ComboSource™

6300 SERIES

USER'S MANUAL

**LASER DIODE
CONTROLLER**

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Introduction

Thank you for choosing the **ComboSource** from Arroyo Instruments. The **ComboSource** combines the features of our **LaserSource** and **TECSource** into a single, powerful instrument. The **ComboSource** represents years of experience in the field of current and temperature control.

With a large, crystal clear VFD display, both RS232 and USB computer interfaces, and small footprint, the **ComboSource** will fit into almost any laser diode control application. Unlike other controllers in its class, which use inexpensive 7-segment displays, the **ComboSource** takes advantage of its large VFD display to simultaneously show the set points and measurements.

The **ComboSource** also includes complete 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. The **ComboSource** 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 user interface of the **ComboSource** 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 **ComboSource** offers all the features you would expect from a modern precision laser controller, including:

- Laser driver:
  - 10ppm current stability
  - 100mA to 4A current ranges
  - High compliance versions for QCL applications
  - 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.
- Temperature Controller:
  - AutoTune for automatic PID parameter calculation
  - 0.004°C temperature stability and 0.01°C set point resolution
  - 60W (5A/12V) output power
- Simultaneous display of set points and readings

What's in the Box

Along with the **ComboSource** 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 **ComboSource**. These include:

- **1220B LaserSource Cable, 4A, 2m**
  This cable has DB-9 male/female connectors for interfacing to the LaserMount or other connectorized fixtures, and shielded twisted pair conductors for improved modulation performance. A pigtailed version of this cable, with tinned ends for soldering into custom solutions, is available as p/n **1221B**.
- **1260B TECSource Cable, 5A, 2m**
  This cable has DB-15 male/female connectors for interfacing to the LaserMount or other connectorized fixtures, and supports up to 5A of TE current and connections for the fan interface. A pigtailed version of this cable, with tinned ends for soldering into custom solutions, is available as p/n **1261B**.
- **1401-RM-1 4300/5300/6300 Series 2U Rack Mount Kit, 1 unit**
  1401-RM-2 4300/5300/6300 Series 2U Rack Mount Kit, 2 units
  For installing your instrument into a standard 19" rack. The **1401-RM-1** is used when installing a single instrument into a 2U rack space. For mounting two instruments side-by-side, use the **1401-RM-2** rack mount kit. A **1401-RM-1** cannot be converted to a **1401-RM-2**, or vise versa, so be sure to purchase the correct rack mount kit.
- **10kΩ Thermistor (p/n 1600-10K)**
- **100Ω Platinum RTD (p/n 1600-100RTD)**
- **1200-NULL RS-232 NULL Cable, 2m**
- **1201 USB Cable, 3m**

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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 a 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.

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Quick Start

The **ComboSource** was designed with ease of use in mind, and you will likely have little need for this manual for most of the features the unit offers. This section will show how you can quickly get the unit up and running in almost no time.

After unpacking the unit, *ensure that the voltage selection on the Input Power Connector (IPC) on the back of the unit is set to the correct voltage*. This is critical, as incorrect voltages can damage the unit. The **ComboSource** is typically shipped in the 120V configuration from the factory, but always verify the voltage selection. Change the voltage as needed. For more information, refer to *Changing the Voltage Selection* under the **Installation** section below.

Once the voltage selection has been completed, 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.

Press the **Menu** button to enter the menu, select the **»Goto Laser Menu** by pressing the knob, then scroll down until **Io Lim** setting is displayed. Press the knob again to edit the setting, and adjust the limit as appropriate to your laser diode. Press the knob again to save the value. Scroll down and make the same adjustments to the voltage limit (**Vf Lim**). Next, you should adjust the temperature control settings appropriate for your device. Scroll back to the top of the list and choose **«Return to Main Menu**, scroll down and select **»Goto TEC Menu**, then scroll down and adjust the TEC current limit (**I Lim**) and high and low temperature limits (**T-High Lim** and **T-Low Lim**), as appropriate for your application. Once you have made all your adjustments, press the **Menu** button to exit the menu.

The unit comes pre-programmed for the BetaTHERM 10K3A1 thermistor. If the **ComboSource** is being connected to a LaserMount, no changes need to be made, as this is the thermistor used in the mount (except for 150°C rated mounts, which use RTDs). However, if you are using a different manufacturer's thermistor or BetaTHERM thermistor, you will need to select the correct sensor and verify the coefficients are set correctly. Change the **Sensor** setting and navigate to the **Sensor Coeffs** sub-menu, pressing the knob to enter the sub-menu. Adjust the constants to reflect the values for your sensor, if needed.

