LaserSource™

4400 SERIES

USER'S MANUAL

LASER DIODE DRIVER

arroyo instruments

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Introduction

Thank you for choosing the **LaserSource** from Arroyo Instruments. Your **LaserSource** is a combination of leading-edge technology combined with years of experience in the field of current control.

With a crystal clear VFD display, both RS232 and USB computer interfaces, and small footprint, the **LaserSource** will fit into almost any laser diode control application.

A key feature of the **LaserSource** is its optical isolation of both modulation and photodiode inputs. By isolating these inputs, it prevents unwanted ground loop problems. No other laser diode driver in the industry has this feature.

Another important feature of the **LaserSource** is its ability to operate in quasi-CW (QCW) mode. This mode permits operation of lasers to a higher current and power, minimizing the thermal load by turning the laser on for only a brief period of time, taking measurements, then turning off the laser. The **LaserSource** supports both internal and external triggering of pulses, and also includes a trigger out to synchronize the **LaserSource** with other instruments.

The **LaserSource** also operates in constant voltage control mode, allowing you to use it in precision voltage applications, such as EML devices, or for doing V-I measurement graphs.

The **LaserSource** includes another feature not found in other products: the ability to program the photodiode bias level from the front panel or over the computer interface, to any voltage from 0 to -5V. No more tweaking a potentiometer with a screwdriver and a DMM. Simply dial in the voltage you need.

Unlike other laser diode drivers in its class, which use inexpensive 7-segment displays, the **LaserSource** takes advantage of its large VFD display to simultaneously show the set point, laser voltage, and photodiode read back.

The user interface of the **LaserSource** is engineered to make using the instrument straightforward. With its text-based menus, there is never any confusion over which setting is being changed, and parameters are displayed in clear English (no cryptic numbers or LEDs to decode).

The **LaserSource** offers all the features you would expect from a modern precision laser diode driver, including:

- 10ppm current stability over one hour
- 10A to 100A current ranges

- Comprehensive laser protection circuitry, including hardware voltage and current limits, and fast transient shutdown.
- External analog modulation
- Power mode control, both in photodiode current (AMC) or computed photodiode power (APC) modes.
- Simultaneous reading of current set point, voltage measurement, and photodiode current or power measurement.

What's in the Box

Along with the LaserSource itself, a CD with electronic copies of this manual, the ***Computer Interfacing Manual***, and USB drivers are included. For USA customers, a power cord is included. For non-USA customers, an IEC-60320-C13 rated AC power cord must be provided.

Accessories

Arroyo Instruments also sells several accessories designed to work with the LaserSource. These include:

- **LaserSource Cables:**
  - **1230:** 20A, 2m, 13W3F connector on device end
  - **1231:** 20A, 2m, pigtailed (bare) wires on device end
  - **1232:** 40A, 2m, 13W3F connector on device end
  - **1233:** 40A, 2m, pigtailed (bare) wires on device end
- **4400/5400 Series 2U Rack Mount Kit (p/n 1403-RM)**
  For installing your **4400/5400** Series TECSource into a standard 19" rack.
- **10kΩ Thermistor (p/n 1600-10K)** for use with the auxiliary temperature sensor inputs.
- **RS-232 NULL Cable, 3m (p/n 1200-NULL)**
- **USB Cable, 3m (p/n 1201)**

Safety Terms and Symbols

The following safety-related terms are used in this manual:

- **Warnings** (noted by the WARNING heading) explain dangers that could result in physical injury or death.
- **Cautions** (noted by the CAUTION heading) explain conditions that could result in damage to the instrument, other equipment, or your device.
- **Notes** (noted by the NOTES heading) are ***not*** safety-related and are intended simply to point out important information.

If, at any time, any of the following conditions exist, or are suspected of existing, discontinue use of the unit until it can be inspected by qualified service personnel:

- Visible damage to the unit, including damage or stress caused during product shipment.
- Storage of the unit outside the standard storage temperature or humidity rating, or prolonged storage under harsh conditions.
- Failure to operate properly.

If needed, contact your distributor or Arroyo Instruments for service or repair to ensure the safety of the product is maintained.

Symbols


Power Off

Power On


Caution, refer to manual


Earth Ground


Caution, risk of electric shock

General Warnings

WARNING

Potentially lethal voltages exist within this instrument. This instrument is intended for use by qualified personnel who understand the shock and laser hazards and are familiar with safety procedures required to avoid injury. Read this manual completely before attempting to use this product.

WARNING

To avoid electrical shock, ensure a 3-prong power cord is used, and is plugged into an earth-grounded receptacle. Failure to do so can result in severe injury or death.

CAUTION

There are no user-serviceable parts inside. All service and repair work shall be done by Arroyo Instruments or personnel authorized by Arroyo Instruments. Modifications done by non-authorized personnel will void the warranty. Please see the Service section later in this manual for instructions on how to obtain service for this instrument.

Quick Start

The LaserSource was designed with ease of use in mind. This section will show how you can quickly get the unit up and running.

The unit uses a universal AC input, just ensure you are within the 100V to 250V AC operating range. Plug the AC cord into the unit and into the wall outlet. Turn on the power switch located on the front panel, and the unit will power up, displaying the model information, serial number, and firmware version number.

The most important setting of the controller is the current limit. A proper current limit will ensure you do not over-drive the laser. The voltage limit is not as critical, but a well-set voltage limit is also recommended.

Press the **Menu** button to enter the menu, and using the knob, turn to the right until the **Io Limit** setting is displayed. This is perhaps the most critical setting you can adjust on the instrument, as it will protect your laser against over-current conditions. Press the knob to edit the setting and adjust the limit as appropriate to your laser diode. Set a bit above the target operating current, as you do not want to be driving into the limit. Press the knob again to save the value. Make the same adjustments to the voltage limit (**Vf Limit**), setting between 0.5V and 1V above the typical operating voltage of your device (the extra voltage will take into account any voltage losses in the cables and connectors). Once you have made all your adjustments, press the **Menu** button to exit the menu.

Next, connect the cable between your LaserMount or other fixture and the **Output** connector of the LaserSource. We recommend using our cables as they have been designed to work well with the LaserSource. If using your own cables, ensure they have been properly wired according to the pin-out of the LaserSource and your fixture.

When starting a system for the first time, it is recommended that you start with the set point at zero and ramp up the set point to your target operating current. The "gentle" turn-on is a good way to verify everything is hooked up correctly. For subsequent turn-ons, you can leave the set point at your target and simply turn the output on.

After a 3-second delay (defeatable, see **On Delay** setting), the output will turn on and you will see the actual voltage of the laser displayed.

Detailed information on the operation of the unit can be found in the remainder of this manual.

Installation

Installation of the **4400 LaserSource** is very straightforward, as the quick start section above illustrated. This section will provide additional details and considerations for installing your **LaserSource**.

After unpacking the unit, make sure all packing materials have been removed and nothing obscures the ventilation ports on the back and bottom of the unit.

The **LaserSource** has a universal input power supply, accepting 90 to 240 VAC, and 50 or 60 Hz. This covers all conventional power worldwide but ensure your AC power meets these requirements.

CAUTION

Do not exceed 250VAC on the line input.

Excessive line voltage can damage the controller.

Powering Up the Unit

Connect the AC power cord to the unit. Turn the power switch, located on the front of the unit, into the on (|) position. The unit will display the current firmware revision, go through a quick power-up self-test, and return to the last known operating state.

Ventilation

The **LaserSource** has vent holes on the side and front of the unit. You must not block these vent holes or overheating may occur causing damage to the unit.

CAUTION

Do not operate the unit above +40°C ambient, and ensure the instrument is properly ventilated, or the unit may overheat and possible damage to the unit may occur.

Rack Mounting

The rack mounting kit (**p/n 1403-RM**) for standard 19" racks are available for the **LaserSource**. Because the unit draws air from the side, and therefore inside the rack housing, be sure that the internal rack ambient temperature (which will

typically be several degrees higher than room ambient) does not exceed the unit's operating temperature.

Warm-up and Environmental Considerations

In order to achieve the highest level of accuracy, the LaserSource should be powered on for at least one hour prior to taking measurements. In addition, ensure that the unit is not operating outside the ambient temperature range or humidity conditions.

Front Panel Connections

The front panel has connections for modulation and QCW triggers.

Modulation Input

The modulation input BNC accepts a 0V to 10V input signal for analog set point control of the driver. The modulation input is optically isolated from the rest of the control circuits in the LaserSource and electrically isolated from ground, so you should not need to be concerned about ground interference from any modulation source.

BNC	Description
Center Pin	Signal+
Shell	Signal–

Modulation Connector (BNC)

Trigger Input & Output

The trigger input and output BNCs are used in QCW modes. For more information on their use, see the **Using QCW Modes** section.

BNC	Description
Center Pin	Signal+
Shell	Ground

Trigger In and Trigger Out Connectors (BNCs)

Rear Panel Connections

In addition to the front panel connections described, the rear panel has connections for AC power, Output connector or bus bars, Auxiliary connector, Interlock connector, USB connector, and RS232 connector.

LaserSource Rear Panel, 40 Amp Rated Units and Below

LaserSource Rear Panel, Units Rated Above 40 Amps

13W3 Laser Output Connector

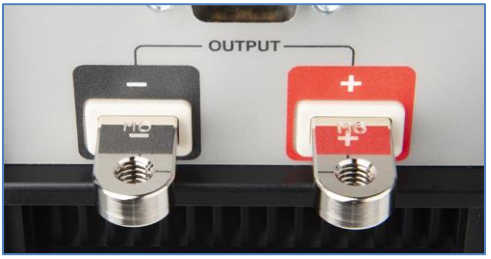
For controllers with a current rating of 40 Amps and lower, the Output connector is a female 13W3, and has the following pin-out:

Pin	Description	Pin	Description
A1	Laser Cathode	A2	Earth Ground
A3	Laser Anode		
1	Interlock/LED+	6	Laser Cathode Remote Sense
2	Interlock/LED–	7	Photodiode Anode
3	Pilot Anode	8	Photodiode Cathode
4	Pilot Cathode	9	Temperature Sensor
5	Laser Anode Remote Sense	10	Temperature Sensor

Output Connector (13W3 Female)

Bus Bar Laser Output Connector

For controllers with a current rating of over 40 Amps, the Output connector is bus bar with M6 threaded holes.



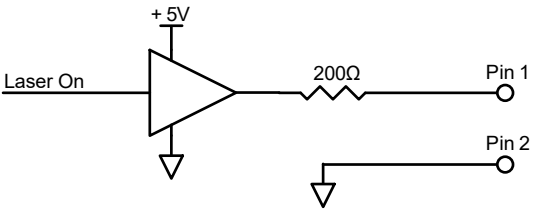
The remaining signals are housed in a DB9 female signal connector directly above the bus bar terminals:

Pin	Description	Pin	Description
1	Interlock/LED+	6	Photodiode Cathode
2	Interlock/LED–	7	Photodiode Anode
3	Earth Ground	8	Pilot Cathode
4	Laser Cathode Remote Sense	9	Pilot Anode
5	Laser Anode Remote Sense		

Signal Connector (DB9 Female)

Using the Interlock/LED

The Interlock/LED pins can be used to drive an LED to indicate when the laser is on. The signal is driven from a +5V buffer with a 200Ω resistor in series with the output, limiting the current to 20mA. This is suitable for the direct connection of most green and red LEDs. Add additional series resistance for lower current devices, such as blue LEDs.



Laser On LED Circuit Diagram

See *Using the Interlocks* section for additional information.

Using Remote Voltage Sense

The Remote Sense pins are used to remotely measure the laser voltage. See *Using Remote Voltage Sense* section for more information.

Auxiliary Connector

The Auxiliary connector is a female DB-25, and has the following pin-out:

Pin	Description	Pin	Description
1	Digital Input 1	14	Digital I/O Ground
2	Digital Input 2	15	Digital I/O Ground
3	Digital Output 1	16	Digital I/O Ground
4	Digital Output 2	17	Digital I/O Ground
5	+5V (100mA MAX)	18	Digital I/O Ground
6	Relay N/C Contact	19	Relay Common
7	Relay N/O Contact	20	*Reserved, no connection*
8	*Reserved, no connection*	21	*Reserved, no connection*
9	*Reserved, no connection*	22	Sensor Ground
10	Auxiliary Sensor 1	23	Sensor Ground
11	Auxiliary Sensor 2	24	*Reserved, no connection*
12	*Reserved, no connection*	25	*Reserved, no connection*
13	*Reserved, no connection*		

Auxiliary Connector (DB-25 Female)

See *Using the Auxiliary Interface* section for more information on using the auxiliary interface.

Interlock Connector

The Interlock connector is a 2-pin Phoenix socket with the following pin-out:

Pin	Description
1	Interlock
2	Interlock Ground

Interlock Connector (2-Pin Phoenix)

The mating plug is a Phoenix part number 1803578, and one is included with the instrument. See *Using the Interlocks* section for additional information.

USB Connector

The USB connector is a standard Type B female connector. For more information on using the USB interface, see the *Computer Interfacing Manual* which is included on the CD that accompanied this product.

