENTS

MINIMUM CONTROLLING COMPUTER REQUIREMENTS

HARDWARE	
Processor	≥ 600 MHz
RAM	≥ 256 MB
Video	≥ 800 x 600, 256 Color or better
Other	USB Hub, Mouse, CD ROM Drive
Processor	≥ 600 MHz
RAM	≥ 256 MB
Video	≥ 800 x 600, 256 Color or better
Other	USB Hub, Mouse, CD ROM Drive
SOFTWARE	
Operating System	≥ Windows XP (SP1)

Table 1.4: Minimum Controlling Computer Requirements

In keeping with our commitment to continuing improvement, PSE Technology reserves the right to update specifications without notice or liability for such changes.

CHAPTER 2 – BASIC OPERATIONS

INTRODUCTION

This chapter introduces you to the basic (non-computer controlled) operation of the LDCM-4371 Laser Diode Controller Mount. It offers instructions for connecting your laser to the mount, connecting a modulation source, powering the instrument, and using the front panel buttons for basic operations. Prior to operating the instrument the user must configure the operational parameters through a computer, see chapter 3 for details on how to setup the instrument.

CONNECTING THE LASER DIODE

The LDCM-4371 Laser Diode Controller Mount is equipped with a grounding jack at the front of the unit, which is electrically connected to the instrument. We strongly recommend that you electrically ground yourself with a wrist strap so that you are assured of being at the same potential as the laser diode controller circuitry.

Always use a personal grounding strap when opening the instrument. Failure to do so may result in internal instrument damage that is not covered under the warranty.

When connecting/disconnecting a laser diode to/from the LDCM-4371 Laser Diode Controller Mount, we recommend that the instrument be switched off. In this state, a low impedance shunt is placed across the laser anode and cathode terminals. This will help protect the device from potential damage due to Electro-Static Discharge (ESD).

The LDM-4371 ensures dependable laser case to mount fastening and allows simple electrical connection through the use of flat Zero Insertion Force (ZIF) sockets. Once properly installed and securely fastened, the entire laser package bottom surface is in solid contact with a thermally controlled heat sink. This ensures optimum performance by providing a stable thermal reference for the internal Thermo-Electric Cooler (TEC) device.

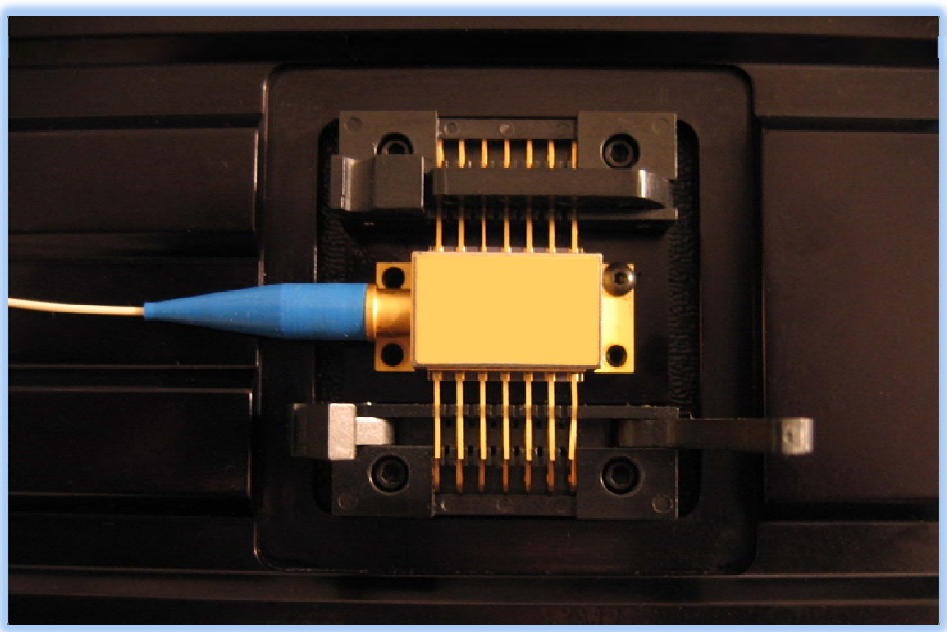


Figure 2.1: Laser Diode Installation (ZIF Socket)

To mount a 14-pin butterfly-packaged laser diode, reference figure 2.1 and follow steps 1 – 8:

WARNING *The LDCM-4371 butterfly socket has been designed to accept standard 14-pin butterfly packaged laser diodes. If your laser diode package is not a 14-pin butterfly package, please contact us for a custom configuration that will match your exact needs.*

---

1. Remove the protective laser cover from the mount housing.
2. Open both ZIF sockets by releasing the lock-latch, and lifting the contact arm.
3. Remove the four 1/4" long 2-56 button head cap screws used to secure the laser package to the heat sink.
4. Holding the laser package by the corners, carefully lower the laser onto the heat sink, while aligning the laser leads with the contacts of each socket. Note that on the front of the housing there is a relief milled in the chassis. The laser is to be mounted so that the fiber is routed freely through this relief. Use caution when installing the laser to ensure it is not inserted backwards.

WARNING *The LDCM-4371 butterfly socket has been designed for laser lead heights of 6mm, nominally. If your laser diode lead height is greater than 6.6mm, please contact us for a custom hot plate that matches your exact needs. If your lead height is less than 6mm, you may wish to insert more thermal pad material on the base of your laser diode package, or contact us for a custom hot plate that matches your exact needs.*

---

5. It is possible to misalign the leads in the ZIF sockets when installing the laser. Verify that all leads are properly positioned in the socket before continuing. Failure to properly align the leads in the sockets may result in laser device damage.
6. Attach the laser diode to the instrument by fastening the package flange mounting holes with the 1/4" long 2-56 button head cap screw holes into the instrument hot plate. Hand-tighten the four laser hold down screws with a 0.05" hex key wrench.
7. Carefully lower the contact arm on each ZIF socket and rotate the lock-latch up over the arm until it snaps in place. Verify all connections; the laser is ready for operation.
8. After installing your laser, replace the laser cover. The cover improves thermal stability and helps provide shielding from radiated noise and transients in your laboratory.

WARNING *Experience indicates that should an inadvertent open circuit occur during laser operation (while the LASER is ON); your laser may be damaged by a momentary circuit break-and-remake before the final circuit break. Your LDCM-4371 has circuitry designed to detect open circuits and will shut the output off under most conditions. However, we still recommend that the socket connections to the laser be secure enough that they won't open-circuit should they be jostled or bumped.*

CONNECTING A MODULATION SOURCE

The LDCM-4371 Laser Diode Controller Mount is equipped with a SMA type RF connector located on the rear of the instrument. This input can be used to modulate the laser drive current with an external analog modulation signal. The modulation input is 50Ω terminated inside the instrument.

WARNING *Do NOT apply a modulation voltage in excess of ±15 volts. Voltages exceeding this maximum value will result in internal instrument damage that is not covered under the warranty.*

Turning the Instrument External Power On/Off

As shown in figure 1.4 the power on/off rocker switch located on the rear panel is used to switch on or off the external power supply. The external power supply is connected to the 2.1mm power jack located on the left rear panel of the instrument. The instrument can be configured through a computer without the need to plug in the external power source. The minimal current required to power up the digital portion of the instrument is well within the 100mA USB limit. However, the current required for the laser drive, TE controller, and case TE controller necessitate the use of the external power supply. The rear power rocker switch enables or disables this external power supply.

The external power rocker switch has an integrated bi-color LED that provides a visual indication of the power source state. When operating on USB power only, the power rocker switch is illuminated solid red. When the instrument is operating on external power and switched on, the LED will flash green while it is initializing and performing the built-in self test. Once the initialization process is complete the LED will be illuminated a solid green, indicating the instrument is operating properly and ready for laser diode control.

Turning the Laser Current Source On/Off

WARNING *Make sure the instrument settings have been properly configured for your laser diode prior to turning On the laser current source. Incorrect configuration values may result in destruction or damage of the laser diode.*

Prior to turning on the laser current source, it is important that the instrument settings be properly configured. Refer to Chapter 3 – Setup Program for detailed instructions on installing the Instrument Controller Program, it will allow you to configure the instruments operating parameters.

As shown in figure 1.2 the right most momentary switch located on the front panel is used to enable or disable the laser drive output. This button contains an internal bi-color LED that is programmed to provide a visual indication of the laser state. When the button is not illuminated the laser drive is disabled and was not forced off by an error condition. When the button is illuminated a continuous green, the laser drive output is enabled and functioning properly. When the button is flashing green, it indicates the laser drive output is going through the CDRH US21 CFR 1040.10 required laser safety output emission delay of 5-seconds. When the button is illuminated continuous red, the laser drive output was automatically disabled because of an instrument detected error condition.

The following are error conditions that can be configured to automatically disable the laser drive:

- Laser enable key turned to disable output
- Laser interlock opened
- Laser drive current limit detected
- Laser high power limit condition
- Laser drive voltage limit detected
- TEC output disabled with the laser drive enabled
- TEC high temperature limit condition
- Only operating on USB power
- Instrument digital platform temperature sensor limit
- Instrument analog platform temperature sensor limit

TURNING THE TEC CONTROLLER ON/OFF

WARNING *Make sure the instrument settings have been properly configured for your laser diode prior to turning On the TEC controller. Incorrect configuration values may result in destruction or damage of the laser diode.*

As shown in figure 1.2 the left output momentary switch located on the front panel is used to enable or disable the TEC controller drive output. This button contains an internal bi-color LED that is programmed to provide a visual indication of the TEC control state. When the button is not illuminated the TEC drive is disabled and was not forced off by an error condition. When the button is illuminated a continuous green, the TEC drive output is enabled and function properly. When the button is illuminated a continuous red, the laser drive output was automatically disabled because of a detected error condition.

The following are error conditions that can be configured to automatically disable the TEC drive:

- Laser TEC high temperature limit
- Laser TEC control error limit
- Laser TEC voltage limit
- Case TEC high temperature limit
- Case TEC control error limit
- Only operating on USB power
- Instrument digital platform temperature sensor limit
- Instrument analog platform temperature sensor limit

COMPATIBLE LASER DIODE PACKAGE PIN OUT

The instrument can be easily configured (refer to Chapter 3: Laser Driver Setup>Laser Cathode Configuration, or Chapter 4: Set Laser Cathode Pin Number) to operate with most commercial DFB laser diodes, including the following devices:

MANUFACTURER	MODEL	CATHODE PIN
Alcatel (Avanex)	A 1905 LMI	Pin 3
JDS Uniphase	CQF975	Pin 3
Lasertron	QLM715	Pin 3
Lucent	D2525, D2570	Pin 3
Mitsubishi	FU-68PDF	Pin 3
NEL	**NLK1556STx, NLK1655STx**	**Pin 12**[19]
Sumitomo	SLT5411x	Pin 3

Table 2.1: Compatible Laser Diode Models

[19] NEL (NTT Electronics) DFB lasers have a unique pin out, they use pin 12 as the laser diode cathode.

If your device has both pin 3 and pin 12 connected to the laser cathode through passive components (R1 = 20 Ω and L1 = 180 nH) as depicted in the following electrical schematic:

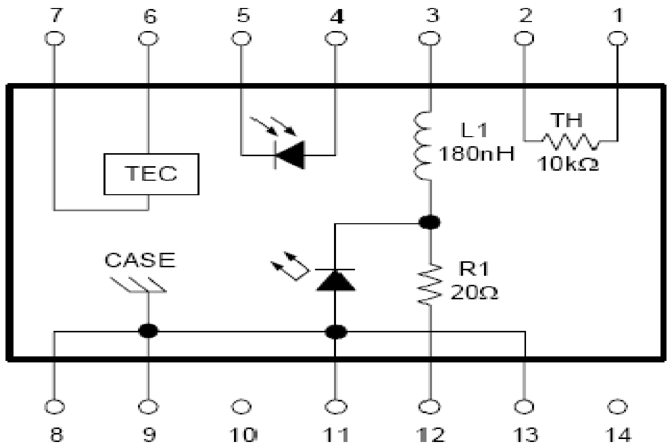


Figure 2.2: Dual Cathode Connection

The LDCM-4371 should be configured to use the pin with the inductor (PIN 3) as the laser diode cathode. Using PIN 12 will result in an excessive forward voltage that will significantly limit the maximum drive current that can be used.

If you do not see your specific device listed above, please feel free to contact us for additional assistance. We will either verify instrument compatibility with your device or provide you the option of purchasing a custom designed instrument that will meet your unique needs.

WARNING *It is extremely important that you verify that the instrument is properly configured for your laser type (pin-out). An incorrect configuration may result in destruction or damage of the laser diode.*

Figure 2.2 details the standard product pin-out, please note that the instrument is user programmable to select either pin 3 or pin 12 for the laser diode cathode.

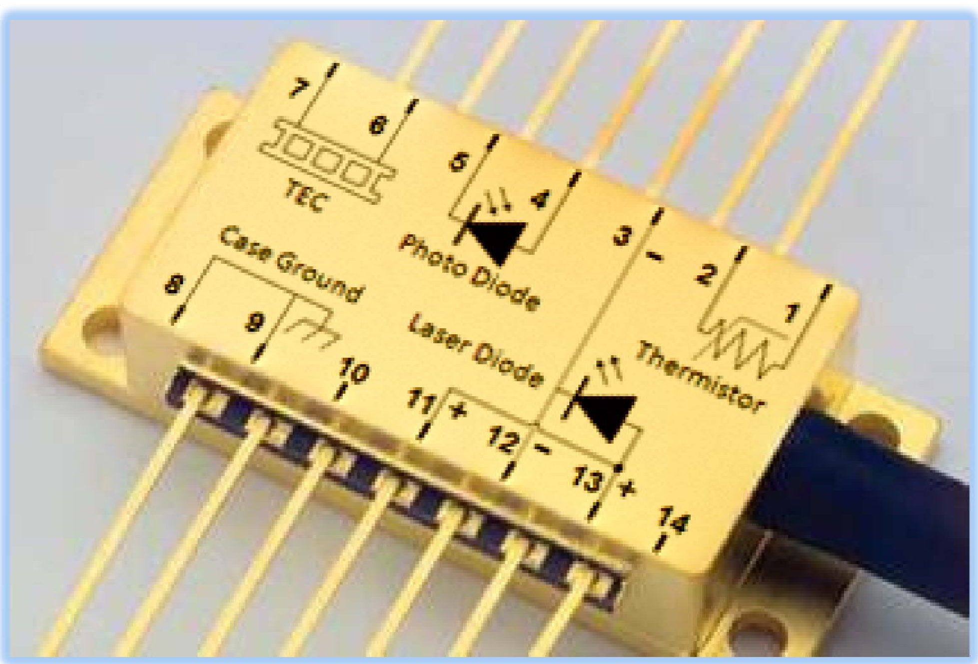


Figure 2.3: Compatible Laser Diode Pin Out

PIN NUMBER	DESCRIPTION
1	Thermistor
2	Thermistor
3	**Configurable Laser Diode Cathode**
4	Back Facet Monitor Photo Diode Anode
5	Back Facet Monitor Photo Diode Cathode
6	Thermo-Electric Cooler +
7	Thermo-Electric Cooler -
8	Device Case Ground
9	Device Case Ground
10	No Connect
11	Laser Diode Anode
12	**Configurable Laser Diode Cathode**
13	Laser Diode Anode
14	No Connect

Table 2.2: Laser Diode Pin Number and Description

CHAPTER 3 – SETUP PROGRAM

INTRODUCTION

This chapter provides a description of the computer controlled instrument setup, configuration, and operation. The bulk of the chapter provides a description of the LDCM-4371 Instrument Controller Program menu structure. These sections provide pictures of the computer display associated with each menu for the LDCM-4371 Instrument Controller Program. The individual menus are used to configure the operational parameters of the instrument. This section also provides instructions on how to select each menu and how to perform the operations relevant to the menu selected.

LDCM-4371 INSTRUMENT CONTROLLER PROGRAM

All the key operating parameters for the instrument can be set, adjusted, and displayed through established menus in the LDCM-4371 Instrument Controller Program.

DROPDOWN TOOLBAR

There are two drop-down menus (Output State and Help) located in the toolbar along the top of the form. These are highlighted in the screenshot below, figure 3.1.

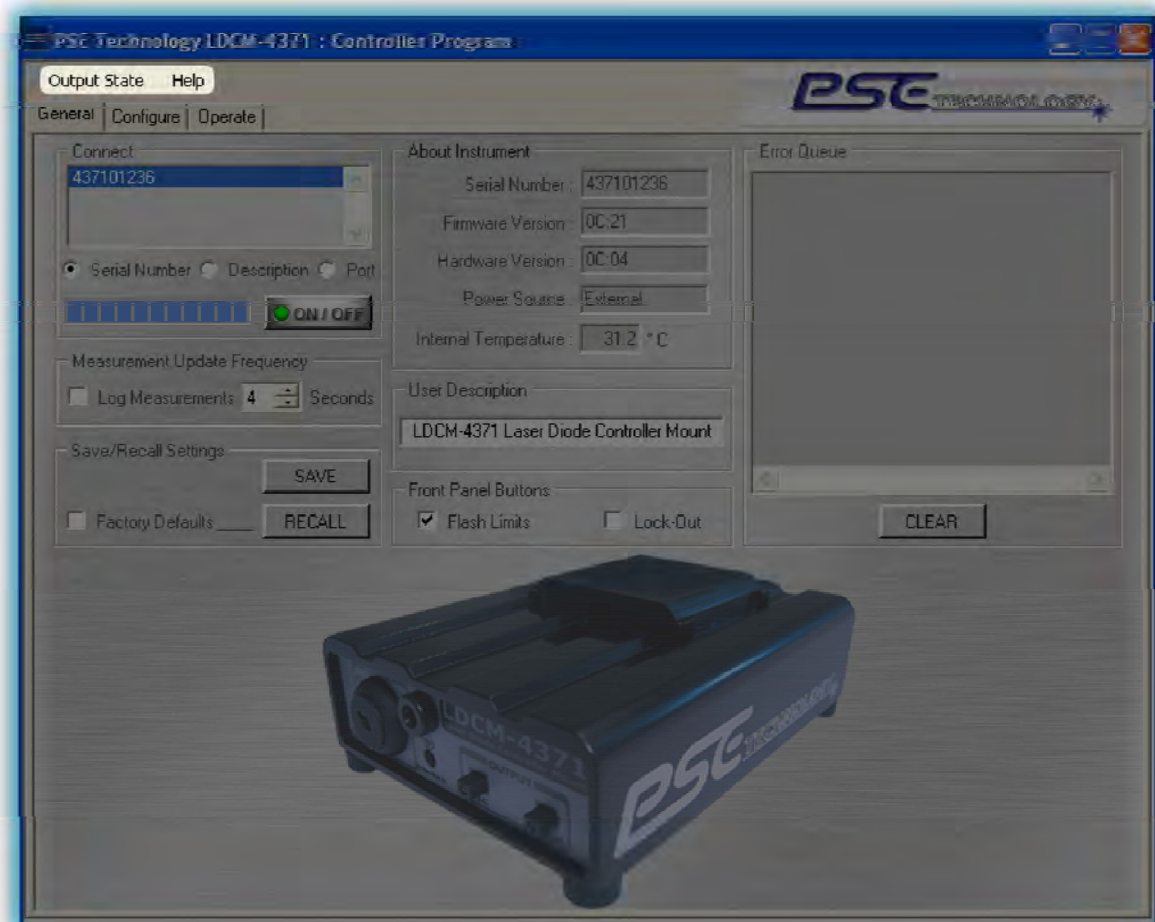


Figure 3.1: Dropdown Menu Toolbar Screenshot

1. **Output State:** As shown below in figure 3.2, within the first dropdown menu item the user has the choice to enable or disable the Laser Output, Internal TEC Output, or Case TEC Output independently or simultaneously.

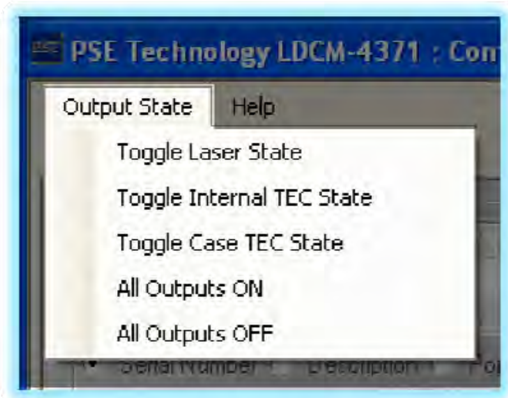


Figure 3.2: Output State Dropdown Menu Screenshot

2. **Help:** As shown below in figure 3.3, within the second and last dropdown menu item the user has the choice to read about the Instrument Controller Program, or this manual in PDF format.

Figure 3.3: Help Dropdown Menu Screenshot

CONFIGURATION TABS

The three (General, Configure, and Operate) menu tabs located just below the toolbar towards the top of the form provide the primary method for controlling the instrument. These are highlighted in the screenshot below, figure 3.4.

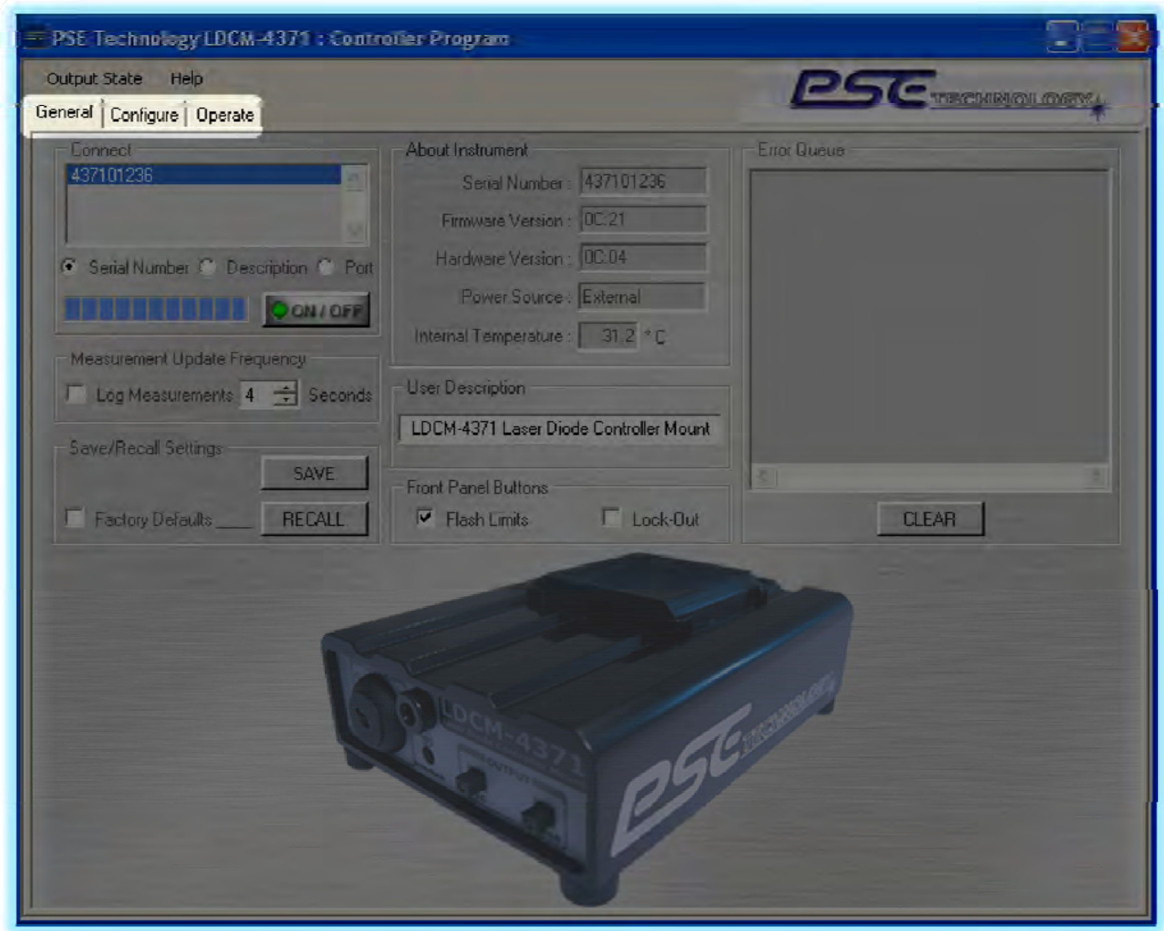


Figure 3.4: Tab Menus Screenshot

GENERAL TAB MENU

General: This is the first of the three menu tabs. All the General system level parameters for the instrument can be set, adjusted, and displayed through this menu in the LDCM-4371 Instrument Controller Program. When the program starts up it automatically identifies all the available instruments that are connected to the USB bus.

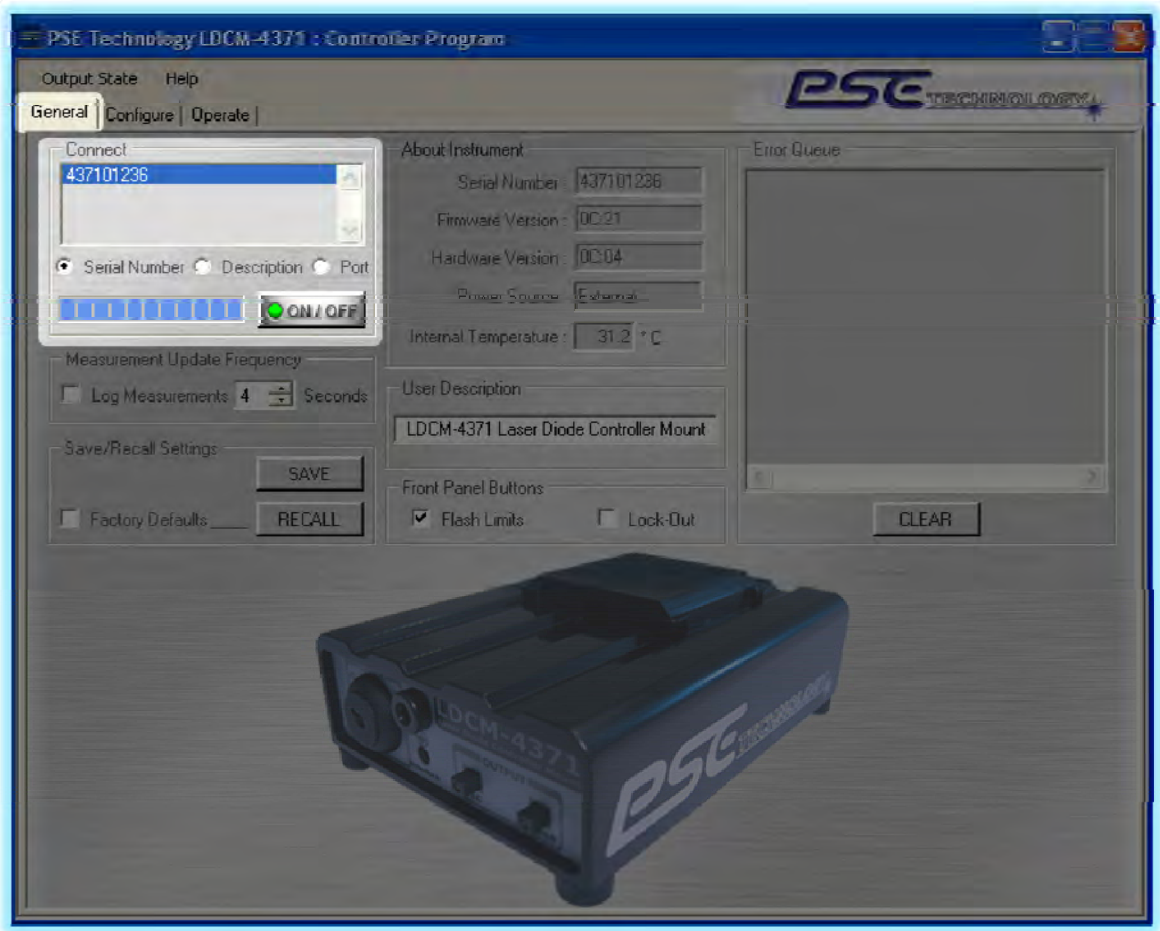


Figure 3.5: Attached Instruments Menu Screenshot

1. **Available Instruments:** By default the first instrument identified during the program initialization sequence is automatically selected in the Attached Instruments section as shown above in figure 3.5. The user can choose a specific attached instrument using the Instrument Selection list box. The selection can either be performed using the unique serial number assigned to each instrument, the user assigned instrument description, or the computer assigned communications Port. The instrument listing option, **Serial Number**, **Description**, or communications **Port** can be changed by selecting one of the three radio buttons below the select instrument list box.

   If the Instrument Controller Program does not detect any instruments attached to the USB bus, the select instrument list box is blank. In addition, a pop-up warning will be displayed.

   The **ON/OFF** button can be used to connect or disconnect from the USB bus. This can be used to reinitiate the automatic instrument discovery process after a new instrument is connected to the USB bus.