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

Finally, set the set points to an appropriate current and temperature and press the **On**/**Off** buttons to turn the outputs on. Typically, you will want to turn the TEC on first, allow it to stabilize, and then turn on the laser. When turning on the laser for the first time, it is a good idea to start with a set point of zero and ramp up to the desired set point. In this way, if the laser is wired incorrectly, the safety circuits will trip earlier and minimize any chance of damaging the laser. Once you have confirmed proper operation, the set point can be left at the desired operating point, and simply use the **On**/**Off** button to turn the laser on and off.

If you notice the temperature is oscillating around the set point and not stabilizing, you may need to adjust the **Gain** setting in the menu. You can use the AutoTune feature to automatically calculate the best PID values, or select from a set of eight factory preset values that typically cover most applications. To use the factory gains, if the temperature is quickly jumping up and down, the **Gain** will typically need to be reduced. If the temperature is slowly moving up and down, try a higher **Gain**. You may need to experiment with several gain settings to find the ideal value, and for even finer control, you can set the **Gain** to *PID* and directly set the PID control values.

For more detailed operating and installation instructions, read on.

Installation

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

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

Changing the Voltage Selection

Before powering on the unit, ensure that the voltage selection on the IPC is set correctly. Improper voltage selection can easily damage the unit. Changing the voltage selection requires that you remove the voltage selection module from the IPC. You can select from 100V, 120V, and 230V. Choose the voltage that most closely matches your AC voltage.

Remove the power cord from the unit. Using a small, flat-blade screwdriver, insert the tip of the screwdriver into the two small openings on the sides of the voltage indication to release the voltage selection module from the IPC, as shown in the picture below.

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Input Power Connector (IPC)

Once the module has been removed, remove the small, white voltage selection tumbler from the module, and then re-insert so that the desired voltage is shown. Re-insert the module into the IPC.

CAUTION

Do not exceed 250VAC on the line input.

It is critical to select the proper voltage selection prior to applying power to the unit. If the actual voltage exceeds the voltage selection by +/-10%, damage to the unit may occur.

Powering Up the Unit

Once the correct voltage selection has been made, connect the AC power cord to the unit. You must properly ground the unit by plugging the supplied power cord into a three prong grounded outlet, or using a three-to-two prong adapter and connecting the ground tab to earth ground.

Turn the power switch, located on the front panel, into the on (|) position. The unit will display the model, serial number, and firmware version, go through a quick power-up self-test, and return to the last known operating state.

Ventilation

The **ComboSource** has vent holes on both sides 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

Rack mounting kits (**p/n 1401-RM-1** or **p/n 1401-RM-2**) for standard 19" racks are available for the **ComboSource**, and supports the rack mount of one (**1401-RM-1**) or two (**1401-RM-2**) units in a 2U (3.5") high opening. 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. When using **1401-RM-2** to rack mount two units, either unit may also be a **4300 Series LaserSource** or **5300 Series TECSource**.

Warm-up and Environmental Considerations

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

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Operation

The Front Panel

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

6300 ComboSource Main Screen

The front panel is designed for ease of operation. There is an On/Off button for the Laser and TEC outputs, one to change which set point is adjusted by the knob, and one to enter the menu. The remaining three keys are the function buttons, which can be assigned a variety of actions. More information on the function keys are available in the section titled *Using the Function Keys*, below.

The outputs are controlled via the two **On/Off** buttons:

- For the laser, when turning the output on, there is a programmable delay (factory default of 3 seconds) where the unit will indicate that the output is on (the blue output LED will be lit), but the output stage is, in fact, not on. This is a CDRH safety feature required for some laser applications, and this delay can be adjusted in the menu. The output will be energized once the delay has expired.
- For the TEC, when the output is turned on, it will immediately begin driving current as needed to achieve the set point.

The **Menu** button is used to enter the **ComboSource** menu. When in remote mode, it also acts as a **Local** button, returning the instrument to local mode.

The 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/enter

button, primary used when making changes in the menu, but can also be used to change the view mode in the main display (see *Main Display Screen* below).

There are eight LEDs: two blue LEDs to indicate the on/off state of the laser or TEC; a red **Error** LED that indicates an error has occurred; a yellow **Remote** LED that indicates the unit is being controlled via a computer; two green LEDs to indicate which set point will be adjusted by the knob; and two more green LEDs to indicate which current control range is active.

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 below.

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 below.

Main Display Screen

On the main display you will find both set points and measurements. Which set point and measurements are displayed is dependent on the control mode you have selected.

You can select which set point is adjusted by pressing the **Select** button. The active set point is displayed on the screen via inverted text, and either the **Laser** or **TEC** selection LED will be lit.