RS232 Connector

The RS232 connection is male DB-9 connector wired in a NULL modem configuration.

Pin	Description
2	Receive
3	Transmit
5	Ground
1,4,6	Commoned together
7,8	Commoned together
9	No connection
Shell	Earth ground

RS232 Connector (DB-9 Male)

For more information on using the RS232 interface, see the *Computer Interfacing Manual* which is included on the CD that accompanied this product.

Front Panel Operation

Operation of the LaserSource is very straightforward. The sections below will help familiarize you with the front panel, the display, and the menu structure.

The front panel is designed for simplicity in operation. There are seven buttons on the front panel: **Output**, **Menu**, **Display**, **Func A**, **Func B**, **Pilot Laser**, and the adjustment knob button.

The **Output** button is used to turn the high-power laser output on and off. Whenever the output is on, the blue Output On LED will be lit.

The **Pilot Laser** button is used to turn the Pilot Laser output on and off. Whenever the output is on, the blue Pilot Laser Output On LED will be lit.

The **Menu** button is used to enter the LaserSource menu. When in remote mode, it acts as a **Local** button, returning the instrument to local mode. There are two menus in the system: the Main Menu, which can be accessed by pressing the Menu button on any screen except the pilot laser, and the Pilot Menu, which can only be accessed when on the pilot laser screen.

The **Display** button is used to cycle through the display modes of the controller. Because the controller monitors more information than can be displayed at once, the **Display** button allows you to cycle between the laser information, auxiliary temperature measurements, digital I/O status, and pilot laser control.

The **Func A** and **Func B** buttons are used to execute user-defined macros, recall saved settings, or other actions as defined in the **Function Keys Menu**.

The large adjustment knob located on the right-hand side of the unit is used to change the set point or parameters in the menu. It also acts as a push button, primarily as an enter button, when making changes in the menu.

There are eleven LEDs:

Function	Color	When lit, indicates:
Main Output On	Blue	LaserSource is driving the main laser output
Pilot Output On	Blue	LaserSource is driving the pilot laser output
Error	Red	Error has occurred
Remote	Yellow	Unit is being controlled via a computer
Low	Green	Main laser output is in low current range
High	Green	Main laser output is in high current range
High BW	Green	Main laser output is in high bandwidth mode
QCW	Green	Main laser output is in QCW mode
Io Limit	Green	Main laser output is limiting current
Interlock	Yellow	System interlock is open
Link	Green	Controller is linked to another instrument

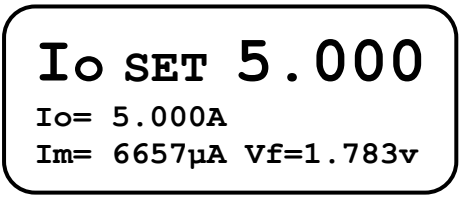
Whenever an error is generated, the red Error LED will light, and the error will be displayed on the VFD display. There may be one or more errors, but only the first error will be displayed. To display the next error, press **Menu** button. To clear all errors, press the knob. A list of error codes can be found in the *Error Messages* section.

When the unit is in remote mode, the yellow Remote LED will be lit. More information about how the instrument behaves in remote mode can be found in the *Remote Mode Operation* section.

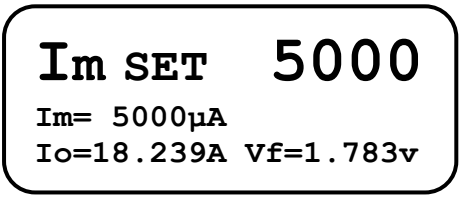
Main Display Screen

The top of the main display will be the set point or actual read of the control mode value (for example, current when in constant current mode). The bottom half of the display can display additional measurements depending on the mode of operation.

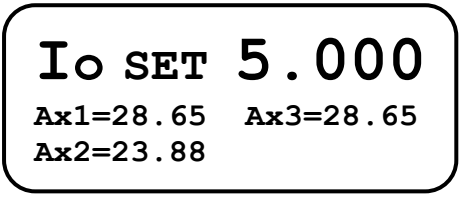
Example displays are shown below:



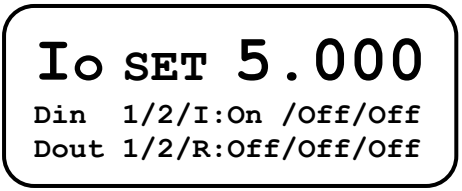
Main Display: Constant current mode



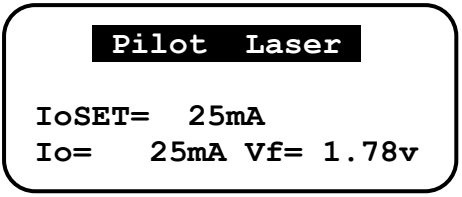
Main Display: constant photodiode power mode



Main Display: auxiliary temperature sensors



Main Display: digital I/O state



Main Display: pilot laser

The set point will depend on the control mode you have selected.

Using Limits

The LaserSource supports five different types of limits: current, voltage, photodiode current, photodiode power, and temperature. Current and voltage limits are implemented in hardware for high speed response. The other limits are monitored in software with up to 100ms delay before triggering. There is both a temperature high and temperature low limit, and if the actual temperature exceeds either of these limits, the output will be shut off. Likewise, both high and

low limits exist for the sensor (R limits), and the output will be shut off if the sensor measurement exceeds either of these limits, as determined by settings in the **Output Off Menu**.

Status Messages

The instrument will display status messages indicating several different conditions that may be of interest to the user. If multiple conditions exist simultaneously, then the instrument will cycle through each condition, displaying each status message for approximately one second.

Possible condition messages are:

Status	When showing, indicates
LoBW	The unit is in Io (LoBW) mode.
HiBW	The unit is in Io (HiBW) mode.
Pulse	The unit is in Io (Pulse) mode.
ExtTrig	The unit is in Io (Ext Trig) mode.
Burst	The unit is in Io (Burst) mode.
DLock	An interlock triggered by a digital input is open and the unit cannot be turned on.
Shrt	A short circuit has been detected on the output.
ILim	The unit is in current limit.
ImLim	The unit is in photodiode current limit.
PoLim	The unit is in photodiode power limit.
VPEAK	High peak voltage detected

Notice that the mode indicators are in reverse text and are used to highlight the operating mode.

Settings and Menus

All parameters of the **LaserSource** can be viewed and changed within the menu. To change any setting, press **Menu** to enter the menu then rotate the knob to select the parameter to change. Press the knob to begin changing the value. You will see an asterisk appear next to the value to indicate that you are in edit mode. Once you have made your change, press the knob or **Menu** button to store the value. Pressing the **Menu** button will store and exit the menu, while pressing the knob will store the value but leave you in the menu to make additional changes.

Some settings are contained inside a sub menu, such as communications settings. To access the sub menu, simply press the knob to enter the sub menu when its name is displayed.

When the Main Display is showing any other screen except the Pilot Laser, pressing **Menu** will enter the main laser menu. To enter the pilot laser menu, first switch to the Pilot Laser screen then press the **Menu** button.

Main Laser Menu

Menu	Description	Factory Default
	Top Level Menu	
Mode	As described in the *Control Modes* section, the unit offers seven control modes: Io (ACC), Io HiBW (ACC), Io (Pulse), Io (Ext Trig), Io (Burst), Im (AMC), Po (APC), and Vf (AVC). Change this setting to select a new mode.	Io (ACC)
Range	Selects the high or low current range.	Low
Bandwidth	Selects the bandwidth when operating in **Io HiBW** mode. Only available when in **Io HiBW** mode.	Max
Io Res	Resolution of the Io set point and measurement. Available options are dependent on the range of the instrument.	Depends on model
QCW Const	When in **Io (Pulse)** or **Io (Burst)** mode, this controls which parameter (frequency or duty cycle) is adjusted when the pulse width is adjusted. This setting will only be displayed when in **Io (Pulse)** or **Io (Burst)** modes.	Freq
QCW Width	Sets the pulse width in QCW mode. See *QCW Mode* section for more details. This setting will only be displayed when in **Io (Pulse)**, **Io (Ext Trig)**, or **Io (Burst)** modes.	0.1ms
QCW Duty	Sets the duty cycle in QCW mode. See *QCW Mode* section for more details. This setting will only be displayed when in **Io (Pulse)** or **Io (Burst)** modes.	10%
QCW Freq	Sets the frequency of the QCW pulse. See *QCW Mode* section for more details. This setting will only be displayed when in **Io (Pulse)** or **Io (Burst)** modes.	1000 Hz
QCW Pulses	Sets the number of pulses to generate when in **Io (Burst)** mode. This setting will only be displayed when in **Io (Burst)** mode.	1

Menu	Description	Factory Default
QCW Low	Sets the low (or off) current for QCW pulses. Setting to zero will use the minimum allowable pulse current, which will typically only be a few milliamps.	0.00 A
QCW Risetime	Selects the pulse risetime when operating in QCW mode. Only available when in QCW mode.	Min
DelayIn	Sets the delay, in seconds, from the start of trigger input pulse to the start of the current pulse. This setting will only be displayed when in **Io (Ext Trig)** mode.	0.000025s
DelayOut	Sets the delay, in seconds, from the current pulse to the start of the trigger output pulse. This setting will only be displayed when in **Io (Pulse)**, **Io (Ext Trig)**, or **Io (Burst)** modes.	0.000000s
Io limit	This setting controls the maximum amount of forward current that can be delivered to the laser diode. This limit is implemented in hardware for immediate response. For more information about limits, see *Using Limits* section.	Maximum
Im limit	This setting controls the maximum amount of monitor photodiode current the unit will allow. This limit is implemented in software. For more information about limits, see *Using Limits* section.	Maximum
Po limit	This setting controls the maximum amount of monitor photodiode power the unit will allow. This limit is implemented in software. For more information about limits, see *Using Limits* section.	Maximum
Vf limit	This setting controls the maximum amount of forward voltage that can be delivered to the laser diode. This limit is implemented in hardware for immediate response. For more information about limits, see *Using Limits* section.	Maximum
Vf Sense	Selects the remote voltage sense lines for diode voltage measurement. Pins 4 & 5 of the **Monitor / Interlock** connector must be wiring to the diode. See *Using Remote Voltage Sense* section for more details.	Local

Menu	Description	Factory Default
Vf Sense Warn	When operating in remote voltage sense mode, if the remote voltage is significantly lower that the voltage at the **Output** connector, a warning message is displayed. Only available when **Vf Sense** is set to **Remote**.	No
Cable R	The cable resistance, in ohms. This setting can be used to compensate for voltage losses in the cable due to cable and connector resistances. **Cable R** is ignored in Vf (AVC) Mode. For more information about this feature, see *Using the Cable R Setting* section. Not available when using remote voltage sense.	0.0000 Ω
Int Contact	Enables or disables intermittent contact. Not available in **Io (Pulse)**, **Io (Ext Trig)**, or **Io (Burst)** modes	Off
PD Resp	This factor is used by the unit to convert from monitor photodiode current into optical power. The value is in terms of microamps per milliwatt (µA/mW), such that power = photodiode current divided by the factor.	0.00µA/mW
PD Bias	This is the photodiode bias voltage, which is applied to the PD+/PD- pins of the output connector.	5.0V
On Delay	The delay, from the time the **Output** button is pressed to when the output is actually energized.	3000ms
	Aux Sensor Menu	
ThermA	The A term in the Steinhart-Hart equation for use with auxiliary sensors.	1.12924E-03
ThermB	The B term in the Steinhart-Hart equation for use with auxiliary sensors.	2.34108E-04
ThermC	The C term in the Steinhart-Hart equation for use with auxiliary sensors.	0.87755E-07
T# Lo Lim	Low temperature limit for Aux Sensor 1, 2 or 3	-99°C
T# Hi Lim	High temperature limit for Aux Sensor 1, 2 or 3	125°C
R# Lo Lim	Low resistance limit for Aux Sensor 1, 2 or 3	0.01kΩ
R# Hi Lim	High resistance limit for Aux Sensor 1, 2 or 3	45kΩ

Menu	Description	Factory Default
	Digital I/O Menu	
Di1 Func	Selects the action to perform when Digital Input 1 is true.	None
Di1 Invert	Inverts the active state of Digital Input 1.	No
Di2 Func	Selects the action to perform when Digital Input 2 is true.	None
Di2 Invert	Inverts the active state of Digital Input 2.	No
Do1 Func	Selects what status is used to control Digital Output 1.	Off
Do1 Invert	Inverts the state of Digital Output 1.	No
Do2 Func	Selects what status is used to control Digital Output 2.	Off
Do2 Invert	Inverts the state of Digital Output 2.	No
Relay	Selects what status is used to control the relay.	Off
	Func Keys Menu	
Key A and **Key B**	The Key A and Key B settings control the action assignment for the two function keys. See *Using the Function Keys* section for additional information.	None
	Communications Menu	
Baud	This sets the baud rate for the RS-232 serial port. See the *Computer Interfacing Manual* which is included on the CD that accompanied this product.	9600
Set While Rmt	To disable changing the set point while in Remote Mode, set this value to *No*. To enable changing the set point while in Remote mode, set this Value to *Yes*.	No
Err While Rmt	To turn off the display of errors while in remote mode, set this value to *No*. To display errors while in remote mode, set this value to *Yes*.	Yes
Terminal Mode	Terminal mode simply echoes any characters received over the serial or USB interfaces.	No
Msg Term	This controls the output message termination, and can be set to *CR/LF, CR, LF,* or *None.*	CR/LF