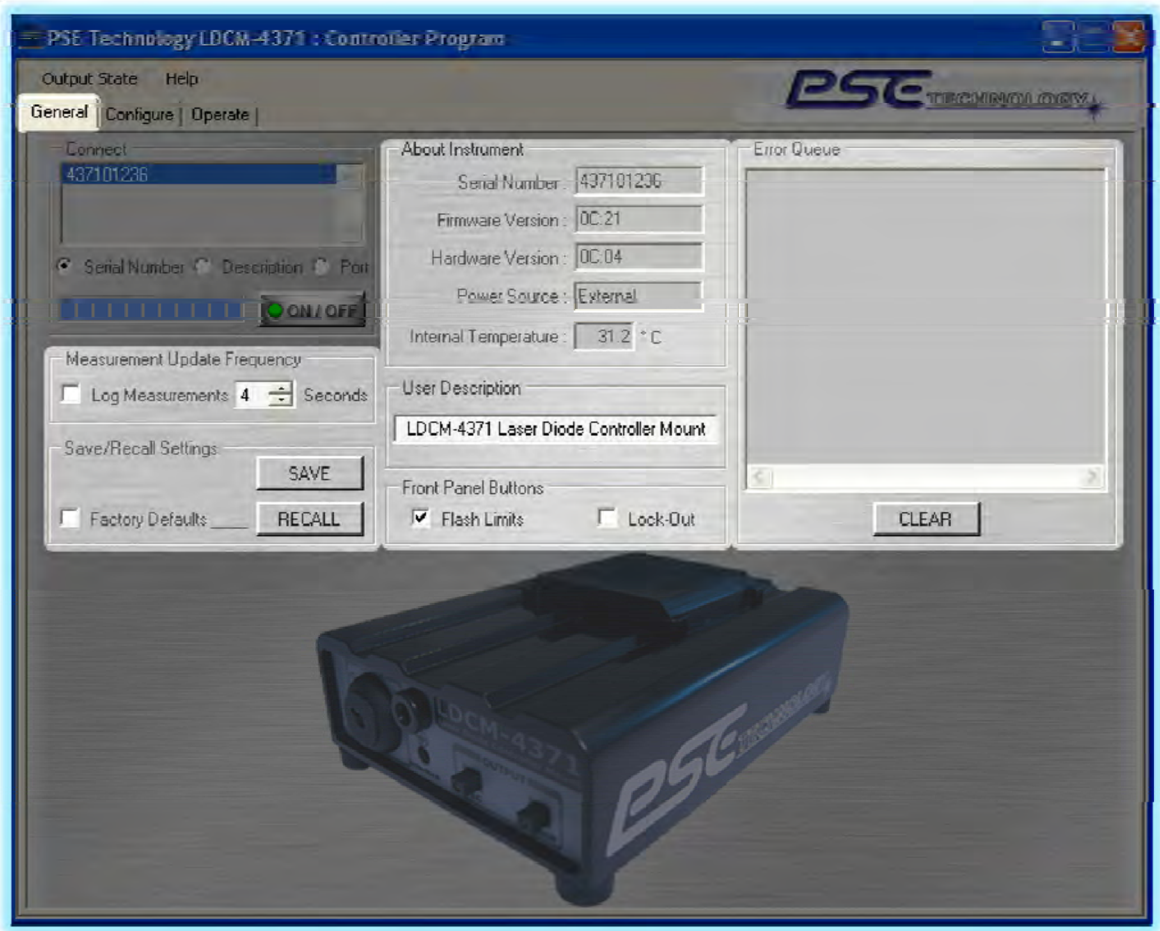


Figure 3.6: General Instrument Setup – Sections Screenshot

1. **Measurement Update Frequency:** The next menu section, directly below the Attached Instruments section is the Measurement Update Frequency. This section allows the user to configure the frequency at which the Instrument Controller Program automatically updates the measured readings in the General and Operations tab. The Log Measurements check box can be used to write the measured values into a user defined data file. This file will be written in a Comma Separated Value (CSV) format that can be easily imported into Microsoft Excel for analysis.

2. **Save/Recall Settings:** Directly below the Measured Update Frequency section is the Save/Recall Settings section. This section allows the user to save preferred instrument settings to a file on the computer. This is accomplished by clicking on the SAVE button on the left of the section. Using the recall button with the Factory Default check box checked will force the instrument to reset to the factory default values. Using the recall button with the Factory Default button cleared will bring up a file selection dialog box. When the user selects a previously saved settings file, the instrument will be configured to the values contained in the file.

3. **About Instrument:** The next menu section located at the top middle of the windows form displays the unique serial number, firmware version, and hardware version for the selected instrument. The user can force the program to refresh the information by clicking in each of the individual text boxes. It also contains a text box, “Power Source” that indicates how the instrument is being powered, USB or External Power. Lastly, it contains a text box, “Internal Temperature” that displays the instruments internal operating temperature when operating on external power.

4. **User Description:** The next menu section, directly below the About Instrument section is the User Description section. This section allows the user to set a user defined instrument description. To set a new user description, type the new text (limited to 39 characters) in the window and press enter or click outside of the text box.

5. **Front Panel Buttons:** Just below the User Description section is the Front Panel Buttons section. This section allows the user to:

   a. Enable or Disable the flash front-panel On/Off button LEDs when limit condition is active. When enabled the associated front-panel On/Off button LED will flash to indicate one of the limit condition is active (e.g. the TEC LED will flash when the internal TEC is in voltage limit). When disabled the associated On/Off button will be illuminated green when the output is on, regardless of an active limit condition. Note that if the limit condition is configured to disable the output, this operational state is meaningless; the output will be disabled before the LED flashes.

   b. Enable or Disable the front panel button lock-out. This can be useful to prevent accidentally changing the instrument state when bumping one of the buttons while operating in remote mode.

6. **Error Queue:** On the right of the windows form is the Error Queue section. In the event of an instrument error condition, the offending output will be disabled and the corresponding output button LED will be illuminated red. The user can read a maximum of ten previous error codes and their associated descriptions by clicking anywhere in the error queue text box. When this is done, all of the error codes which are resident in the error queue are returned (up to the last 10 may be stored). Reading the errors does not clear the error queue. The user can force the instrument to clear the internal error queue by clicking on the CLEAR button located at the bottom center of the section. For additional details on the error conditions and their associated codes please refer to the Appendix of this manual. Note that errors are stored in the instruments flash memory; therefore they are preserved when power is removed.

CONFIGURE TAB MENU

Configure: The second tab in the sequence is the Configure tab as shown in Figure 3.7 below. All the key laser driver and TEC Controlller parameters for the instrument can be set, adjusted, and displayed through this menu in the Instrument Controller Program.

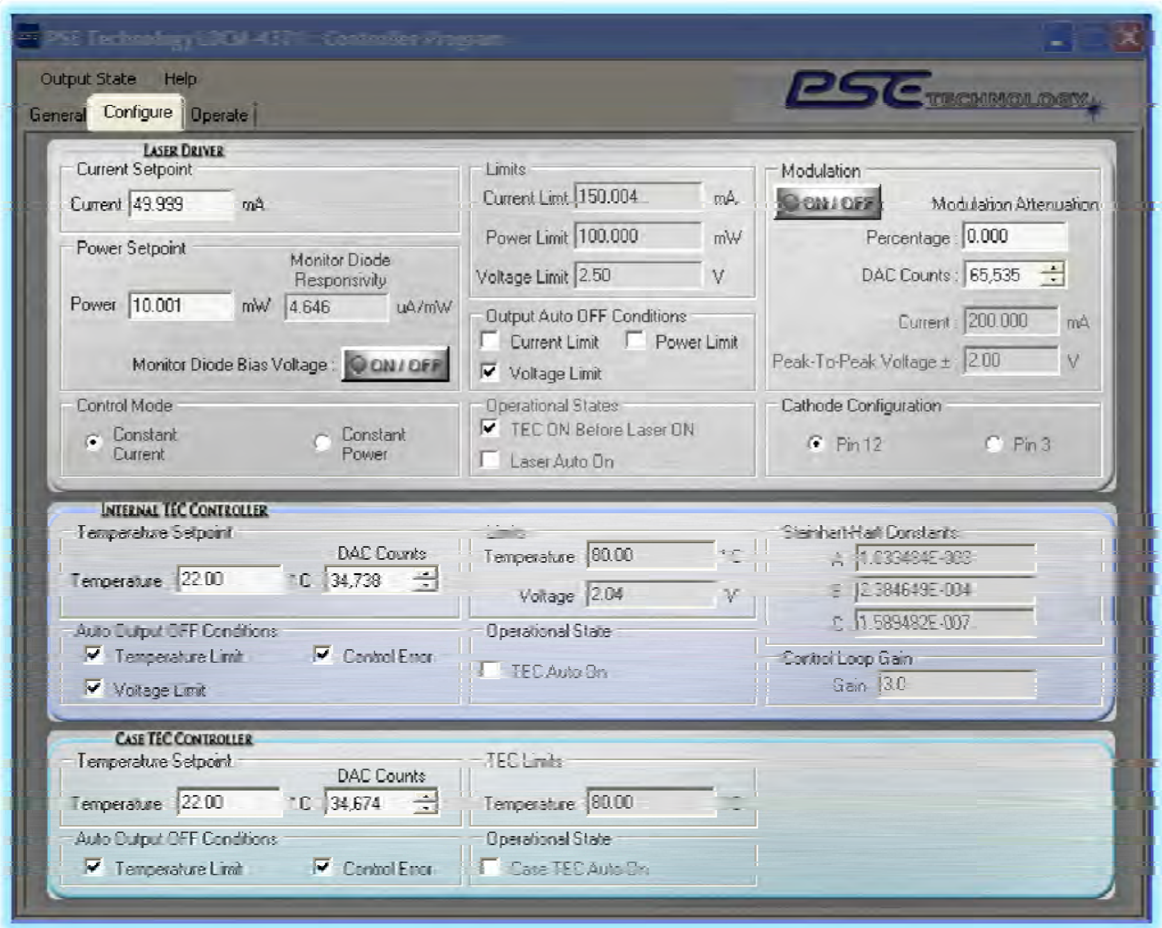


Figure 3.7: Operation Menu Screenshot

1. **Laser Driver:** The top section is for configuring the Laser Driver. Within this section the user can adjust all the laser driver operating parameters.
2. **Internal TEC Controller:** The middle section is for configuring the Internal TEC Controller. Within this section the user can adjust all the internal TEC controller operating parameters.
3. **Case TEC Controller:** The bottom section is for configuring the Case TEC Controller. Within this section the user can adjust all the case TEC controller operating parameters.

Laser Driver Sub-Section

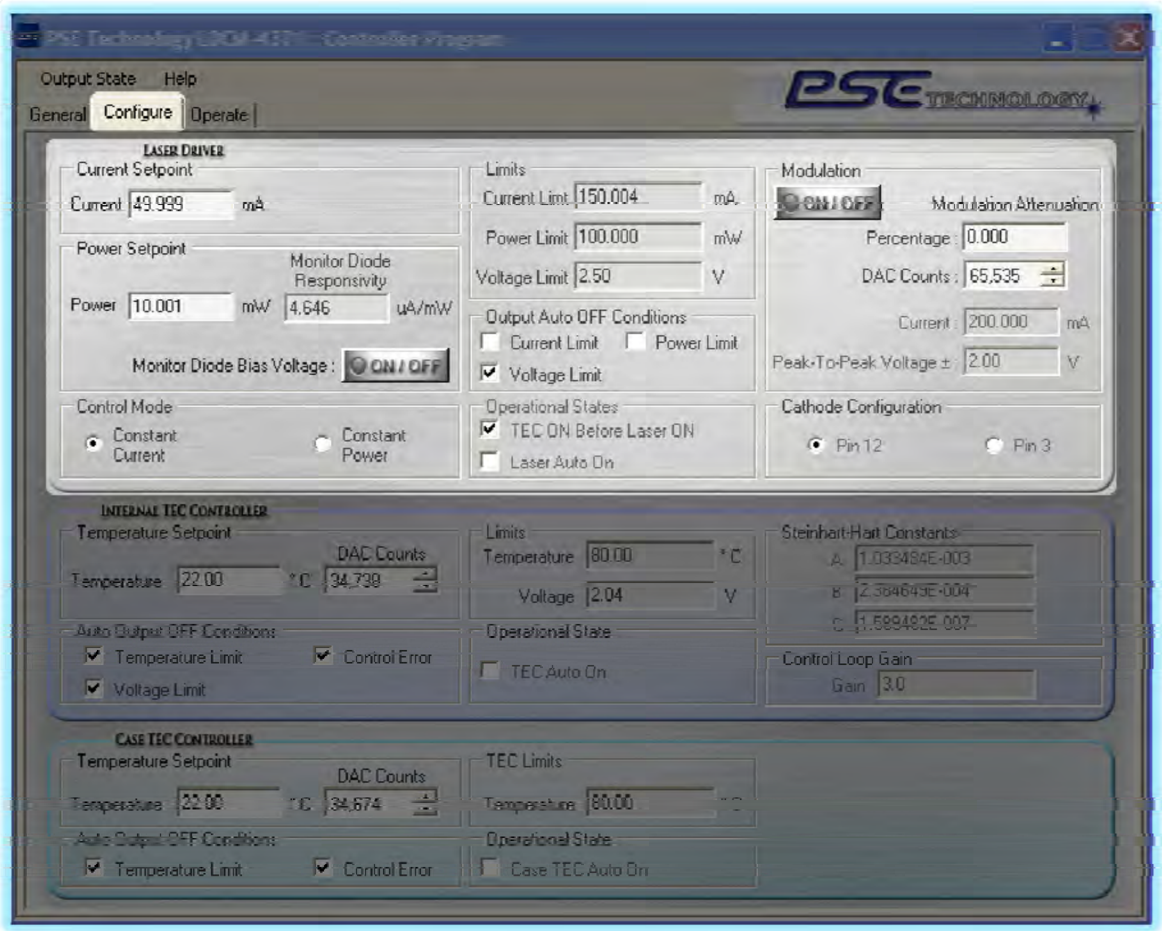


Figure 3.8: Configure – Laser Driver Menu Screenshot

1. **Laser Current Setpoint:** The upper left sub-section, Laser Current Setpoint, allows the user to adjust the laser driver current setpoint value in milliamps. The Laser current setpoint value has a minimum of 0.0 milliamps and a maximum of 250.0 milliamps. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. If the measured current is significantly below the laser setpoint value, verify that the current limit setpoint is not set below the laser current setpoint value.

2. **Laser Power Setpoint:** The center left sub-section, Laser Power Setpoint, allows the user to adjust the laser driver power setpoint value in milliwatts. The laser power setpoint value has a minimum of 0.0 milliwatts and a maximum of 100.0 milliwatts. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. If the measured power is significantly below the laser setpoint value, verify that the current limit setpoint is not clipping the drive current. Also within the Laser Power Setpoint subsection are the:

   a. Monitor Diode Responsivity:

      The monitor diode responsivity value is used to convert the measured monitor diode current to an output optical power. See the Laser Constant Power Calibration section in the appendix of this manual for calculating the Monitor Diode Responsivity constant for your specific laser.

b. Monitor Diode Bias Voltage On:

When ON, a 5 volt back facet monitor photo-diode bias voltage is applied. When OFF, NO Back Facet Monitor Photo-Diode Bias Voltage is applied. To help ensure the Monitor Photo-Diode is operating in the linear photoconductive mode a reverse voltage can be applied to the diode (i.e., a voltage in the direction where the diode is not conducting without incident light). In this mode the dependence of the photocurrent on the light power can be very linear over six or more orders of magnitude of the light power. The magnitude of the reverse voltage has nearly no influence on the photocurrent and only a weak influence on the (typically rather small) dark current (obtained without light), but a higher voltage tends to make the response faster. This instrument implements a fixed 5V monitor diode reverse bias voltage.

3. **Laser Control Mode:** The bottom left sub-section, Laser Control Mode, allows the user to change the laser diode control mode to either Constant Current or Constant Power. To avoid the possibility of damaging your laser diode due to a momentary open-circuit the instrument automatically prevents the user from changing the laser control mode with the output on.

4. **Laser Limits:** The top middle sub-section, Laser Limits, allows the user to adjust the laser driver limits. This sub-section contains the following:

   a. The **Current Limit** value entered in milliamps sets the maximum current that will be delivered to the laser. It is important to note that the current limit is active in both the constant current and constant power modes of operation. Therefore, if the measured current or power is significantly below their respective setpoint value, verify that the current limit is not clipping the drive current.

   b. The **Power Limit** value allows the user to adjust the laser driver power limit value in milliwatts. The laser power limit does not actively clamp the power, this limit is binary in the sense that when configured it will force the output off if the limit condition occurs.

   c. The **Voltage Limit** allows the user to adjust the laser driver voltage limit value in volts. The laser voltage limit does not actively clamp the voltage, this limit is binary in the sense that when configured it will force the output off if the limit condition occurs.

5. **Laser Output Auto OFF Conditions:** The center middle sub-section, Laser Output Auto OFF Conditions, configures the limit conditions that will force the laser driver to automatically disable the laser output when they occur.

6. **Laser Operational States:** The bottom middle sub-section, Laser Operational States, configures the state of various laser operational flags.

   a. TEC ON Before Laser ON

   Enabling this feature will require that the TEC output be turned on before allowing the laser to be switched on. In addition, if the TEC is disabled for any reason while the laser is enabled the laser will automatically shut off. This protection feature is provided to help ensure that the laser diode reliability is not adversely affected by excessive thermal stress at the diode junction.

The TEC should always be operational before the laser output is enabled. Failure to do so may cause excessive thermal stress to the diode junction that may result in destruction or damage of the laser diode.

   b. Laser Auto On

   When enabled, the laser automatic on instructs the instrument to enable the laser output at power-up. This mode of operation implements the required five second safety activation delay before the laser output is enabled. It is possible to disable the laser output with either the laser interlock key switch or the laser on/off front panel button, assuming the on/off button lockout is not enabled.

When using the Laser Auto On feature exercise caution to avoid accidental exposure to possibly hazardous laser radiation.

7. **Modulation:** The top right sub-section, Modulation, allows the user to configure the laser modulation.

    a. ON/OFF button

    With the Modulation button LED is OFF, the rear SMA connector is isolated from the laser drive current. With the Modulation button LED is illuminated green, the modulation current is superimposed on the laser control current. When modulating the laser with one of the protection features enabled the laser drive may automatically turn off. If the laser output is being forced off unexpectedly, reading the error queue may help diagnose the cause.

    b. Modulation Attenuation (Percentage)

    The user can adjust the modulation attenuation percentage, no attenuation is active with a value of 0.0 and the maximum attenuation is applied with a value of 100.0. This feature allows the user to independently adjust the modulation depth or scan width for individual lasers that are ganged together with a single function generator. See the appendix of this manual for a detailed explanation of how the modulation attenuation value affects the modulation bandwidth. To maximize the instrument modulation bandwidth, use smaller modulation input voltages. This will yield a lower calculated instrument attenuation setting, which results in a greater modulation bandwidth. Changes to the modulation attenuation percentage will automatically update the corresponding DAC counts value.

    c. Modulation Attenuation (DAC Counts)

    In addition to the attenuation percentage, the user can directly set the modulation attenuation DAC counts, no attenuation is active with a value of 65,535 and the maximum attenuation is applied with a DAC value of 0. Changing the modulation attenuation DAC counts will automatically update the corresponding percentage value.

    d. Current and Peak-to-Peak Voltage

    The instrument can also automatically set an attenuation DAC value for a user requested modulation current give a user entered peak-to-peak modulation voltage. The required modulation attenuation is calculated by applying the user entered modulation current in milliamps and the peak-to-peak modulation voltage of the function generator. Note that the modulation current is superimposed on the laser control current. Therefore the actual laser drive current is the sum of the peak modulation current and the constant current setpoint value. The modulation transfer function (voltage-to-current) is calculated with the following equation:

$$I_{Modulation} = \frac{\frac{1}{2} \times V_{Modulation(Peak-to-Peak)}}{5\Omega} \times \frac{DAC_{Set}}{65{,}535}$$

WARNING

Do NOT apply a modulation voltage in excess of ±15 volts. Voltages exceeding this maximum value will result in internal instrument damage that is not covered under warranty.

8. **Laser Cathode Configuration:** The bottom right section, Laser Cathode Configuration, allows the user to change the laser diode cathode configuration to either Pin 12 or Pin 3. To avoid the possibility of damaging your laser diode due to a momentary open-circuit the instrument automatically prevents the user from changing the laser cathode pin with the output on.

INTERNAL TEC CONTROLLER SUB-SECTION

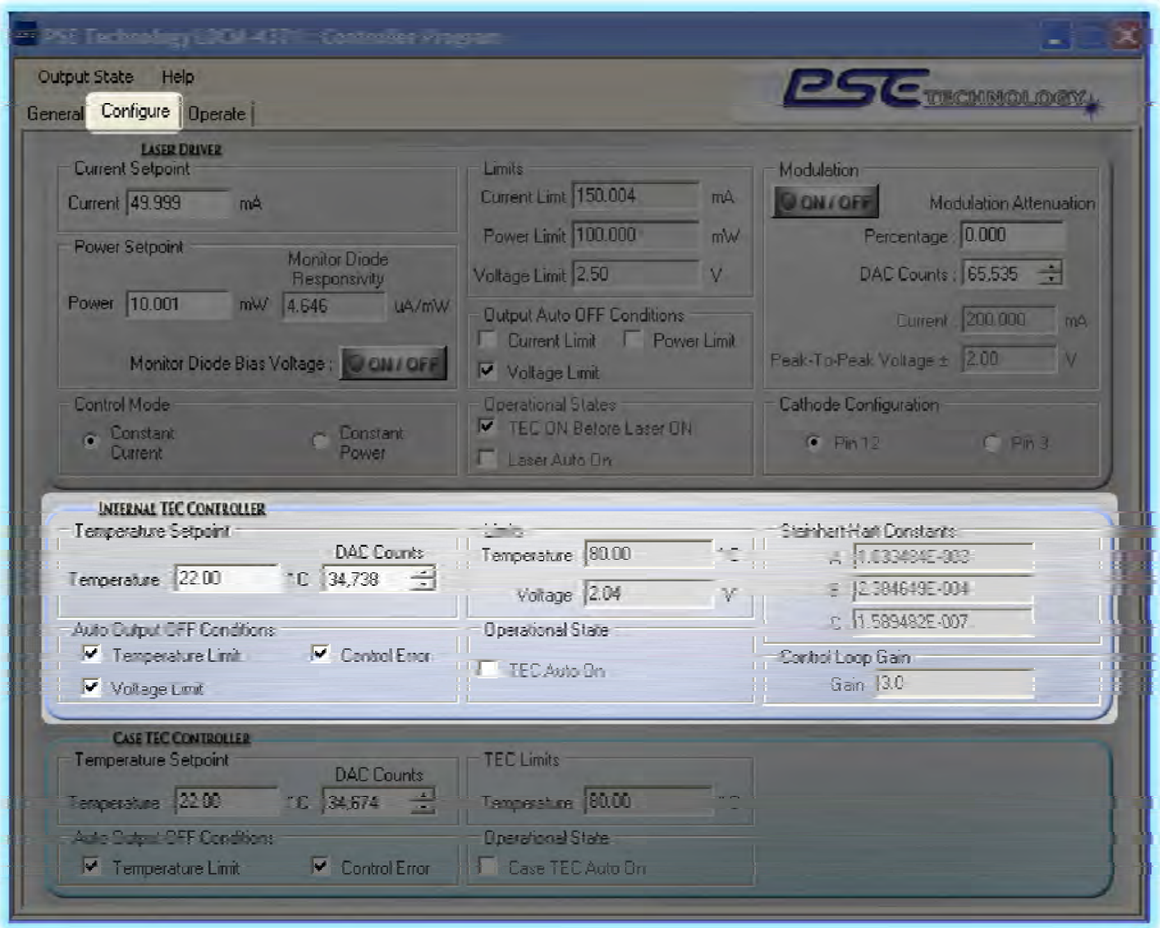


Figure 3.9: Configure – Internal TEC Controller Menu Screenshot

1. **TEC Temperature Setpoint:** The upper left sub-section, TEC Temperature Setpoint, allows the user to adjust the TEC controller temperature setpoint value in either Celsius or actual DAC (Digital to Analog Converter) counts. The TEC temperature setpoint value has a minimum of -100.0 degrees Celsius and a maximum of +100.0 degrees Celsius. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. Although this command accepts a wide range of setpoint values, the temperature limit for some of the more extreme temperatures may be limited by the maximum available drive voltage of 5 volts.

2. **TEC Auto Output OFF Conditions:** The bottom left sub-section, TEC Auto Output OFF Conditions, configures the limit conditions that will force the instrument to automatically disable the TEC and/or laser output when they occur. When the TEC is first enabled, it is normal for the controller to drive to the voltage limit and for the control error signal to be active. Therefore the instrument automatically waits for these two conditions to reach their normal steady state for a one minute period before enabling. Please note that when the “TEC On Before Laser” feature is enabled, any of these conditions will not only disable the TEC output but also the Laser output.

3. **TEC Limits:** The upper middle sub-section, TEC Limits, allows the user to adjust the two TEC controller limit values. These include the following:

   a. The **TEC Temperature Limit** allows the user to adjust the TEC controller temperature limit setpoint value in degrees Celsius. The TEC temperature limit setpoint value has a maximum of +100.0 degrees Celsius. Attempting to set a value above this maximum will generate an error and the requested setting will be ignored. The TEC temperature limit is single ended; it is only active when the temperature exceeds the temperature limit. This laser protection feature does not actively limit the TEC temperature, when configured it disables both the TEC and laser output.

b. The **TEC Voltage Limit** allows the user to adjust the TEC controller voltage limit setpoint value in volts. The TEC voltage limit setpoint value has a minimum of 0.0 volts and a maximum of 5.0 volts. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. This laser protection feature will actively limit the TEC voltage, when configured it can also automatically disable both the TEC and laser output when the TEC voltage exceeds the limit.

4. **TEC Operational State:** The lower middle sub-section, TEC Operational State, configures the state of TEC Auto On flag. As an added layer of protection for the laser diode, it is recommended to use the TEC on before laser enabled feature in conjunction with this feature. This will ensure thermal damage does not occur to the laser diode in the event a TEC error automatically disables the output.

5. **Steinhart-Hart Constants:** The top right section, Steinhart-Hart Constants, allows the user to adjust the Steinhart-Hart thermistor equation constants. The three-term Steinhart-Hart thermistor equation is shown below:

$$\frac{1}{T} = A + B \times \ln(R) + C \times \ln(R)^3$$

Where T is the absolute temperature in Kelvin and R is the thermistor resistance in ohms. The terms A, B, and C are the Steinhart-Hart constants for the thermistor. The factory default settings are:

- A term for a typical DFB laser = $1.033\text{x}10^{-3}$
- B term for a typical DFB laser = $2.385\text{x}10^{-4}$
- C term for a typical DFB laser = $15.894\text{x}10^{-8}$.

6. **Control Loop Gain:** The lower right sub-section, Control Loop Gain, allows the user to adjust the TEC controller PID gain setpoint value. The TEC gain setpoint value has a minimum of 1.0 and a maximum of 51.0. Setting a gain value that is too low will result in a slow response and a gain that is set too high may oscillate.

CASE TEC CONTROLLER SUB-SECTION

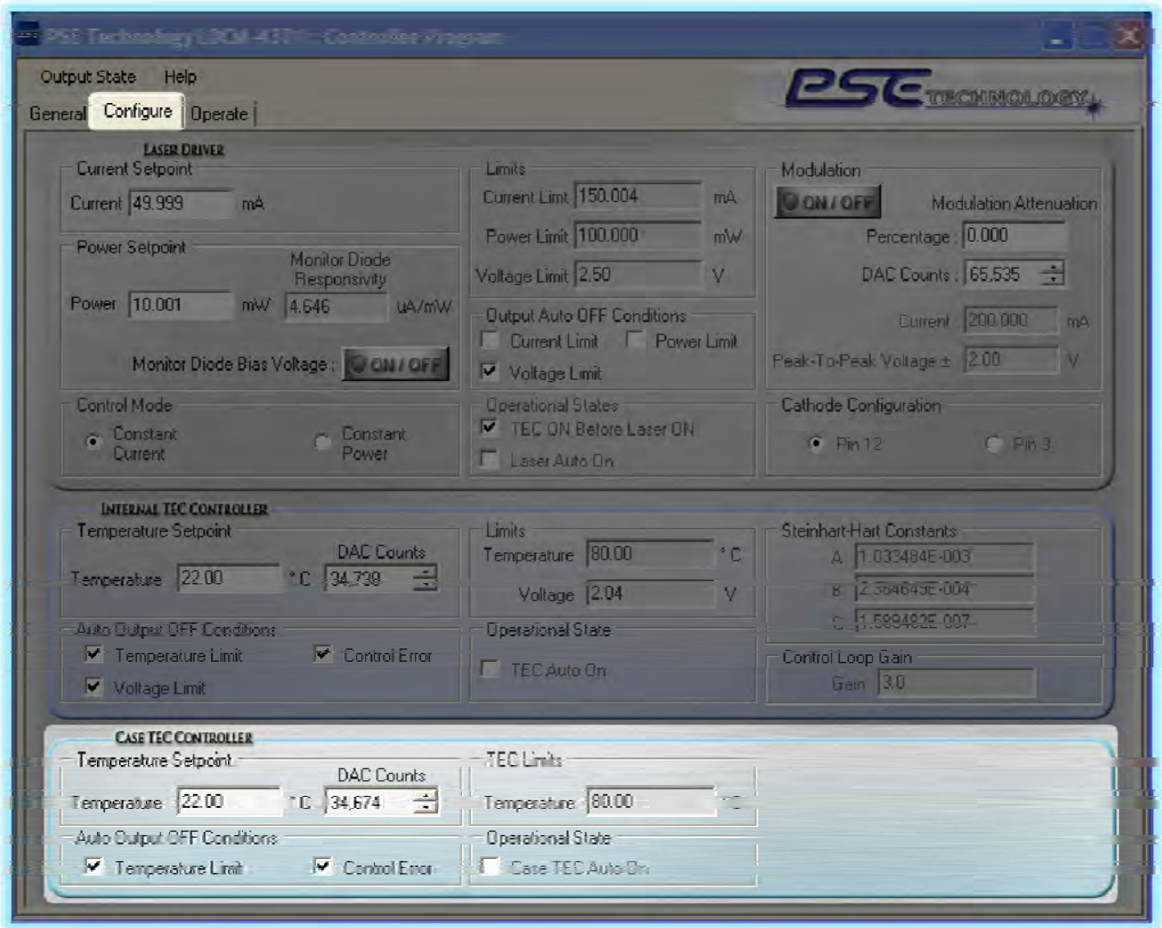


Figure 3.10: Configure – Case TEC Controller Menu Screenshot

1. **Case TEC Temperature Setpoint:** The upper left sub-section, Case TEC Temperature Setpoint, allows the user to adjust the Case TEC controller temperature setpoint value in either degrees Celsius or actual DAC (Digital to Analog Converter) counts. The Case TEC temperature setpoint value has a minimum of -100.0 degrees Celsius and a maximum of +100.0 degrees Celsius. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. Although this command accepts a wide range of setpoint values, the temperature limit for some of the more extreme temperatures may be limited by the maximum available drive voltage of 5.0 volts.