You can also control the size of the characters by enlarging either the Laser, the TEC, or both. When on the main display, this can be done by pressing the **Enter** button (the knob), or by changing the **Display** setting in the **System** menu. When in large display mode, only the actual operating value is displayed. When the set point is changed via the knob, the display will briefly show the set point, and then return to displaying the actual measurement.

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Example displays are shown below:

```
Io_SET=  3850.1mA   LoBW
Im=950.1µA Vf=1.941V
T_SET= 25.00°C V= 6.72V
T=  25.00°C I= 3.25A
```

Main Display: Both Small

```
Io= 3850.1
T_SET= 25.00°C V= 6.72V
T=  25.00°C I= 3.25A
```
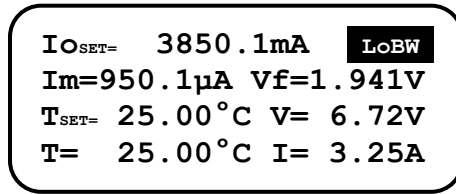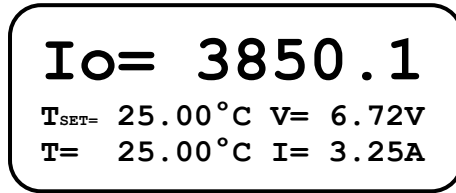
Main Display: Laser Large

```
Io_SET=  3850.1mA   LoBW
Im=950.1µA Vf=1.941V
T=     25.00
```
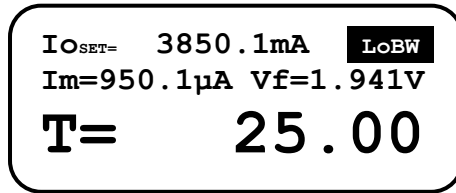
Main Display: TEC Large

```
Io= 3850.1
T=     25.00
```
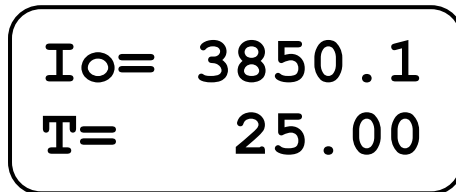
Main Display: Both Large

Measurements

One of the advantages of the **ComboSource** is its ability to display both the set point and measurements simultaneously (when in small display mode). The table below shows which values will appear on the display depending on the mode selected:

Mode	Setpoint	Displayed Measurements
Laser		
Io	Current (mA)	PD current or power and voltage
Im	PD current (µA)	Current and voltage
Po	PD power (mW)	Current and voltage
Vf	Voltage (V)	Current and PD current or power
TEC		
T	Temperature (°C)	Temperature, current and voltage
R	Sensor (kΩ, mV, uA, or Ω)	Sensor, current and voltage
ITE	TEC current (A)	Temperature, current and voltage

The instrument will show photodiode current or photodiode power, depending on the value of **PD Resp**. Photodiode current is shown whenever **PD Resp** is zero, while photodiode power will be shown whenever **PD Resp** is non-zero. See the *Laser* or *TEC Control Modes* sections below for more information on the various modes.

Status Messages

The instrument will display status messages in upper right corner indicating several different conditions for the laser 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 laser condition messages are:

LoBW The unit is in Io (LoBW) mode.
HiBW The unit is in Io (HiBW) mode.
Script The unit is executing a script or remote command.
Lock The interlock 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.
MLim The unit is in photodiode current limit.
PLim The unit is in photodiode power limit.

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

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Settings and Menus

All parameters of the **ComboSource** can be viewed and changed within the menu. The menus are constructed with the most used parameters first, and grouped by section. To change any setting, press **Menu** to enter the menu then rotate the knob to select the submenu. The laser settings are grouped below the Laser menu, the TEC settings are grouped below the TEC menu, etc. To enter a menu or begin edting a setting, simply press the knob to begin changing the value. As a visual indication that you are in edit mode, you will see an asterisk appear next to the value. 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.

Menu	Description	Factory Default
Laser Menu		
Mode	As described in the *Control Modes* section above, the unit offers seven control modes: Io (ACC), Io HiBW (ACC), 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. Only applies in Io or Io HiBW modes (all other modes operate in high range).	High
Io Res	Resolution of the Io set point and measurement. Available options are dependent on the range of the instrument.	Depends on model
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 high speed response. For more information about limits, see *Using the Laser Limits* below.	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 the Laser Limits* below.	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 the Laser Limits* below.	Maximum