Menu	Description	Factory Default
System Menu		
Config	Allows for restoring the instrument to defaults, saving configurations, and restoring configurations. See *Saving and Restoring Configurations* for more information.	No Change
Brightness	The vacuum florescent display can be set to one of eight brightness levels.	100%
AutoDim Display	Automatically dims the display after 1 hour.	Yes
Audible Beep	This setting controls when the unit produces audible feedback. Set to *No* to prevent sound, or *Yes* to enable audible alerts such an error message.	Yes
Lockout Knob	Lockout knob allows you to disable knob operation from the main display. This prevents accidental changes of the set point. The knob will always work in the menus regardless of this setting.	No
Knob Speed	Controls the adjustment speed of the knob. Possible values are *slow*, *medium*, and *fast*.	Slow
System Menu ➔ Dig Out Modes The Dig Out Modes control how to combine the digital I/O signals from the main and pilot laser sections. See *Using Digital I/O* for more information.		
D1 Mode	Controls how to merge the digital control signals for the Digital 1 output from the main and pilot lasers.	Any High
D2 Mode	Controls how to merge the digital control signals for the Digital 2 output from the main and pilot lasers.	Any High
Relay	Controls how to merge the digital control signals for the relay output from the main and pilot lasers.	Any High
Advanced Menu		
Off if T Lim	Enables output shutdown on temperature limit. Adjusts the OUTOFF register.	Yes
Off if R Lim	Enables output shutdown on resistance limit. Adjusts the OUTOFF register.	Yes

Menu	Description	Factory Default
Off if Io Lim	Enables output shutdown on current limit. Adjusts the OUTOFF register.	No
Off if Im Lim	Enables output shutdown on photodiode current limit. Adjusts the OUTOFF register.	Yes
Off if Po Lim	Enables output shutdown on photodiode power limit. Adjusts the OUTOFF register.	Yes
Off on OutTol	Enables output shutdown on out of tolerance. Adjusts the OUTOFF register.	No
Ramp Time	Sets the ramp time for power up, power down, and set point changes for **Io** and **Io HiBW** modes.	80ms
Disable Vf Lim	Disables Vf Limit hardware safety (E-505 errors). Use with caution. See "Optimizing for Pulse Performance" for more information.	No
V Comp Detect	Disables Voltage Compliance detection (E-537 errors). Use with caution, can result in significant current overshoots. See "Optimizing for Pulse Performance" for more information.	Yes
Overcurrent Det	Disabled detection of overcurrent conditions (E-541 errors). Use with caution, can result in damage to laser or controller. See "Optimizing for Pulse Performance" for more information.	Yes

Pilot Laser Menu

To enter the pilot laser menu, first switch to the Pilot Laser screen then press the **Menu** button.

Menu	Description	Factory Default
	Top Level Menu	
Mode	The pilot laser offers only two control modes: Io (ACC), and Vf (AVC). Change this setting to select a new mode.	Io (ACC)

Menu	Description	Factory Default
Io limit	This setting controls the maximum amount of forward current that can be delivered to the laser diode. This limit is implemented in hardware for immediate response. For more information about limits, see *Using Limits* section.	Maximum
Vf limit	This setting controls the maximum amount of forward voltage that can be delivered to the laser diode. This limit is implemented in hardware for immediate response. For more information about limits, see *Using Limits* section.	Maximum
	Digital I/O Menu	
Di1 Func	Selects the action to perform when Digital Input 1 is true.	None
Di1 Invert	Inverts the active state of Digital Input 1.	No
Di2 Func	Selects the action to perform when Digital Input 2 is true.	None
Di2 Invert	Inverts the active state of Digital Input 2.	No
Do1 Func	Selects what status is used to control Digital Output 1.	Off
Do1 Invert	Inverts the state of Digital Output 1.	No
Do2 Func	Selects what status is used to control Digital Output 2.	Off
Do2 Invert	Inverts the state of Digital Output 2.	No
Relay	Selects what status is used to control the relay.	Off
	Advanced Menu	
Off if Main On	Enables output shutdown of the pilot laser if the main laser output turned on. Adjusts the OUTOFF register.	No
Off if T Lim	Enables output shutdown on temperature limit. Adjusts the OUTOFF register.	Yes
Off if R Lim	Enables output shutdown on resistance limit. Adjusts the OUTOFF register.	Yes
Off if Io Lim	Enables output shutdown on current limit. Adjusts the OUTOFF register.	No
Off on OutTol	Enables output shutdown on out of tolerance. Adjusts the OUTOFF register.	No

Remote Mode Operation

Remote mode operation is when the LaserSource is being controlled by a computer over the USB or RS232 interfaces. When in remote mode, the LaserSource behaves differently, preventing you from affecting the operation of the instrument, such as changing the set point. You cannot enter the menu without taking the unit out of remote mode, and the knob is disabled.

You can exit remote mode at any time by pressing the **Menu** button, which has a secondary function to return the LaserSource to local operation.

Details on how to communicate with the LaserSource can be found in the ***Computer Interfacing Manual*** which is included on the CD that accompanied this product.

Installing the USB Drivers

Using the LaserSource via USB is just as simple as using the serial port. In fact, once you have installed the USB drivers, the instrument will appear as a virtual serial port that you can use just like a normal serial port.

To install the drivers, simply plug in the instrument to your computer. When the **Add New Hardware** wizard appears, insert the CD you received with the LaserSource and follow the on-screen instructions.

Once the drivers are installed, to determine the COM port number, go to **Control Panel** and select **System**. Once the **System Properties** dialog appears, choose the **Hardware** tab then click on the **Device Manager** button. When the **Device Manager** appears, click on the plus sign to the left of **Ports**. The port identified as an **Arroyo Instruments Virtual COM Port** or **USB Serial Port** is the LaserSource. In the event you have multiple Arroyo Instruments products plugged in simultaneously, you will need to experiment to see which instrument was assigned to which port. For example, you could send a *IDN? query and see which instrument goes into remote mode.

Connecting to the LaserSource

A laser diode is very sensitive to electro-static discharge (ESD), over-voltage, and over-current conditions. When connecting a laser to the LaserSource, make sure proper ESD procedures are taken. In addition, it is critical that the proper current limit and voltage limit be set for the laser diode. Exceeding the laser diode's rated current or voltage can damage or destroy the laser diode, and the LaserSource's hardware protection features can only protect the laser diode if these limits are properly set.

CAUTION

The interlock connections must be kept isolated from all other connections and from earth ground. Failure to do so may damage the instrument.

The Laser anode and cathode outputs are electrically isolated from ground, as are the photodiode inputs. In addition, the photodiode inputs are optically isolated from the laser outputs, ensuring complete electrical isolation of the drive circuit and photodiode measurement circuit.

NOTE

Connections to the LaserSource and the laser diode fixture must be secure. Tighten any retaining screws on all connectors and make sure all connections are in good condition. Poor or intermittent connections can damage or destroy the laser diode.

Depending on the model, Arroyo Instruments carries cables specifically designed for this controller. Contact the factory for more information.

See the manual for your laser (and fixture) for additional safety and operational information.

Grounding Considerations

A key feature of the LaserSource is the optical isolation of both the photodiode and modulation inputs. By isolating their inputs, earth grounding of the photodiode anode or cathode, or earth grounding the modulation input, cannot cause a ground loop through the instrument. Likewise, the laser anode and cathode connections are also isolated from earth ground.

The However, if you use the earth ground pin of the **Output** connector (pin A2), it is possible to create a ground loop if the instrument's earth ground is connected to a fixture or optical table that is also earth grounded. Make sure that from your laser diode package there is only a single path to earth ground.

Cable Wiring for Modulation and QCW

When modulating with square wave signals at any frequency, sine wave at higher frequencies (>1 kHz) or operating in QCW modes, it is critical that high quality twisted pair cabling with low inductance and capacitance be used, and wire size suitable for the applied current (or the equivalent if using a multi-conductor cable). Shielding is recommended for improved noise immunity, but not required.

See the chart below for suggested sizes. Failure to do so may result in current oscillations or overshoots that may damage your laser. Reducing wire size by one or two wire gauges for lower duty cycle pulse operation is generally okay, although peak voltages and initial current ringing can be significantly higher.

When constructing your own cable out of individual wires, twist the current carrying wires (LDA and LDC) as tightly as possible. When using large wires where twisting is impractical, zip-tie every 2" [4cm] or heat shrink to keep the wires as close together as possible.

If in doubt, use a current probe attached to an oscilloscope to monitor actual performance.

Current (A)	Recommend Wire Gauge
10	16 AWG
20	14 AWG
30	12 AWG
40	10 AWG
60	8 AWG
80	6 AWG
100	4 AWG

For instruments equipped with the 13W3 output connector, the following CONEC part numbers can be used to build 13W3 cables. Components can be found at Digikey, Mouser, and other electronic components suppliers.

Component	Male End	Female End	Wire Size
Pin/Socket	131C10039X	132C10039X	10-12 AWG
	131C10049X	132C10049X	8-10 AWG
D-Sub	3013W3PCM99A10X	3013W3SCM99A10X	
Hood	952-025-030R121		

Arroyo Instruments' cables are shielded, twisted-pair cables, and designed to support these applications. For questions, contact the factory or your local representative for additional help.

Laser Control Modes

The LaserSource offers eight laser control modes:

- **Io (ACC)** – "eye-oh"
  Current set point, automatic current control
- **Io HiBW (ACC)** – "eye-oh-Hi-B-W"
  Current set point, high bandwidth mode, automatic current control
- **Io (Pulse)** – "eye-oh-Pulse"
  Current set point, internally triggered pulse mode
- **Io (Ext Trig)** – "eye-oh-External-Trigger"
  Current set point, externally triggered pulse mode
- **Io (Burst)** – "eye-oh-Burst"
  Current set point, internally or externally triggered pulse trains (one or more pulses)
- **Im (AMC)** – "eye-M"
  Monitor photodiode set point, automatic monitor control
- **Po (APC)** – "P-oh"
  Monitor power set point, automatic power control
- Vf (AVC) – "V-F"
  Voltage set point, automatic voltage control

Changing the control mode is done through the menu by changing the **Mode** parameter in the menu to one of these values.

Io and **Io HiBW** modes (referred to collectively as ACC, or automatic current control modes) are used to drive a specific current through the laser diode. The LaserSource will drive the desired current set point through the laser diode as long as the voltage at the chosen set point does not exceed the voltage limit. In **Io** mode, you will be limited to less than a 10 Hz bandwidth. To modulate above that rate, use the **Io HiBW**, which is a high bandwidth current mode supporting modulation. For performance reasons, the system will dissipate more heat when operating **Io HiBW** mode. This is to provide the dynamic performance needed for high frequency modulation signals. **Io** mode is recommended unless modulation is required.

Io (Pulse), Io (Ext Trig), and **Io (Burst)** are quasi-CW (QCW) modes, where the laser output is pulsed on based on the pulse width, duty cycle, and frequency, as defined in the menu. See *Using QCW Modes* section for more details.

Im mode (also referred to as AMC, or automatic monitor control, mode) is used to control the laser diode using the photodiode monitor diode feedback. You select the target photodiode monitor diode current, and the LaserSource will drive exactly enough forward current through the laser diode to generate the target monitor diode current. Only low frequency modulation (10Hz or less) is possible in **Im** mode due to the feedback latencies of the photodiode itself.

Po mode (also referred to as APC, or automatic power control, mode) is simply **Im** mode with a mathematical constant applied to the set point, providing a convenient way of operating in milliwatts. Using the **PD Resp** factor (in µA/mW), a **Po** set point is internally converted to an equivalent **Im** set point by the driver, which is then used to control the photodiode feedback. For example, if the **PD Resp** factor was 10, then a set point of 1mW would be the same as a set point of 10µA.

Vf mode (also referred to as AVC, or automatic voltage control, mode) is used to control the voltage driven through the device. Unlike ACC mode, AVC mode allows the current to drive to whatever current is necessary to achieve the voltage set point, so long as it does not exceed the current limit. As with **Im** mode, only low frequency modulation (10Hz or less) is possible in **Vf** mode.

Modulation

The instrument supports external analog modulation using the **Modulation** BNC on the front panel of the instrument. Modulation rates vary by model, so see your model's specification for the maximum modulation rates. Only **Io HiBW** mode supports high speed modulation. All other modes of operation have a modulation bandwidth of 10Hz or less.

Using QCW Modes

Io (Pulse), Io (Ext Trig), and **Io (Burst)** are quasi-CW (QCW) modes, where the laser is turned on and off, typically with very short on times and long off times to minimize the thermal loading of the laser. Measurements are taken only during the on cycle (although at a reduced accuracy and resolution), and external instruments can by synchronized using the trigger input and trigger output signals.