WARNING *Avoid setting a case temperature below the dew point. The case TEC is Not hermetically sealed; allowing condensation to form on the case TEC will result in internal instrument damage that is not covered under warranty.*

2. **Case TEC Auto Output OFF Conditions:** The bottom left sub-section, Case TEC Auto Output OFF Conditions, configures the conditions that will force the instrument to automatically disable the TEC and/or laser outputs when they occur. When the Case TEC is first enabled, it is normal for the control error signal to be active. Therefore the instrument automatically waits for these this condition to reach the normal steady state for a one minute period before enabling. Please note that when the “TEC On Before Laser” feature is enabled, either of these conditions will not only disable the TEC output but also the Laser output.

3. **Case TEC Limits:** The top right sub-section, Case TEC Limits, contains the Case TEC Temperature Limit. This allows the user to adjust the Case TEC controller temperature limit setpoint value in degree Celsius. The Case TEC temperature limit setpoint value has a maximum of +100.0 degrees Celsius. Attempting to set a value above the maximum will generate an error and the requested setting will be ignored. As with the internal TEC controller,

the limit is single ended (i.e. it is only active when the temperature exceeds the limit). This laser protection feature does not actively limit the Case TEC temperature, when configured it disables both TECs and the laser output when the Case TEC temperature exceeds the limit.

4. **Case TEC Operational State:** The bottom right sub-section, Case TEC Operational State, configures the state of Case TEC Auto On flag. As an added layer of protection for the laser diode, it is recommended to use the TEC on before laser enabled feature in conjunction with this feature. This will ensure thermal damage does not occur to the laser diode in the event a Case TEC error automatically disables the output.

OPERATE TAB MENU

Operate: As shown in Figure 3.11 below, the third tab in the sequence is the Operate tab. Key instrument parameters can be set, adjusted, and displayed through this menu in the Instrument Controller Program. This menu is not intended for detailed instrument configuration, the main purpose of this menu is for instrument operation. It is broken into three individual sections.

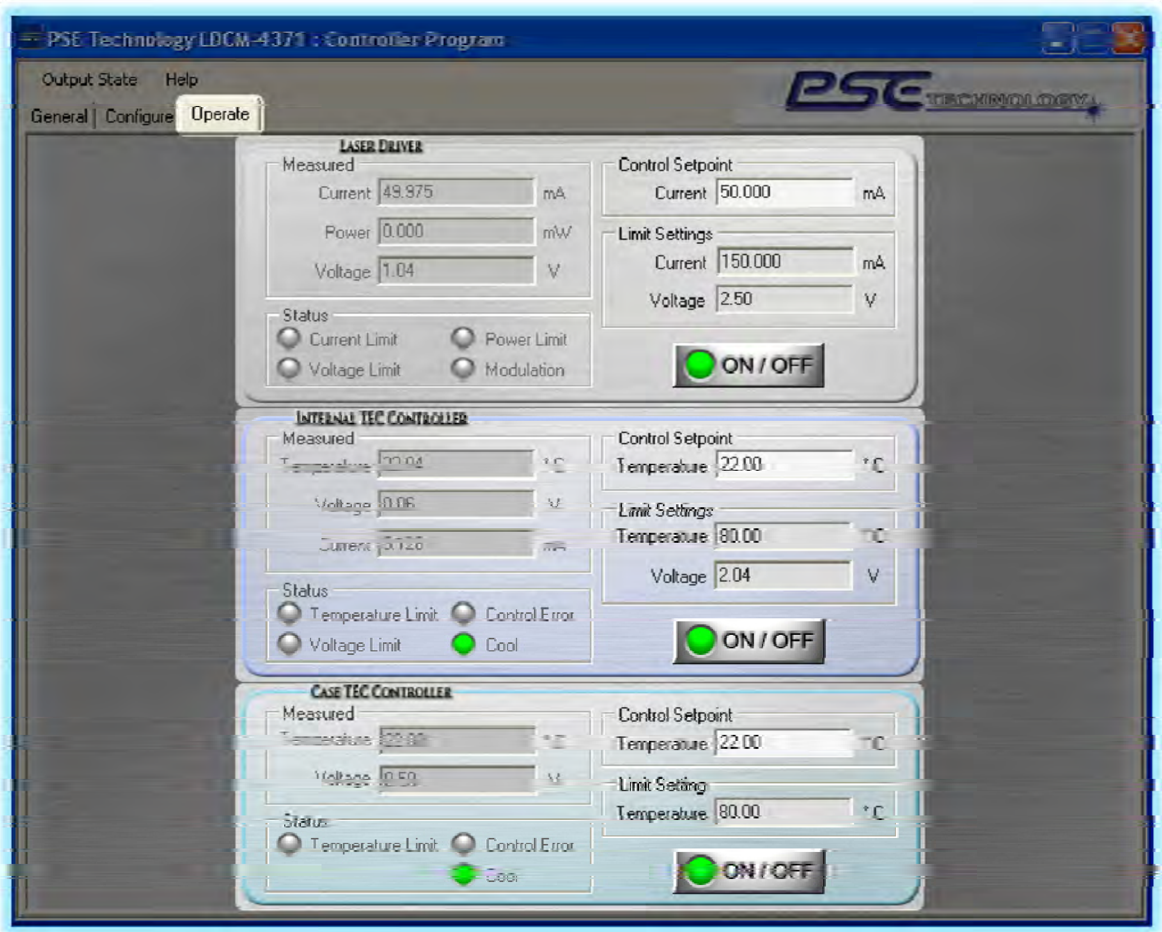


Figure 3.11: Operate Menu Screenshot

1. **Laser Driver:** The top section is for operating the Laser Driver. Within this section the user can monitor the measured values, update the limit setpoint values, update the control setpoint values, and monitor the status states. Depending on which of the two control modes (Constant Current or Constant Power) the program will dynamically update the control and limit prefix to either current or power and the postfix to either mA or mW.

2. **Internal TEC Controller:** The middle section is for operating the Internal TEC Controller. Within this section the user can monitor the measured values, update the limit setpoint values, update the control setpoint value, and monitor the status states.

3. **Case TEC Controller:** The bottom section is for operating the Case TEC Controller. Within this section the user can monitor the measured values, update the limit setpoint value, update the control setpoint value, and monitor the status states.

LASER DRIVER SUB-SECTION

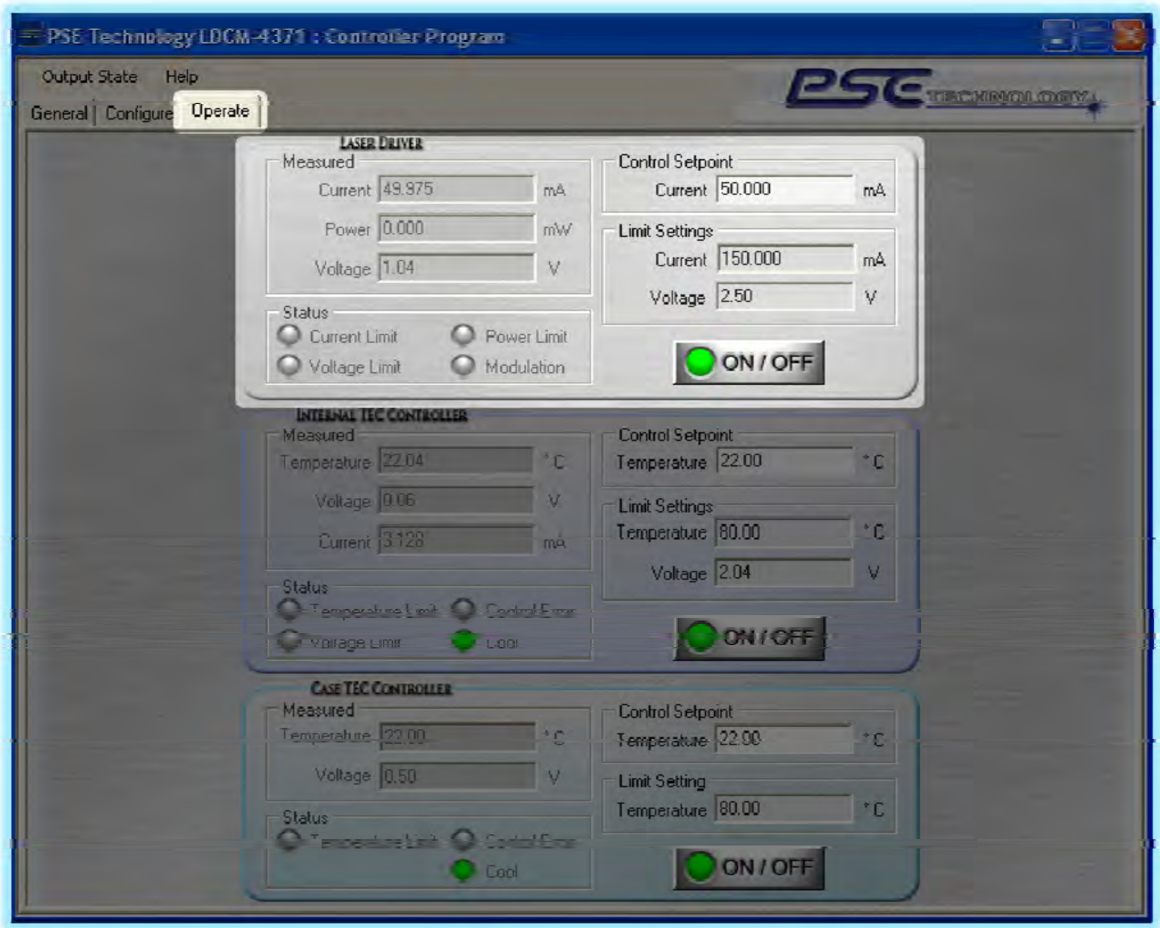


Figure 3.12: Operate – Laser Driver Menu Screenshot

1. **Measured:** The Measured sub-section is located in the upper left of the Laser Driver section. This sub-section is used to display the measured laser diode current, forward voltage and calculated power.

2. **Status:** Directly below the Measured sub-section is the Status sub-section. This sub-section displays the current state of laser diode driver status flags.

3. **Control Setpoint:** The Control Setpoint sub-section is located in the upper right of the Laser Driver section. This sub-section provides the user with a convenient location to adjust the constant current or power control setpoint value depending on the selected control mode.

4. **Limit Settings:** Located on the directly below the control setpoint sub-section is the Limit Settings sub-section. This sub-section provides the user with a convenient location to adjust the two limit setpoint values.

5. **LASER Output ON/OFF Button:** The LASER Output Button is located directly below the Limit Settings sub-section. It contains the Laser ON / OFF button, and associated state indicator LED. Clicking this button will toggle the on or off state of the laser output. Laser safety requirements mandate that a five second safety activation delay expire prior to the laser output actually being enabled. During the safety delay period the button will flash green, indicating the delay is active. Once the laser is ON, the button LED will turn green unless a limit condition is active. If one of the three limit conditions is active the button LED will flash red, warning the

user about the active limit condition. If the laser fails to go on or quickly turns itself off, read the error queue to help determine the reason.

Whenever enabling the laser output the user should always exercise caution to avoid accidental exposure to possibly hazardous laser radiation.

INTERNAL TEC CONTROLLER SUB-SECTION

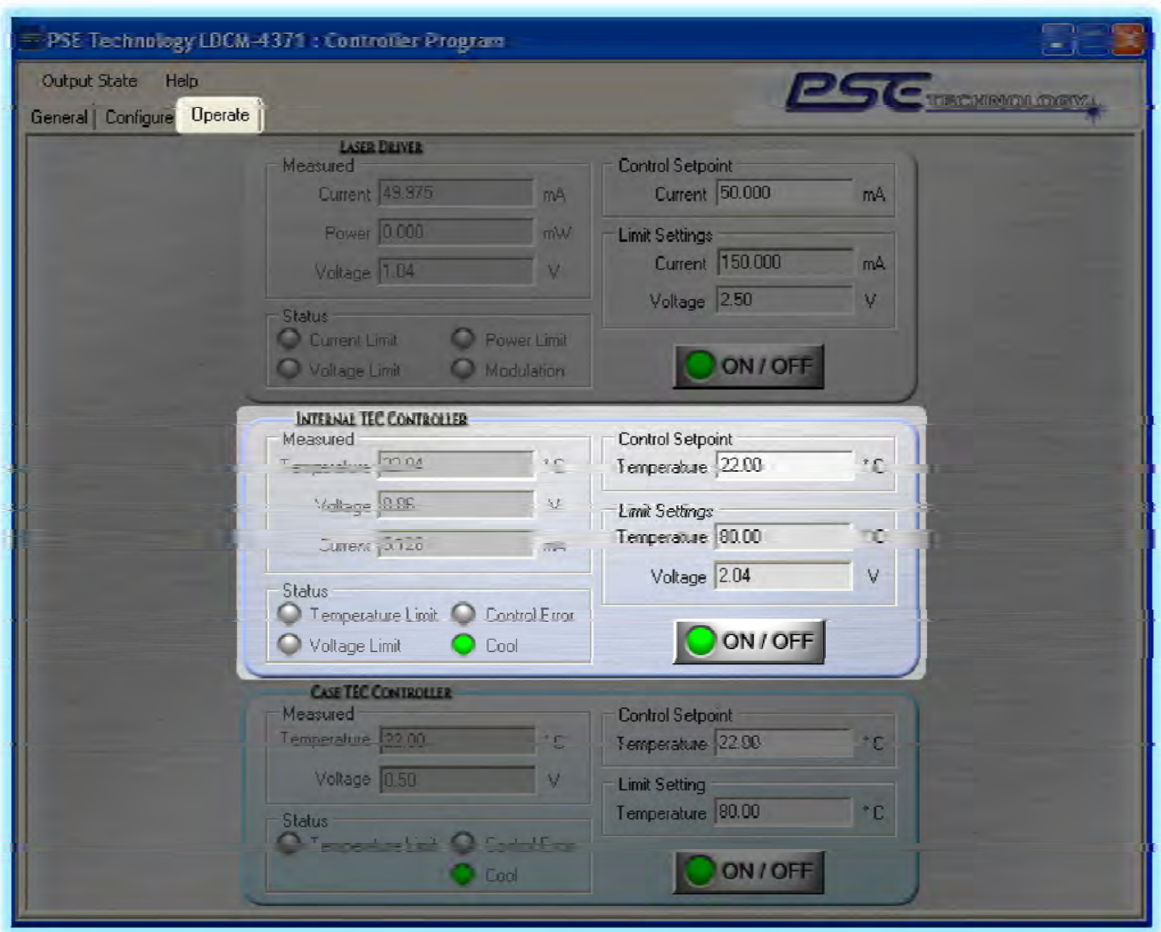


Figure 3.13: Operate – Internal TEC Controller Menu Screenshot

1. **Measured:** The Measured sub-section is located in the upper left of the Internal TEC section. This sub-section is used to display the measured Internal TEC temperature, current, and voltage.
2. **Status:** Directly below the Measured sub-section is the Status sub-section. This sub-section displays the current state of TEC status flags.
3. **Control Setpoint:** The Control Setpoint sub-section is located in the upper right of the Internal TEC section. This sub-section provides the user with a convenient location to adjust the Internal TEC temperature setpoint value.
4. **Limit Settings:** Located directly below the control setpoint sub-section is the Limit Settings sub-section. This sub-section provides the user with a convenient location to adjust the two limit setpoint values.
5. **Internal TEC Output ON/OFF Button:** The laser Internal TEC Output ON / OFF Button is located directly below the Limit Settings sub-section. It contains the TEC ON / OFF button and

indicator LED. Clicking this button will toggle the on or off state of the internal TEC output. When the TEC is ON, the indicator LED will turn green unless a limit condition is active. If one of the three limit conditions is active the indicator LED will flash red, warning the user about the active limit condition. If the Internal TEC fails to go on or quickly turns itself off, read the error queue to help determine the reason. The Heat/Cool status LED and text will indicate which one of the three TEC operational states is active, Heating, Cooling, or TEC Output Off.

Case TEC Controller Sub-Section

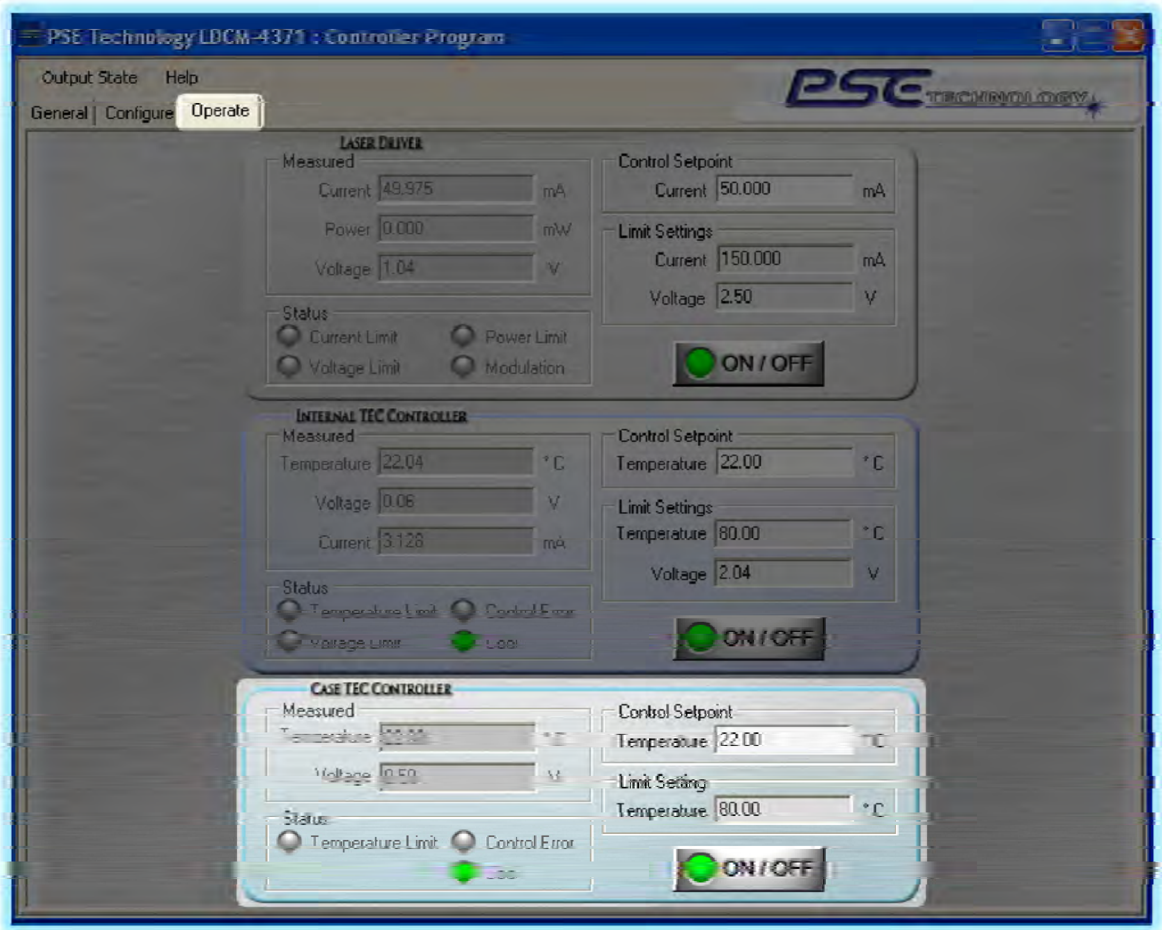


Figure 3.14: Operate – Case TEC Controller Menu Screenshot

1. **Measured:** The Measured sub-section is located in the upper left of the Case TEC section. This sub-section is used to display the measured Case TEC temperature and voltage.

2. **Status:** Directly below the Measured sub-section is the Status sub-section. This sub-section displays the current state of the two Case TEC status flags.

3. **Control Setpoint:** The Control Setpoint sub-section is located in the upper right of the Case TEC section. This sub-section provides the user with a convenient location to adjust the Case TEC temperature setpoint value.

WARNING *Avoid setting a case temperature below the dew point. The case TEC is Not hermetically sealed; allowing condensation to form on the case TEC will result in internal instrument damage that is not covered under the warranty.*

4. **Limit Settings:** Located directly below the control setpoint sub-section is the Limit Settings sub-section. This sub-section provides the user with a convenient location to adjust the temperature limit setpoint value.

5. **Case TEC Output State:** The Case TEC Output ON/OFF Button is located directly below the Limit Settings sub-section. It contains the Case TEC ON / OFF button and indicator LED. Clicking this button will toggle the on or off state of the case TEC output. When the Case TEC is ON, the indicator LED will turn green unless a limit condition is active. If one of the two limit conditions is active the indicator LED will flash red, warning the user about the active limit condition. If the Case TEC fails to go on or quickly turns itself off, read the error queue to help determine the reason. The Heat/Cool status LED and text will indicate which one of the three Case TEC operational states is active, Heating, Cooling, or TEC Output Off.

Operational Error Messages

During instrument operation the following unexpected error conditions may occur. In the event of one of these operational error conditions, the offending output will be automatically disabled and the corresponding instrument's Output On/Off button LED will be illuminated red. This automatic action by the instrument may leave the instrument in an unexpected state that confuses the user. When an output is automatically disabled the best troubleshooting technique is to determine the cause of the condition by reading the non-volatile instrument error queue. As described earlier in this section, the errors can be accessed using the Instrument Controller Program. The following list provides a summary of the operational errors that may occur.

ERROR CODE	DESCRIPTION
12	[20] Instrument internal temperature sensor is over limit, disables all outputs
13	[20] Laser mode changed with output on, automatically disables the laser output
14	[20] Laser cathode pin changed output on, automatically disables the laser output
15	[20] External interlock switch state disabled the laser output
16	[20] Laser key switch state disabled the laser output
17	[20] Switched to USB power with a controller output on
18	[20] User attempted to enable laser output when operating on USB power
19	[20] User attempted to enable TEC output when operating on USB power
20	[20] User attempted to enable case TEC output when operating on USB power
55	[20,21] User attempted to enable the laser with the TEC output off
60	[20,21] The laser current limit automatically turned the laser output off
61	[20,21] The laser power limit automatically turned the laser output off
62	[20,21] The laser voltage limit automatically turned the laser output off
70	[20,21] User disabled the TEC with the laser output on, automatically disables laser
71	[20,21] The TEC temperature limit automatically turned the TEC output off
72	[20,21] The TEC control error automatically turned the TEC output off
73	[20,21] The TEC voltage limit automatically turned the TEC output off
74	[20] The TEC Thermistor sensor shorted, resistance is less than 25Ω or +465 °C
75	[20] The TEC Thermistor sensor open, resistance is greater than 1.2MΩ or -65 °C
80	[20,21] The case TEC temperature limit automatically turned the case TEC off
81	[20,21] The case TEC control error limit automatically turned the output off
82	[20] The Case Thermistor sensor shorted, resistance is less than 25Ω or +465 °C
83	[20] The Case Thermistor sensor open, resistance is greater than 1.2MΩ or -65 °C
100	**USB Configuration EEPROM is not responding**
101	**Program Configuration Memory is corrupted**
102	**Temperature sensor data format error detected**
103	**An unrecognized type 1 interrupt was received**
104	**An unrecognized type 2 interrupt was received**
105	**Internal oscillator fault detected**
106	**Invalid flash memory access fault detected**

Table 3.1: Instrument Operational Error Codes

WARNING

The 100 series error codes, highlighted in bold, indicate that a severe hardware error condition has been detected. Service is recommended; please return the instrument for repair by trained service personnel.

[20] These error conditions can automatically disable some or all the controller outputs
[21] These error conditions can be configured by the user to automatically disable the controller outputs

CHAPTER 4 – PROGRAMMING REFERENCE

INTRODUCTION

This chapter provides a detailed explanation for all the individual user programmable instrument commands available through the USB interface. The instrument communicates with the host computer by receiving properly formatted messages and returning appropriately formatted reply data. The messages contain device-specific information such as programming instructions, measurement results, and instrument status.

Everything you can do from the front panel or configuration program can also be done programmatically, and in some cases, with more flexibility. For instance, with programming you have access to commands for functions not found on the front panel. The following chapter describes the fundamentals of the general setup of your LDCM-4371 Laser Diode Controller Mount programmatically through the USB interface. For the most efficient and effective remote control of your instrument, we recommend you study this chapter.

PROGRAMMING COMMAND SUMMARY

The following list is a summary of all the user programmable instrument commands. The specific detail for each command is contained later in this chapter at the page number indicated in the right most column.

TYPE	DESCRIPTION	HEADER	PAGE
General	Set Instrument User Description	10	58
General	Query Instrument User Description	11	59
General	Query Instrument Serial Number	12	59
General	Query Firmware Version	13	60
General	Query Hardware Version	14	60
General	Query Configuration	15	61
General	Query Active Limits	16	62
General	Query Internal Instrument Temperature	17	63
General	Query Power Source	18	63
General	Query Error Queue	19	64
General	Clear Error Queue	20	64
General	Set/Clear TEC On Before Allowing Laser On State	21	65
General	Query TEC On Before Allowing Laser On State	22	65
General	Set/Clear Flash Button LED's On Limit Condition State	23	66
General	Query Flash Button LED's On Limit Condition State	24	67
General	Set/Clear Front Panel Button Lockout State	25	67
General	Query Front Panel Button Lockout State	26	68
General	Reset Instrument To Factory Default Settings	27	69
Laser Driver	Query Measured Laser Current Value	40	71
Laser Driver	Query Measured Laser Voltage Value	41	72
Laser Driver	Query Measured Laser Power Value	42	73
Laser Driver	Query Laser Current Limit State	43	74
Laser Driver	Query Laser Voltage Limit State	44	74
Laser Driver	Query Laser Power Limit State	45	75
Laser Driver	Query Laser Safety Interlock State	46	75
Laser Driver	Set/Clear Laser Output State	47	76
Laser Driver	Query Laser Output State	48	76
Laser Driver	Set/Clear Laser Modulation Enabled State	49	77
Laser Driver	Query Laser Modulation Enabled State	50	77
Laser Driver	Set/Clear Monitor Diode Reverse Bias Voltage State	51	78
Laser Driver	Query Monitor Diode Reverse Bias State	52	79
Laser Driver	Set Laser Cathode Pin Number	53	80

TYPE	DESCRIPTION	HEADER	PAGE
Laser Driver	Query Laser Cathode Pin Number	54	81
Laser Driver	Set Laser Control Mode (CC = 1 or CP = 0)	55	82
Laser Driver	Query Laser Control Mode (CC = 1, CP = 0)	56	83
Laser Driver	Set/Clear Laser Output Automatic On State	57	84
Laser Driver	Query Laser Output Automatic On State	58	85
Laser Driver	Set/Clear Laser Off When Current Limit Occurs State	59	85
Laser Driver	Query Laser Off When Current Limit Occurs State	60	86
Laser Driver	Set/Clear Laser Off When Voltage Limit Occurs State	61	86
Laser Driver	Query Laser Off When Voltage Limit Occurs State	62	87
Laser Driver	Set/Clear Laser Off When Power Limit Occurs State	63	88
Laser Driver	Query Laser Off When Power Limit Occurs State	64	88
Laser Driver	Set Laser Constant Current Setpoint	65	88
Laser Driver	Query Laser Constant Current Setpoint	66	89
Laser Driver	Set Laser Constant Current DAC Counts	67	89
Laser Driver	Query Laser Constant Current DAC Counts	68	90
Laser Driver	Set Laser Modulation Current Setpoint	69	91
Laser Driver	Query Laser Modulation Current Setpoint	70	92
Laser Driver	Set Laser Modulation Attenuation DAC Counts	71	93
Laser Driver	Query Laser Modulation Attenuation DAC Counts	72	94
Laser Driver	Set Modulation Peak-To-Peak Voltage	73	95
Laser Driver	Query Modulation Peak-To-Peak Voltage	74	96
Laser Driver	Set Laser Current Limit Setpoint	75	96
Laser Driver	Query Laser Current Limit Setpoint	76	97
Laser Driver	Set Laser Voltage Limit Setpoint	77	97
Laser Driver	Query Laser Voltage Limit Setpoint	78	98
Laser Driver	Set Laser Constant Power Setpoint	79	98
Laser Driver	Query Laser Constant Power Setpoint	80	99
Laser Driver	Set Laser Constant Power DAC Counts	81	99
Laser Driver	Query Laser Constant Power DAC Counts	82	100
Laser Driver	Set Laser Power Limit Setpoint	83	100
Laser Driver	Query Laser Power Limit Setpoint	84	101
Laser Driver	Set Monitor Diode Responsivity	85	102
Laser Driver	Query Monitor Diode Responsivity	86	103
TEC Controller	Query Measured TEC Temperature Value	100	105
TEC Controller	Query Measured TEC Voltage Value	101	106
TEC Controller	Query Measured TEC Current Value	102	107
TEC Controller	Query TEC Upper Temperature Limit State	103	107
TEC Controller	Query TEC Voltage Limit State	104	108
TEC Controller	Query TEC Control Error State	105	108
TEC Controller	Set/Clear TEC Output State	106	109
TEC Controller	Query TEC Output State	107	109
TEC Controller	Set/Clear TEC Automatic Output On State	108	110
TEC Controller	Query TEC Automatic Output On State	109	110
TEC Controller	Set/Clear TEC Off When Temperature Limit Occurs State	110	111
TEC Controller	Query TEC Off When Temperature Limit Occurs State	111	111
TEC Controller	Set/Clear TEC Off When Voltage Limit Occurs State	112	112
TEC Controller	Query TEC Off When Voltage Limit Occurs State	113	113
TEC Controller	Set/Clear TEC Off When Control Error Occurs State	114	114
TEC Controller	Query TEC Off When Control Error Occurs State	115	114
TEC Controller	Set TEC Temperature Setpoint	116	115
TEC Controller	Query TEC Temperature Setpoint	117	115
TEC Controller	Set TEC Temperature DAC Counts	118	116
TEC Controller	Query TEC Temperature DAC Counts	119	116