Menu	Description	Factory Default
Vf Limit	This setting controls the maximum allowable operating voltage of the laser diode. This limit is implemented in hardware for high speed response. For more information about limits, see *Using the Laser Limits* below.	Maximum
Vf Sense	Selects the remote voltage sense lines for diode voltage measurement. The remote voltage sense pins must be wired to the diode. See *Using Remote Voltage Sense* below for more details.	Local
Vf Sense Warn	When operating in remote voltage sense mode, if the remote voltage is significantly lower that the voltage at the **Laser Output** connector, a warning message is displayed. The setting disabled the warning. Only available when **Vf Sense** is set to **Remote**.	Yes
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* below. Not available when using remote voltage sense.	0.0000 Ω
Int Contact	Enables or disables intermittent contact.	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
Tol Time	Tolerance time is the amount of time, in seconds, that the measured value (current, voltage, etc.) must be within the set point +/- the tolerance for the unit to be considered in tolerance. In Io modes, the tolerance is defined by **Tol Io**. For Im/Po modes, the tolerance is fixed at 50uA. For Vf mode, the tolerance is fixed at 50mV.	5 seconds
Tol Io	Tolerance current is a band (in mA) around the set point. When the actual current is within this band for longer than the Tol Time setting, then the unit is considered to be in tolerance.	10.0mA

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Menu	Description	Factory Default
On Delay	The delay, from the time the **Output** button is pressed to when the output is actually energized.	3000ms
Laser Menu » Advanced		
Off if TEC Off	Turns off the laser output if the TEC turns off	No
Off if TEC Tlim	Turns off the laser output if the TEC exceeds the temperature limit	No
Off if Io Lim	Turns off the laser output if the Io limit is active	No
Off if Im Lim	Turns off the laser output if the Im limit is exceeded	Yes
Off if Po Lim	Turns off the laser output if the Po limit is exceeded	Yes
Off if OutTol	Turns off the laser output if the laser goes out of tolerance	No
Laser Menu » Advanced » User Cal		
Edit Cal	Must be set to *Yes* before user calibration settings can be changed.	No
Reset Cal	Reset the Laser user calibration data to factory defaults (all slopes to 1, all offsets to 0). Requires **Edit Cal** to be set to *Yes* before this setting will be displayed.	No
Various M & B Settings	Slope (M) and Offset (B) user calibration settings for each set point and measurement. See the *User Cal - Field Calibration* section below for additional details on using slope/offset calibration.	No
TEC Menu		
Mode	This sets the operating mode (*T Mode*, *R Mode*, or *Ite Mode*) of the temperature controller.	T Mode
Mount	Specify the mount connected to the **ComboSource**. If using a **LaserMount**, select the appropriate model. Otherwise, select *User Defined*.	User Defined
I Lim	**I Lim** sets the current limit of the temperature controller. The limit should be set to a value that is suitable for your Peltier device.	3A

Menu	Description	Factory Default
Gain	**Gain** controls the response of the temperature controller. A higher gain value will cause the controller to respond more quickly to the difference between the set point and the actual temperature, while a lower value will cause it to respond more slowly. Select *PID* for direct access to the PID parameters. Read more on setting gain below.	10
PID P	The proportional term of the PID loop. Will only be available if **Gain** is set to *PID*.	1
PID I	The integral term of the PID loop. Will only be available if **Gain** is set to *PID*.	0.01
PID D	The derivative term of the PID loop. Will only be available if **Gain** is set to *PID*.	0
Sensor	Sets the temperature measurement sensor. Can be *Therm 100uA*, *Therm 10uA*, *LM335*, *AD590*, *RTD*, or *RTD (4-wire)*, *RTD 1k*, or *RTD 1k (4-wire)*.	Therm 100uA
T-Low Lim	**T-Low Lim** is the lower temperature limit. If operating in T Mode and the actual temperature drops below this value, the output will be turned off. Temperature limits not monitored in R Mode or Ite Mode. Limit monitoring can also be disabled in software (see TEC:ENAB:OUTOFF command).	-99°C
T-High Lim	**T-High Lim** is the upper temperature limit. If operating in T Mode and the actual temperature rises above this value, the output will be turned off. Temperature limits not monitored in R Mode or Ite Mode. Limit monitoring can also be disabled in software (see TEC:ENAB:OUTOFF command).	125°C
R-Low Lim	**R-Low Lim** is the sensor low limit. If operating in R Mode and the actual sensor measurement drops below this value, the output will be turned off. R limits are not monitored in Ite Mode. Limit monitoring can also be disabled in software (see TEC:ENAB:OUTOFF command).	0.01kΩ
R-High Lim	**R-High Lim** is the sensor high limit. If operating in R Mode and the actual sensor measurement exceeds this value, the output will be turned off. R limits are not monitored in Ite Mode. Limit monitoring can also be disabled in software (see TEC:ENAB:OUTOFF command).	45kΩ