In pulse (**Io Pulse**) mode, the current pulses are based on the pulse width, duty cycle, and frequency, as defined in the main menu. To use this mode, set the **Mode** to **Io (Pulse)**, and then set the **QCW Width**, **QCW Duty**, and **QCW Freq** as needed for your application. These three parameters are interrelated as defined by the following equation:

$$Frequency = \frac{DutyCycle}{PulseWidth}$$

However, if you take the values directly from the menu, then a modified version of this equation that takes the various decimal places of the menu values into account could be written this way:

$$QCW\,Freq = \frac{QCW\,Duty}{QCW\,Width} * 10$$

As an example, a 0.6ms pulse width and 30% duty cycle results in a frequency of 500 Hz. Put into the formula above, it would be written:

$$500 = \frac{30}{0.6} * 10$$

Because of this relationship, when adjusting any of these parameters, it requires a change in one of the others. To achieve this, when adjusting frequency, duty cycle is adjusted and when adjusting duty cycle, the frequency is adjusted. For pulse width adjustments, the frequency or duty cycle is adjusted based on the setting of **QCW Hold**. For example, if **QCW Hold** is set to **Duty**, then when the pulse width is adjusted, the frequency is adjusted (the duty cycle is *held* constant).

In external trigger mode (**Io Ext Trig**), only the pulse width is defined by the instrument. The frequency and duty cycle are defined by the trigger input. For each rising edge of the trigger input, one current pulse will be generated with the pulse width defined by the **QCW Width** setting.

Burst mode (**Io Burst**) operates as a combination of pulse and external trigger modes. Like pulse mode, the pulse train is defined in terms of frequency and duty cycle, but only a specific number of pulses are generated, which can be as few as one, or as many as 60,000. Like external trigger mode, no pulses are generated until a trigger is received. As in external trigger mode, this trigger can be generated from the trigger input, but unlike external trigger mode, it can also be generated from the front panel using the **Output** button. When in burst mode, the BURST icon will be displayed in the upper right corner of the display.

Burst mode operation from the front panel is distinctly different from the other operating modes. Normally, you will use the **Output** button to turn the output on or off. This is true of burst mode, but the **Output** button does double-duty: it serves both as an output on/off button as well as a trigger button. To turn the output on in burst mode, press and hold the **Output** button for at least one second, then release. When you release the button, you will hear an audible click inside the unit, and the blue LED will start flashing. This indicates the output is ready to start producing pulses. To generate a pulse train, press and release the **Output** button quickly (holding it down for less than one second). On the button release, the pulse train will start. The blue LED will remain lit solid until the pulse train has completed, at which point it will begin flashing again to indicate it's ready to start the next pulse train. To turn the output off, press and hold the **Output** button for at least one second, then release.

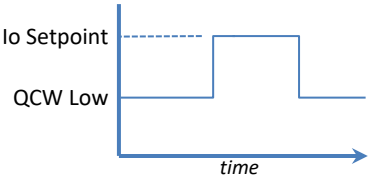
When triggering remotely (or via the LASER:TRIGGER command), the LED will also remain lit solid during the pulse train. Also, the LASER:OUTPUT command is only used to turn the output on or off; use the LASER:TRIGGER command to start a pulse train.

Laser measurements are made just before the falling edge of the pulse, maximizing the time the laser has to settle. A hardware sample and hold samples current, voltage, and power simultaneously, ensuring all three measurements are made at the same point in time.

Note that QCW mode is not designed to operate below approximately 5% of the range of the instrument. When operating below this point, the accuracy of the pulse degrades, overshoot increases, and the rise time of the pulse increases. These errors can be overcome somewhat by operating at longer pulse widths, but actual performance can only be determined through empirical measurements using an oscilloscope and current probe.

QCW Low Setpoint

A QCW driver will typically generates a square wave output that cycles between the set point (high state) and zero (low state). The **4400** allows for adjustment of the low pulse state to operate at a non-zero current (often referred to as the bias current). This allows QCW operation to operate the laser in such a way that current is always flowing through the laser, even in the "off" state of the QCW pulse. The **QCW Low** set point is completely independent of the **Io Setpoint** – it can be adjusted to any value from zero to the maximum current of the driver. During low QCW periods, the output current will be set by **QCW Low**, while at high periods, the output current will be set by **Io Setpoint** (**QCW Low** does not add to the set point during the high periods):



To maintain maximum performance, when in the low pulse state, a minimum current (typically only a few milliamps) will flow. Setting the **QCW Low** to zero will reduce the low pulse state current to the minimum possible.

When operating in pulse modes, the **Io Setpoint** cannot be adjusted below the **QCW Low** setting. If the **Io Setpoint** was adjusted below the **QCW Low** setting while in a non-QCW mode, when switching to pulse mode the **Io Setpoint** will be adjusted up to the **QCW Low** setting and a W-807 warning message will be generated to indicate the change.

Trigger Input and Trigger Output

The Trigger Input and Trigger Output connectors located on the front panel of the **4400** can be used to synchronize the **4400** with other instruments. Using the Trigger Input, another instrument can act as the master, sending a trigger to the **4400** to generate a pulse output when in **Io (Ext Trig)** mode. Conversely, the **4400** can act as the master in the system, using the Trigger Output to trigger other instruments to take a measurement.

The Trigger Input is a 5V input that triggers on the edge of the input pulse. The pulse should be 1 microsecond or longer.

The Trigger Output is always 10 microseconds wide, positive going pulse that typically aligns with the start of the current pulse but can be delayed using the Trigger Out Delay (see below).

Trigger In and Trigger Out Delay

Using the trigger in delay (**DelayIn**), you can delay the beginning of the current pulse up to 1 second, and only applies in **Io (Ext Trig)** mode. Likewise, using the trigger out delay (**DelayOut)**, you can delay when the trigger output up to 1 second from the start of the current pulse.

When setting the trigger in or trigger out values, another pulse cannot start until the current pulse (which starts after the trigger input delay) and the trigger output have both completed. This can limit the range of the frequency or duty cycle if the trigger delays are large.

For example, if the trigger output delay is 10 milliseconds and the pulse width is 1 millisecond, then the minimum duty cycle is about 10%, because the next pulse cannot start until after the trigger output is complete.

Risetime Control

The **QCW Risetime** setting provides the ability to increase the risetime of the QCW pulse, particularly useful for cable configurations where significant ringing would otherwise occur. Risetime can be set to *Min* (fastest risetime), *100µs* or *500µs*. The latter two times are estimates and may vary slightly depending on your specific load and cable setup.

See *Optimizing for Pulse Performance* below for additional information on pulse operation.

Using Limits

The LaserSource provides several limit features for protection of the laser diode. These include current, voltage, intermittent contact, photodiode current, and photodiode power limits.

Both the current and voltage limits are implemented in hardware, providing for fast response to changes in laser diode operation. When a voltage limit is detected, the output is immediately shutdown. Because of the sensitivity of the voltage limit, operating near the limit (within one to two hundred millivolts) is not recommended. In general, you should set the voltage limit to 0.5V to 1V higher than any anticipated operating point. The voltage limit is tested against *the voltage at the connector*, unless in remote voltage sense mode. Any **Cable R** value is ignored, as **Cable R** is a software only calculation, and the voltage limit is implemented in hardware. See *Using the Cable R Setting* section for more information on the **Cable R** setting.

Unlike the voltage limit, the current limit simply prevents the LaserSource from delivering more current than the limit is set to. When the current limit engages, the output will remain on, unless corresponding bit is set in Outoff register.

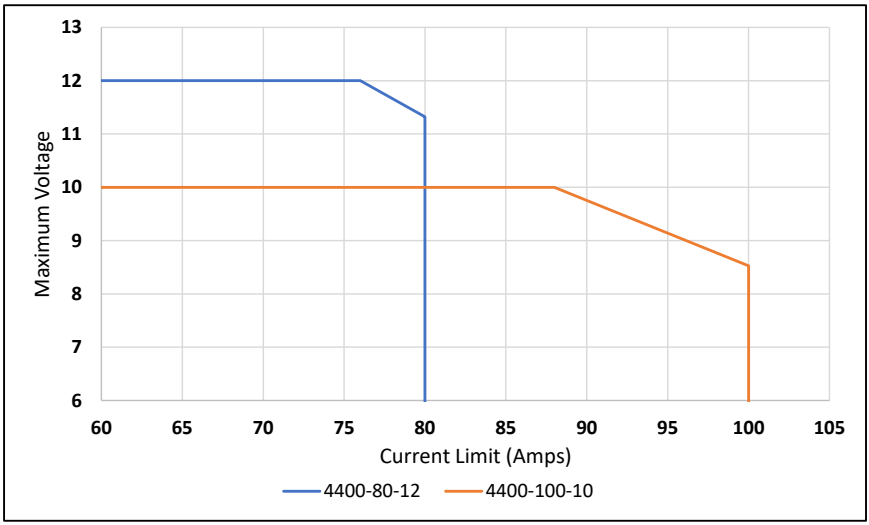
The intermittent contact circuit is designed to protect against faulty connections by detecting fast changes in voltages which can be caused by poor wiring or faulty connectors. If false trigging of the intermittent contact circuit is frequently occurring, it can be turned off from the menu.

The photodiode current and photodiode power limits are implemented in software and may take up to one second to trigger when these conditions occur, and therefore should not be relied on to provide fast protection of the laser diode.

Voltage Operating Region

The **4400-80-12** and **4400-100-10** have a maximum power constraint at the maximum current and maximum voltage operating region. The graph below details the maximum voltage at a given current limit setting.

If the current limit is raised such that it might result in operation outside the allowable region, the controller will automatically reduce the voltage limit and voltage set point and generate a W-809 warning message to indicate the change. To restore operation at a higher voltage limit, reduce the current limit then adjust the voltage limit.



Maximum voltage at a given current limit

Using the Cable R Setting

The **Cable R** setting allows you to calculate the voltage at the laser by subtracting the voltage loss through the cable and connectors. This is done by measuring or calculating the cable resistance and entering the value, in ohms, into the menu. The instrument will then use the V = I * R formula to calculate the voltage loss in the cable and subtract that from the actual measured voltage, displaying the result as Vf on the display.

Common values for **Cable R** range from 0.0300 Ω to 0.0900 Ω but can be significantly higher if you have long runs, many connector interfaces, or small gauge wire.

While it is possible to use a DMM to measure the resistance of the cable, because resistance is so small, you will not typically get proper readings. A better approach is to use the instrument to drive current through the system and then measure the voltage loss to determine resistance. There are two ways to best calculate the voltage loss:

Measure the Voltage at the Laser

If you have an accurate DMM and can measure the voltage across the laser (or accurately know the voltage of the laser at a specific current) and voltage across the pins at the **Output** connector, then the difference between the measured voltages is the voltage loss in the cable. Use this formula to calculate resistance:

$$CableR = \frac{V_{Output} - V_{laser}}{I}$$

V is in volts, I is in Amps.

Short the Connection at the End of the Cable

A second method, which can be done with just the 4400, is to short the cable at the end of the cable (nearest the laser diode), drive current through the cable and measure the voltage. The resistance is found using a simpler version of the formula above:

$$CableR = \frac{V_{4400}}{I}$$

Note that the current is expressed in *amps*, not *milliamps*. The easiest way is to drive 1 Amp of current. When I equals 1 Amp, the displayed voltage is the resistance of the cable. Another method is to drive 10 Amps of current and then divide the voltage by 10.

To short the cable, disconnect the laser and short the anode and cathode together as close to the end of the cable as possible. Ideally, the short should be done by soldering the anode and cathode wires together to minimize the resistance in the short itself.

How the Calculation Is Used

The 4400 continuously takes the measured current, multiplies it by the resistance (**Cable R**), subtracts the result from the actual voltage at the output connector, and displays this value on screen as **Vf**. However, there are some limitations to how the cable loss calculation is used:

1. The value for **Vf Limit** *is always the voltage at the connector* (except when using remote voltage sense, see below). This means that the **Vf Limit** must take into account all the voltage required, including the cable loss (i.e., the voltage displayed if the **Cable R** value were zero).
2. **Cable R** is ignored in Vf mode. This means that the set point and measured voltage are always the voltages at the connector, and **Cable R** is not used.

Using Remote Voltage Sense

The **LaserSource** also supports remote (4-wire type) voltage measurement of the laser diode, providing a higher accuracy voltage measurement by directly measuring voltage at the diode itself. While the **Cable R** setting described above

can provide some of the same benefits of remote voltage sense, they differ in a few key ways:

1. No need to calculate cable resistance
2. Voltage measurement is accurate even if the cable resistance changes
3. The hardware safety circuits use the remote voltage, providing for a greater degree of protection (**Vf Limit** works on the voltage at the laser rather than the voltage at the connector)
4. Works in voltage control mode

However, remote voltage sense does have a few drawbacks:

1. If the remote sense wires are disconnected, it disables the hardware voltage limit
2. Requires two additional wires to be run to the device

It is the first of these two drawbacks that is of the biggest concern. In order to protect against this fault, the instrument monitors the voltage at the connector as well as the remote voltage, and if the difference is too great, a warning message is displayed. Once the warning is displayed, it will not be displayed again until the output is turned off and back on. The warning can be disabled in the menu by setting the **Vf Sense Warn** to **Off** in the menu.