TYPE	DESCRIPTION	HEADER	PAGE
TEC Controller	Set TEC Gain Setpoint	120	117
TEC Controller	Query TEC Gain Setpoint	121	117
TEC Controller	Set TEC Gain DAC Counts	122	118
TEC Controller	Query TEC Gain DAC Counts	123	118
TEC Controller	Set TEC Upper Temperature Limit Setpoint	124	119
TEC Controller	Query TEC Upper Temperature Limit Setpoint	125	119
TEC Controller	Set TEC Voltage Limit Setpoint	126	120
TEC Controller	Query TEC Voltage Limit Setpoint	127	120
TEC Controller	Set Steinhart-Hart Constant A	128	121
TEC Controller	Query Steinhart-Hart Constant A	129	122
TEC Controller	Set Steinhart-Hart Constant B	130	123
TEC Controller	Query Steinhart-Hart Constant B	131	124
TEC Controller	Set Steinhart-Hart Constant C	132	125
TEC Controller	Query Steinhart-Hart Constant C	133	126
Case Controller	Query Measured Case TEC Temperature Value	200	128
Case Controller	Query Measured Case TEC Voltage Value	201	129
Case Controller	Query Case TEC Upper Temperature Limit State	202	129
Case Controller	Query Case TEC Control Error State	203	130
Case Controller	Set/Clear Case TEC Output State	204	130
Case Controller	Query Case TEC Output State	205	131
Case Controller	Set/Clear Case TEC Output Automatically On State	206	131
Case Controller	Query Case TEC Output Automatically On State	207	132
Case Controller	Set/Clear Case TEC Off When Temperature Limit Occurs State	208	132
Case Controller	Query Case TEC Off When Temperature Limit Occurs State	209	133
Case Controller	Set/Clear Case TEC Off When Control Error Occurs State	210	133
Case Controller	Query Case TEC Off When Control Error Occurs State	211	134
Case Controller	Set Case TEC Temperature Setpoint	212	135
Case Controller	Query Case TEC Temperature Setpoint	213	135
Case Controller	Set Case TEC Temperature DAC Counts	214	136
Case Controller	Query Case TEC Temperature DAC Counts	215	136
Case Controller	Set Case TEC Upper Temperature Limit Setpoint	216	137
Case Controller	Query Case TEC Upper Temperature Limit Setpoint	217	137

Table 4.1: Programming Command Summary

PROGRAMMING GENERAL INFORMATION

DATA PACKET FORMAT

The generic communications format consists of a data packet organized as follows:

LENGTH	HEADER	PAYLOAD	CRC
1 – Byte	1 – Byte	0 to 39 Bytes	2 – Bytes
4 to 43	Unique to command	None (0 – Bytes)	CRC-16-IBM Algorithm[22]
		Boolean (1 – Byte)	
		String (1 to 39 – Bytes)	
		Unsigned Integer (2 – Bytes)	
		Long (4 – Bytes)	
		Double (8 – Bytes)	

Table 4.2: Data Packet Format

[22] See the appendix for a detailed explanation of the CRC-16-IBM Algorithm

- The length byte holds a numeric representation of the total message length. This includes the length byte, header byte, payload bytes, and CRC bytes. Valid message lengths for this instrument vary from 4 to 43 bytes.
- The header is a single byte that contains a unique value that represents each of the individual programmable commands.
- As depicted in Table 4.2 above, the payload or command parameter can consist of several different data types. The data types are further explained below:
  1. Boolean – or flag is also referred to as the logical data type, it can have one of two values: one or zero (which are equivalent to true and false, respectively). Since we use a full byte to represent the Boolean data type, a value of zero represents false and all other values are evaluated as a true.
  2. String – an array of single characters in ASCII format that denotes text.
  3. Unsigned Integer – can hold a whole number, but no fraction. Integers may be either signed (allowing negative values) or unsigned (non-negative values only). The range of a signed integer is ±32,768 and the range of an unsigned integer is 0 to 65,535.
  4. Long – identical to the standard integer type described directly above, with the exception that the range has been extended to ±2,147,483,648 for the signed version and 0 to 4,294,967,295 for the unsigned version. However, the one long implemented in this instrument is non-typical, it is a compilation of several individual Boolean flags grouped together to provide a convenient method to query all the program flags with a single command. See the general instrument command, Query Configuration for more details.
  5. Double – an extended range floating point number. A floating point number represents a real number that may have a fractional part. The range for the double floating point number is ≈ $\pm 2.22507 \times 10^{-308}$. The bits are laid out as follows:

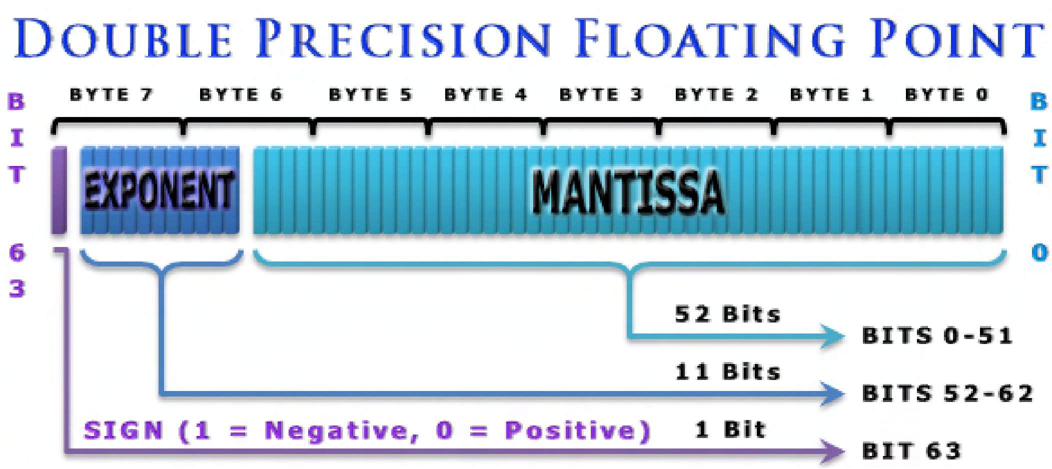


Figure 4.1: Double Number Format

- The cyclic redundancy check, CRC, is a coding technique for detecting errors in data. It is primarily used to protect data transmission. A number of check bits are appended to the message being transmitted. The receiver determines whether the check bits agree with the message to ascertain with a certain probability whether a transmission error occurred. CRC's are only used for error detection; they are not usable for error correction. Therefore, when an error occurs it is essential that the controlling program detect the condition and retransmit the corrupted data packet. Please reference the appendix for details on the CRC algorithm implementation.

PROGRAMMING RESPONSE

To ensure communications were received by the instrument, all commands will result in a response message. When data is transmitted in response to a query, the instrument will signify proper operation by returning valid data. When a command is issued that does not require response data, the instrument while signify success by returning an acknowledge character (ACK) in the payload. However, in both cases when a problem is detected the instrument will return a NOT acknowledge character (NAK) in the payload. These ACK and NAK characters are the standard communications characters defined in the ASCII code set:

- ACK = 6 = Acknowledge, valid communications
- NAK = 21 = Negative Acknowledge, invalid communications

PROGRAMMING ERROR MESSAGES

The following list of error codes can occur while programming the instrument. These indicate a problem with the instrument command issued, payload data, or the communications activity. The errors can be accessed by issuing the error query. When this is done, all of the error codes which are resident in the non-volatile error queue are returned (up to the last 10 may be stored). Reading the error queue does not clear the error queue. The error queue can only be emptied by sending the clear error queue command.

ERROR CODE	DESCRIPTION
10	Factory protected command received without proper security access
11	Invalid factory security access code detected
30	Unrecognized system type command header
31	Unrecognized laser type command on USB message receipt
32	Unrecognized TEC type command on USB message receipt
33	Unrecognized case TEC type command on USB message receipt
40	Invalid packet size for command
41	Indicated packet length is less than the minimum
42	Indicated packet length is greater than the maximum
43	Incomplete message packet was detected
44	Corrupted packet detected
45	Over-run error detected, new byte received before last message was processed
46	Byte framing error detected
47	Byte overflow error detected, new byte received before buffer empty
50	User requested DAC count above maximum value
51	User requested DAC count below zero
52	User requested a value greater than the maximum allowed for the parameter
53	User requested a value less than the minimum allowed for the parameter
54	User sent a case TEC command without the case TEC option installed

Table 4.3: Programming Error Codes

The remaining chapter is divided into two parts. The first contains an overview of the programmable commands used by the instrument, as shown in Table 4.4. The second part describes and details each of the individual commands listed in the table, these are listed in order of the unique command header code.

GENERAL COMMAND SUMMARY

HEADER	LENGTH	PARAMETER	RESPONSE	DESCRIPTION
10	42	39 x String	ACK or NAK	Set Instrument User Description
11	4	None	39 x String	Query Instrument User Description
12	4	None	9 x String	Query Instrument Serial Number
13	4	None	5 x String	Query Firmware Version
14	4	None	5 x String	Query Hardware Version
15	4	None	Unsigned Long	Query Configuration
16	4	None	Unsigned Integer	Query Active Limits
17	4	None	Double	Query Internal Instrument Temperature
18	4	None	Boolean	Query Instrument Power Source
19	4	None	10 x Bytes	Query Error Queue
20	4	None	ACK or NAK	Clear Error Queue
21	5	Boolean	ACK or NAK	Set/Clear TEC On Before Allowing Laser On State
22	4	None	Boolean	Query TEC On Before Allowing Laser On State
23	5	Boolean	ACK or NAK	Set/Clear Flash Button LED's On Limit Condition State
24	4	None	Boolean	Query Flash Button LED's On Limit Condition State
25	5	Boolean	ACK or NAK	Set/Clear Front Panel Button Lockout State
26	4	None	Boolean	Query Front Panel Button Lockout State
27	4	None	ACK or NAK	Reset Instrument To Factory Default Settings

Table 4.4: General Instrument Commands

GENERAL COMMAND DETAILS

GENERAL
LASER
TEC
CASE

SET INSTRUMENT USER DESCRIPTION

Action	Writes a user configurable ASCII formatted text string to the instruments non-volatile memory.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The description string is limited to a maximum of 39 characters. The description string is useful in providing a means to uniquely identify individual instruments connected with multiple instruments on a multiport USB hub.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 to 39 Bytes)	CRC (2 Bytes)
43	10	String	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	10	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY INSTRUMENT USER DESCRIPTION

Action	Reads the user configurable description stored in the instruments non-volatile memory.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a variable length character string, up to a maximum of 39 characters, is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The description string is limited to a maximum of 39 characters. The description string is useful in providing a means to uniquely identify individual instruments connected with multiple instruments on a multiport USB hub. The default description when shipped from the factory is "LDCM-4371 Laser Diode Controller Mount".

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	11	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (39 Bytes)	CRC (2 Bytes)
43	11	String	Calculated
5	11	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY INSTRUMENT SERIAL NUMBER

Action	Reads the instruments unique serial number identifier.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a nine digit ASCII formatted character string that represents the unique instrument serial number is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	To help ensure prompt support please provide customer service with the instrument serial number when requesting assistance.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	12	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 9 Bytes)	CRC (2 Bytes)
13	12	String	Calculated
5	12	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY FIRMWARE VERSION

Action	Reads the version number of the firmware controlling the instrument.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a five character ASCII string formatted as follows XX:YY is returned. Where the digits in the XX position represent the major firmware version and the digits in the YY position represent the minor firmware version. The major and minor firmware versions are separated with the colon character. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	To help ensure accurate service please provide customer service with the full instrument firmware version when requesting assistance.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	13	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 5 Bytes)	CRC (2 Bytes)
9	13	String	Calculated
5	13	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY HARDWARE VERSION

Action	Reads the version number of the hardware installed on the instrument.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a five character ASCII string formatted as follows XX:YY is returned. Where the digits in the XX position represent the analog platform hardware version and the digits in the YY position represent the digital platform hardware version. The two platform versions are separated with the colon character. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	To help ensure prompt support please provide customer service with the instrument hardware version when requesting assistance.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	14	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 5 Bytes)	CRC (2 Bytes)
9	14	String	Calculated
5	14	NAK	Calculated

QUERY CONFIGURATION

Action	Reads all the program configuration flags. This consists of 19 individual Boolean flags grouped into four bytes. The individual Boolean flags are listed: 1. BIT 0 : Laser Control Mode (1 = Constant Current, 0 = Constant Optical Power) 2. BIT 1 : Laser Current Limit condition forces output off (1 = True, 0 = False) 3. BIT 2 : Laser Voltage Limit condition forces output off (1 = True, 0 =False) 4. BIT 3 : Laser Optical Power Limit condition forces output off (1 = True, 0 = False) 5. BIT 4 : Laser Output Auto On when instrument powered up (1 = True, 0 = False) 6. BIT 5 : Laser Modulation Enabled (1 = True, 0 = False) 7. BIT 6 : Laser Monitor Photo-Diode 5V Reverse Bias On (1 = True, 0 = False) 8. BIT 7 : TEC Temperature Limit condition forces output off (1 = True, 0 = False) 9. BIT 8 : TEC Control Error Limit condition forces output off (1 = True, 0 = False) 10. BIT 9 : TEC Voltage Limit condition forces output off (1 = True, 0 = False) 11. BIT 10 : TEC Output Auto On when instrument powered up (1 = True, 0 = False) 12. BIT 11 : Case TEC Temperature Limit condition forces output off (1 = True, 0 = False) 13. BIT 12 : Case TEC Control Error Limit condition forces output off (1 = True, 0 = False) 14. BIT 13 : Require TEC Output On Before Laser Output On (1 = True, 0 = False) 15. BIT 14 : Heart Beat LED enabled (1 = True, 0 = False) 16. BIT 15 : Case TEC Output Auto On when instrument powered up (1 = True, 0 = False) 17. BIT 16 : Flash Button LED's when a limit condition is active (1 = True, 0 = False) 18. BIT 17 : Laser Safety Interlock state (1 = True, 0 = False) 19. BIT 18 : Lock Front Panel Buttons state (1 = Locked, 0 = Not Locked) 20. BIT 19 : Laser Cathode Pin (1 = Pin 3 as Cathode [Other], 0 = Pin 12 as Cathode [NEL]) BIT 20 – BIT 23 : Unused, will be read as zero's
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a long (4 bytes) value that represents the bit field flags listed above is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	If the instrument is not operating as expected, read the configuration flags and verify they are all set to the desired state.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	15	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 4 Bytes)	CRC (2 Bytes)
8	15	0 – 524287	Calculated
5	15	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY ACTIVE LIMITS

Action	Reads all the Boolean flags that indicate the state of the individual controller limits. This consists of 8 individual Boolean flags grouped into two bytes as follows: 1. BIT 0 : Laser reached Current Limit (1 = True, 0 = False) 2. BIT 1 : Laser exceeded Voltage Limit (1 = True, 0 = False) 3. BIT 2 : Laser exceeded Power Limit (1 = True, 0 = False) 4. BIT 3 : TEC exceeded Temperature Limit (1 = True, 0 = False) 5. BIT 4 : TEC exceeded Control Error Limit (1 = True, 0 = False) 6. BIT 5 : TEC reached Voltage Limit (1 = True, 0 = False) 7. BIT 6 : Case TEC exceeded Temperature Limit (1 = True, 0 = False) 8. BIT 7 : Case TEC exceeded Control Error Limit (1 = True, 0 = False) BIT 8 – BIT 23 : Unused, will be read as all zero's
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a (2-byte) unsigned integer value that represents the bit field flags listed above is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The response payload is two bytes to avoid confusion between a valid active limits value and the error indicator of NAK. The limit flags are only active when their respective output is on.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	16	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 2 Bytes)	CRC (2 Bytes)
6	16	0 – 255	Calculated
5	16	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY INTERNAL INSTRUMENT TEMPERATURE

Action	Reads the instruments built-in temperature sensor. The measured temperature value units are in degrees Celsius.
Results	The response payload message indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number temperature in Celsius is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The internal temperature sensor has been implemented in this instrument as an added laser diode protection feature. The instrument will automatically disable the laser, TEC, and case TEC output if an excessive (>80 °C) internal operational temperature is detected.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	17	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	17	Double Precision Real Number	Calculated
5	17	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY POWER SOURCE

Action	Reads the instruments power source, USB or external.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the instrument is powered from the USB bus and a value of 0 indicates that the instrument is powered from the external power supply. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The internal temperature sensors have been implemented in this instrument as an added laser diode protection feature. The instrument will automatically disable the laser, TEC, and case TEC output if an excessive (>80 °C) internal operational temperature is detected.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	18	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
5	18	1 = USB Power or 0 = External Power	Calculated
5	18	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY ERROR QUEUE

Action	Reads the last ten error codes from the instruments non-volatile error queue memory.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation the last ten error codes (bytes) are returned. Each payload byte contains one of the individual error codes. When less than ten previous errors have been logged the nonexistent error code positions will be filled with zero. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The error queue can retain up to a maximum of ten previously occurring errors in the non-volatile error queue memory. Once cleared, this query will return ten zero filled bytes in the payload.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	19	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 10 Bytes)	CRC (2 Bytes)
14	19	10 Individual Error Codes	Calculated
5	19	NAK	Calculated

GENERAL
LASER
TEC
CASE

CLEAR ERROR QUEUE

Action	Removes all the previously generated error codes that have been logged into the instruments non-volatile error queue memory.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The error queue can retain up to a maximum of 10 previously occurring errors in the non-volatile error queue memory.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	20	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	20	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

SET/CLEAR TEC ON BEFORE ALLOWING LASER ON STATE

Action	Enables or disables the built-in laser diode protection feature that ensures that the TEC is always on when the laser output is on.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Enabling this feature requires that the TEC be turned on before allowing the laser to be switched on. In addition, if the TEC is disabled for any reason while the laser is enabled the laser will automatically shut off.

WARNING

This protection feature ensures that the TEC is operational prior to allowing the laser to be enabled. This helps ensure that the laser diode reliability is not adversely affected by excessive thermal stress at the diode junction.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	21	1 = Enabled or 0 = Disabled	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	21	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY TEC ON BEFORE ALLOWING LASER ON STATE

Action	Reads the state of the built-in laser diode protection feature that ensures that the TEC is always on when the laser output is on.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the feature is enabled and a value of 0 indicates that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	When this feature is enabled it will provide an added level of laser diode protection. It will ensure that the TEC is always on when the laser diode is on. This will help avoid accelerated laser aging that may occur if the laser diode junction is thermally stressed.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	22	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	22	1 = Enabled or 0 = Disabled	Calculated
5	22	NAK	Calculated

SET/CLEAR FLASH BUTTON LEDS ON LIMIT CONDITION STATE

Action	Enables or disables flashing the On/Off button red LED when one of the respective laser diode control limit condition is active and is not configured to automatically shut off the output.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Any one of the three laser limit conditions will cause the laser On/Off button LED to flash red. Whereas, any one of the three TEC or two case TEC limit conditions will cause the TEC On/Off button LED to flash red. To determine which limit(s) are causing the LED to flash perform a query of the active limits. The blinking red LED provides the user with feedback that at least one of the limits is active and may need attention. When disabled the associated On/Off button will be illuminated green when the output is on, regardless of an active limit condition. Note that if the limit condition is configured to disable the output, this operational state is meaningless, the output will be disabled before the LED flashes.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	23	1 = Enabled or 0 = Disabled	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	23	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY FLASH BUTTON LEDS ON LIMIT CONDITION STATE

Action	Reads the state of the flag that represents the flash On/Off button red LED when one of the respective laser diode control limit condition is active.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the feature is enabled and a value of 0 indicates that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Any one of the three laser limit conditions will cause the laser On/Off button LED to flash red. Whereas, any one of the three TEC or two case TEC limit conditions will cause the TEC On/Off button LED to flash red. To determine which limit(s) are causing the LED to flash perform a query of the active limits. The blinking red LED provides the user with feedback that at least one of the limits is active and may need attention. The flashing LED feature is not available when the limit condition is configured to shut the output off.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	24	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	24	1 = Enabled or 0 = Disabled	Calculated
5	24	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET/CLEAR FRONT PANEL BUTTON LOCKOUT STATE

Action	Locks or unlocks the front panel button action, TEC On/Off and Laser On/Off.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The button locked mode is useful when operating under computer control or when the outputs are configured in automatic on mode. This can be used to ensure that the output is not changed if a front panel button is accidently bumped. Please be careful when operating in this mode, it can easily be confused as malfunctioning buttons.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
5	25	1 = Enabled or 0 = Disabled	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	25	ACK or NAK	Calculated

QUERY FRONT PANEL BUTTON LOCKOUT STATE

Action	Reads the state of the front panel button lockout feature.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the feature is enabled and a value of 0 indicates that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	It is important to always check the state of this feature when a malfunctioning button is suspected.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	26	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	26	1 = Enabled or 0 = Disabled	Calculated
5	26	NAK	Calculated

RESET INSTRUMENT TO FACTORY DEFAULTS

Action	Resets the user configurable instrument settings to their factory default values. The user configurable instrument settings and their associated default value are listed below: 1. Laser Current Setpoint ....50.0.0 mA 2. Laser Power Setpoint ....5.0 mW 3. Laser Current Limit Setpoint ....150.0 mA 4. Laser Power Limit Setpoint ....8.0 mW 5. Laser Voltage Limit Setpoint ....3.75 V 6. Modulation Current Setpoint ....0.0 mA 7. Modulation Peak-to-Peak Voltage....10.0 V 8. TEC Temperature Setpoint ....22.0 °C 9. TEC Temperature Limit Setpoint....80.0 °C 10. TEC Voltage Limit Setpoint ....3.0 V 11. TEC Control Loop Gain....3 12. Steinhart–Hart Thermistor Constants....A = 1.033×10^{-3} ....B = 2.384×10^{-4} .... C = 15.894×10^{-8} 13. Case TEC Temperature Setpoint....22.0 °C 14. Case TEC Temperature Limit Setpoint ....80.0 °C 15. Description ....LDCM-4371 Laser Diode Controller Mount
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This feature may be useful as an easy method to get all the instrument settings to a known state. However, please exercise caution; all the previous user configured instrument settings will be permanently discarded.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	27	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	27	ACK or NAK	Calculated

LASER DRIVER COMMAND SUMMARY

HEADER	LENGTH	PARAMETER	RESPONSE	DESCRIPTION
40	4	None	Double	Query Measured Laser Current Value
41	4	None	Double	Query Measured Laser Voltage Value
42	4	None	Double	Query Measured Laser Power Value
43	4	None	Boolean	Query Laser Current Limit State
44	4	None	Boolean	Query Laser Voltage Limit State
45	4	None	Boolean	Query Laser Power Limit State
46	4	None	Boolean	Query Laser Safety Interlock State
47	5	Boolean	ACK or NAK	Set/Clear Laser Output State
48	4	None	Boolean	Query Laser Output State
49	5	Boolean	ACK or NAK	Set/Clear Laser Modulation Enabled State
50	4	None	Boolean	Query Laser Modulation Enabled State
51	5	Boolean	ACK or NAK	Set/Clear Monitor Diode Reverse Bias Voltage State
52	4	None	Boolean	Query Monitor Diode Reverse Bias State
53	5	Boolean	ACK or NAK	Set Laser Cathode Pin Number
54	4	None	Boolean	Query Laser Cathode Pin Number
55	5	Boolean	ACK or NAK	Set Laser Control Mode (CC = 1 or CP = 0)
56	4	None	Boolean	Query Laser Control Mode (CC = 1, CP = 0)
57	5	Boolean	ACK or NAK	Set/Clear Laser Output Automatic On State
58	4	None	Boolean	Query Laser Output Automatic On State
59	5	Boolean	ACK or NAK	Set/Clear Laser Off When Current Limit Occurs State
60	4	None	Boolean	Query Laser Off When Current Limit Occurs State
61	5	Boolean	ACK or NAK	Set/Clear Laser Off When Voltage Limit Occurs State
62	4	None	Boolean	Query Laser Off When Voltage Limit Occurs State
63	5	Boolean	ACK or NAK	Set/Clear Laser Off When Power Limit Occurs State
64	4	None	Boolean	Query Laser Off When Power Limit Occurs State
65	12	Double	ACK or NAK	Set Laser Constant Current Setpoint
66	4	None	Double	Query Laser Constant Current Setpoint
67	6	Unsigned Integer	ACK or NAK	Set Laser Constant Current DAC Counts
68	4	None	Unsigned Integer	Query Laser Constant Current DAC Counts
69	12	Double	ACK or NAK	Set Laser Modulation Current Setpoint
70	4	None	Double	Query Laser Modulation Current Setpoint
71	6	Unsigned Integer	ACK or NAK	Set Laser Modulation Attenuation DAC Counts
72	4	None	Unsigned Integer	Query Laser Modulation Attenuation DAC Counts
73	12	Double	ACK or NAK	Set Modulation Peak-To-Peak Voltage
74	4	None	Double	Query Modulation Peak-To-Peak Voltage
75	12	Double	ACK or NAK	Set Laser Current Limit Setpoint
76	4	None	Double	Query Laser Current Limit Setpoint
77	12	Double	ACK or NAK	Set Laser Voltage Limit Setpoint
78	4	None	Double	Query Laser Voltage Limit Setpoint
79	12	Double	ACK or NAK	Set Laser Constant Power Setpoint
80	4	None	Double	Query Laser Constant Power Setpoint
81	6	Unsigned Integer	ACK or NAK	Set Laser Constant Power DAC Counts
82	4	None	Unsigned Integer	Query Laser Constant Power DAC Counts
83	12	Double	ACK or NAK	Set Laser Power Limit Setpoint
84	4	None	Double	Query Laser Power Limit Setpoint
85	12	Double	ACK/NAK	Set Monitor Diode Responsivity
86	4	None	Double	Query Monitor Diode Responsivity

Table 4.5: Laser Instrument Commands

LASER DRIVER COMMAND DETAILS

QUERY MEASURED LASER CURRENT VALUE

Action	Reads the measured laser drive current value in milliamps.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the measured current value in milliamps is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Implemented in this instrument is a high precision, low offset closed loop analog control circuit. The measured laser current analog to digital conversion is not integral to this closed loop control. Therefore, it is perfectly normal to have a small (100 µA) offset between the measured current and the setpoint current. Rest assured that the instrument was optimized for accuracy, using the industries best components where they will truly affect performance. The measurement latency is typically 100 milliseconds.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	40	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	40	0.0 – 250.0	Calculated
5	40	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY MEASURED LASER VOLTAGE VALUE

Action	Reads the measured laser diode forward voltage value in volts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the measured voltage value in volts is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Implemented in this instrument is a high precision, low offset closed loop analog control circuit. The measured laser voltage analog to digital conversion is not integral to this closed loop control. Therefore, it can be perfectly normal to have a small (100 mV) offset between the measured voltage and the voltage limit setpoint. Rest assured that the instrument was optimized for accuracy, using the industries best components where they will truly affect performance. The measurement latency is typically 100 milliseconds.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	41	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	41	0.0 – 3.75	Calculated
5	41	NAK	Calculated

QUERY MEASURED LASER POWER VALUE

Action	Reads the measured laser monitor diode power value in milliwatts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the measured optical power value in milliwatts is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Implemented in this instrument is a high precision, low offset closed loop analog control circuit. The measured laser optical power analog to digital conversion is not integral to this closed loop control. Therefore, it can be perfectly normal to have a small (1 μW) offset between the measured and setpoint optical powers. Rest assured that the instrument was optimized for accuracy, using the industries best components where they will truly affect performance. The measurement latency is typically 100 milliseconds.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	42	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	42	0.0 – 100.0	Calculated
5	42	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER CURRENT LIMIT STATE

Action	Reads the state of the laser current limit.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the laser current limit is active and a value of 0 indicates that the laser is NOT in current limit. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	It is important to note that the current limit can be active in both the constant current and constant power modes of operation. Therefore, if the measured current or power is significantly below their respective setpoint value, verify that the current limit is not clipping the drive current by querying the laser current limit state.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	43	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	43	1 = Limit Active or 0 = Limit NOT Active	Calculated
5	43	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER VOLTAGE LIMIT STATE

Action	Reads the state of the laser voltage limit.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the laser forward voltage is exceeding the limit setpoint and a value of 0 indicates that the laser forward voltage has NOT exceeded the limit setpoint. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	It is important to note that the voltage limit can be active in both the constant current and constant power modes of operation.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	44	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	44	1 = Limit Active or 0 = Limit NOT Active	Calculated
5	44	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER POWER LIMIT STATE

Action	Reads the state of the laser power limit.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the laser power is exceeding the power limit setpoint and a value of 0 indicates that the laser has NOT exceeded the power limit setpoint. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The power limit state is only active when operating in constant power control mode.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	45	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	45	1 = Limit Active or 0 = Limit NOT Active	Calculated
5	45	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER SAFETY INTERLOCK STATE

Action	Reads the state of the laser interlock hardware.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte value is returned. Where a value of 1 indicates that the front panel laser key switch is disabling the laser output, a value of 2 indicates that the front panel external interlock is disabling the laser output, and a value of 0 indicates that the interlock is enabling laser output. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	When the laser output fails to go on or is being forced off unpredictably, reading the error queue may help diagnose the cause. If the error queue indicates the laser is being disabled due to an interlock, using this query will help isolate which one of the two interlocks is disabling the laser output.