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Menu	Description	Factory Default
Tol Time	Tolerance time is the amount of time, in seconds, that the actual temperature must be within the set point temperature +/- the Tol Temp value for the unit to be considered in tolerance.	5 seconds
Tol Temp	Tolerance temperature is a temperature band (in °C) around the set point temperature. When the actual temperature is within this band for longer than the Tol Time setting, then the unit is considered to be in tolerance.	0.1°C
H/C Mode	This selects the heating and/or cooling mode of the ComboSource. See the section below titled "Resistive Heaters and Heat/Cool Only Modes" for more information.	Heat/Cool
Ext Fan	This selects the voltage for the auxiliary fan power supply. See the section below titled "External Fan Control" for more information.	Off
Ext Fan Pwr	When Ext Fan is set to Custom, this sets the specific fan voltage from 4.0 to 12.0 volts. See the External Fan Control section below for more information.	12.0
Ext Fan Mode	Controls when the fan operates. See the External Fan Control section below for more information.	Auto
Ext Fan Off	When Ext Fan Mode is set to Delay, this setting defines the number of minutes to delay turning off the fan after the TEC output has been turned off. See the External Fan Control section below for more information.	5 minutes
Cable R	The resistance of the cable and connectors, in ohms. This setting allows for accurate voltage measurement at the TEC by removing the voltage loss of the cable.	0.0080Ω
TEC Menu » Sensor Coeffs		
ThermA	The A term in the Steinhart-Hart equation.	1.12924E-03
ThermB	The B term in the Steinhart-Hart equation.	2.34108E-04
ThermC	The C term in the Steinhart-Hart equation.	0.87755E-07
RTD A	The A term in the RTD equation.	3.98480E-03
RTD B	The B term in the RTD equation.	-0.58700E-06

Menu	Description	Factory Default
RTD C	The C term in the RTD equation.	4.00000E-12
RTD R_0	The R_0 term (in Ω) in the RTD equation.	100.00
AD590 M	The slope term in the AD590 correction equation.	1.00000
AD590 B	The offset term, in °C, in the AD590 correction equation.	0.000
LM335 M	The slope term in the LM335 correction equation.	1.00000
LM335 B	The offset term, in °C, in the LM335 correction equation.	0.000
TEC Menu » AutoTune PID		
	See using the AutoTune Function later in this manual for details on this item.	
TEC Menu » Advanced		
Invert ITE	Reverses the direction of the current	No
Off if Thi Lim	Turns off the TEC output if the TEC exceeds the temperature high limit	Yes
Off if Tlo Lim	Turns off the TEC output if the TEC exceeds the temperature low limit	Yes
Off if R Lim	Turns off the TEC output if the TEC exceeds the sensor limit	No
Off if ITE Lim	Turns off the TEC output if the TEC hits the current limit	No
Off if TE Open	Turns off the TEC output if the TEC module appears to be an open circuit	Yes
Off if Out Tol	Turns off the TEC output if the TEC is out of tolerance	No
Off if Sens Open	Turns off the TEC output if the sensor appears to be an open circuit	Yes
Off if Sens Shrt	Turns off the TEC output if the sensor appears to be a short circuit	Yes

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Menu	Description	Factory Default
TEC Menu » Advanced » User Cal		
Edit Cal	Must be set to 'Yes' before user calibration settings can be changed.	No
Reset Cal	Reset the TEC user calibration data to factory defaults (all slopes to 1, all offsets to 0). Requires **Edit Cal** to be set to *Yes* before this setting will be displayed.	No
Various M & B Settings	Slope (M) and Offset (B) user calibration settings for each set point and measurement. See the *User Cal - Field Calibration* section below for additional details on using slope/offset calibration.	No
Comm 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
Function Menu		
Key A to **Key D**	The Key A, Key B, Key C, and Key D settings control the action assignment for the four function keys available on the **ComboSource**. See *Using the Function Keys* below for additional information.	None
System Menu		
Config	Allows for restoring the instrument to defaults, saving configurations, and restoring configurations. See *Saving and Restoring Configurations* below for more information.	No Change

Menu	Description	Factory Default
Display	Display mode, which is used to control the layout on the main screen. *Normal* will display more information in a smaller font, while *Large* will display the actual values only in a larger font. When changing the set point, the set point will be displayed during the set point change.	Normal
Brightness	The vacuum florescent display can be set to one of eight brightness levels.	100%
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 messages.	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

Saving and Restoring Configurations

Using the **Main Menu » System Menu » Config** menu item, or the *SAV and *RCL commands over the computer interfaces, ComboSource allows you to save up to four configurations. Each configuration will store all of the instrument settings (except scripts and the function key definitions), and allow you to quickly recall them. This is particularly useful when the instrument is used in multiple setups, and the particular configuration of each setup can be stored and later recalled for a quick reconfiguration.