Using Remote Voltage Sense

Using remote voltage sense is very simple. Connect the laser remote sense pins to the corresponding terminals at the laser, then in the menu, set **Vf Sense** to **Remote**. Indicated voltage will now be the remote diode voltage.

When using remote voltage sense, any **Cable R** setting is ignored.

Using the Auxiliary Interface

The Auxiliary Interface provides connections to the auxiliary sensors, the digital inputs and output, an electromechanical relay, and an auxiliary +5V power supply.

Auxiliary Sensors

Auxiliary sensors are wired for a common ground return, so take care to ensure that a common ground will not cause interference with other parts of your system. In addition, auxiliary sensors should be electrically isolated from all other signal and power connections on the instrument.

CAUTION

Connecting a sensor signal or sensor ground to any other signal or power interface could cause damage to your instrument. Sensors should be fully electrically isolated from all other connections.

Auxiliary sensor settings can be adjusted in the **Aux Sensor** menu. The auxiliary sensors share a common set of Steinhart-Hart coefficients for temperature conversions.

Each auxiliary sensor has a corresponding high and low temperature limit. By default, auxiliary sensors that exceed their temperature limits will cause the output to shut down. If you want to change this behavior, adjust the corresponding settings in the **Advanced** menu. See *Working With Thermistors* section for more information on using thermistors.

Auxiliary sensors one and two are found on the Auxiliary DB25 interface. For non-bus-bar drivers, the 13W3 laser connector features a third sensor input.

Digital Inputs

The **4400** has two digital inputs: Digital Input 1 and Digital Input 2. They share a common ground with the digital outputs and 5V auxiliary power supply. If left unconnected, each digital input will be pulled up into an 'On' state via internal pull-up resistors.

Each digital input can be assigned to act as either an additional interlock input, a remote output on/off control, or a trigger input. The logic of the digital input can be reversed, or inverted, to allow for active low signals. These settings can be found in the **Digital I/O Menu** » **Di# Func** and **Di# Invert** menu entries.

The digital input is not a high-speed circuit and may take many milliseconds to detect and react to a signal. Therefore, it is not suitable in applications where high-speed response is required. For high speed triggering, use the Trigger Input on the front panel on the instrument. Similarly, for high speed interlocks, use the Chassis or Laser Interlock.

Digital Outputs

The **4400** has two digital outputs: Digital Output 1 and Digital Output 2. They share a common ground with the digital inputs and 5V auxiliary power supply.

Each digital output can be directly set to be *Off* (0V) or *On* (5V), or assigned a function to control its output state. The available functions are:

- *Output On* – the digital output will turn on when the output is on
- *Stable* – the digital output will turn on when the instrument is considered to be stable
- *T Limit* – the digital output will turn on if the temperature limit is exceeded
- *I Limit* – the digital output will turn on if the instrument is operating at its current limit.
- *Remote* – the digital output will turn on if the instrument is in remote mode.

Each digital output includes a 200Ω series resistor, limiting current draw to about 25mA. If the output is to be used as a signaling LED, in many cases, an LED can be directly connected across the digital output and ground.

Each digital output has an invert setting to reverse the state of the output if an active low signal is required. These settings can be found in the **Digital I/O Menu** » **Do# Func** and **Do# Invert** menu entries.

Relay

In addition to the digital outputs, the **4400** has an electro-mechanical relay which can be used as an isolated contact for applications such controlling external solenoids for valve control, or powering on an external piece of equipment (1A, 30VDC maximum). Relay control is identical to the digital output control, with all of the same functions available. There is no invert function, but both the normally open and normally closed contacts are available, allowing for either polarity to be wired in.

The N/C (Normally Closed) pin 6 will be *closed* (shorted) to the common pin 19 when the unit is powered off or when the relay is in the "off" state. Similarly, the N/O (Normally Open) pin 7 will be *open* (not shorted) to the common pin 19. When the relay is energized, either by changing the menu setting to *On*, or when

the assigned function is true, the polarity will reverse: pin 6 will be *open* (not shorted) and pin 7 will be *closed* (shorted) to the common pin 19.

Dig Out Modes

The **System->Dig Out Modes** settings are used to control how to merge the digital signals generated from the main and pilot laser. Because each channel independently requests the digital output based on the setting in the **Digital I/O** menu, the **Dig Out Modes** menu settings determine how to resolve conflicts when the two channels do not match.

Each mode has the following options:

- *Off* (*Open* for Relay) – ignore the digital signals from each channel and force the digital output off (or open the relay).
- *On* (*Closed* for Relay) – ignore the digital signals from channel and force the digital output on (or close the relay).
- *All Low* – if **both** of the digital signals from the main and pilot laser are **low**, then turn the digital output on (or close the relay)
- *Any High* – if **either** of the digital signals from the main or pilot laser are **high**, then turn the digital output on (or close the relay)
- *All High* – if **both** of the digital signals from the main and pilot laser are **high**, then turn the digital output on (or close the relay)

For example, consider the control of the Digital 1 output: if the main laser was requesting D1 to be high but the pilot laser was requesting low, here is how each of the above modes would then set the Digital 1 output on the Auxiliary connector:

Mode Setting	Main D1 Out	Pilot D1 Out	Auxiliary Digital 1 Output State
Off	Don't care	Don't care	Low (Off)
On	Don't care	Don't care	High (On)
All Low	High	Low	Low (Off)
Any Low	High	Low	High (On)
All High	High	Low	Low (Off)

Example Output States

Using the Interlocks

The **4400** has two interlock inputs that can be used to disable the laser output. The Chassis Interlock is the two-pin green Phoenix connector located next to the USB connector on the rear of the unit. The Laser Interlock is located either on the 13W3 connector or the DB-9 Signal connector on units equipped with bus-bar outputs.

The Interlock inputs are electrically isolated input allowing for safe integration into both mechanical-type switch closures as well as electronic switches. Both must be shorted (or pulled below 4V. It has a pull-up resistor, so if left disconnected, the interlock status will be "on." In addition to the dedicated Interlock input, the digital inputs can also be configured for interlock operation. See the Interlock section in *Using the Auxiliary Interface*.

The Laser Interlock/LED Interface

When using the laser interlock without the LED function, simply short the pins using a mechanical relay or electronic switch to allow for laser operation.

The laser interlock also can be used to drive an LED to indicate the operating state of the laser. When the laser is on, the LED is always on. When the laser is off, it can be controlled via the computer interface to turn on or flash the LED, such that it can be used as a signal light to the user.

Closing the Circuit

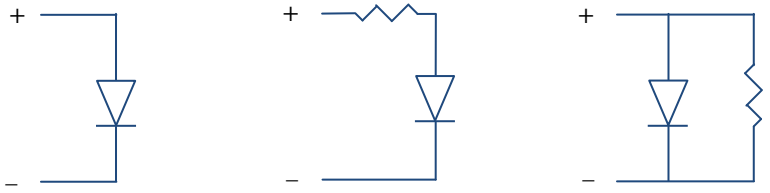
Inside the controller, a +5V supply is used to bias the LED and goes through a 200Ω series resistor. To close the circuit, there must be 4V or less across the interlock input pins. A short circuit can be used, but an LED can optionally be connected.

Depending on the type of LED, no resistor, series resistor, or parallel resistor can be used. Red, green, and yellow LEDs may require no resistor. Blue LEDs are too efficient to be wired with a series resistor and must use the parallel resistor option.

When using a series resistor, the higher the resistor value, the dimmer the LED. Do not use too high of a resistance value or it may always register as an open circuit.

When using a parallel resistor, the lower the resistor value, the dimmer the LED. Red, green, and yellow LEDs will typically use higher resistances (1kΩ or more), while blue LEDs will use smaller resistor values (typically around 100Ω).

The voltage drop must be less than 4V when circuit is complete for proper interlock operation.



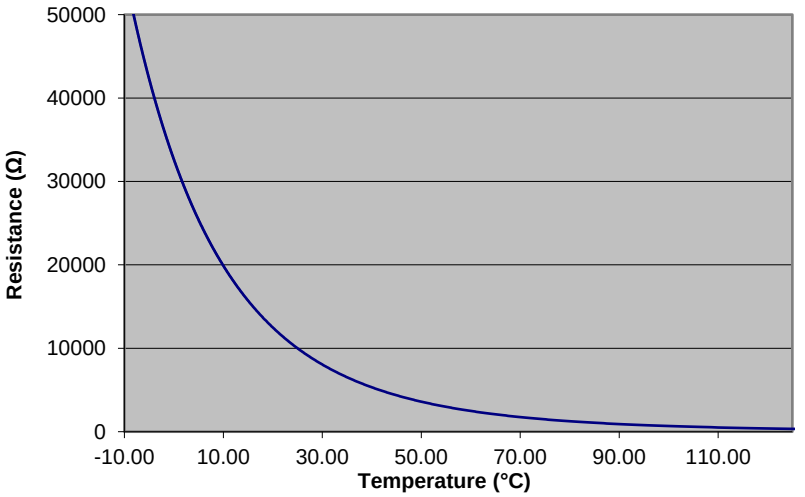
No Resistor ***Series Resistor*** ***Parallel Resistor***

Working With Thermistors

The auxiliary sensor inputs allow for monitoring of a thermistor temperature sensor, often located in the laser module itself. This sensor can used for simple thermal monitoring of the diode, and can also be used as a safety by shutting down the laser diode when temperature limits are exceeded

The **LaserSource** is designed to work with negative temperature coefficient (NTC) thermistors, such as the BetaTHERM 10K3A1 thermistor used in many of the Arroyo Instruments **LaserMounts** and **TECMounts**. A thermistor works by translating temperature into resistance, with resistance decreasing as temperature increases (hence the 'negative coefficient').

Here is a typical response curve of a thermistor:



Typical Resistance vs. Temperature Graph

As can be seen be the graph, the resistance of the thermistor drops very quickly. In the typical control range (0°C to 40°C), typical 10K thermistors offer good sensitivity to changes in temperature, and this is the range in which most 10K thermistors are typically used. 10K thermistors can be used at much higher temperatures but will suffer poorer temperature stability performance because of the lower sensitivity. When evaluating the performance of a thermistor, it is important to understand the resistance sensitivity of the thermistor at your application temperature, which varies greatly by temperature and thermistor types.

The **LaserSource** supports an upper measurement range of 45kΩ. For most 10K thermistors, this translates into a low-operating range of approximately -7°C before a sensor open error is indicated. Different thermistor types can be used if a different measurement range is required.

The Steinhart-Hart Equation

As can be seen from the temperature versus resistance graph above, resistance varies inversely with temperature in a non-linear fashion. This relationship can be accurately modeled by polynomial equations, and one such being the Steinhart-Hart equation:

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

The coefficients A, B, and C can usually be obtained from the thermistor manufacturer. The **LaserSource** defaults to the coefficients for the BetaTHERM 10K3A1 thermistor ($A = 1.12924x10^{-3}$, $B = 2.34108x10^{-4}$, $C = 0.87755x10^{-7}$).

Temperature limits, as well as the Steinhart-Hart coefficients can be set in the **Aux Sensor** menu.

Analog Modulation

The analog modulation input allows for external control of the current set point using a ±10V analog signal. 10V equals the maximum operating range, which is dependent on the model. For example, a **LaserSource** which has a maximum output current of 40 Amps, a modulation input of 5V would equal 20 Amps output (the "transfer function" is 4 A/V).

In addition, the set point **adds** to the modulation input, so using the same example, if you were to apply 5V and the set point was 5 Amps, then the resulting drive current would be 25 Amps (5 V = 20 A plus the 5 A set point).

You must also consider that the modulation input is not a precision input, so for accurate current control, you should calibrate the modulation input using a one point or two-point calibration and apply the calibration to your voltage input. You can read actual current using the LAS:I? query.

The modulation input on the 4400 supports bipolar modulation (not all Arroyo Instruments controllers do). Therefore, a negative modulation input will result in a **subtraction** from the set point.

It is *not* recommended to modulate the instrument in such a way that the combination of the instrument set point and modulation input would result in a target set point below zero. Doing so will not damage the laser or the instrument but can cause significant waveform distortion as the signal transitions from the negative to the positive set point region.

When modulating with square wave inputs or at higher frequencies (>1 kHz), it is critical that high quality, shielded twisted pair cabling be used, and wire size suitable for the applied current (or the equivalent if using a multi-conductor cable). Failure to do so may result in current oscillations or overshoots that may damage your laser. When operating in these modes, always use shielded cable and never use individual wires to connect the instrument to your laser. If in doubt, use a current probe attached to an oscilloscope to monitor actual performance.

When modulating with a square wave input, if high peak voltages are detected due to poor cable configuration, the instrument the instrument will alternate the current measurement with the peak voltage measurement (**Vpk**) and also display a **VPEAK** icon. Note that sine wave operation may also trigger this condition if there is significant cable resistance, but if thermal overload errors are not being generated (E-537), it can safely be ignored.