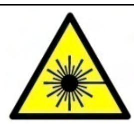
TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	46	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	46	0 = Laser Enabled 1 = Laser Disabled (Laser Key Switch) 2 = Laser Disabled (External Interlock)	Calculated
5	46	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET / CLEAR LASER OUTPUT STATE

Action	Turns the laser diode output on or off.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Laser safety requirements mandate that a five second safety activation delay expire prior to the laser output actually being enabled. If the laser fails to go on or quickly turns itself off, read the error queue to help determine the cause.



Whenever enabling the laser output the user should always exercise caution to avoid accidental exposure to possibly hazardous laser radiation.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Bytes)	CRC (2 Bytes)
5	47	1 = On or 0 = Off	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	47	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER OUTPUT STATE

Action	Reads the state of the laser diode output.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the laser output is ON and a value of 0 indicates that the laser output is OFF. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	When the state of the laser output is off and the user expects it to be on, a built-in laser protection feature is likely automatically disabling the laser output. To determine which of the many protection features is disabling the output, read the error codes and reference the code descriptions contained in the appendix of this manual.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	48	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	48	1 = On or 0 = Off	Calculated
5	48	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET/CLEAR LASER MODULATION ENABLED STATE

Action	Enables or disables isolation of the laser modulation input.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	When the modulation input is disabled, the signal present at the rear connector is isolated from the laser drive current. This command provides a convenient method to quickly disable the modulation signal and observe the constant current laser performance (e.g. wavelength and optical power). When modulating the laser with one of the protection features enabled the laser drive may automatically turn off. If the laser output is being forced off unexpectedly, reading the error queue may help diagnose the cause.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	49	1 = Enabled or 0 = Disabled	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	49	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER MODULATION ENABLED STATE

Action	Reads the laser modulation input isolation state.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the laser modulation input is enabled and a value of 0 indicates that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	With the modulation input disabled, the rear connector is isolated from the laser drive current. When modulating the laser with one of the protection features enabled the laser drive may automatically turn off. If the laser output is being forced off unexpectedly, reading the error queue may help diagnose the cause.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	50	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	50	1 = Enable or 0 = Disable	Calculated
5	50	NAK	Calculated

SET/CLEAR MONITOR DIODE REVERSE BIAS VOLTAGE STATE

Action	Enables or disables the 5V reverse bias voltage applied to the monitor photodiode.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	To help ensure the monitor photodiode is operating in the linear photoconductive mode a reverse voltage can be applied to the diode (i.e., a voltage in the direction where the diode is not conducting without incident light). In this mode the dependence of the photocurrent on the light power can be very linear over six or more orders of magnitude of the light power. The magnitude of the reverse voltage has nearly no influence on the photocurrent and only a weak influence on the (typically rather small) dark current (obtained without light), but a higher voltage tends to make the response faster. This instrument implements a fixed 5V monitor diode reverse bias voltage.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	51	1 = On or 0 = Off	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	51	ACK or NAK	Calculated

QUERY MONITOR DIODE REVERSE BIAS VOLTAGE STATE

Action	Reads the state of the 5V reverse bias voltage applied to the monitor photodiode.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the 5V reverse bias voltage is applied to the monitor photodiode and a value of 0 represents that no reverse bias voltage is applied to the monitor photodiode. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	To help ensure the monitor photodiode is operating in the linear photoconductive mode a reverse voltage can be applied to the diode (i.e., a voltage in the direction where the diode is not conducting without incident light). In this mode the dependence of the photocurrent on the light power can be very linear over six or more orders of magnitude of the light power. The magnitude of the reverse voltage has nearly no influence on the photocurrent and only a weak influence on the (typically rather small) dark current (obtained without light), but a higher voltage tends to make the response faster.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	52	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	52	1 = On or 0 = Off	Calculated
5	52	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET/CLEAR LASER CATHODE PIN

Action	Configures the instrument to sink the laser drive current from either Pin 12 (NEL Lasers) or Pin 3 (Other Laser Manufacturers).
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Changing the laser cathode pin number with the output on will automatically turn off the laser output. It is important to review the laser data sheet to fully verify the laser pin out configuration is compatible with this instrument. Refer to Chapter 2 – Basic Operation, for a complete description of the instruments expected pin out. If you believe your specific device will not work with the standard instrument, please feel free to contact us for additional assistance. We will either verify instrument compatibility with your device or provide you the option of purchasing a custom designed instrument that will meet your unique needs.

It is extremely important that you verify that the instrument is properly configured for your laser type (pin-out). An incorrect configuration may result in destruction or damage of the laser diode.

To help protect the laser from damage due to a momentary open circuit, the instrument will automatically disable the laser output if the user changes the laser cathode pin number with the laser output on.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	53	1 = Pin 3 (Other) or 0 = Pin 12 (NEL)	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	53	ACK or NAK	Calculated

QUERY LASER CATHODE PIN

Action	Reads with pin is configured to sink the laser drive current. Pin 12 (NEL Lasers) or Pin 3 (Other Laser Manufacturers).
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the laser cathode is configured as Pin 3 (Other Laser Manufacturers) and a value of 0 indicates that the laser cathode is configured as Pin 12 (NEL Lasers). o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	It is important to review the laser data sheet to fully verify the laser pin out configuration is compatible with this instrument. Refer to Chapter 2 – Basic Operation, for a complete description of the instruments expected pin out. If you believe your specific device will not work with the standard instrument, please feel free to contact us for additional assistance. We will either verify instrument compatibility with your device or provide you the option of purchasing a custom designed instrument that will meet your unique needs.

WARNING It is extremely important that you verify that the instrument is properly configured for your laser type (pin-out). An incorrect configuration may result in destruction or damage of the laser diode.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	54	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	54	1 = Pin 3 Cathode or 0 = Pin 12 Cathode	Calculated
5	54	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET LASER CONTROL MODE

Action	Sets the mode of control for the laser operation to either constant current (CC) = 1 or constant optical power (CP) = 0.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Changing the laser mode of operation with the output on will automatically turn off the laser output. Constant Current mode combined with precise control of the diode's operating temperature is generally the preferred operating method. The constant current mode provides a faster control loop and a precision current reference for accurately monitoring the laser current. Further, in many cases the laser diode's internal photodiode may exhibit drift and have poor noise characteristics. If performance of the internal photodiode is inferior, the diode's optical output is likely to be noisy and unstable as well. The constant optical power mode of operation requires the laser's monitor photodiode feedback to maintain constant power.

WARNING

To help protect the laser from damage due to a momentary open circuit, the instrument will automatically disable the laser output if the user changes control modes with the laser output on.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	55	1 = Current or 0 = Optical Power	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	55	ACK or NAK	Calculated

QUERY LASER CONTROL MODE

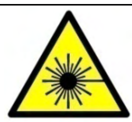
Action	Reads the laser control mode, 1 = constant current (CC) and 0 = constant optical power (CP).
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the laser control mode is constant current and a value of 0 indicates that the laser control mode is constant optical power. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	If the laser package contains an internal TEC that is controlled by this instrument, typically the best method for laser drive control is constant current. With constant power mode of operation the laser's monitor photodiode is the feedback element in the control loop. Depending on the manufacturer's process and component quality, the monitor photodiode can introduce additional inaccuracies due to back reflections and/or thermal drift. If additional detail is needed please reference the appendix of this manual.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	56	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	56	1 = Current or 0 = Optical Power	Calculated
5	56	NAK	Calculated

SET/CLEAR LASER AUTOMATIC ON STATE

Action	Enables or disables the laser diode output automatically turning on when the instrument powers up.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The automatic on mode of operation implements the required five second safety activation delay before the laser output is enabled. It is possible to disable the laser output with either the laser interlock key switch or the laser on/off front panel button, assuming the on/off button lockout is not enabled.



When using the Laser Auto On feature exercise caution to avoid accidental exposure to possibly hazardous laser radiation.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	57	1 = Enabled or 0 = Disabled	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	57	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER AUTOMATIC ON STATE

Action	Reads the state of the laser diode automatically turning on when the instrument powers up feature.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the feature is enabled and a value of 0 indicates that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The automatic on mode of operation implements the required five second safety activation delay before the laser output is enabled. It is possible to disable the laser output with either the laser interlock key switch or the laser on/off front panel button, assuming the on/off button lockout is not enabled.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	58	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	58	1 = Enabled or 0 = Disabled	Calculated
5	58	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET/CLEAR LASER OFF WHEN CURRENT LIMIT OCCURS STATE

Action	Enables or disables the instrument from automatically turning the laser output off when a laser drive current limit condition is detected.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	One of the many laser protection features designed into this instrument ensure that the laser drive current can never exceed the current limit. An extension of this laser protection feature is the ability to automatically disable the laser output when the current limit condition is detected. If the sum of the modulation current and constant current setpoint exceeds the current limit and this feature is enabled, the laser output will automatically be disabled.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	59	1 = Enable or 0 = Disable	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	59	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER OFF WHEN CURRENT LIMIT OCCURS STATE

Action	Reads the state of the automatic laser output off when the laser drive is in current limit.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the turn laser off when current limit condition occurs feature is enabled and a value of 0 indicates that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	With this feature enabled and using modulation, a current limit condition can easily cause the output to turn off unexpectedly. When the laser output is being forced off unpredictably, reading the error queue may help diagnose the cause.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	60	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	60	1 = Enable or 0 = Disable	Calculated
5	60	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET/CLEAR LASER OFF WHEN VOLTAGE LIMIT OCCURS STATE

Action	Enables or disables the instrument from automatically turning the laser output off when the laser forward voltage exceeds the limit value.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The voltage limit setting is useful for laser protection. When the maximum operating voltage of a laser is known, the user may set the voltage limit to a value slightly higher (250mV) than the maximum operating voltage. Then, if the laser is accidentally disconnected, the current source will quickly sense the over-voltage and shut off.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	61	1 = Enable or 0 = Disable	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	61	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER OFF WHEN VOLTAGE LIMIT OCCURS STATE

Action	Reads the state of the automatic laser output off when the laser forward voltage exceeds the limit.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the turn laser off when voltage limit occurs feature is enabled and a value of 0 indicates that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	With this feature enabled and using modulation, a voltage limit condition can cause the output to turn off unexpectedly. When the laser output is being forced off unpredictably, reading the error queue may help diagnose the cause.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	62	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	62	1 = Enable or 0 = Disable	Calculated
5	62	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET/CLEAR LASER OFF WHEN POWER LIMIT OCCURS STATE

Action	Enables or disables the instrument from automatically turning the laser output off when a laser power limit condition is detected.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	When operating in constant power mode, the output is only limited by the current limit value. An additional laser protection feature available is to enable this feature which will disable the laser output when the power limit condition is exceeded. This feature is only available when operating in constant power mode of laser diode control.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	63	1 = Enable or 0 = Disable	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	63	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER OFF WHEN VOLTAGE POWER OCCURS STATE

Action	Reads the state of the automatic laser output off when the laser exceeds the power limit.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the turn laser off when power limit occurs feature is enabled and a value of 0 indicates that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	With this feature enabled thermal runaway can cause the output to turn off unexpectedly. When the laser output is being forced off unpredictably, reading the error queue may help diagnose the cause.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	64	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	64	1 = Enable or 0 = Disable	Calculated
5	64	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET LASER CONSTANT CURRENT SETPOINT

Action	Sets the laser current setpoint value in milliamps for the constant current control mode.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The laser current setpoint value has a minimum of 0.0 milliamps and a maximum of 250.0 milliamps. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. The laser current setpoint value should always be set below the laser current limit value or the actual output will be clipped at the current limit value.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	65	0.0 – 250.0	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	65	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER CONSTANT CURRENT SETPOINT

Action	Reads the laser current setpoint value in milliamps for the constant current control mode.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number current value in milliamps is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	If the measured current is significantly (>100 µA) below the laser setpoint value, verify that the current limit setpoint is not set below the laser current setpoint value.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
4	66	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	66	0.0 – 250.0	Calculated
5	66	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET LASER CONSTANT CURRENT DAC COUNTS

Action	Adjusts the laser current DAC (Digital to Analog Converter) value in counts for the constant current control mode. The laser current setpoint DAC is 16-bits, therefore the expected value is a (2-Byte) unsigned integer.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The laser current setpoint DAC value has a minimum of 0 counts and a maximum of 65,535 counts. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. The laser setpoint value should always be set below the laser current limit value or the actual output will be clipped at the current limit value.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (2 Bytes)	CRC (2 Bytes)
6	67	0 – 65,535	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	67	ACK or NAK	Calculated

QUERY LASER CONSTANT CURRENT DAC COUNTS

Action	Reads the laser current setpoint value in DAC (Digital to Analog Converter) counts for the constant current control mode.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a (2-Byte) unsigned integer value representing the DAC counts for the current setpoint value is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The DAC is 16-bits therefore valid values are 0 through 65,535.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	68	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 2 Bytes)	CRC (2 Bytes)
6	68	0 – 65,535	Calculated
5	68	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET LASER MODULATION CURRENT SETPOINT

Action	Sets the peak-to-peak laser modulation current setpoint value in milliamps. This value is used by the instrument to calculate a modulation attenuation DAC setting that will yield the user requested modulation peak current. The following equation details how the modulation peak current setpoint value is used to calculate the modulation attenuation DAC setting: $$DAC_{Set} = \frac{I_{Modulation} \times 5\Omega}{\frac{1}{2} \times V_{Modulation(Peak-to-Peak)}} \times 65{,}535$$ Where, $I_{modulation}$ is the modulation peak current set with this command.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The laser modulation current setpoint value has a minimum of 0.0 milliamps and a maximum of 250.0 milliamps. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. If the sum of the laser modulation current setpoint value and the laser current setpoint value result is a value greater than the current limit setpoint value or below zero the output will be clipped. When modulating the laser with one of the protection features enabled the laser drive may automatically turn off. If the laser output is being forced off unexpectedly, reading the error queue may help diagnose the cause. Due to aliasing, using a modulation signal may result in a fluctuating or unexpected offset in the measured laser current value.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	69	0.0 – 250.0	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	69	ACK or NAK	Calculated

QUERY LASER MODULATION CURRENT SETPOINT

Action	Reads the peak-to-peak laser modulation current setpoint value in milliamps.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the peak-to-peak laser modulation current value in milliamps is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	If the sum of the laser modulation current setpoint value and the laser current setpoint value result in a value greater than the current limit setpoint value or below zero the output will be clipped. When modulating the laser with one of the protection features enabled the laser drive may automatically turn off. If the laser output is being forced off unexpectedly, reading the error queue may help diagnose the cause. Due to aliasing, using a modulation signal may result in a fluctuating or unexpected offset in the measured laser current value.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	70	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	70	0.0 – 250.0	Calculated
5	70	NAK	Calculated

SET LASER MODULATION ATTENUATION DAC COUNTS

Action	Allows direct access to set the laser modulation attenuation DAC (Digital to Analog Converter) value. The laser modulation attenuation DAC is 16-bits, therefore the expected value is a (2-Byte) unsigned integer. This value will result in the following transfer function: $$DAC_{Set} = \frac{I_{Modulation} \times 5\Omega}{\frac{1}{2} \times V_{Modulation(Peak-to-Peak)}} \times 65{,}535$$
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The laser modulation attenuation DAC value has a minimum of 0 counts and a maximum of 65,535 counts. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. See the appendix of this manual for a detailed explanation of how the modulation attenuation value affects the modulation bandwidth. To maximize the instrument modulation bandwidth, use smaller modulation input voltages. This will yield a lower calculated instrument attenuation setting, which results in a greater modulation bandwidth.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (2 Bytes)	CRC (2 Bytes)
6	71	0 – 65,535	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	71	ACK or NAK	Calculated

QUERY LASER MODULATION ATTENUATION DAC COUNTS

Action	Reads the laser modulation attenuation 16-bit DAC (Digital to Analog Converter) setting.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation an unsigned integer (2-byte) value representing the modulation attenuation DAC setting is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The DAC is 16-bits therefore valid values are 0 through 65,535.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	72	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 2 Bytes)	CRC (2 Bytes)
6	72	0 – 65,535	Calculated
5	72	NAK	Calculated

SET LASER MODULATION PEAK-TO-PEAK VOLTAGE

Action	Sets the peak-to-peak laser modulation voltage. This value is used by the instrument to calculate a modulation attenuation DAC setting that will yield the user requested modulation peak-to-peak current. The following equation details how the modulation peak-to-peak voltage value is used to calculate the modulation attenuation DAC setting: $$DAC_{Set} = \frac{I_{Modulation} \times 5\Omega}{\frac{1}{2} \times V_{Modulation(Peak-to-Peak)}} \times 65{,}535$$ Where, $V_{modulation(Peak\text{-}to\text{-}Peak)}$ is the modulation peak-to-peak voltage set with this command.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	An external modulation voltage of ±10 volts is a peak-to-peak voltage of 20 volts. See the appendix of this manual for a detailed explanation of how the modulation attenuation value affects the modulation bandwidth. To maximize the instrument modulation bandwidth, use smaller modulation input voltages. This will yield a lower calculated instrument attenuation setting, which results in a greater modulation bandwidth.

WARNING

Do NOT apply a modulation voltage in excess of ±15 volts. Voltages exceeding this maximum value will result in internal instrument damage and is not covered under warranty.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	73	0.0 – 30.0	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	73	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER MODULATION PEAK-TO-PEAK VOLTAGE

Action	Reads the peak-to-peak laser modulation voltage.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the modulation peak-to-peak voltage value in volts is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	An external modulation voltage of ±10 volts is a peak-to-peak voltage of 20 volts.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	74	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	74	0.0 – 30.0	Calculated
5	74	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET LASER CURRENT LIMIT SETPOINT

Action	Sets the laser current limit setpoint value in milliamps.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The laser current limit setpoint value has a minimum of 0.0 milliamps and a maximum of 250.0 milliamps. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. The laser current limit setpoint value should always be set above the laser current setpoint value or the actual output will be clipped at the current limit value. It is important to note that the current limit is active in both the constant current and constant power modes of operation.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	75	0.0 – 250.0	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	75	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER CURRENT LIMIT SETPOINT

Action	Reads the laser current limit setpoint value in milliamps.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the current limit value in milliamps is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	It is important to note that the current limit can be active in both the constant current and constant power modes of operation. Therefore, if the measured current or power is significantly below their respective setpoint value, verify that the current limit is not clipping the drive current.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	76	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	76	0.0 – 250.0	Calculated
5	76	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET LASER VOLTAGE LIMIT SETPOINT

Action	Reads the laser voltage limit setpoint value in volts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the voltage limit value in volts is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	It is important to note that the voltage limit is active in both the constant current and constant power modes of operation.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	77	0.0 – 3.75	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	77	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER VOLTAGE LIMIT SETPOINT

Action	Reads the laser voltage limit setpoint value in volts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the voltage limit value in volts is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	It is important to note that the voltage limit is active in both the constant current and constant power modes of operation.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	78	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	78	0.0 – 3.75	Calculated
5	78	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET LASER CONSTANT POWER SETPOINT

Action	Sets the laser power setpoint value in milliwatts for the constant power control mode.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The laser power setpoint value has a minimum of 0.0 milliwatts and a maximum of 100.0 milliwatts. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. If the measured power is significantly (>1 μW) below the laser setpoint value, verify that the current limit setpoint is not clipping the drive current.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	79	0.0 – 100.0	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	79	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER CONSTANT POWER SETPOINT

Action	Reads the laser power setpoint value in milliwatts for the constant power control mode.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the power setpoint value in milliwatts is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	If the measured power is significantly (>1 µW) below the laser setpoint value, verify that the current limit setpoint is not clipping the drive current.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	80	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	80	0.0 – 100.0	Calculated
5	80	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET LASER CONSTANT POWER DAC COUNTS

Action	Sets the laser power DAC (Digital to Analog Converter) setpoint value in counts for the constant power control mode. The laser power setpoint DAC is 16-bits, therefore the expected value is a (2-Byte) unsigned integer.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The laser power setpoint DAC value has a minimum of 0 counts and a maximum of 65,535 counts. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (2 Bytes)	CRC (2 Bytes)
6	81	0 – 65,535	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	81	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY LASER CONSTANT POWER DAC COUNTS

Action	Reads the laser power setpoint value in DAC (Digital to Analog Converter) counts for the constant power control mode.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a (2-Byte) unsigned integer value representing the DAC counts for the power setpoint value is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The DAC is 16-bits therefore valid values are 0 through 65,535.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	82	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 2 Bytes)	CRC (2 Bytes)
6	82	0 – 65,535	Calculated
5	82	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET LASER POWER LIMIT SETPOINT

Action	Sets the laser power limit setpoint value in milliwatts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The laser power limit setpoint value has a minimum of 0.0 milliwatts and a maximum of 100.0 milliwatts. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. This laser protection feature does not actively limit the laser power, when configured it disables the laser output when the optical power exceeds the limit. The power limit is only active when operating in constant power control mode.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	83	0.0 – 100.0	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	83	ACK or NAK	Calculated

QUERY LASER POWER LIMIT SETPOINT

Action	Reads the laser power limit setpoint value in milliwatts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number power limit value in milliwatts is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	It is important to note that the power limit is only active in the constant power mode of operation.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	84	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	84	0.0 – 100.0	Calculated
5	84	NAK	Calculated

SET MONITOR PHOTODIODE RESPONSIVITY

Action	Sets the laser diode monitor photodiode responsivity value, this is used to convert between the photodiode current and optical power of the laser diode. The value sent, an (8 - Byte) double precision real number represents the responsivity parameter in µA/mW.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	In constant power mode, the instrument controls the laser drive current to keep the monitor diode current constant. The monitor diode constant current setpoint value is calculated from a user requested optical power value in millwatts. The user requested optical power is converted to a monitor diode current by applying the monitor diode responsivity value as follows: $I_{Control}(\mu A) = SetPoint_{OpticalPower}(mW) \times MonitorDiode_{Responsivity}(\mu A/mW)$ • minimum monitor diode responsivity value is = 250 µA / 100 mW = 2.5 µA/mW • maximum monitor diode responsivity value is = 50,000 µA / 100 mW = 250.0 µA/mW

Caution, it is extremely important that you verify the proper monitor diode responsivity value. Entering a value that is lower than actual value may cause the laser driver to deliver excessive current resulting in damage or destruction of the laser diode.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	85	2.5 – 250.0	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	85	ACK or NAK	Calculated

QUERY MONITOR PHOTODIODE RESPONSIVITY

Action	Reads the laser diode monitor photodiode responsivity value in µA/mW.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the monitor photodiode responsivity value in microamps/milliwatt is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	In constant power mode, the instrument controls the laser drive current to keep the monitor diode current constant. The monitor diode constant current setpoint value is calculated from a user requested optical power value in millwatts. The user requested optical power is converted to a monitor diode current by applying the monitor diode responsivity value as follows: $I_{Control}(\mu A) = SetPoint_{OpticalPower}(mW) \times MonitorDiode_{Responsivity}(\mu A/mW)$

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	85	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	85	2.5 – 250.0	Calculated
5	85	NAK	Calculated

INTERNAL THERMO-ELECTRIC COOLER (TEC) COMMAND SUMMARY

HEADER	LENGTH	PARAMETER	RESPONSE	DESCRIPTION
100	4	None	Double	Query Measured TEC Temperature Value
101	4	None	Double	Query Measured TEC Voltage Value
102	4	None	Double	Query Measured TEC Current Value
103	4	None	Boolean	Query TEC Upper Temperature Limit State
104	4	None	Boolean	Query TEC Voltage Limit State
105	4	None	Boolean	Query TEC Control Error Limit State
106	5	Boolean	ACK or NAK	Set/Clear TEC Output State
107	4	None	Boolean	Query TEC Output State
108	5	Boolean	ACK or NAK	Set/Clear TEC Automatic Output On State
109	4	None	Boolean	Query TEC Automatic Output On State
110	5	Boolean	ACK or NAK	Set/Clear TEC Off When Temperature Limit Occurs State
111	4	None	Boolean	Query TEC Off When Temperature Limit Occurs State
112	5	Boolean	ACK or NAK	Set/Clear TEC Off When Voltage Limit Occurs State
113	4	None	Boolean	Query TEC Off When Voltage Limit Occurs State
114	5	Boolean	ACK or NAK	Set/Clear TEC Off When Control Error Limit Occurs State
115	4	None	Boolean	Query TEC Off When Control Error Limit Occurs State
116	12	Double	ACK or NAK	Set TEC Temperature Setpoint
117	4	None	Double	Query TEC Temperature Setpoint
118	6	Unsigned Integer	ACK or NAK	Set TEC Temperature DAC Counts
119	4	None	Unsigned Integer	Query TEC Temperature DAC Counts
120	6	Double	ACK or NAK	Set TEC Gain Setpoint
121	4	None	Double	Query TEC Gain Setpoint
122	6	Unsigned Integer	ACK or NAK	Set TEC Gain DAC Counts
123	4	None	Unsigned Integer	Query TEC Gain DAC Counts
124	12	Double	ACK or NAK	Set TEC Upper Temperature Limit Setpoint
125	4	None	Double	Query TEC Upper Temperature Limit Setpoint
126	12	Double	ACK or NAK	Set TEC Voltage Limit Setpoint
127	4	None	Double	Query TEC Voltage Limit Setpoint
128	12	Double	ACK or NAK	Set Steinhart-Hart Constant A
129	4	None	Double	Query Steinhart-Hart Constant A
130	12	Double	ACK or NAK	Set Steinhart-Hart Constant B
131	4	None	Double	Query Steinhart-Hart Constant B
132	12	Double	ACK or NAK	Set Steinhart-Hart Constant C
133	4	None	Double	Query Steinhart-Hart Constant C

Table 4.6: TEC Instrument Commands

INTERNAL THERMO-ELECTRIC COOLER (TEC) COMMAND DETAILS

GENERAL
LASER
TEC
CASE

QUERY MEASURED TEC TEMPERATURE VALUE

Action	Reads the measured TEC temperature in degrees Celsius.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the temperature value in degrees Celsius is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Implemented in this instrument is a high precision, low offset closed loop TEC control circuit. The measured TEC temperature circuitry is not integral to this closed loop control. Therefore, it is perfectly normal to have a small offset (<100 m°C) between the measured temperature and the setpoint temperature. Rest assured that the instrument was optimized for accuracy, using the industries best components where they will truly affect performance. The measurement latency is typically 100 milliseconds.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	100	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	100	-100.0 – +100.0	Calculated
5	100	NAK	Calculated

QUERY MEASURED TEC VOLTAGE VALUE

Action	Reads the measured TEC voltage in volts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the voltage value in volts is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Implemented in this instrument is a high precision, low offset closed loop control circuit. The measured laser voltage circuitry is not integral to this closed loop control. Therefore, it can be perfectly normal to have a small (< 100 mV) offset between the measured voltage and the voltage limit setpoint. Rest assured that the instrument was optimized for accuracy, using the industries best components where they will truly affect performance. The measurement latency is typically 100 milliseconds.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	101	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	101	0.0 – 5.0	Calculated
5	101	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY MEASURED TEC CURRENT VALUE

Action	Reads the measured TEC current in milliamps.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the current value in milliamps is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Implemented in this instrument is a high precision, low offset closed loop control circuit. The measured laser current circuitry is not integral to this closed loop control. Therefore do not be alarmed if a small offset (<200 mA) is observed between the expected drive current and the measured current. Rest assured that the instrument was optimized for accuracy, using the industries best components where they will truly affect performance. The measurement latency is typically 100 milliseconds.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	102	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	102	0.0 – 1500.0	Calculated
5	102	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY TEC UPPER TEMPERATURE LIMIT STATE

Action	Reads the state of the TEC temperature limit.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the TEC temperature limit is active and a value of 0 indicates that the TEC temperature has NOT exceeded the temperature limit. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The TEC temperature limit state returns true when the measured temperature exceeds the upper TEC temperature limit setpoint value.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	103	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	103	1 = Limit Active or 0 = Limit NOT Active	Calculated
5	103	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY TEC VOLTAGE LIMIT STATE

Action	Reads the state of the TEC voltage limit.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the TEC voltage limit is active and a value of 0 indicates that the TEC voltage has NOT exceeded the voltage limit. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The TEC voltage limit state returns true when the TEC voltage is being limited.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	104	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	104	1 = Limit Active or 0 = Limit NOT Active	Calculated
5	104	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY TEC CONTROL ERROR STATE

Action	Reads the state of the TEC control error signal.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the TEC control error is active and a value of 0 indicates that the TEC control error is NOT active. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The TEC control error state query returns true when the TEC control error is none zero.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	105	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	105	1 = Error Active or 0 = Error NOT Active	Calculated
5	105	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET / CLEAR TEC OUTPUT STATE

Action	Turns the TEC output on or off.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	If the TEC fails to go on or quickly turns itself off, read the error queue to help determine the cause of the fault.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	106	1 = On or 0 = Off	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	106	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY TEC OUTPUT STATE

Action	Reads the state of the TEC output.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the TEC output is on and a value of 0 indicates that the TEC output is off. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	If the TEC fails to go on or quickly turns itself off, read the error queue to help determine the cause of the fault.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	107	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	107	1 = On or 0 = Off	Calculated
5	107	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET/CLEAR TEC OUTPUT AUTOMATIC ON STATE