To store a configuration, simply change the **Config** menu item to select which configuration slot you want to store the current configuration into. The instrument will generate a message indicating the save was successful (or not). You can also use the *SAV command over the computer interface to do this as well.

To recall a configuration, change the **Config** menu item to recall the configuration you would like to use. You can also use the *RCL command over the computer interface to do this as well.

A special option for the **Config** menu item is *Defaults*, and as the name implies, it will restore the unit to factory default configuration, however, scripts and

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configurations are *not* erased, and user calibration data is *not* cleared. To erase user calibration data, you must use the **Reset Cal** menu item found in the Laser and TEC User Cal menus, or manually adjust each user calibration entry to 1 (for slope) or 0 (for offset). See *Field Calibration,* below, for more details.

Using the Function Keys

The **ComboSource** 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, which can be assigned both a primary and secondary (or shifted) function.

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 effect virtually the entire operation of the instrument. Any command (except DELAY or *WAI 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 much be done over the computer interface, see the *Computer Interfacing Manual* for more information on how to construct and store scripts.

Loading a previously stored configuration

Using the **Main Menu » 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 **Main Menu » 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.

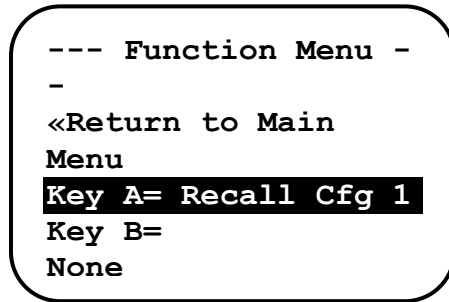Once your configurations and scripts have been created, go to **Main Menu » Func Key Menu » Key A** and assign a recall configuration or execute script function. You will only be allowed to select the scripts and configurations you have created.

```
--- Function Menu -
-
«Return to Main
Menu
Key A= Recall Cfg 1
Key B=
None
```

Func Key Menu

Once actions have been assigned to keys, return to the main screen. There two two physical keys for four buttons: the primary **A** and secondary **C** actions both use the same **A / C** button, and likewise, the primary **B** and secondary **D** actions both use the same **B / D** button.

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. Executing the **C** or **D** actions requires two presses of the **Function** button: once to select the function summary screen (with **A** and **B** actions highlighted), and a second time to change the highlight to the **C** and **D** actions. You can then press the **C** or **D** button to start the corresponding action.

```
Key A: Recall Cfg 1
Key B: Recall Cfg 2
Key C: Exec Script
1
Key D: None
```
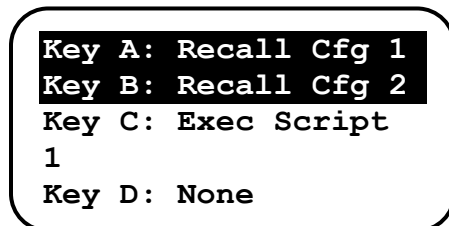
Function Summary Screen

The function key assignments are not part of a saved configuration, and will remain unchanged when a recall configuration is done.

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Connecting to the ComboSource

A laser diode is very sensitive to electro-static discharge (ESD), over-voltage, and over-current conditions. When connecting a laser to the **ComboSource**, 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 **ComboSource'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 **ComboSource** and the laser diode fixture must be secure. Tighten any screws on the DB-9 connectors, and make sure all connections are in good condition. Poor or intermittent connections can damage or destroy the laser diode.

A cable is required for both the TEC and Laser outputs. Arroyo Instruments carries cables specifically designed for these applications, both with a DB connector on the device end or with a bare wire pigtail for terminating the connection into a custom mount or device:

Function	DB to DB p/n	DB to Pigtail p/n
Laser	1220B	1221B
TEC	1260B	1261B
TEC w/ remote sense	1262B	1263B

The 1262B or 1263B cables are only needed if you will be operating the **ComboSource** with an RTD sensor *and* using the 4-wire sensor connection. Otherwise, the 1260B or 1261B cables are sufficient.

> ## NOTE
>
> Connections to the **ComboSource** and the fixture must be secure. Tighten any screws on the DB connectors, and make sure all connections are in good condition.