Optimizing for Pulse Performance

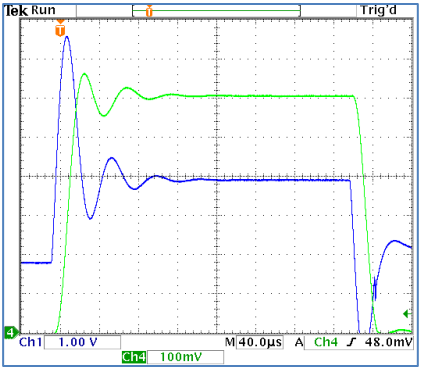
The LaserSource is a high-power instrument that requires an understanding of proper setup when operating the unit in pulse mode, either via with a square wave signal into the analog modulation input or in QCW mode.

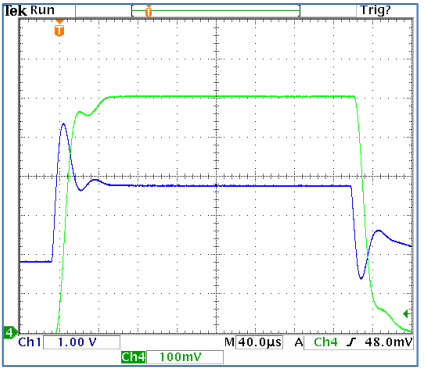
Cables

The most critical aspect of your setup is the cable connecting the LaserSource to your device. You should use the shortest possible wires, particularly in high current applications, and avoid the use of connectors. Poor cables can result in significant voltage spikes at the leading edge of the pulse which cause significant overshoot and ringing of the current waveform as well as challenging thermal management conditions for the **4400**.

To start, ensure you are working with a wire gauge that is adequate for the application. Review the *Cable Wiring* section above for recommend wire sizes.

In addition to wire guage, it is highly recommended to use twisted-pair wire, as that can have an even bigger impact on pulse performance. Consider the two pulses below. Pulse is voltage (1 volt per division), green is current (10 Amps per division). Both use 12 AWG stranded wire, 24 inches [60cm] in length, but the wires in the right pulse are twisted, approximately one twist every 2 inches [5cm]). The current waveform is much cleaner and the voltage overshoot is far less.





In addition to poor waveform performance, high peak voltages can also cause one of two error conditions: excessive power loads inside the LaserSource, resulting the driver turning itself off and generating an E-537 thermal error; or insufficient compliance to meet the peak voltage, resulting in the E-540 headroom violation. In either case, the driver will shut down the output to prevent damage to the driver or the laser.

Lowering BW or Risetime

When using cables that are not well suited for high performance modulation, the **4400** includes settings to lower the bandwidth or risetime and virtually eliminate current overshoot or ringing but at the sacrifice of lower BW or rise time.

- In *Io HiBW* mode, a **Bandwidth** setting allows for the lowering of the bandwidth from maximum ("Max") to 3kHz or 0.7kHz.
- In pulse modes, a **QCW Risetime** setting allows for the reduction of risetime from the minimum possible ("Min") to approximately 100µs or 500µs.

Lowering the appropriate setting will generally tame even the worst cable arrangement.

Dead Shorts

The **4400** is a high-performance laser diode driver and not designed to drive very low resistance loads in pulse mode. Driving a dead short can result in very high current oscillations and should always be avoided. An E-541 error is an indication of oscillation problems.

Eliminating E-537 (Thermal Overload) Error

The E-537 error is always associated with a large difference between the peak voltage and the nominal voltage. When the peak voltage is significantly above (more than 2 volts) the nominal operating voltage, the instrument will alternate the current measurement with the peak voltage measurement (**Vpk**) and also display a **VPEAK** icon. Higher differences indicate poorer cable interfaces and therefore the possibility of higher current overshoots when operating in square wave modulation or QCW modes. Equally important, it forces the instrument to operate with a higher supply voltage, resulting in additional heat being generated inside the **4400**. If the amount of heat being generated exceeds an internal limit, the E-537 error is generated.

The E-537 error can be prevented in one of three ways:

1. Improve the wire harness – by switching to a twisted pair cable, eliminating connectors, and shortening the wires, you will reduce the capacitance and inductance that causes the higher peak voltages.
2. Lower the duty cycle – by operating with a lower duty cycle, the thermal load is reduced by a similar amount.
3. Lower the set point – like lowering the duty cycle, lowering the current will reduce the thermal load by a similar amount.
4. Increase risetime (if pulse modes) or lower bandwidth (if modulating) via **QCW Risetime** or **Bandwidth** settings, respectively.

Eliminating E-540 (Voltage Headroom) Error

The E-540 error is caused when the difference between the peak voltage and the supply voltage drops below an internal safety limit. While the cause of the error is different than an E-537 error, the same methods above can be used to prevent the error. E-540 errors can be disabled with the **V Comp Detect** setting, more information below.

Eliminating E-505 (Voltage Limit) Error

Because of the peak voltages that are generated in pulse modes, the voltage limit will typically need to be set higher than normal as compared to CW mode. In CW mode, voltage limits should be set 0.5V to 1V higher than the typical operating voltage of the laser. In modulation or QCW modes, the voltage limit needs to be higher than the peak voltage, which can be several volts above nominal, depending on the current.

Increasing the voltage limit does not significantly reduce the safety protection for the laser, as even the maximum voltage limit provides good open-circuit detection. In some cases, particularly with high compliance loads and high currents, E-505 errors may be generated at even the maximum voltage limit. In that case, follow the guidelines above for eliminating the E-537 error. E-505 errors can be disabled with the **Disable Vf** setting, more information below.

Eliminating E-541 (Excessive Current Detected) Error

This error indicates a dangerous oscillation condition caused by very low resistance loads, such as dead shorts or highly inductive loads, and can destroy sensitive laser diodes. Depending on the frequency and magnitude of the oscillation, the driver may not detect this condition.

CAUTION

E-541 errors indicate a serious fault condition that can indicate possible damage to a laser diode due to significant over-current conditions. Extreme care needs to be taken in diagnosing this fault before reenergizing the laser output.

The driver will typically protect itself from physical damage, but the cable and load should be carefully inspected before turning the output back on, starting with a set point of zero and slowly ramping back to the operating point. If in doubt, contact the factory for assistance. This warning can be disabled by turning the **Overcurrent Det** setting in the Advanced Menu to *No*, but this should only be done on advice of the factory.

Noise

On some controllers, lowering the voltage limit will allow for the power supply to operate at a lower voltage and reduce current noise. This is particularly true for low compliance loads operating on high compliance drivers. In general, operating with the voltage limit as low as possible without generating E-505 errors will provide the best possible noise performance.

Voltage Limit / Headroom Disable

E-505 and E-537 errors can be disabled via settings in the Advanced Menu but should be used with extreme caution. Disabling either can result in unpredictable performance but will allow the controller to operate outside its normal operational parameters which may be useful in some applications. Review your requirements with the factory before changing either of these settings.

- **V Comp Detect** – when set to *Yes*, the instrument will monitor the peak and supply voltages and ensure the voltage compliance is high enough to provide sufficient operating headroom. This can be disabled by setting **V Comp Detect** to *No*.

  CAUTION
  Disabling voltage headroom monitoring can result in significant current overshoots and should only be enabled on advice of the factory or after verification of performance with a high speed current probe.

- **Vf Disable** – when set to *No*, the voltage limit hardware circuit will operate normally. When set to *Yes,* the voltage limit hardware circuit will be disabled and the output allowed to operate even if the limit is exceeded. This should only be enabled on advice from the factory.

Using the Pilot Laser

The **4400** includes an additional low-power driver for controlling a pilot (or aiming) laser that is often included inside high-power laser modules.

With both current and voltage mode operation and a wide current and voltage range, the pilot laser driver meets the requirements of most pilot lasers.

While the prior portions of the manual were written for the main laser output, many of the same concepts and capabilities apply to the Pilot Laser driver:

- Hardware current limit
- Software monitored voltage limit – while it does not have the speed of a hardware voltage monitor, the software voltage monitor will shut down the pilot laser within a few hundred milliseconds of an over-voltage condition.
- Digital I/O and auxiliary sensor interface

Further, the pilot laser driver can be enabled for automatic shutdown when main laser turns on (see **Advanced->Off if Main On** in the Pilot Laser menu).

To enter the Pilot Laser menu, you must first press the **Display** button until the Pilot Laser screen is displayed and then press the **Menu** button. Accessing the menu from any other main screen will enter the main laser menu.

Using the Function Keys

The **4400** offers a unique capability: the ability to assign functions to front panel keys, allowing powerful configuration abilities at the touch of a button. There are two programmable function buttons.

The function keys can be assigned either of the following actions:

- Run a script
- Load a stored configuration

Running a script

The most powerful capability of the function keys is the ability to execute command strings, or scripts. These scripts are made up of commands, as defined in the *Computer Interfacing Manual*, and can affect virtually the entire operation of the instrument. Any command (except DELAY, *WAI, SCRIPT:GO, or SCRIPT:PUT commands) can be used to construct a script, allowing you to configure the instrument, change modes, change set points, turn outputs on or off, or any other of a wide range of actions. Script creation must be done over

the computer interface, see the *Computer Interfacing Manual* for more information on how to construct and store scripts.

Because the **4400** is a multi-channel controller, if you are including any laser commands in the script, be sure to include a LAS:CHAN command at the start of the script to specify which channel the script should run against.

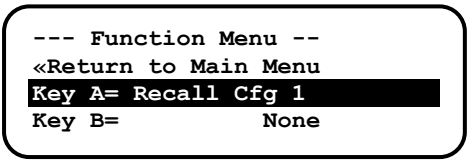
Loading a previously stored configuration

Using the **System Menu** » **Config** menu item, or the *SAV command over the computer interface, up to four different configurations can be saved to memory and can then be assigned as a recall function. For example, consider an application where different laser and/or temperature set points are used. By saving the different configurations, you can then assign the recall of the configurations to a function key, allowing you to switch between different setups or set points with a single button press.

Prior to configuring the function keys, you need to create your configurations or scripts. Configurations are easy: simply setup the instrument the way you want, then go to **System Menu** » **Config** to store the configuration into one of the four configuration bins. Repeat the process for each setup you want to recall.

Scripts are a bit more difficult, as you need to create them using the computer interface. See the *Computer Interfacing Manual* for more information on how to construct and store scripts.

Once your configurations and scripts have been created, go to **Func Key Menu** » **Key A** and assign a recall configuration or execute script function. You will only be allowed to select the scripts and configurations you have created.



Func Key Menu

Once actions have been assigned to keys, return to the main screen. To initiate the action assigned to the **A** or **B** keys, press and hold the **A** or **B** key until the instrument does a double beep (approximately one second). This indicates the action has executed.

User Calibration

The LaserSource supports the ability to apply a user calibration to all measurement and control functions of the instrument. This allows for field calibration of the instrument as needed to meet the requirements of the user's application.

NOTE

Changing the user calibration parameters directly modifies the performance of the instrument. User calibrations should only be performed by individuals experienced in instrument calibration.

NOTE

Ensure that the standards used to calibrate the instrument exceed the instrument's specifications. A test uncertainty ratio of 4:1 or better is recommended, unless otherwise required by your application.

User calibration can only be performed by sending appropriate commands to the instrument over the computer interface (either USB or RS232). The commands are more fully documented in the *Computer Interfacing Manual*, but the essential commands are:

LASER:USERCAL:EDIT	Enabled modification of user calibration settings
LASER:USERCAL:PUT	Changes user calibration settings
LASER:USERCAL:GET	Retrieves user calibration settings
LASER:USERCAL:RESET	Resets all user calibration settings to factory defaults

NOTE

For the sensor, the calibration is applied to the measurement of the sensor, not the temperature. To adjust the resistance-to-temperature conversion, change the sensor coefficients as needed.

To prevent accidental modification of the calibration settings, the entries are only editable when LASER:USERCAL:EDIT 1 command is sent remotely. By default,

M and **B** values are 1.000 and 0.00, respectively, but can be adjusted to change the sensor measurement. The calibrated measurement is computed as follows:

$$\text{User calibrated reading} = \mathbf{M} * \text{reading} + \mathbf{B}$$

For set points, the set point is calculated as follows:

$$\text{User calibrated setpoint} = \mathbf{M} * \text{set point} + \mathbf{B}$$

B is always in the units of the measurement (for example, volts for laser voltage, etc.).