Action	Enables or disables the TEC output automatically turning on when the instrument powers up.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	As an added layer of protection for the laser diode, it is recommended to use the TEC on before laser enabled feature in conjunction with this feature. This will ensure thermal damage does not occur to the laser diode in the event a TEC error automatically disables the output.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	108	1 = Enabled or 0 = Disabled	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	108	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY TEC OUTPUT AUTOMATIC ON STATE

Action	Reads the state of the TEC automatically turning on when the instrument power up feature.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the feature is enabled and a value of 0 indicates that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	As an added layer of protection for the laser diode, it is recommended to use the TEC on before laser enabled feature in conjunction with this feature. This will ensure thermal damage does not occur to the laser diode in the event a TEC error automatically disables the output.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	109	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	109	1 = Enabled or 0 = Disabled	Calculated
5	109	NAK	Calculated

SET/CLEAR TEC OFF WHEN TEMPERATURE LIMIT OCCURS

Action	Enables or disables the instrument from automatically turning the TEC and laser drive output off when the measured TEC temperature exceeds the temperature limit setpoint.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This feature can protect the laser from damage by preventing a thermal runaway condition. This feature will automatically disable both the TEC output and laser drive output.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	110	1 = Enable or 0 = Disable	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	110	ACK or NAK	Calculated

QUERY TEC OFF WHEN TEMPERATURE LIMIT OCCURS

Action	Reads the state of the automatic TEC and laser drive output off when the TEC measured temperature exceeds the temperature limit setpoint.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the TEC and laser turn off when the temperature limit condition occurs and a value of 0 represents that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This feature can protect the laser from damage by preventing a thermal runaway condition. This feature will automatically disable both the TEC output and laser drive output.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	111	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	111	1 = Enabled or 0 = Disabled	Calculated
5	111	NAK	Calculated

SET/CLEAR TEC OFF WHEN VOLTAGE LIMIT OCCURS

Action	Enables or disables the instrument from automatically turning the TEC and laser drive output off when the TEC drive voltage is being limited by the voltage limit setpoint.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	One of the many laser protection features designed into this instrument ensure that the TEC drive voltage can never exceed the voltage limit. An extension of this laser protection feature is the ability to automatically disable the TEC and/or laser output when the voltage limit condition is detected. When the TEC is first enabled, it is normal for the controller to drive to the voltage limit. Therefore the instrument automatically waits for this condition to reach the normal steady state for a one minute period before enabling. Please note that when the “TEC On Before Laser” feature is enabled, this condition will not only disable the TEC output but also the Laser output.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	112	1 = Enable or 0 = Disable	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	112	ACK or NAK	Calculated

QUERY TEC OFF WHEN VOLTAGE LIMIT OCCURS

Action	Reads the state of the automatic TEC and laser drive output off when the TEC voltage is being limited by the voltage limit setpoint.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the feature is enabled and a value of 0 indicates that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	One of the many laser protection features designed into this instrument ensure that the TEC drive voltage can never exceed the voltage limit. An extension of this laser protection feature is the ability to automatically disable the TEC and/or laser output when the voltage limit condition is detected. When the TEC is first enabled, it is normal for the controller to drive to the voltage limit. Therefore the instrument automatically waits for this condition to reach the normal steady state for a one minute period before enabling. Please note that when the “TEC On Before Laser” feature is enabled, this condition will not only disable the TEC output but also the Laser output.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	113	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	113	1 = Enabled or 0 = Disabled	Calculated
5	113	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET / CLEAR TEC OFF WHEN CONTROL ERROR OCCURS

Action	Enables or disables the instrument from automatically turning the TEC and laser drive output off when the TEC control error signal exceeds a fixed limit value.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	When the TEC is first enabled, it is normal for the control error signal to be active. Therefore the instrument automatically waits for this condition to reach the normal steady state for a one minute period before enabling. Please note that when the “TEC On Before Laser” feature is enabled, this condition will not only disable the TEC output but also the Laser output.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	114	1 = Enable or 0 = Disable	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	114	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY TEC OFF WHEN CONTROL ERROR OCCURS

Action	Reads the state of the automatic TEC and laser drive output off when the TEC control error signal exceeds a fixed limit value.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the feature is enabled and a value of 0 indicates that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	When the TEC is first enabled, it is normal for the control error signal to be active. Therefore the instrument automatically waits for this condition to reach the normal steady state for a one minute period before enabling. Please note that when the “TEC On Before Laser” feature is enabled, this condition will not only disable the TEC output but also the Laser output.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	115	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	115	1 = Enabled or 0 = Disabled	Calculated
5	115	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET TEC TEMPERATURE SETPOINT

Action	Sets the TEC temperature setpoint value in degrees Celsius.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The TEC temperature setpoint value has a minimum of -100.0 degrees Celsius and a maximum of +100.0 degrees Celsius. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. Although this command accepts a wide range of setpoint values, the temperature limit for some of the more extreme temperatures may be limited by the maximum available drive voltage of 4.9 volts.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	116	-100.0 – +100.0	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	116	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY TEC TEMPERATURE SETPOINT

Action	Reads the TEC temperature setpoint value in degrees Celsius.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the temperature value in degrees Celsius is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	If the measured temperature is significantly (>100 m°C) different than the TEC temperature setpoint value, verify that the TEC voltage limit or gain are not set to low to achieve the desired temperature.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	117	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	117	-100.0 – +100.0	Calculated
5	117	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET TEC TEMPERATURE DAC COUNTS

Action	Sets the TEC temperature DAC (Digital to Analog Converter) setpoint value in counts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The TEC temperature DAC is 16-bits therefore valid values are 0 through 65,535. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (2 Bytes)	CRC (2 Bytes)
6	118	0 – 65,535	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	118	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY TEC TEMPERATURE DAC COUNTS

Action	Reads the TEC temperature setpoint value in DAC (Digital to Analog Converter) counts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a (2-Byte) unsigned integer value representing the DAC counts for the TEC temperature setpoint value is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The DAC is 16-bits therefore valid values are 0 through 65,535.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	119	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 2 Bytes)	CRC (2 Bytes)
6	119	0 – 65,535	Calculated
5	119	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET TEC GAIN SETPOINT

Action	Sets the programmable TEC control loop gain setting.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The TEC gain setpoint value has a minimum of 1.0 and a maximum of 51.0. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. Setting a gain value that is to low will result in a slow response and a gain that is set to high may oscillate.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	120	1.0 – 51.0	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	120	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY TEC GAIN SETPOINT

Action	Reads the programmable TEC control loop gain setting.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the gain setting is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The TEC gain setpoint value has a minimum of 1.0 and a maximum of 51.0. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. Setting a gain value that is to low will result in a slow response and a gain that is set to high may oscillate.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	121	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	121	1.0 – 51.0	Calculated
5	121	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET TEC GAIN DAC COUNTS

Action	Sets the programmable TEC gain DAC (Digital to Analog Converter) setpoint value in counts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The TEC gain DAC value has a minimum of 0 counts and a maximum of 255 counts. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. Setting a gain value that is to low will result in a slow response and a gain that is set to high may oscillate.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	122	0 – 255	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	122	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY TEC GAIN DAC COUNTS

Action	Reads the programmable TEC gain setpoint value in DAC (Digital to Analog Converter) counts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a (2-Byte) integer value representing the DAC counts for the TEC gain setpoint value is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The DAC is 8-bits therefore valid values are 0 through 255. To differentiate the NAK from a DAC gain value, the valid response returns the result as an integer.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	123	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 2 Bytes)	CRC (2 Bytes)
6	123	0 – 255	Calculated
5	123	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET TEC UPPER TEMPERATURE LIMIT SETPOINT

Action	Sets the TEC upper temperature limit setpoint value in degrees Celsius. This limit is single ended; it is only active when the temperature exceeds the limit value.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The TEC temperature limit setpoint value has a maximum of +100.0 degrees Celsius. Attempting to set a value above this maximum will generate an error and the requested setting will be ignored. This laser protection feature does not actively limit the TEC temperature, when configured it disables both the TEC and laser output when the TEC temperature exceeds the limit.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	124	100.0	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	124	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY TEC UPPER TEMPERATURE LIMIT SETPOINT

Action	Reads the TEC upper temperature limit setpoint value in degrees Celsius. This limit is single ended; it is only active when the temperature exceeds the limit value.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number that represents the temperature limit value in degrees Celsius is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This laser protection feature does not actively limit the TEC temperature, when configured it disables both the TEC and laser output when the TEC temperature exceeds the limit.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	125	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	125	100.0	Calculated
5	125	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET TEC VOLTAGE LIMIT SETPOINT

Action	Sets the TEC voltage limit setpoint value in volts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The TEC voltage limit setpoint value has a minimum of 0.0 volts and a maximum of 5.0 volts. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. This laser protection feature actively limits the TEC voltage, when configured it disables both the TEC and laser output when the TEC voltage exceeds the limit.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	126	0.0 – 5.0	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	126	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY TEC VOLTAGE LIMIT SETPOINT

Action	Reads the TEC voltage limit setpoint value in volts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the voltage limit value in volts is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This laser protection feature actively limits the TEC voltage, when configured it disables both the TEC and laser output when the TEC voltage exceeds the limit.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	127	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	127	0.0 – 5.0	Calculated
5	127	NAK	Calculated

SET TEC STEINHART-HART CONSTANT A

Action	Sets the Steinhart-Hart thermistor equation constant A value.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This is the A term in the three-term Steinhart-Hart thermistor equation shown below: $$\frac{1}{T} = A + B \times \ln(R) + C \times \ln(R)^3$$ Where T is the absolute temperature in Kelvin and R is the thermistor resistance in ohms. The terms A, B, and C are the Steinhart-Hart constants for the thermistor. The factory default setting for the A term in a typical DFB laser is $1.033x10^{-3}$.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	128	$1.033x10^{-3}$	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	128	ACK or NAK	Calculated

QUERY TEC STEINHART-HART CONSTANT A

Action	Reads the Steinhart-Hart thermistor equation constant A value.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the Steinhart-Hart thermistor equation constant A is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This is the A term in the three-term Steinhart-Hart thermistor equation shown below: $$\frac{1}{T} = A + B \times \ln(R) + C \times \ln(R)^3$$ Where T is the absolute temperature in Kelvin and R is the thermistor resistance in ohms. The terms A, B, and C are the Steinhart-Hart constants for the thermistor. The factory default setting for the A term in a typical DFB laser is $1.033x10^{-3}$.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	129	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	129	$1.033x10^{-3}$	Calculated
5	129	NAK	Calculated

SET TEC STEINHART-HART CONSTANT B

Action	Sets the Steinhart-Hart thermistor equation constant B value.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This is the B term in the three-term Steinhart-Hart thermistor equation shown below: $\frac{1}{T} = A + B \times \ln(R) + C \times \ln(R)^3$ Where T is the absolute temperature in Kelvin and R is the thermistor resistance in ohms. The terms A, B, and C are the Steinhart-Hart constants for the thermistor. The factory default setting for the B term in a typical DFB laser is 2.385×10^{-4}.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	130	2.385×10^{-4}	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	130	ACK or NAK	Calculated

QUERY TEC STEINHART-HART CONSTANT B

Action	Reads the Steinhart-Hart thermistor equation constant B value.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the Steinhart-Hart thermistor equation constant B is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This is the B term in the three-term Steinhart-Hart thermistor equation shown below: $$\frac{1}{T} = A + B \times \ln(R) + C \times \ln(R)^3$$ Where T is the absolute temperature in Kelvin and R is the thermistor resistance in ohms. The terms A, B, and C are the Steinhart-Hart constants for the thermistor. The factory default setting for the B term in a typical DFB laser is 2.385×10^{-4}.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	131	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	131	2.385×10^{-4}	Calculated
5	131	NAK	Calculated

SET TEC STEINHART-HART CONSTANT C

Action	Sets the Steinhart-Hart constant C value.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This is the C term in three-term Steinhart-Hart thermistor equation shown below: $\frac{1}{T} = A + B \times \ln(R) + C \times \ln(R)^3$ Where T is the absolute temperature in Kelvin and R is the thermistor resistance in ohms. The terms A, B, and C are the Steinhart-Hart constants for the thermistor. The factory default setting for the C term in a typical DFB laser is 15.894×10^{-8}.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	132	15.894×10^{-8}	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	132	ACK or NAK	Calculated

QUERY TEC STEINHART-HART CONSTANT C

Action	Reads the Steinhart-Hart thermistor equation constant C value.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the Steinhart-Hart thermistor equation constant C is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This is the C term in three-term Steinhart-Hart thermistor equation shown below: $\frac{1}{T} = A + B \times \ln(R) + C \times \ln(R)^3$ Where T is the absolute temperature in Kelvin and R is the thermistor resistance in ohms. The terms A, B, and C are the Steinhart-Hart constants for the thermistor. The factory default setting for the C term in a typical DFB laser is 15.894×10^{-8}.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	133	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	133	15.894×10^{-8}	Calculated
5	133	NAK	Calculated

CASE THERMO-ELECTRIC COOLER (TEC) COMMAND SUMMARY

HEADER	LENGTH	PARAMETER	RESPONSE	DESCRIPTION
200	4	None	Double	Query Measured Case TEC Temperature Value
201	4	None	Double	Query Measured Case TEC Voltage Value
202	4	None	Boolean	Query Case TEC Upper Temperature Limit State
203	4	None	Boolean	Query Case TEC Control Error Limit State
204	5	Boolean	ACK or NAK	Set/Clear Case TEC Output State
205	4	None	Boolean	Query Case TEC Output State
206	5	Boolean	ACK or NAK	Set/Clear Case TEC Output Automatically On State
207	4	None	Boolean	Query Case TEC Output Automatically On State
208	5	Boolean	ACK or NAK	Set/Clear Case TEC Off When Temperature Limit Occurs State
209	4	None	Boolean	Query Case TEC Off When Temperature Limit Occurs State
210	5	Boolean	ACK or NAK	Set/Clear Case TEC Off When Control Error Limit Occurs State
211	4	None	Boolean	Query Case TEC Off When Control Error Limit Occurs State
212	12	Double	ACK or NAK	Set Case TEC Temperature Setpoint
213	4	None	Double	Query Case TEC Temperature Setpoint
214	6	Unsigned Integer	ACK or NAK	Set Case TEC Temperature DAC Counts
215	4	None	Unsigned Integer	Query Case TEC Temperature DAC Counts
216	12	Double	ACK or NAK	Set Case TEC Upper Temperature Limit Setpoint
217	4	None	Double	Query Case TEC Upper Temperature Limit Setpoint

Table 4.7: Case TEC Instrument Commands

CASE THERMO-ELECTRIC COOLER (TEC) COMMAND DETAILS

QUERY MEASURED CASE TEC TEMPERATURE VALUE

Action	Reads the measured Case TEC temperature in degrees Celsius.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the temperature value in degrees Celsius is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Implemented in this instrument is a high precision, low offset closed loop analog TEC control circuit. The measured case TEC temperature analog to digital conversion is not integral to this closed loop control. Therefore, it is perfectly normal to have a small offset (< 100 m°C) between the measured temperature and the setpoint temperature. Rest assured that the instrument was optimized for accuracy, using the industries best components where they will truly affect performance. The measurement latency is typically 100 milliseconds.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	200	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	200	-100.0 – +100.0	Calculated
5	200	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY MEASURED CASE TEC VOLTAGE VALUE

Action	Reads the measured Case TEC voltage in volts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the voltage value in volts is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	Implemented in this instrument is a high precision, low offset closed loop control circuit. The measured laser voltage circuit is not integral to this closed loop control. Therefore if the voltage limit is active, it is perfectly normal to have a small (<250 mV) offset between the measured voltage and the limit voltage setpoint. Rest assured that the instrument was optimized for accuracy, using the industries best components where they will truly affect performance. The measurement latency is typically 100 milliseconds.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	201	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	201	0.0 – 5.0	Calculated
5	201	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY CASE TEC UPPER TEMPERATURE LIMIT STATE

Action	Reads the state of the Case TEC temperature limit.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the Case TEC temperature limit is active and a value of 0 indicates that the Case TEC temperature has NOT exceeded the temperature limit. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The Case TEC temperature limit state returns true when the measured temperature exceeds the upper Case TEC temperature limit setpoint value.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	202	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	202	1 = Limit Active or 0 = Limit NOT Active	Calculated
5	202	NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY CASE TEC CONTROL ERROR STATE

Action	Reads the state of the Case TEC control error signal condition.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the Case TEC control error is exceeding the fixed value and a value of 0 indicates that the Case TEC control error is within the limit. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The Case TEC control error state returns true when the Case TEC control error signal indicates the setpoint temperature has not been reached.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	203	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	203	1 = Error Active or 0 = Error NOT Active	Calculated
5	203	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET / CLEAR CASE TEC OUTPUT STATE

Action	Turns the Case TEC output on or off.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	If the Case TEC fails to go on or quickly turns itself off, read the error queue to help determine the cause of the fault.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	204	1 = On or 0 = Off	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	204	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY CASE TEC OUTPUT STATE

Action	Reads the state of the Case TEC output.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the case TEC output is on and a value of 0 indicates that the case TEC output is off. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	If the case TEC fails to go on or quickly turns itself off, read the error queue to help determine the cause of the fault.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	205	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	205	1 = On or 0 = Off	Calculated
5	205	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET/CLEAR CASE TEC OUTPUT AUTOMATIC ON STATE

Action	Enables or disables the Case TEC output automatically turning on when the instrument powers up.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	When the case TEC automatic output on feature is disabled, both the internal laser TEC and case TEC output state are linked to the TEC front panel on/off button. Therefore, when operating through the front panel on/off button, both the TEC and case TEC are always in the same state.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	206	1 = Enabled or 0 = Disabled	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	206	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY CASE TEC OUTPUT AUTOMATIC ON STATE

Action	Reads the state of the Case TEC automatically turning on when the instrument powers up feature.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the feature is enabled and a value of 0 indicates that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	When the case TEC automatic output on feature is disabled, both the internal laser TEC and case TEC output state are linked to the TEC front panel on/off button. Therefore, when operating through the front panel on/off button, both the TEC and case TEC are always in the same state.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	207	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	207	1 = Enabled or 0 = Disabled	Calculated
5	207	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET/CLEAR CASE OUTPUT OFF WITH UPPER TEMPERATURE LIMIT

Action	Enables or disables the instrument from automatically turning both TECs and laser drive output off when the measured Case TEC temperature exceeds the upper temperature limit setpoint.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This feature can protect the laser from damage by preventing a thermal runaway condition. This feature will automatically disable both TECs and the laser drive output.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	208	1 = Enabled or 0 = Disabled	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	208	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY CASE OUTPUT OFF WITH UPPER TEMPERATURE LIMIT

Action	Reads the state of the automatic TECs and laser drive output off when the Case TEC measured temperature exceeds the upper temperature limit setpoint.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that both TECs and laser turn off when the temperature limit condition occurs and a value of 0 represents that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This feature can protect the laser from damage by preventing a thermal runaway condition. This feature will automatically disable both TECs and the laser drive output.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	209	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	209	1 = Enabled or 0 = Disabled	Calculated
5	209	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET/CLEAR CASE OUTPUT OFF WHEN CONTROL ERROR OCCURS

Action	Enables or disables the instrument from automatically turning both TECs and laser drive output off when the measured Case TEC control error is exceeding the fixed limit.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	When the case TEC is first enabled, it is normal for the control error signal to be active. Therefore the instrument automatically waits for this condition to reach the normal steady state for a one minute period before enabling. Please note that when the “TEC On Before Laser” feature is enabled, this condition will not only disable both TEC outputs but also the Laser output.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	210	1 = Enabled or 0 = Disabled	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	210	ACK or NAK	Calculated

QUERY CASE OUTPUT OFF WHEN CONTROL ERROR OCCURS

Action	Reads the state of the automatic TECs and laser drive output off when the Case TEC control error is outside the fixed limit window.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a single byte Boolean value is returned. Where a value of 1 indicates that the feature is enabled and a value of 0 indicates that the feature is disabled. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	When the case TEC is first enabled, it is normal for the control error signal to be active. Therefore the instrument automatically waits for this condition to reach the normal steady state for a one minute period before enabling. Please note that when the "TEC On Before Laser" feature is enabled, this condition will not only disable both TEC outputs but also the Laser output.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	211	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	211	1 = Enabled or 0 = Disabled	Calculated
5	211	NAK	Calculated

SET CASE TEC TEMPERATURE SETPOINT

Action	Sets the Case TEC temperature setpoint value in degrees Celsius.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The Case TEC temperature setpoint value has a minimum of -100.0 degrees Celsius and a maximum of +100.0 degrees Celsius. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored. Although this command accepts a wide range of setpoint values, the temperature limit for some of the more extreme temperatures may be limited by the maximum available drive voltage of 4.9 volts.

WARNING

Avoid setting a case temperature below the dew point. The case TEC is Not hermetically sealed; allowing condensation to form on the case TEC will result in internal instrument damage that is not covered under the warranty.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	212	-100.0 – +100.0	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	212	ACK or NAK	Calculated

QUERY CASE TEC TEMPERATURE SETPOINT

Action	Reads the Case TEC temperature setpoint value in degrees Celsius.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number representing the temperature value in degrees Celsius is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	If the measured Case TEC temperature is significantly different (> 100 m°C) from the Case TEC temperature setpoint value, verify that the Case TEC voltage limit is not set to low to achieve the desired temperature.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	213	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	213	-100.0 – +100.0	Calculated
5	213	NAK	Calculated

GENERAL
LASER
TEC
CASE

SET CASE TEC TEMPERATURE DAC COUNTS

Action	Sets the Case TEC temperature DAC (Digital to Analog Converter) setpoint value in counts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The Case TEC temperature DAC is 16-bits therefore valid values are 0 through 65,535. Attempting to set a value outside of this range will generate an error and the requested setting will be ignored.

WARNING

Avoid setting a case temperature below the dew point. The case TEC is Not hermetically sealed; allowing condensation to form on the case TEC will result in internal instrument damage that is not covered under the warranty.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (2 Bytes)	CRC (2 Bytes)
6	214	0 – 65,535	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	214	ACK or NAK	Calculated

GENERAL
LASER
TEC
CASE

QUERY CASE TEC TEMPERATURE DAC COUNTS

Action	Reads the Case TEC temperature setpoint value in DAC (Digital to Analog Converter) counts.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a (2-Byte) unsigned integer value representing the DAC counts for the Case TEC temperature setpoint value is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The DAC is 16-bits therefore valid values are 0 through 65,535.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	215	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 2 Bytes)	CRC (2 Bytes)
6	215	0 – 65,535	Calculated
5	215	NAK	Calculated

SET CASE TEC UPPER TEMPERATURE LIMIT SETPOINT

Action	Sets the Case TEC upper temperature limit setpoint value in degrees Celsius. This limit is single ended; it is only active when the temperature exceeds the limit value.
Results	The response message payload byte(s) indicates the status of the requested command operation. o ACK – indicates that the requested command operation was successfully performed. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	The Case TEC upper temperature limit setpoint value has a maximum of +100.0 degrees Celsius. Attempting to set a value above this maximum will generate an error and the requested setting will be ignored. This laser protection feature does not actively limit the Case TEC temperature, when configured it disables both the TECs and laser output when the Case TEC temperature exceeds the limit.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (8 Bytes)	CRC (2 Bytes)
12	216	100.0	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 Byte)	CRC (2 Bytes)
5	216	ACK or NAK	Calculated

QUERY CASE TEC UPPER TEMPERATURE LIMIT SETPOINT

Action	Reads the Case TEC upper temperature limit setpoint value in degrees Celsius. This limit is single ended; it is only active when the temperature exceeds the limit value.
Results	The response message payload byte(s) indicates the status of the requested command operation. o On successful operation a double precision (8-Byte) real number that represents the temperature limit value in degrees Celsius is returned. o NAK – indicates that the requested command operation failed to execute. To help determine the cause of the failure, read the error queue. The first error code in the queue will indicate why the last command operation failed to execute.
Note	This laser protection feature does not actively limit the Case TEC temperature, when configured it disables the TECs and laser output when the Case TEC temperature exceeds the limit.

TRANSMIT MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (0 Bytes)	CRC (2 Bytes)
4	217	N/A	Calculated

INSTRUMENT RESPONSE MESSAGE FRAME			
LENGTH (1 Byte)	HEADER (1 Byte)	PAYLOAD (1 or 8 Bytes)	CRC (2 Bytes)
12	217	100.0	Calculated
5	217	NAK	Calculated

Appendix

Useful Information

Temperature Control Calibration

The typical feedback element used for laser diode temperature control is the 10-kΩ thermistor. These provide an inexpensive and accurate temperature monitor for use with laser diodes. The nonlinear resistance-temperature (R-T) characteristics of a Negative-Temperature Coefficient (NTC) Thermistor may be modeled to a high degree of accuracy using the Steinhart-Hart equation, LaGrange polynomials, or other modeling techniques. Figure A.1 shows a common R-T relation curve for a 10-kΩ NTC thermistor.

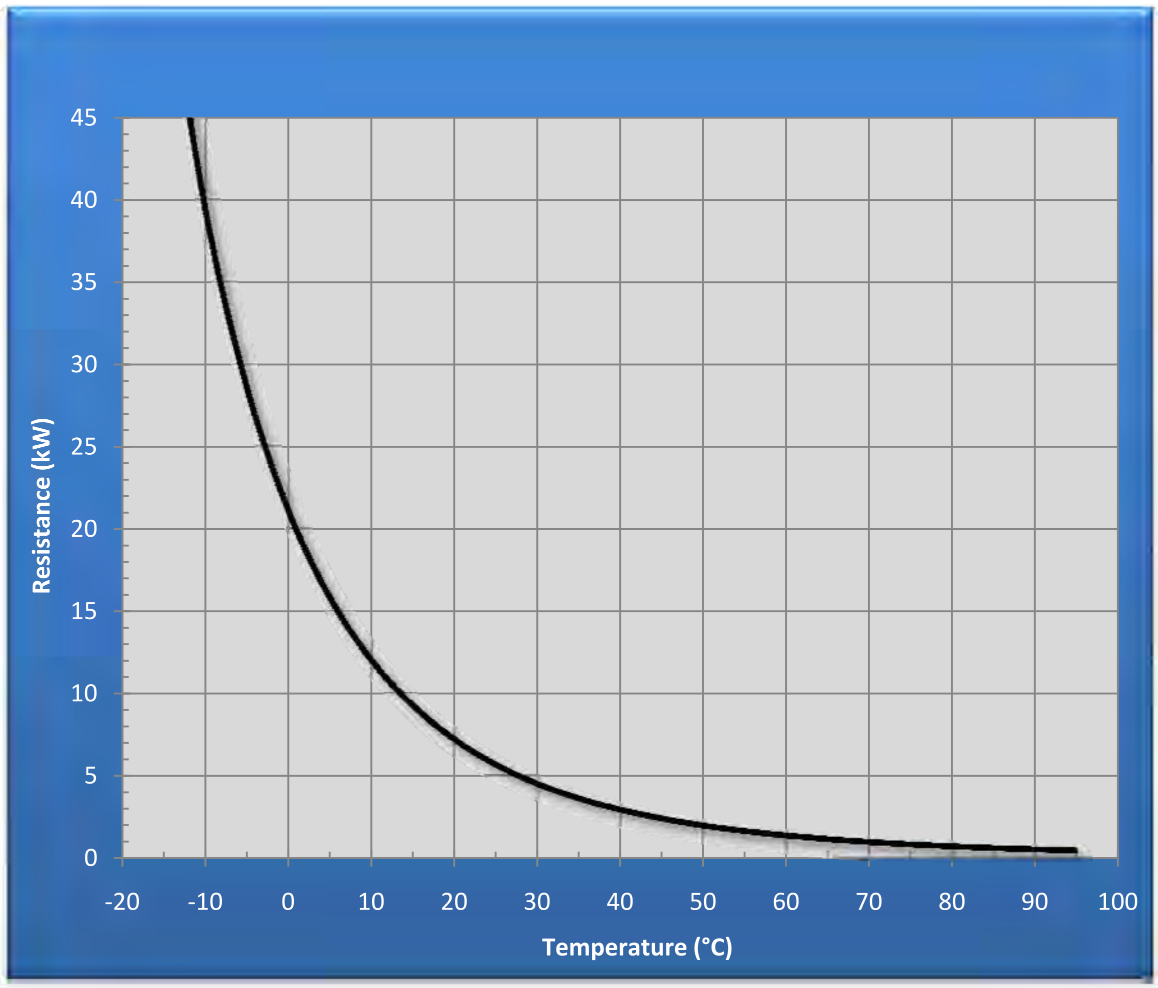


Figure A.1: Resistance vs. Temperature Curve

In 1968, Steinhart and Hart developed a model for thermistor R-T characteristics in order to make accurate temperature measurements for oceanic studies. Today, the most popular model for R-T characterization is the Steinhart-Hart equation.

The three-term Steinhart-Hart equation is the most popular model used for thermistor R-T modeling.

$$\frac{1}{T} = \left(A \times 10^{-3}\right) + \left[\left(B \times 10^{-4}\right) \times \ln(R)\right] + \left[\left(C \times 10^{-7}\right) \times \ln(R)^{3}\right]$$

Where T is the absolute temperature in Kelvin and R is the thermistor resistance in ohms. The terms A, B, and C are the Steinhart-Hart constants for the thermistor.

Temperature accuracy, which is the variance from true temperature, depends primarily on the thermistor calibration. Temperature stability, which is the invariance from the set temperature, depends on the controller design and the environment of the thermistor and TEC module.

The LDCM-4371 is designed from the ground up to maximize temperature stability. The control loop has been optimized using low temperature coefficient components, precision matched resistor networks, and the highest grade components.