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

Power and Cable Connections

ComboSource Rear Panel

Laser Output Connector

The laser **Output** connector is a female DB-9, and has the following pin-out:

DB-9 Pin	Description
1	Interlock+
2	Interlock −
3	Earth Ground
4	Laser Cathode Voltage Sense
5	Laser Cathode
6	Photodiode (PD) Cathode
7	Photodiode (PD) Anode
8	Laser Anode Voltage Sense
9	Laser Anode
Shell	Earth Ground

LASER Output Connector (DB-9 Female)

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Arroyo Instruments has followed industry conventions for laser DB-9 connections, and is compatible with pin-outs from other vendors, such as ILX and Newport. However, care should still be taken when interfacing the **ComboSource** to other vendors' products, and if you have any questions, please contact your distributor or the factory.

Modulation Input

The modulation input BNC on the front panel 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 **ComboSource** and electrically isolated from ground, so you should not need to be concerned about ground interference from any modulation source. The center pin is positive and the outer shell is ground.

TEC Output Connector

The TEC Output connection is a female DB-15, and has the following pin-out:

DB-15 Pin	Description
1, 2, & 9	TE (+)
3, 4, & 10	TE (-)
5 & 6	Earth Ground
7	Sensor+
8	Sensor −
11	Fan+
12	Fan −
13	Reserved (no connect)
14	Remote Sensor+
15	Remote Sensor −

TEC Output Connector (DB-15 Female)

Using Remote Sensor

The remote sensor pins (pins 14 & 15) are used in RTD 4-wire mode, and provide a remote measurement of the RTD voltage to eliminate voltage measurement errors. See *Working With RTDs* below for more information. Do not connect these pins to the TE+ or TE− pins, as damage may result.

USB Connector

The USB connector is a standard Type B female connector, and can be plugged into any USB 1.1 or USB 2.0 port. 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.

Grounding Considerations

A key feature of the ComboSource is the optical isolation of both the photodiode and modulation inputs. By isolating these 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.

However, if you use the earth ground pin of the **Output** connector, 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.

Remote Mode Operation

"Remote mode" operation is when the ComboSource is being controlled by a computer over the USB or RS232 interfaces. When in remote mode, the ComboSource 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, unless it has been explicitly enabled by the **Set While Rmt** setting in the **Comm Menu**.

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

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While in remote mode, the **Remote** LED also acts as an activity indicator, and will flash whenever there is communication with the computer.

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

Installing the USB Drivers

Using the **ComboSource** 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 **ComboSource** 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 a **USB Serial Port** is the **ComboSource**. 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.

Thermal Considerations

The **ComboSource** is designed to provide high power in a small enclosure. Both the laser and TEC sections of the **ComboSource** can be thermally overloaded if operated at high currents with a low voltage, and each section handles the thermal overload condition differently.

For the TEC section, the **ComboSource** will automatically protect itself by lowering the TEC current until it is no longer in an overload condition. While this may lower the deliverable power to your TEC, it will prevent any damage to the **ComboSource**. One exception to this is if you are operating in ITE (or constant current) mode. In this morn, because you are specifying a specific drive current for the TEC, if there is a thermal overload condition, the output will be turned off and an E-438 error message will be generated.

For the laser section, the driver will always respond by turning the output off and generating an E-537 error message in an overload condition. A possible fix to this condition is lowering the **Vf Limit** setting in the menu (in the **Laser Menu**) to

just above the highest voltage needed for the maximum set point you will be using. This gives the unit a "hint" as to the required voltage, and may be enough to eliminate the thermal trip error.

If your instrument still continues to thermally trip, you can add a series resistor (to the laser or TEC, as appropriate) to remove some of the power from inside the unit. Typically, a 30W 1Ω load resistor in series with the output is sufficient, but higher resistances and or power handling may be needed, depending on the voltage and current configuration of your **ComboSource**. Please feel free to contact the factory for more information and support.

Below is a graph that illustrates the minimum voltage requirements for the TEC section of all **ComboSource** controllers:

Safe Operating Range for TEC Output of a 6300 ComboSource

Example:
At 3.8A, the minimum voltage at the TEC connector must be greater than ~3V. Anything less, and the instrument will lower the current to stay outside the red zone.

Operating Zone
Any combination of current and voltage that lies outside the red shaded area is acceptable.

Non-Operating Zone
TEC current will be limited if operating in the red zone.

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The **6340-QCL ComboSource** also has the following minimum voltage requirements for the laser output:

Safe Operating Range for Laser Output of a 6340-QCL ComboSource

Example:
At 3.41A, the minimum voltage at the laser connector must be greater than ~7V. Anything less, and the instrument will shut down the laser output.

Operating Zone
Any combination of current and voltage that lies outside the red shaded area is acceptable.

Non-Operating Zone
Laser output will be shut off if operating in the red zone.