Specifications

10A to 20A Unit Specifications

Description	4400-10-56	4400-15-28	4400-20-48
CW Specifications			
SETPOINT			
LASER CURRENT			
Range (A)	0 – 10	0 – 15	0 – 20
Max Resolution (A)	0.0005	0.0005	0.001
Accuracy (±[% set+A])	0.05 + 0.005	0.05 + 0.0075	0.05 + 0.01
Stability (± ppm, 1 hour)	10	10	10
Temperature Coeff (± ppm/°C)	50	50	50
Noise/Ripple (mA rms)[2]	< 15	< 25	< 25
Transients (mA)[3]	< 20	< 30	< 40
Compliance Voltage (V)	56 / 52[4]	28	48
Maximum Deliverable Power (W)	560	420	960
PHOTODIODE CURRENT			
Range (µA)	25 – 20000	25 – 20000	25 – 20000
Resolution (µA)	1	1	1
Accuracy (±[% set+µA])	0.05 + 2	0.05 + 2	0.05 + 2
Stability (± ppm, 24 hours)	200	200	200
Temperature Coeff (± ppm/°C)	200	200	200
PD Bias (V)	0 to -5V	0 to -5V	0 to -5V
LASER VOLTAGE			
Range (V)	0 – 56 (52[4])	0 – 28	0 – 48
Resolution (V)	0.001	0.001	0.001
Accuracy (±[% set+V])	0.05 + 0.005	0.05 + 0.005	0.05 + 0.005
Stability (± ppm, 1 hour)	< 50	< 50	< 50
Temperature Coeff (± ppm/°C)	< 100	< 100	< 100
EXTERNAL MODULATION			
Input Range / Impedance	0 – 10V, 10kΩ	0 – 10V, 10kΩ	0 – 10V, 10kΩ
Modulation Bandwidth (kHz)[5]	12 to 15	15	12 to 15
MEASUREMENT			
LASER CURRENT			
Resolution (A)	0.001	0.01	0.01
Accuracy (±[% reading+A])	0.05 + 0.005	0.05 + 0.008	0.05 + 0.010
LASER VOLTAGE			
Resolution (V)	0.001	0.001	0.001
Accuracy (±[% reading+V])	0.05 + 0.005	0.05 + 0.005	0.05 + 0.005
PHOTODIODE CURRENT			
Resolution (µA)	1	1	1
Accuracy (±[% reading+µA])	0.05% + 2	0.05% + 2	0.05% + 2
QCW Specifications[6]			
SETPOINT			
LASER CURRENT (ACC)			
Range (A)[7]	0.75 – 10	1.13 – 15	1.50 – 20
Max Resolution (A)	0.0005	0.0005	0.001
Accuracy (±[% set+A])	0.1 + 0.010	0.1 + 0.015	0.1 + 0.020
Compliance Voltage (V)	52	28	48
MEASUREMENT			
LASER CURRENT			
Resolution (A)	0.01	0.01	0.01

Description	4400-10-56	4400-15-28	4400-20-48
Accuracy (±[% reading+A])	0.1 + 0.010	0.1 + 0.015	0.1 + 0.020
LASER VOLTAGE			
Resolution (V)	0.01	0.01	0.01
Accuracy (±[% reading+V])	2 + 0.1	2 + 0.1	2 + 0.1
PHOTODIODE CURRENT			
Resolution (µA)	10	10	10
Accuracy (±[% reading+µA])	2 + 100	2 + 100	2 + 100
QCW PARAMETERS			
PULSE WIDTH			
Range (ms)	0.1 – 600	0.1 – 600	0.1 – 600
Resolution (ms)	0.001	0.001	0.001
Accuracy (ms)	0.015	0.015	0.015
FREQUENCY			
Range (Hz)	1 – 1000	1 – 1000	1 – 1000
Resolution (Hz)	0.1	0.1	0.1
Accuracy (Hz)	0.5	0.5	0.5
DUTY CYCLE			
Range (%)	0.1 – 90	0.1 – 90	0.1 – 90
Resolution (%)	0.1	0.1	0.1
Rise/Fall Times (µs)[8]	< 15 to 25	< 20	< 15 to 25
Overshoot (%)	< 10	< 7	< 7
Zero Current (A)[9]	< 0.020	< 0.030	< 0.040
LIMITS			
LASER CURRENT			
Resolution (mA)	0.02	0.05	0.05
Accuracy (±[% set+A])	1 + 0.05	1 + 0.075	1 + 0.1
LASER VOLTAGE			
Resolution (V)	0.1	0.1	0.1
Accuracy (±[% set+V])	1 + 0.2	1 + 0.2	1 + 0.2
OUTPUT CONNECTOR			
Laser Connector	13W3 Female	13W3 Female	13W3 Female
Pilot/Signal Connector	On 13W3	On 13W3	On 13W3
Auxiliary Connector	DB25 Female	DB25 Female	DB25 Female

30A and 40A Unit Specifications

Description	4400-30-14	4400-30-28	4400-40-24
CW Specifications			
SETPOINT			
LASER CURRENT			
Range (A)	0 – 30	0 – 30	0 – 40
Max Resolution (A)	0.001	0.002	0.002
Accuracy (±[% set+A])	0.05 + 0.015	0.05 + 0.015	0.05 + 0.02
Stability (± ppm, 1 hour)	10	10	10
Temperature Coeff (± ppm/°C)	50	50	50
Noise/Ripple (mA rms)[2]	< 15	< 25	< 25
Transients (mA)[3]	< 60	< 60	< 80
Compliance Voltage (V)	14	28	24
Maximum Deliverable Power (W)	420	840	960
PHOTODIODE CURRENT			
Range (µA)	25 – 20000	25 – 20000	25 – 20000
Resolution (µA)	1	1	1
Accuracy (±[% set+µA])	0.05 + 2	0.05 + 2	0.05 + 2
Stability (± ppm, 24 hours)	200	200	200
Temperature Coeff (± ppm/°C)	200	200	200
PD Bias (V)	0 to -5V	0 to -5V	0 to -5V
LASER VOLTAGE			
Range (V)	0 – 14	0 – 28	0 – 24
Resolution (V)	0.001	0.001	0.001
Accuracy (±[% set+V])	0.05 + 0.005	0.05 + 0.005	0.05 + 0.005
Stability (± ppm, 1 hour)	< 50	< 50	< 50
Temperature Coeff (± ppm/°C)	< 100	< 100	< 100
EXTERNAL MODULATION			
Input Range / Impedance	0 – 10V, 10kΩ	0 – 10V, 10kΩ	0 – 10V, 10kΩ
Modulation Bandwidth (kHz)[5]	15	15	15
MEASUREMENT			
LASER CURRENT			
Resolution (A)	0.02	0.02	0.02
Accuracy (±[% reading+A])	0.05 + 0.015	0.05 + 0.015	0.05 + 0.020
LASER VOLTAGE			
Resolution (V)	0.001	0.001	0.001
Accuracy (±[% reading+V])	0.05 + 0.005	0.05 + 0.005	0.05 + 0.005
PHOTODIODE CURRENT			
Resolution (µA)	1	1	1
Accuracy (±[% reading+µA])	0.05% + 2	0.05% + 2	0.05% + 2
QCW Specifications[6]			
SETPOINT			
LASER CURRENT (ACC)			
Range (A)[7]	2.25 – 30	2.25 – 30	3.00 – 40
Max Resolution (A)	0.001	0.002	0.002
Accuracy (±[% set+A])	0.1 + 0.030	0.1 + 0.030	0.1 + 0.040
Compliance Voltage (V)	14	28	24
MEASUREMENT			
LASER CURRENT			
Resolution (A)	0.01	0.01	0.01
Accuracy (±[% reading+A])	0.1 + 0.030	0.1 + 0.030	0.1 + 0.040
LASER VOLTAGE			
Resolution (V)	0.01	0.01	0.01
Accuracy (±[% reading+V])	2 + 0.1	2 + 0.1	2 + 0.1

Description	4400-30-14	4400-30-28	4400-40-24
PHOTODIODE CURRENT			
Resolution (µA)	10	10	10
Accuracy (±[% reading+µA])	2 + 100	2 + 100	2 + 100
QCW PARAMETERS			
PULSE WIDTH			
Range (ms)	0.1 – 600	0.1 – 600	0.1 – 600
Resolution (ms)	0.001	0.001	0.001
Accuracy (ms)	0.015	0.015	0.015
FREQUENCY			
Range (Hz)	1 – 1000	1 – 1000	1 – 1000
Resolution (Hz)	0.1	0.1	0.1
Accuracy (Hz)	0.5	0.5	0.5
DUTY CYCLE			
Range (%)	0.1 – 90	0.1 – 90	0.1 – 90
Resolution (%)	0.1	0.1	0.1
Rise/Fall Times (µs)[8]	< 15	< 15	< 20
Overshoot (%)	< 7	< 7	< 7
Zero Current (A)[9]	< 0.060	< 0.060	< 0.080
LIMITS			
LASER CURRENT			
Resolution (mA)	0.1	0.1	0.1
Accuracy (±[% set+A])	1 + 0.15	1 + 0.15	1 + 0.2
LASER VOLTAGE			
Resolution (V)	0.1	0.1	0.1
Accuracy (±[% set+V])	1 + 0.2	1 + 0.2	1 + 0.2
OUTPUT CONNECTOR			
Laser Connector	13W3 Female	13W3 Female	13W3 Female
Pilot/Signal Connector	On 13W3	On 13W3	On 13W3
Auxiliary Connector	DB25 Female	DB25 Female	DB25 Female

60A to 100A Unit Specifications

Description	4400-60-14	4400-80-12	4400-100-10
CW Specifications			
SETPOINT			
LASER CURRENT			
Range (A)	0 – 60	0 – 80	0 – 100
Max Resolution (A)	0.005	0.005	0.005
Accuracy (±[% set+A])	0.05 + 0.03	0.05 + 0.04	0.05 + 0.05
Stability (± ppm, 1 hour)	10	10	10
Temperature Coeff (± ppm/°C)	50	50	50
Noise/Ripple (mA rms)[2]	< 30	< 40	< 60
Transients (mA)[3]	< 120	< 160	< 200
Compliance Voltage (V)	14	12	10
Maximum Deliverable Power (W)	840	> 900	> 850
PHOTODIODE CURRENT			
Range (µA)	25 – 20000	25 – 20000	25 – 20000
Resolution (µA)	1	1	1
Accuracy (±[% set+µA])	0.05 + 2	0.05 + 2	0.05 + 2
Stability (± ppm, 24 hours)	200	200	200
Temperature Coeff (± ppm/°C)	200	200	200
PD Bias (V)	0 to -5V	0 to -5V	0 to -5V
LASER VOLTAGE			
Range (V)	0 – 14	0 – 12	0 – 10
Resolution (V)	0.001	0.001	0.001
Accuracy (±[% set+V])	0.05 + 0.005	0.05 + 0.005	0.05 + 0.005
Stability (± ppm, 1 hour)	< 50	< 50	< 50
Temperature Coeff (± ppm/°C)	< 100	< 100	< 100
EXTERNAL MODULATION			
Input Range / Impedance	0 – 10V, 10kΩ	0 – 10V, 10kΩ	0 – 10V, 10kΩ
Modulation Bandwidth (kHz)[5]	15	12	12
MEASUREMENT			
LASER CURRENT			
Resolution (A)	0.05	0.05	0.05
Accuracy (±[% reading+A])	0.05 + 0.030	0.05 + 0.040	0.05 + 0.050
LASER VOLTAGE			
Resolution (V)	0.001	0.001	0.001
Accuracy (±[% reading+V])	0.05 + 0.005	0.05 + 0.005	0.05 + 0.005
PHOTODIODE CURRENT			
Resolution (µA)	1	1	1
Accuracy (±[% reading+µA])	0.05% + 2	0.05% + 2	0.05% + 2
QCW Specifications[6]			
SETPOINT			
LASER CURRENT (ACC)			
Range (A)[7]	4.50 – 60	6.00 – 80	7.50 – 100
Max Resolution (A)	0.005	0.005	0.005
Accuracy (±[% set+A])	0.1 + 0.060	0.1 + 0.080	0.1 + 0.100
Compliance Voltage (V)	14	12	10
MEASUREMENT			
LASER CURRENT			
Resolution (A)	0.01	0.01	0.01
Accuracy (±[% reading+A])	0.1 + 0.060	0.1 + 0.080	0.1 + 0.100
LASER VOLTAGE			
Resolution (V)	0.01	0.01	0.01

Description	4400-60-14	4400-80-12	4400-100-10
Accuracy (±[% reading+V])	2 + 0.1	2 + 0.1	2 + 0.1
PHOTODIODE CURRENT			
Resolution (µA)	10	10	10
Accuracy (±[% reading+µA])	2 + 100	2 + 100	2 + 100
QCW PARAMETERS			
PULSE WIDTH			
Range (ms)	0.1 – 600	0.1 – 600	0.1 – 600
Resolution (ms)	0.001	0.001	0.001
Accuracy (ms)	0.015	0.015	0.015
FREQUENCY			
Range (Hz)	1 – 1000	1 – 1000	1 – 1000
Resolution (Hz)	0.1	0.1	0.1
Accuracy (Hz)	0.5	0.5	0.5
DUTY CYCLE			
Range (%)	0.1 – 90	0.1 – 90	0.1 – 90
Resolution (%)	0.1	0.1	0.1
Rise/Fall Times (µs)[8]	< 25	< 30	< 50
Overshoot (%)	< 7	< 7	< 7
Zero Current (A)[9]	< 0.120	< 0.160	< 0.200
LIMITS			
LASER CURRENT			
Resolution (mA)	0.2	0.2	0.2
Accuracy (±[% set+A])	1 + 0.3	1 + 0.4	1 + 0.5
LASER VOLTAGE			
Resolution (V)	0.1	0.1	0.1
Accuracy (±[% set+V])	1 + 0.2	1 + 0.2	1 + 0.2
OUTPUT CONNECTOR			
Laser Connector	Bus Bar, M6	Bus Bar, M6	Bus Bar, M6
Pilot/Signal Connector	DB9 Female	DB9 Female	DB9 Female
Auxiliary Connector	DB25 Female	DB25 Female	DB25 Female