Laser Diode Driver Operational Modes

This section helps explain the differences between the two laser diode driver operational modes, constant power and constant current. The characteristics of a laser diode are highly dependent on the temperature of the laser chip. For instance, the wavelength of a typical Distributed Feedback (DFB) laser exhibits approximately 0.11nm change for each 1°C change in temperature ($\Delta\lambda/\Delta T \approx 0.11$nm/°C). With a single mode diode, a change in wavelength may produce an undesirable effect known as "mode hops or mode-hopping". Other characteristics directly related to laser diode's operating temperature are; threshold current, slope efficiency, wavelength, and lifetime. Perhaps the most important characteristic is the effect of temperature on the relationship between the diode's optical output and the injection current. In this case, the optical output decreases as the operating temperature increases or, conversely the optical output increases as the operating temperature decreases. Without limits and safeguards built into the laser drive circuit, a wide swing in operating temperature could be catastrophic. However, there are two techniques commonly used to achieve a stable optical output from a laser diode:

- Constant current mode combined with precise control of the diode's operating temperature is generally the preferred operating method. The constant current mode provides a faster control loop and a precision current reference for accurately monitoring the laser current. Constant Current operation without temperature control is generally not desirable, if the operating temperature of the laser diode decreases significantly, the optical power output will increase and could easily exceed the absolute maximum.
- Constant power mode precludes the possibility of the optical power output increasing as the laser diode's temperature decreases. However, when operating in the constant power mode and without temperature control, mode hops and changes in wavelength will occur. Further, if the diode's heat sink is inadequate and the temperature is allowed to increase, the optical power will decrease. In turn, the drive circuit will increase the injection current, attempting to maintain the optical power at a constant level. Without an absolute current limit, thermal runaway is possible and the laser may be damaged and/or destroyed. Further, in many cases the laser diode's internal photodiode may exhibit drift and have poor noise characteristics. If performance of the internal photodiode is inferior, the diode's optical output is likely to be noisy and unstable as well.

In summary, for stable operation and maximum laser lifetime, temperature control and constant current operation is generally the best solution. However, if precise temperature control of the laser diode is not practical, then constant power mode of operation should be used.

The LDCM-4371 laser diode driver provides two independent modes of operation. This instrument delivers a stable, low-noise output in both constant current and constant power operating modes. The circuitry has been designed to ensure the industry leading accuracy and stability. The control loops have been optimized using low temperature coefficient components, precision matched resistor networks, and highest grade components.

Laser Diode Constant Power Calibration

Generally laser diodes emit power from both ends of their cavity. By monitoring the rear facet output beam of the laser diode with an integrated internal photodiode the laser's optical power can be actively regulated at a constant level. In practice, these integrated back-facet monitor photodiodes typically have a responsivity that varies considerably. To compensate for this variation, the user must enter a device specific calibration transfer function that calibrates the sensitivity of the monitor photodiode with respect to the laser diode optical power output. The value needed for this calibration is usually listed on the laser's test data page, as the Monitoring Current (PD). This will include a condition (optical power) and the test result (current). The instrument expects the monitor responsivity as a measured photodiode current per optical power in the following units (uA/mW).

Using a NTT laser data sheet as an example the test data line of interest is listed below:

Parameter	Symbol	Condition	Specifications			Test Results	Units
			Min	Typ	Max		
Monitoring Current (PD)	$I_{R(E)}$	CW, Φ_e = 10mW	0.1			0.541	mA

Therefore the monitor photo-diode for this device produces 0.541mA of current at 10mW of optical power. This value can easily be converted to the instruments units of uA/mW:

$$\frac{0.541mA}{10mW} = \frac{0.0541mA}{1mW} = \frac{54.1\mu A}{1mW} = 54.1\frac{\mu A}{mW}$$

Therefore, when using this specific device the user would enter 54.1 as the monitor diode responsivity value.

Laser Diode Protection Features

A greater level of protection is provided with the instrument's built-in laser diode protection features. These ensure the protection of the laser diode, including a precisely adjustable maximum laser current limit, a programmable voltage interrupt sensor to shut the laser drive output off in the event of an open connection between the driver and the laser, an automatic shunt feature to protect the laser from electrostatic discharge when it is off or disabled, and a soft-start circuit to ensure a slow, transient-free increase of the laser current whenever the laser is powered on.

In addition, the design incorporates provisions to eliminate spikes, surges, and other switching transients. Regardless of type of circuit used, the current must not overshoot the maximum operating level – exceeding the maximum optical output for even a nanosecond will damage the mirror coatings and the laser diode end facets. A standard laboratory power supply is not suitable for driving laser diodes.

Electro-Static Discharge (ESD) does damage laser diodes, they are extremely sensitive devices! The handling precautions outlined by the laser diode manufacturers are not overstated. To help eliminate potential damage, use only quality purpose built equipment and proper work habits such as personal grounding straps.

Integrated Laser Safety Features

In the United States, compliance with the regulations for lasers and laser products issued by the Center for Devices and Radiological Health (CDRH) of the Food and Drug Administration (FDA) is mandatory. The current CDRH regulations pertaining to laser emissions are found in 21 CFR 1040.10 and 1040.11. The following engineering design features are incorporated into the instrument to ensure class dependant compliance with most standard laser configurations, as specified in CDRH US21 CFR 1040.10.

- *Key Control*
  - *Required for Class 3B and Class 4 laser products.*
  - *The instrument has an integrated laser enable key switch located on the front panel. When switched to the laser disable position, the key should be removed and stored in a way such that untrained and unauthorized personnel cannot operate the laser.*
- *Remote Interlock*
  - *Required for Class 3B and Class 4 laser products.*
  - *The instrument has an integrated remote interlock input located on the front panel.* This device, normally installed on the laser's power supply, prevents operation of the laser unless a connection is made between the terminals of the connector. This allows the user to connect door interlocks or other safety circuits in order to terminate emission when the circuit is broken (for example, when an interlocked door is opened or an emergency stop button is pressed). This can be especially useful when setting up an interlock-protected laser controlled area.

- o While it is not required by the standard, it is nevertheless recommended as good engineering practice that, after the circuit has been broken through the operation of a remote interlock, restarting the laser should require the use of a separate, deliberate reset action unless the laser is in a safe condition when the interlock is closed. Where this is not the case then, for example, while laser emission may be terminated when an interlocked door into a laser room is inadvertently opened, laser emission will restart as soon as the door is closed, clearly not a very sensible safety arrangement if the unauthorized person who opened the door is now inside the room!

❖ *Visual Emission Warning Device*

- o *Required for Class 3B and Class 4 and also invisible-beam Class 3R laser products.*
- o *The standard requires that a visual warning provide a useful indication of the laser's operating state for those not directly in control of laser emission. The instrument front panel contains a laser emission indicator LED integrated into the laser on/off button. Once switched on the laser will perform a five second delay prior to powering the laser, during this delay period the emission indicator LED will flash green. After the delay time has expired the laser will be powered up and the LED will be steady green.*

ERROR CODES

The following list of error codes can occur while operating the instrument. These may indicate a problem with the instrument, command issued, payload data, or the communications activity. The errors can be accessed with the Instrument Controller Program or by issuing the error query. When this is done, all of the error codes that are resident in the non-volatile error queue are returned (up to the last 10 may be stored). Reading the error queue does not clear the error queue. The error queue can only be emptied by sending the clear error queue command.

Error Code	Description
10	Factory protected command received without proper security access
11	Invalid factory security access code detected
12	[23] Internal instrument temperature over limit, disables all outputs
13	[23] Laser mode changed with output on, automatically disables the laser output
14	[23] Laser cathode pin changed output on, automatically disables the laser output
15	[23] External interlock switch state disabled the laser output
16	[23] Laser key switch state disabled the laser output
17	[23] Switched to USB power with a controller output on
18	[23] User attempted to enable laser output when operating on USB power
19	[23] User attempted to enable TEC output when operating on USB power
20	[23] User attempted to enable case TEC output when operating on USB power
30	Unrecognized system type command header
31	Unrecognized laser type command on USB message receipt
32	Unrecognized TEC type command on USB message receipt
33	Unrecognized case TEC type command on USB message receipt
34	Unrecognized factory test mode type command on USB message receipt
40	Invalid packet size for command
41	Indicated packet length is less than the minimum
42	Indicated packet length is greater than the maximum
43	Incomplete message packet was detected
44	Corrupted packet detected
45	Over-run error detected, new byte received before last message was processed
46	Byte framing error detected
47	Byte overflow error detected, new byte received before buffer empty
50	User requested DAC count above maximum value
51	User requested DAC count below minimum value
52	User requested a value greater than the maximum allowed for the parameter
53	User requested a value less than the minimum allowed for the parameter
54	User sent a case TEC command without the case TEC option installed
55	[23,24] User attempted to enable the laser with the TEC output off

Error Code	Description
60	[23,24] The laser current limit automatically turned the laser output off
61	[23,24] The laser power limit automatically turned the laser output off
62	[23,24] The laser voltage limit automatically turned the laser output off
70	[23,24] User disabled the TEC with the laser output on, automatically disables laser
71	[23,24] The TEC temperature limit automatically turned the TEC output off
72	[23,24] The TEC control error limit automatically turned the TEC output off
73	[23,24] The TEC voltage limit automatically turned the TEC output off
74	[23] TEC Thermistor sensor shorted, resistance is less than 25Ω or +465 °C
75	[23] TEC Thermistor sensor open, resistance is greater than 1.2MΩ or -65 °C
80	[23,27] The case TEC temperature limit automatically turned the case TEC off
81	[23,24] The case TEC control error limit automatically turned the case TEC output off
82	[23] Case Thermistor sensor shorted, resistance is less than 25Ω or +465 °C
83	[23] Case Thermistor sensor open, resistance is greater than 1.2MΩ or -65 °C
90	Operating in factory test mode and invalid command received
91	Factory test mode command received while not operating in test mode

Table A.1: Instrument Error Codes

WARNING

The 100 series error codes indicate a severe hardware error condition has been detected. Immediate service is required; do NOT continue to operate the product. Please return the instrument for repair by trained service personnel.

Error Code	Description
100	USB Configuration EEPROM is not responding
101	Program Configuration Memory is corrupted
102	Analog PCBA temperature sensor data format error detected
103	An unrecognized type 1 interrupt was received
104	An unrecognized type 2 interrupt was received
105	Internal oscillator fault detected
106	Invalid memory access fault detected

Table A.2: Instrument Severe Hardware Error Codes

Troubleshooting Guide

Trying to track down and resolve technical problems is, undeniably, one of life's more frustrating experiences. If the instrument can be accessed via the USB port, a very powerful troubleshooting technique is to read the non-volatile error queue. The last ten error codes can be retrieved with either the Instrument Controller Program or a custom application that uses the "Query Error Queue" command. Once the error codes have been read, refer to Tables A.1 and A.2 for a description to each of the individual values. Hopefully, the description will provide enough detail to fully troubleshoot the root cause of the problem.

To help guide you through the troubleshooting process, we've provided an explanation for the more commonly encountered problems and critical issues you may need to understand better. Always precede each trouble shooting section by ensuring a full power cycle to reset the hardware and firmware to a quiescent state. To ensure a full power cycle:

1. Switch the rear panel power switch to the off position (0).
2. Remove the external power supply from the instrument.
3. Remove the USB cable from the instrument.
4. Re-insert the USB cable into the instrument.
5. Re-insert the external power supply into the instrument.

[23] These error conditions can disable some or all the controller outputs
[24] These error conditions are user configurable

6. Switch the rear panel power switch to the on position (I).

TOP LEVEL TROUBLE SHOOTING SCHEMATIC

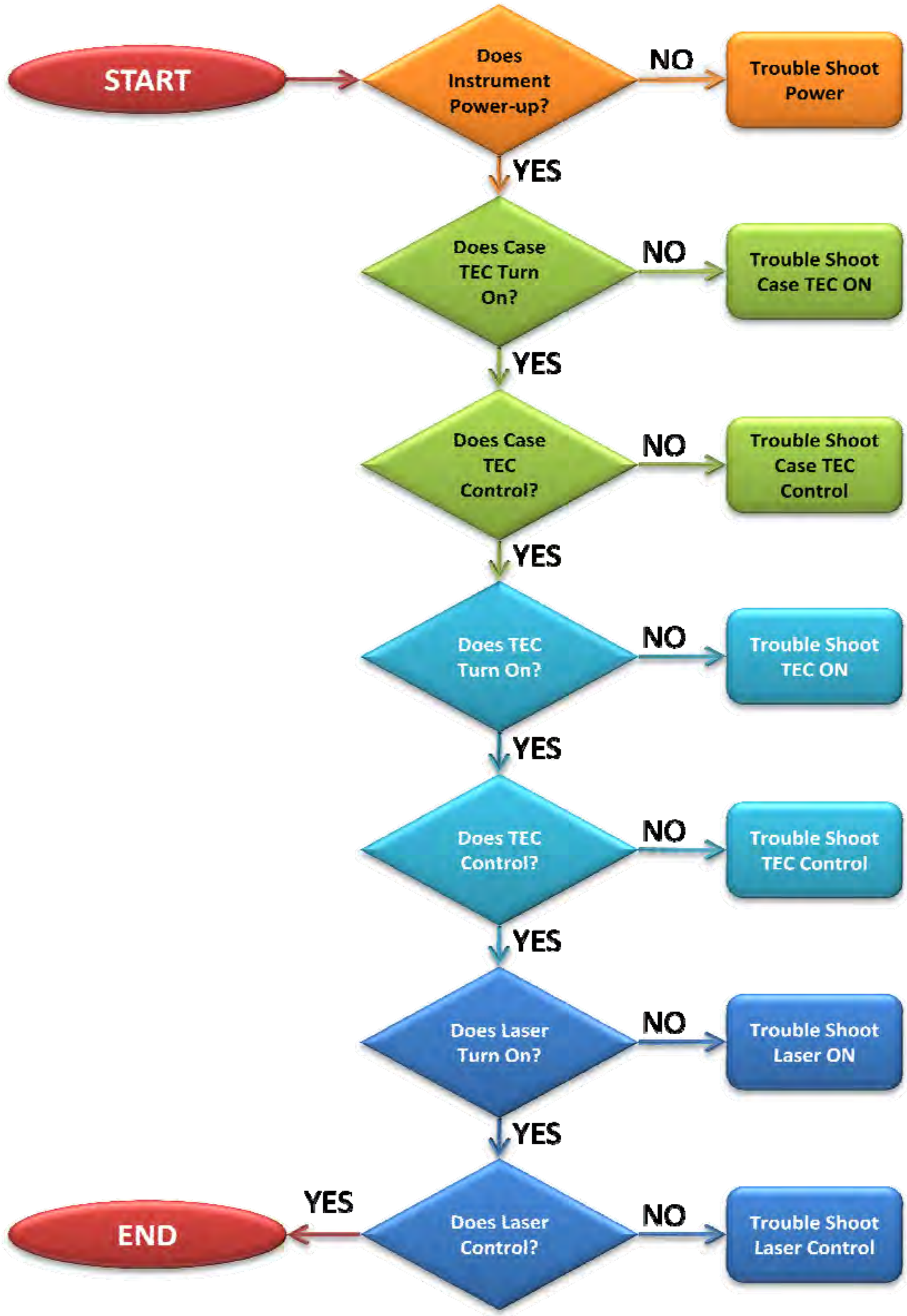


Figure A.2: Top Level Trouble Shooting Schematic

POWER TROUBLE SHOOTING SCHEMATIC

The following steps are intended to assist the user in diagnosing suspected malfunctions with the instruments power system. The external power rocker switch located at the rear of the instrument contains and integrated bi-color LED that is controlled by the instruments processor. Note that when operating on USB bus power, the rear panel power rocker switch is illuminated RED regardless of position. The LED is very useful for performing the diagnostics listed below:

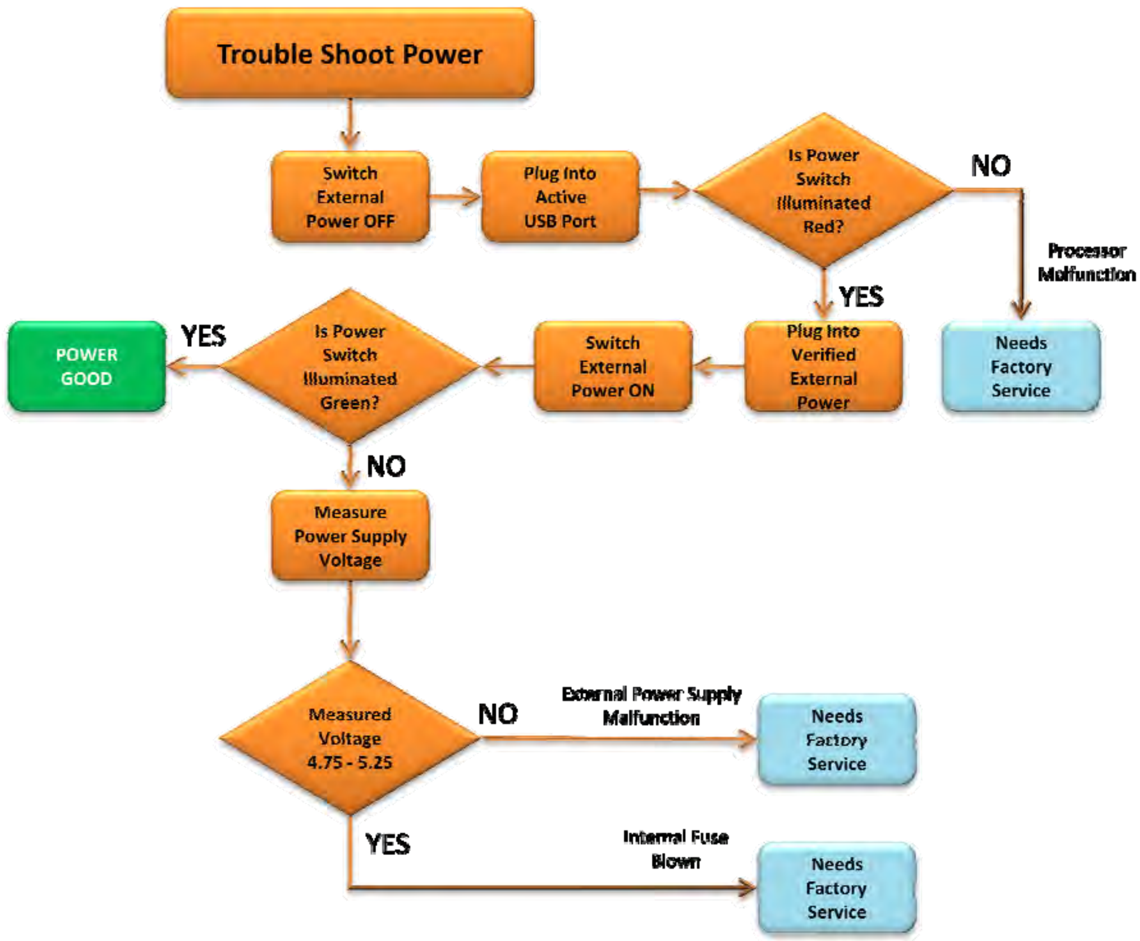


Figure A.3: Power Trouble Shooting Schematic

CASE TEC OUTPUT ON TROUBLE SHOOTING SCHEMATIC

The following steps are intended to assist the user in diagnosing suspected malfunctions with the Case TEC Output not able to turn ON. It is important to remember that when operating the Case TEC with the front panel TEC button, both the Case TEC and internal TEC are coupled together. Therefore the button will either turn both on or off simultaneously.

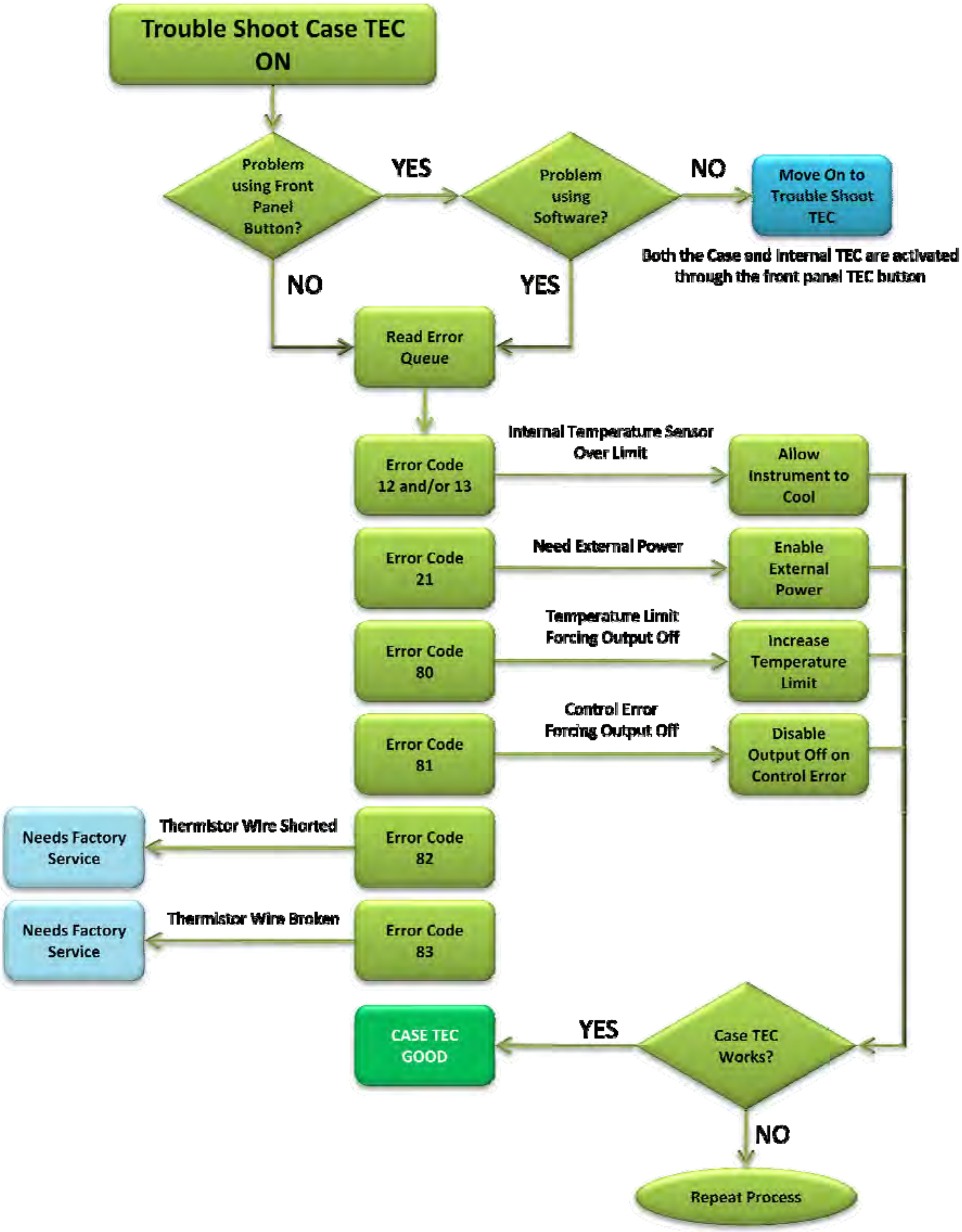


Figure A.4: Case TEC Output On Trouble Shooting Schematic

CASE TEC CONTROL TROUBLE SHOOTING SCHEMATIC

The following steps are intended to assist the user in diagnosing suspected malfunctions with the Case TEC Control.

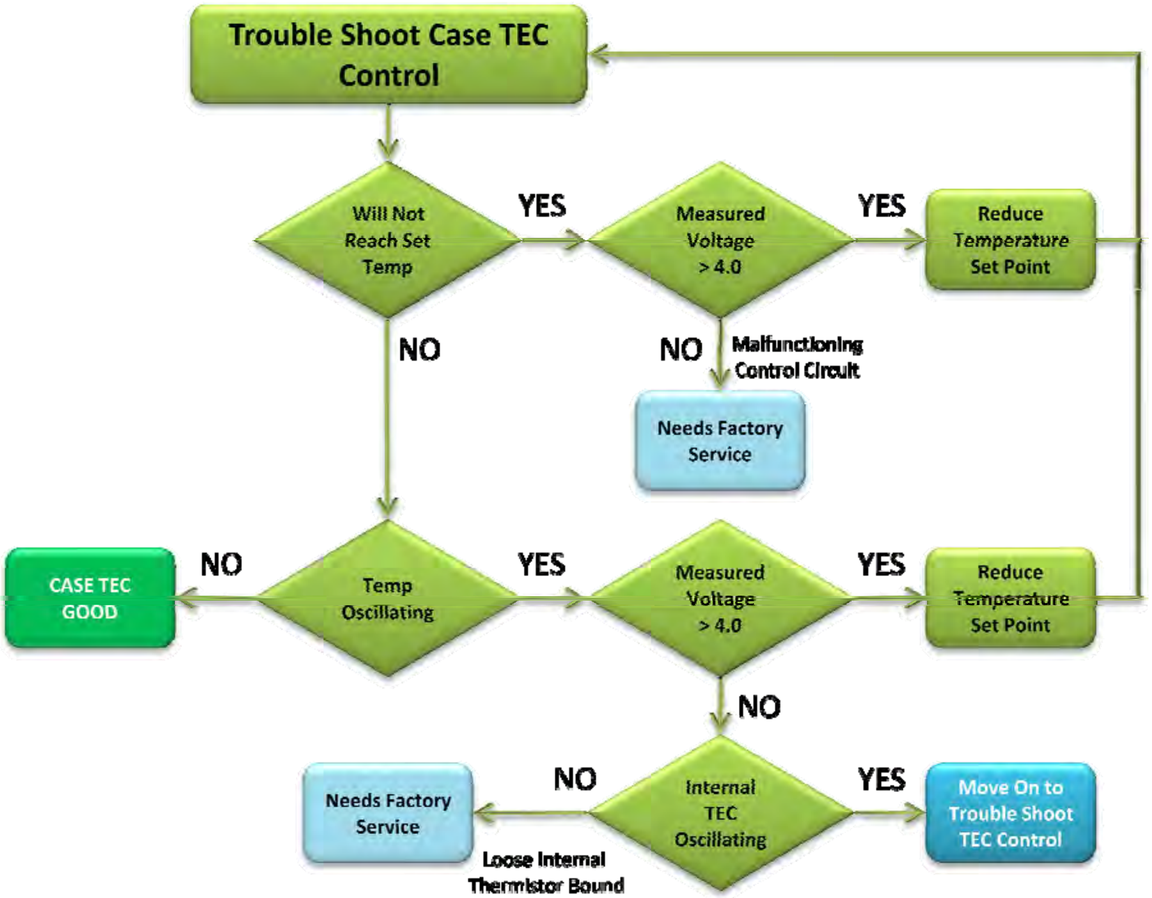


Figure A.5: Case TEC Control Trouble Shooting Schematic

TEC OUTPUT ON TROUBLE SHOOTING SCHEMATIC

The following steps are intended to assist the user in diagnosing suspected malfunctions with the TEC Output not able to turn ON. It is important to remember that when operating the TEC with the front panel TEC button, both the Case TEC and internal TEC are coupled together. Therefore the button will either turn both on or off simultaneously.

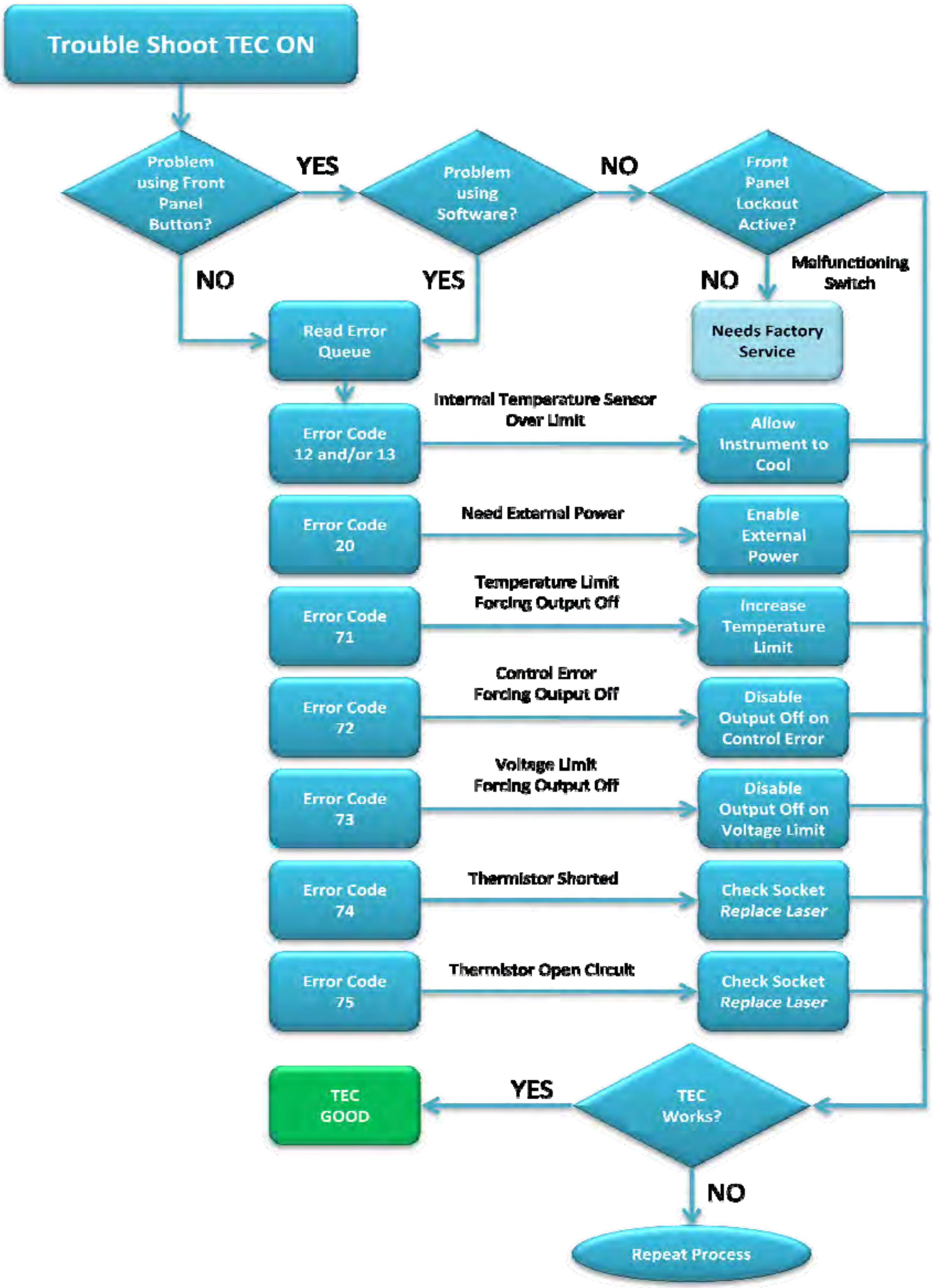


Figure A.6: TEC Output On Trouble Shooting Schematic

TEC Control Trouble Shooting Schematic

The following steps are intended to assist the user in diagnosing suspected malfunctions with the TEC Control.