General Specifications	
PILOT LASER	
CURRENT	
Range (mA)	0 – 500
Resolution (mA)	1
Accuracy (±[% + mA])	1% + 3
Compliance Voltage (V)	> 5
Current Limit Accuracy (±mA)	5
VOLTAGE	
Range (V)	0 – 5
Resolution (V)	0.01
Accuracy (±[% + V])	1% + 0.025
Operating Modes	Constant current or constant voltage
AUXILLARY INTERFACE	
TEMPERATURE SENSOR	
Range (Ω)	100 – 45,000
Resolution (Ω)	1
Accuracy (±[% read+Ω])	0.5% + 10
Relay Limits	30VDC, 1A max
Digital I/O +5V Supply	150mA Max (all signals)
Auxiliary Connector	DB-25 Female
GENERAL	
Display Type	4x20 VFD
Chassis Interlock Connector	2-pin Phoenix part number 1803578
Computer Interface	USB 2.0 (Type B), RS-232 (DB-9 Male)
Power	90 – 240 V, 50 / 60 Hz
Size (H x W x D) [inches (mm)][10]	3.5 (90) x 12 (305) x 14 (356)
Weight (lbs [kg])	13 [5.9]
Operating Temperature	+10°C to +40°C
Storage Temperature	-20°C to +60°C

1. All values measured after 1-hour warm-up and at 25°C.
2. RMS current on resistive load, 350kHz BW, low bandwidth mode, ½ scale, high range
3. Maximum output current transient from normal operations (e.g. power on-off, current on-off), as well as accidental situations (e.g. power line plug removal).
4. Lower compliance voltage for HiBW and QCW modes.
5. 25% to 75% sine wave modulation, -3dB point. When specified as a range, higher load voltages will have lower bandwidths.
6. All QCW specifications taken with short cable directly to laser load.
7. Current set point can adjust to zero (Zero Current specification applies), but QCW specifications only apply to indicated range.
8. 10% to 90% points at ½ scale into diode load. When specified as a range, higher load voltages will have higher risetimes.
9. Minimum current during QCW operation.
10. Excluding feet, front panel switches, knob, or key, or rear panel bus bars.

Error Messages

Error Code	Description	Cause
E-100	General Error	The error code is non-specific, and is generally used when no other error code is suitable.
E-102	Message too long	The message is too long to process (USB/Serial only).
E-123	Path not found	The message used an invalid path command (USB/Serial only).
E-124	Data mismatch	The message contained data that did not match the expected format (USB/Serial only).
E-126	Too few or too many elements	The command requires more or less than the number of parameters actually supplied.
E-127	Change not allowed	An attempt was made to change a parameter that cannot be changed, or is currently read-only.
E-128	Delay or active script terminated	An executing script, or a *WAI or DELAY function was terminated before completing.
E-201	Data out of range	The message attempted to set a value that was outside the allowable range (USB/Serial only).
E-202	Invalid data type	When trying to parse the message, the data was in an invalid format (USB/Serial only).
E-204	Suffix not valid	An invalid number base suffix (radix) was encountered when parsing a number (USB/Serial only).
E-217	Configuration Recall failed	An attempt to recall a configuration failed. This can be caused if no configuration exists in the selected slot, the slot number is out of range, or if the configuration is corrupted.
E-218	Configuration Save failed	An attempt to save a configuration failed. This can be caused if the slot number is out of range, or the configuration memory is corrupted.
E-220	Script Save Failed	An attempt to save a script failed. This can be caused if the script number is out of range, or the script memory is corrupted.
E-221	Cannot embed script	A script was executed that contained a reference to another script.
E-222	Cannot execute script	An attempt to execute a script failed. This can be caused if the script number is out of range, no script exists for the selected index, or the script memory is corrupted.
E-501	Interlock shutdown output	The interlock input (pins 1 and 2 of the output connector) were not shorted when the output was on.
E-504	Laser current limit disabled output.	The laser output was turned off because a current limit was detected and the corresponding bit in the OUTOFF register was set.

E-505	Laser voltage limit disabled output	The laser voltage exceeded the voltage limit and the output was turned off.
E-506	Laser photodiode current limit disabled output	The laser output was turned off because a photodiode current limit was detected and the corresponding bit in the OUTOFF register was set.
E-507	Laser photodiode power limit disabled output	The laser output was turned off because a photodiode power limit was detected and the corresponding bit in the OUTOFF register was set.
E-509	Laser short circuit disabled output	The laser output was turned off because a short condition was detected and the corresponding bit in the OUTOFF register was set.
E-510	Laser out of tolerance disabled output	The laser output was turned off because an out-of-tolerance condition was detected and the corresponding bit in the OUTOFF register was set.
E-511	Laser control error disabled output	A hardware control error was detected which forced a shutdown of the laser output.
E-512	Power failure	A power failure was detected.
E-514	Laser mode change disabled output	The laser output was turned off because a change in the operating mode of the LaserSource while the output was on.
E-516	Incorrect configuration for calibration to start	The LaserSource was not configured properly, including the mode and output on state, to be able to start the desired calibration process.
E-517	Calibration must have the output on to start	The laser output must be on for the calibration process to start.
E-534	Po mode selected with PD Response set to zero	Attempted to select Po mode and PD Response was zero., or LaserSource was in Po mode and PD Response was set to zero.
E-535	Calibration cancelled	The active calibration process was cancelled.
E-536	Intermittent contact fault	The instrument detected an intermittent contact and shutdown the laser output. If this is triggering falsely (such as in a noisy environment), the intermittent contact detection can be disabled in the main menu.
E-537	Thermal trip	Excessive power dissipated inside unit. Lower voltage limit or add series resistance. See "Thermal Considerations" for more details.
E-538	Sensor resistance limit	The sensor resistance exceeded the limit setup in the **Aux Sensors** menu.
E-539	Sensor temperature limit	The sensor temperature exceeded the limit setup in the **Aux Sensors** menu.
E-540	Vf Headroom Violation	Insufficient voltage compliance was detected. See "Optimizing for Pulse Performance" for more information.
E-541	Excessive Current Detected	The driver detected an operating current that was more than 25% over the current limit. See "Optimizing for Pulse Performance" for more information.
I-700	Config saved	Instrument configuration successfully stored.

I-701	Config loaded	Instrument configuration successfully loaded.
I-703	Laser usercal reset	The user-provided calibration for the laser measurements and set points reset by the user.
W-800	Remote voltage sense is low	When in remote voltage sense mode, the controller detected a significant difference between the remote voltage and the voltage at the connector, which may indicate a problem with the remote voltage sense connection.
W-801	Burst Mode, Hold Output	When in Io (Burst) mode, to turn the output on, the Output button must be held down for at least one second. If it is held down for less than one second, this warning message informs the user than the Output button press did not turn the output on.
W-803	User reset to factory defaults	Notification message only: User pressed key sequence on start-up to reset unit to factory defaults.
W-805	User recall turned outputs off	Notification message only: A user configuration was recalled from memory while the outputs were on, resulting in the outputs being turned off.
W-806	No function key assigned	Notification message only: User attempted to execute a function key action that was not assigned.
W-807	Io Setpoint Increased	The Io Setpoint was below QCW Low setting when switching into pulse mode, the Io Setpoint increased to the QCW Low setting.
W-808	Vf set/limit lowered in HiBW and pulse modes	The Vf set point and/or the Vf limit was lowered due to lower voltages available in high bandwidth and pulse mode.
W-809	Vf set/limit lowered, constrained by max power	The Vf set point and/or limit was lowered due to power supply constraints.
E-992 thru E-997	Hardware error	A hardware related error occurred. If problem persists, contact factory.
E-998	Command not supported	A command was recognized but not supported by the LaserSource.
E-999	Non-specific error	A non-specific error was encountered.

Maintenance and Service

Maintenance

The LaserSource requires no regular maintenance other than product calibration. To clean the instrument, use cotton cloth that is only damp (not wet) with a light solution of soap and water.

Fuses

Under normal operation, you should never need to replace a fuse. However, if either fuse does blow, use only T 250V, 10A, IEC 60127-2 5x20mm metric fuses as replacements.

If, after replacing the fuse, it continues to blow, immediately discontinue use of the instrument and contact service for support.

Service

Service and repair for the LaserSource can be obtained by contacting the distributor from where you purchased the instrument, or directly from Arroyo Instruments. A complete list of distributors is available on the Arroyo Instruments web site.

You can contact Arroyo Instruments through one of these methods:

By mail:	Arroyo Instruments 1201 Prospect Street San Luis Obispo, CA 93401 USA
By phone:	+1 (805) 543-1302
By fax:	+1 (805) 543-1303
By email:	support@arroyoinstruments.com
On the web:	http://www.arroyoinstruments.com

In all cases, Arroyo Instruments requires a return materials authorization (RMA) number. You must contact Arroyo Instruments and obtain an RMA number prior to returning your instrument, or the shipment may be rejected and sent back to you.

Warranty

Arroyo Instruments warrants that this product will be free from defects in material and workmanship and will comply with Arroyo Instruments' published specifications at the time of sale for a period of one year from date of shipment. If found to be defective during the warranty period, the product will either be repaired or replaced at Arroyo Instruments' option.

To exercise this warranty, write or call your local Arroyo Instruments representative, or contact the factory directly at the address given above. You will be given prompt assistance and return instructions. Send the product, freight prepaid, to the indicated service facility. Repairs will be made and the instrument returned freight prepaid. Repaired products are warranted for the balance of the original warranty period or 90 days, whichever first occurs.

Limitation of Warranty

The above warranties do not apply to products which have been repaired or modified without Arroyo Instruments' written approval, or products subjected to unusual physical, thermal or electrical stress, improper installation, misuse, abuse, accident or negligence in use, storage, transportation or handling. This warranty also does not apply to fuses, batteries, or damage from battery leakage.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE. ARROYO INSTRUMENTS SHALL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL, OR CONSEQUENTIAL DAMAGES RESULTING FROM THE PURCHASE OR USE OF ITS PRODUCTS.

EC Declaration of Conformity

EC Declaration of Conformity

CE

I/We

Arroyo Instruments

of

1201 Prospect Street
San Luis Obispo, CA 93401
USA

declare that

4400 Series LaserSource Laser Diode Driver

In accordance with the following directives

EMC Directive: 89/336/EEC
Low Voltage Directive: 73/23/EEC
RoHS Directive: 2015/863/EU

has been designed and manufactured to the following specifications:

EMC Directive Test Standards

EN 61326 Electrical Equipment for Measurement, Control and Laboratory Use EMC Requirements. This encompasses 10 individual Tests

Low Voltage Directive Test Standards

EN 61010 Electrical Equipment for Measurement, Control and Laboratory Use Safety Requirements.

This Certificate is the Manufacturer's Declaration which states that the **4400 Series LaserSource Laser Diode Driver** is Compliant to the above noted EU Directives and are therefore, eligible to bear the CE MARK.

I hereby declare that the equipment named above has been designed to comply with the relevant sections of the above referenced specifications. The unit complies with all essential requirements of the Directives.

Paul Corr
(NAME OF AUTHORIZED PERSON)

(SIGNATURE OF AUTHORIZED PERSON)

President
(TITLE OF AUTHORIZED PERSON)

1 June 2020
(DATE OF ISSUE)

UK Declaration of Conformity

EC Declaration of Conformity

UK CA

I/We

Arroyo Instruments

of

1201 Prospect Street
San Luis Obispo, CA 93401
USA

declare that

4400 Series LaserSource Laser Diode Driver

In accordance with the following U.K. Legislation Regulations:

Electrical Equipment (Safety) Regulations 2016
Electromagnetic Compatibility (EMC) Regulations 2016
The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012

has been designed and manufactured to the following specifications:

EMC Directive Test Standards

EN 61326 Electrical Equipment for Measurement, Control and Laboratory Use EMC Requirements. This encompasses 10 individual Tests

Low Voltage Directive Test Standards

EN 61010 Electrical Equipment for Measurement, Control and Laboratory Use Safety Requirements.

This Certificate is the Manufacturer's Declaration which states that the **4400 Series LaserSource Laser Diode Driver** is Compliant to the above noted U.K. Legislation and are therefore, eligible to bear the UKCA MARK.

I hereby declare that the equipment named above has been designed to comply with the relevant sections of the above referenced specifications. The unit complies with all essential requirements of the U.K. Legislation Regulations.

Paul Corr
(NAME OF AUTHORIZED PERSON)

(SIGNATURE OF AUTHORIZED PERSON)

President
(TITLE OF AUTHORIZED PERSON)

September 27, 2022
(DATE OF ISSUE)

NOTES:

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