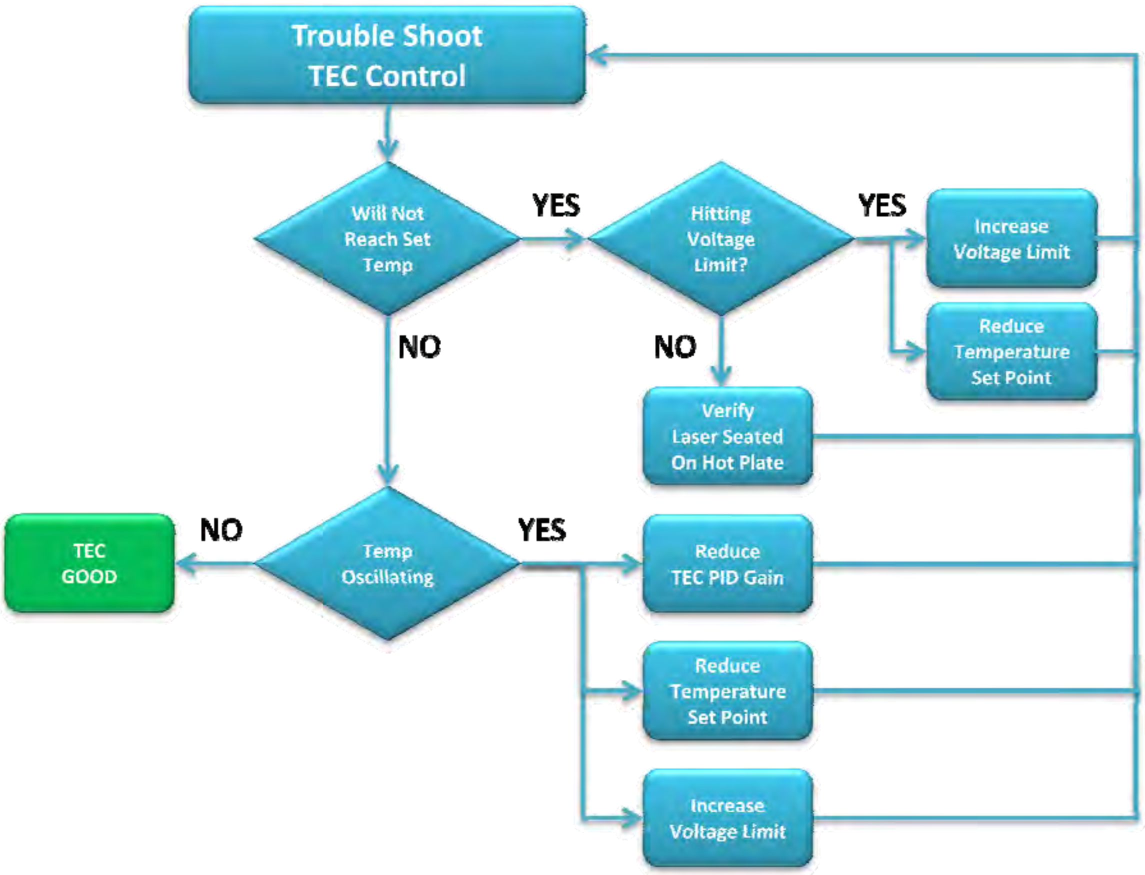


Figure A.7: TEC Control Trouble Shooting Schematic

LASER OUTPUT ON TROUBLE SHOOTING SCHEMATIC

The following steps are intended to assist the user in diagnosing suspected malfunctions with the Laser Output not able to turn ON.

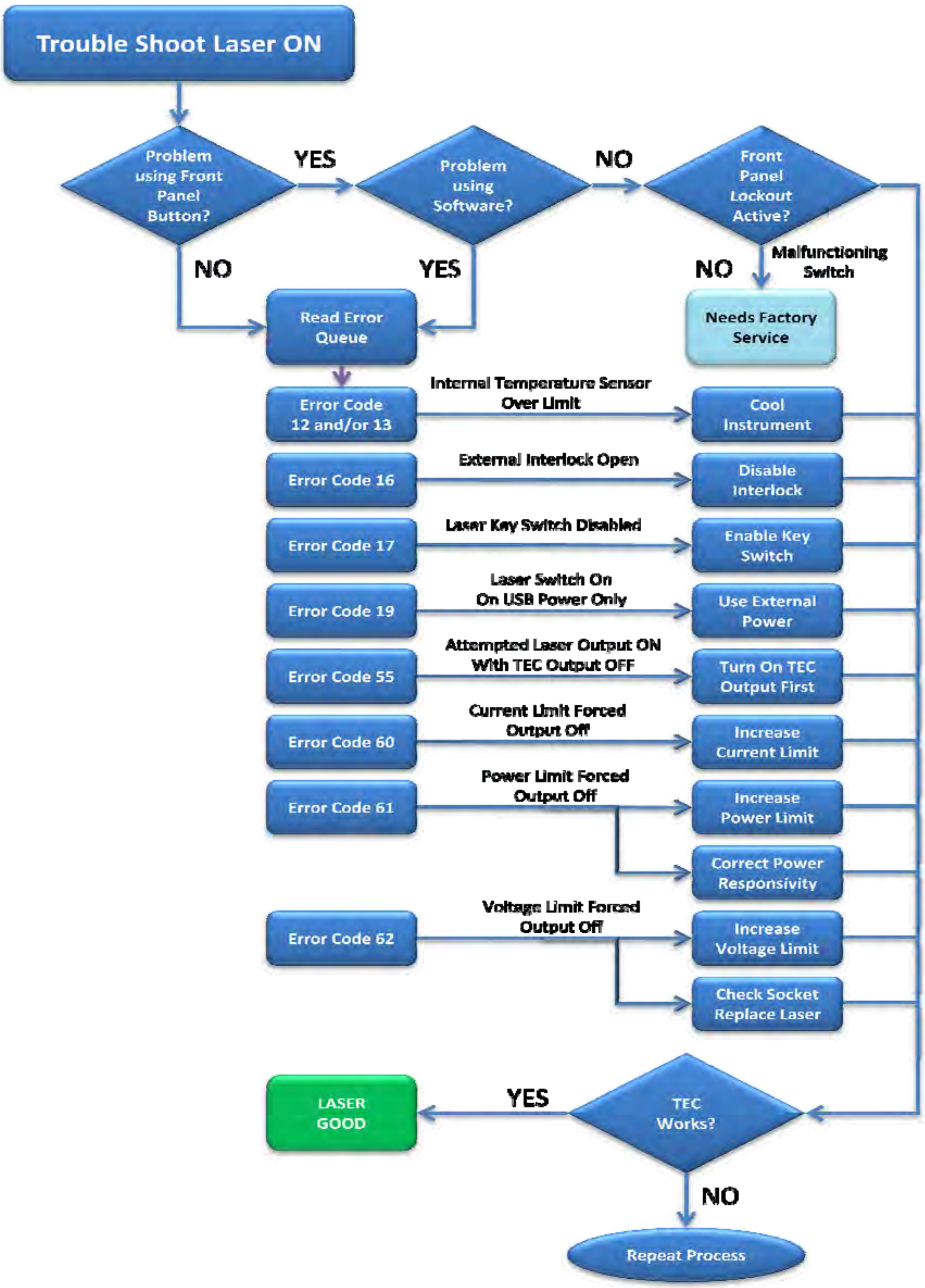


Figure A.8: Laser Output On Trouble Shooting Schematic

LASER CONTROL TROUBLE SHOOTING SCHEMATIC

The following steps are intended to assist the user in diagnosing suspected malfunctions with either the Laser Constant Current or Constant Power Control.

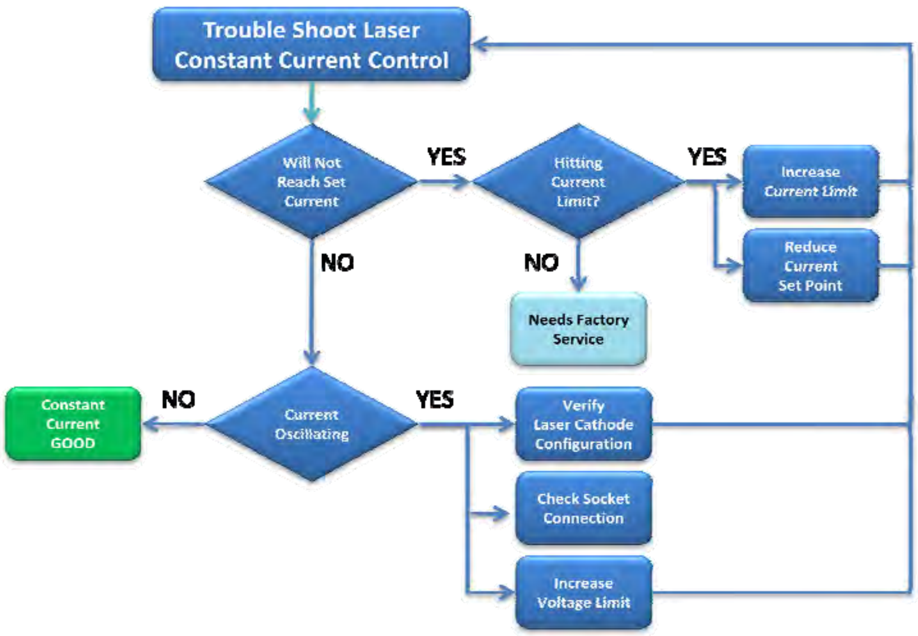


Figure A.9: Laser Constant Current Control Trouble Shooting Schematic

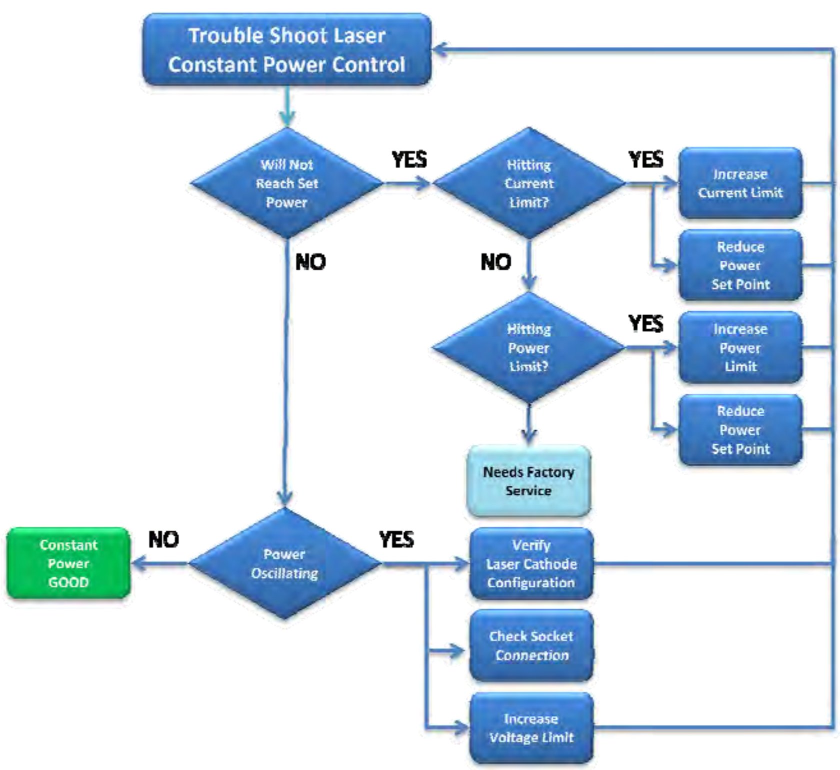


Figure A.10: Laser Constant Power Control Trouble Shooting Schematic

If your problem continues to persist, please feel free to contact our experienced technical professionals who are completely dedicated to ensuring your satisfaction and can provide more extensive troubleshooting support.

DAC VALUE CALCULATIONS

This LDCM-4371 provides direct access to each of the individual set point DAC (Digital to Analog Converter) values. Providing this level of access ensures the finest possible set point resolution. For example, when the user requests a temperature change, the resultant new DAC value depends on two factors:

- o The magnitude of the temperature change requested
- o Where along the Resistance verses Temperature curve (Figure A.1) the change lies

Depending where along the curve the change lies, a single millidegree temperature change may or may not result in an actual change in the DAC value. Therefore, when performing a fine tuning operation, like setting a picometer accurate center wavelength, it may be more useful to directly access the DAC value.

For simplicity reasons, we recommend first using the standard set point commands to do the course tuning. Then query the instrument calculated DAC value associated with that specific set point value. Then as finer tuning is required, increment or decrement the DAC value directly until the exact desired physical attributes are achieved. For example, as depicted in the DAC Fine Tuning Logic Diagram (Figure A.2) below, assume the user wants a center wavelength of 1550.1234 nm and an optical power of 20.0mW.

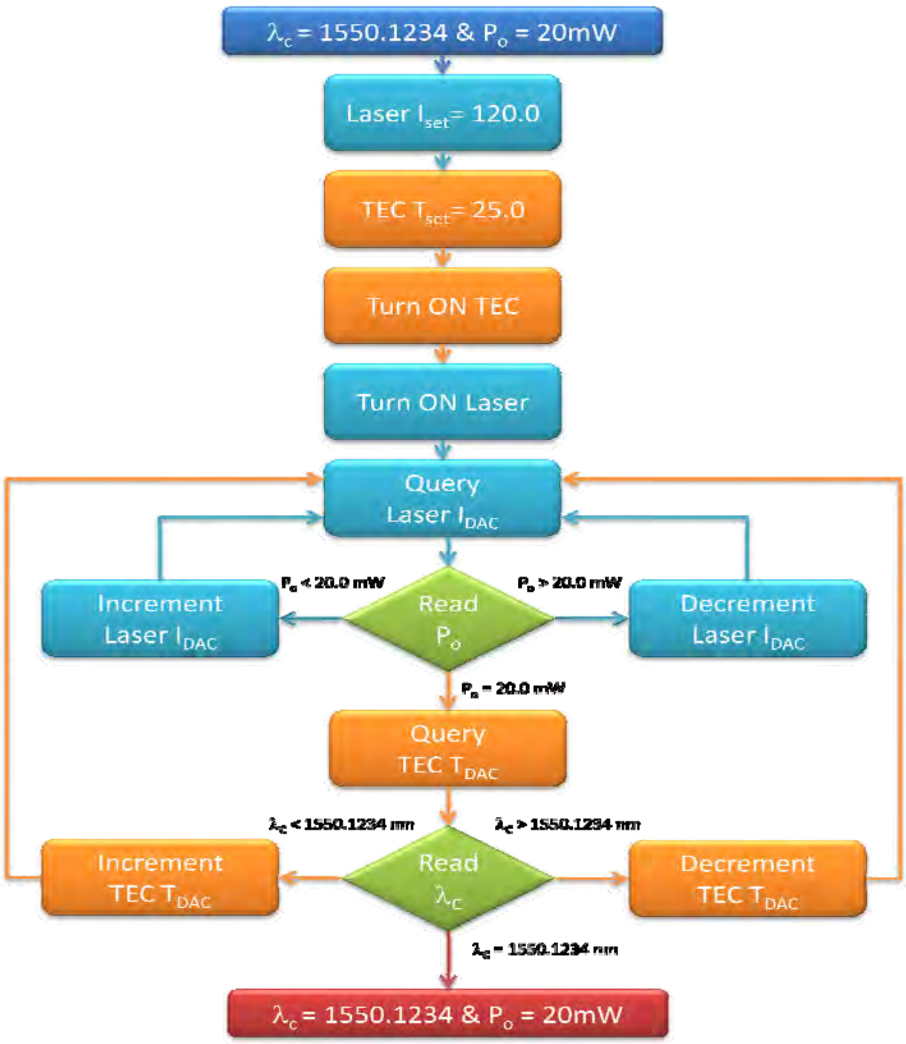


Figure A.11: DAC Fine Tuning Logic Schematic

As depicted in the logic flowchart, changes to either laser drive current or TEC temperature will affect both optical power and center wavelength. Therefore to achieve the setting the user may be required to employ an iterative approach where both are changed in small increments.

As shown in the algorithm implemented in Figure A.2, using the DAC value settings for fine tuning does not necessarily require a full understanding of the internal instrument algorithms. However, for completeness we have included each of the DAC value equations below.

Laser Modulation Attenuation DAC

One of the unique features of this product is the ability to independently attenuate a single modulation signal being delivered to multiple LDCM-4371 instruments. This is critical in applications such as multiplexed spectroscopy, where multiple lasers are synchronously (from a single function generator) being scanned across absorption features of varying widths. The ability to independently tune the modulation signal ensures that the user can tweak each of the individual laser scan widths to exactly fit the unique absorption feature of interest.

The following equation demonstrates how the modulation current ($I_{modualtion}$) is calculated based on the modulation voltage amplitude ($V_{modulation}$) and the DAC counts (DAC_{counts}).

$$I_{Modulation} = \frac{DAC_{Counts}}{2^{16}-1} \times \frac{V_{Modulation}}{5}$$

Where:

$I_{Modulation}$ is in Amps

$V_{Modulation}$ is the maximum modulation amplitude in volts, $V_{Moduation} = V_{peak\text{-}to\text{-}peak} / 2$

DAC_{Counts} is 16-bits, therefore the range is 0 – 65,535

Laser Constant Current DAC

The following equation is used to convert DAC counts (DAC_{Counts}) to a DC current (I_{DC}) in constant current mode of operation.

$$I_{DC} = DAC_{Counts} \times 3.125 \times 10^{-6}$$

Where:

I_{DC} is in Amps

DAC_{Counts} is 16-bits, therefore the range is 0 – 65,535

Laser Constant Power DAC

The following equation is used to convert DAC counts (DAC_{Counts}) to an Optical Power (P_O) in constant power mode.

$$P_O = DAC_{Counts} \times 6.10361 \times 10^{-4}$$

Where:

P_o is in milliwatts

DAC_{Counts} is 16-bits, therefore the range is 0 – 65,535

TEC Gain DAC

The following equation is used to convert DAC counts (DAC_{Counts}) to a TEC Gain (G_{TEC}). The TEC Gain is the proportional portion of the smart integrator.

$$G_{TEC} = \frac{DAC_{Counts}}{5.1} + 1$$

Where:

DAC_{Counts} is 8-bits, therefore the range is 0 – 255, this limits G_{TEC} to a gain range of 1.0 to 51.0.

TEC Temperature DAC and Case TEC Temperature DAC

The following equations are used to convert between temperature set point (T) to DAC counts (DAC_{Counts}).

$$R_{Thermistor} = \frac{DAC_{Counts} \times 10k\Omega}{65{,}535 - DAC_{Counts}}$$

Where:

$$R_{Thermistor} = e^{\left(\beta - \frac{\alpha}{2}\right)^{\frac{1}{3}} - \left(\beta + \frac{\alpha}{2}\right)^{\frac{1}{3}}}$$

Where:

$$\alpha = \frac{A - \frac{1}{T}}{C} \text{ and } \beta = \sqrt{\left(\frac{B}{3 \times C}\right)^3 + \frac{\alpha^2}{4}}$$

Where:

$R_{Thermistor}$ is in ohms

T is temperature in °K

DAC_{Counts} is 16-bits, therefore the range is 0 – 65,535

A is the first Steinhart-Hart constant

B is the second Steinhart-Hart constant

C is the third Steinhart-Hart constant

Modulation Attenuation Verses Bandwidth

As shown in Figure A.2 below, the modulation attenuation is frequency dependent. For example:

Assuming zero attenuation (Digital Code = 0xFFFF), the monotonic attenuation bandwidth is 2 MHz, and gain peaking occurs between 2 MHz and 6 MHz and then rolls off at approximately 6 dB/octave.

Assuming -30 dB of attenuation (Digital Code = 0x0800), the monotonic attenuation bandwidth is 4 MHz. -30 dB of attenuation results in an attenuation factor = 0.032, as shown in the following formula:

$$= 10^{\frac{A(dB)}{20}} = 10^{\frac{-30}{20}} = 0.032$$

Therefore, assuming an input peak voltage of +15 volts, the resulting output voltage would be 0.47V, as shown in the following formula:

$$+15V \times 0.032 = +0.47V$$

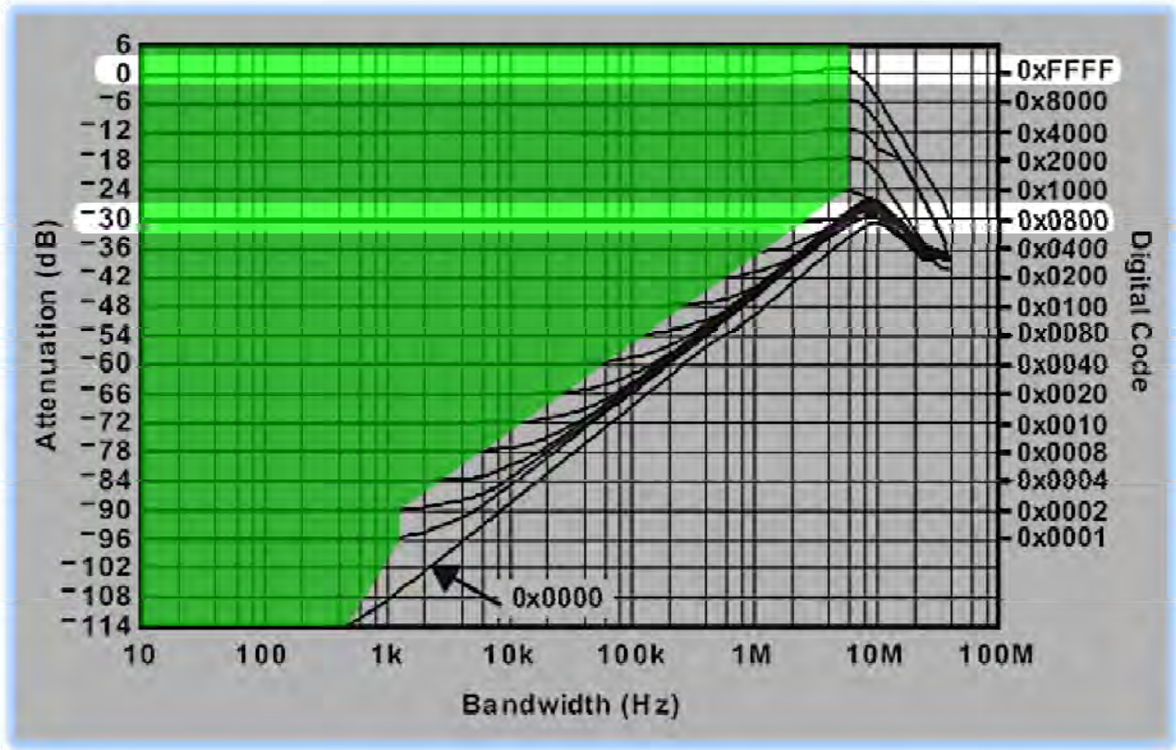


Figure A12: Modulation Bandwidth vs. Modulation Attenuation Curves

When applying attenuation to a modulated signal, the user should consult the graph in Figure A.3 to ensure the requested attenuation remains monotonic throughout the entire bandwidth, or more simply ensure that the intersection of the attenuation value (y-axis) and maximum frequency (x-axis) remain within area highlighted in green.

The following formulas are useful to convert between attenuation values and voltage output:

$$A(dB) = 20 \times \log_{10}\left(\frac{V_{out}}{V_{in}}\right)$$

$$V_{out} = V_{in} \times 10^{\frac{A(dB)}{20}}$$

To convert a modulation voltage into a modulation current apply the following formula:

$$I_{modulation} = \left(\frac{DigitalCode}{2^{16}}\right) \times \left(\frac{V_{peak-modulation}}{5}\right)$$

This instrument uses this equation to calculate the appropriate digital code that will result in the user requested modulation current given the user entered modulation peak-to-peak voltage.

Implementing the CRC-16-IBM Algorithm

The aim of an error detection technique is to enable the receiver of a message transmitted through a noisy (error-introducing) channel to determine whether the message has been corrupted. To do this, the transmitter constructs a value (called a checksum) that is a function of the message, and appends it to the message. The receiver can then use the same function to calculate the checksum of the received message and compare it with the appended checksum to see if the message was correctly received.

Note: The term "checksum" was presumably used to describe early summing formulas, but has now taken on a more general meaning encompassing more sophisticated algorithms such as the CRC ones. The CRC algorithms to be described satisfy the second condition very well, and can be configured to operate with a variety of checksum widths.

At least two aspects are required to form a strong checksum function:

- o WIDTH:

  A register width wide enough to provide a low a-priori probability of failure (e.g. 16-bits gives a $1/2^{16}$ chance of detecting a failure).

- o CHAOS:

  A formula that gives each input byte the potential to change any number of bits in the register.

Simple addition does not provide enough chaos (randomization) to suffice as an effective checksum generator, it turns out that division does, so long as the divisor is about as wide as the checksum register.

The basic idea of CRC algorithms is simply to treat the message as an enormous binary number, to divide it by another fixed binary number, and to make the remainder from this division the checksum. Upon receipt of the message, the receiver can perform the same division and compare the remainder with the "checksum" (transmitted remainder).

The word you will hear all the time when dealing with CRC algorithms is the word "polynomial". A given CRC algorithm will be said to be using a particular polynomial, and CRC algorithms in general are said to be operating using polynomial arithmetic. What does this mean?

Instead of the divisor, dividend (message), quotient, and remainder being viewed as positive integers, they are viewed as polynomials with binary coefficients. This is done by treating each number as a bit-string whose bits are the coefficients of a polynomial. For example, the ordinary number 23 (decimal) is 17 (hex) and 10111 binary and so it corresponds to the polynomial:

$$1\times x^4+0\times x^3+1\times x^2+1\times x^1+1\times x^0$$

or, more simply:

$$x^4+x^2+x^1+x^0$$

Having defined CRC arithmetic, we can now frame a CRC calculation as simply a division, because that's all it is! This section fills in the details and gives an example.

To perform a CRC calculation, we need to choose a divisor. In math marketing speak the divisor is called the "generator polynomial", and is a key parameter of any CRC algorithm.

You can choose any generator polynomial and come up with a CRC algorithm. However, some values are better than others, and so it is wise to stick with the tried and tested ones. Developing a generating polynomial is beyond the scope of this manual, it is sufficient to just use the CRC-16-IBM generator polynomial 0x8005 or in binary 1000 0000 0000 0101.

The width (position of the highest 1 bit) of the generator polynomial is very important as it dominates the whole calculation. Typically, widths of 16 or 32 are chosen so as to simplify implementation on modern computers. The width of a generator polynomial is the actual bit position of the highest bit. For example, the width of 10011 is 4, not 5. For the purposes of example and to simplify the operation, we will chose a generator polynomial of 10011 (which has a width W = 4).

Having chosen a generator polynomial, we can proceed with the calculation. This is simply a division (in CRC arithmetic) of the message by the generator polynomial. The only trick is that W zero bits are appended to the message before the CRC is calculated.

Thus we have:

Original Message : 1101011011

Generator Polynomial : 10011

Message after appending W zeros : 11010110110000

Now we simply divide the augmented message by the generator polynomial using CRC arithmetic. This is the same division as before:

```
             1100001010
10011 ) 1101011011 0000
        1001100000 0000
        ---------------
        0100111011 0000
        0100110000 0000
        ---------------
        0000000101 1000
        0000001011 0000
        ---------------
        0000000010 1000
        0000000010 0110
        ---------------
        0000000000 1110
```

The division yields the all important remainder or CHECKSUM of **1110**, and a quotient of 1100001010, which we throw away. This ends the CRC calculation example.

Usually, the checksum is then appended to the message and the result transmitted. In this case the transmission would be: **11010110111110**.

At the other end, the receiver can do one of two things:

- Separate the message and checksum. Calculate the checksum for the message (after appending W zeros) and compare the two checksums.
- Checksum the whole lot (without appending zeros) and see if it comes out as zero!

These two options are equivalent. However, option b is typically implemented because it is marginally mathematically cleaner.

A summary of the operation for calculating the CRC-16-IBM Algorithm:

1. Choose a width W = 16
2. Choose a generator polynomial G (of width W) = 0x8005 = 1000 0000 0000 0101
3. Append W zero bits to the message M. Call this M'.
4. Divide M' by G using CRC arithmetic. The remainder is the checksum.
5. Append the checksum to the original message M.

That's all there is to it. If you need additional assistance with implementing the CRC-16-IBM Algorithm, please feel free to contact us for the C functions implemented in this instrument.