Voltage (Volts)

Current (Amps)

Using the Laser Driver

Laser Control Modes

The **ComboSource** offers the following control modes: **Io (ACC)**, **Io HiBW (ACC)**, **Im (AMC)**, **Po (APC)**, and **Vf (AVC)**.

Changing the control mode is done through the menu by changing the Mode parameter in the Laser 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. When in this mode, the set point will be in milliamps, and the **ComboSource** will drive the desired current 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.

Im mode (also referred to as AMC, or automatic monitor photodiode control mode) is used to control the laser diode using the monitor diode feedback. You select the target monitor diode current, and the **ComboSource** will drive exactly enough forward current through the laser diode to generate the selected 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**

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mode supports high speed modulation. All other modes of operation have a modulation bandwidth of 10Hz or less.

Current Range

The **ComboSource** offers two current ranges: a high range, which is the maximum rated current for the driver (e.g., 500mA on a **6305**) and low range, which is one-half the maximum rated current for the driver (e.g., 250mA on a **6305**). The lower range offers improved accuracy (in **Io (ACC)** and **Io HiBW** modes) and improved stability in all modes.

Using the Laser Limits

Both the laser 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 0.1V to 0.2V higher than any anticipated operating point. The voltage limit is tested against *the voltage at the connector*, unless in remote voltage sense mode. Any **Laser Cable R** value is ignored, as **Laser Cable R** is a software only calculation, and the voltage limit is implemented in hardware. See *Using the Cable R Setting*, above, for more information on the **Laser Cable R** setting.

Unlike the voltage limit, the current limit simply prevents the **ComboSource** from delivering more current than the limit is set to. When the current limit engages, the output will remain on.

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.

Analog Modulation

The analog modulation input BNC on the front of the instrument allows for external control of the current set point using a 0 to 10V analog signal. 10V equals the maximum operating range, which is dependent on the model and **Range** setting. For example, a **6305** operating in the 500mA range will attempt

to drive 500mA when 10V is applied to the modulation input (so the "transfer function" is 50mA/V).

In addition, the set point **adds** to the modulation input, so using the same **6305** example, if you were to apply 5V and the set point was 100mA, then the resulting drive current would be 350mA (5V = 250mA plus the 100mA 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. The instrument will display actual current flowing when the display is in large font mode (press the knob button to change modes), so turn the output on with the Io set point at 0mA, apply a modulation input signal, and the instrument will indicate the actual current, which you can use to calibrate your voltage set point.

When modulating 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). See the chart below for suggested sizes. Failure to do so may result in current oscillations 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.

The **1220B** or **1221B** cables recommended by Arroyo Instruments are shielded twisted pair, and will provide good modulation performance.

Current (A)	Recommend Wire Gauge
1 or less	24 AWG
2	22 AWG
4	20 AWG

Compensating for Voltage Loss

All cables and connectors have a small, but measureable, resistance. When driving current through them, this resistance causes a voltage loss in the cable, and if not compensated for, will result in errors in laser or LED voltage measurement. In many cases, this is not a problem, as highly accurate voltage measurement ares not required, and the error can be ignored. However, if accurate voltage measurements are required, the ComboSource offers two methods to compensate for this loss: the **Cable R** setting and four-wire sense. **Cable R** compensation is software only, so it requires no special wiring to implement. Four-wire sense, on the other hand, does require additional wiring, but is the most accurate method. Details on both are found below.

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Using Remote Voltage Sense

The **ComboSource** 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 below can provide some of the same benefits of remote voltage sense, remote voltage sense is a superior method, and 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 remote voltage at the laser rather than the local voltage at the connector)
4. Works in voltage control mode

The diagram below shows conceptually how to wire the laser to the **ComboSource**, using a 4-wire connection:
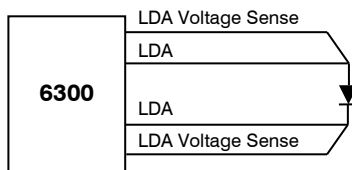
However, remote voltage sense does have a few drawbacks:

1. If the remote sense wires are disconnected, it disables the hardware voltage limit as well as the measurement of laser voltage.
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 always monitors the local 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 *No*.

Using remote voltage sense is very simple. First connect pin 4 of the **Laser Output** DB-9 to the laser cathode, and pin 8 to the laser anode, 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 '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 (most DMMs are not designed to properly measure small resistances). 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 **Laser Output** connector, then the difference between the measured voltages is the voltage loss in the cable. Use this formula to calculate resistance:

$$Cable\ R = \frac{V_{Output} - V_{laser}}{I_{AMPS}}$$

Note that the current is expressed in *amps*, not *milliamps*, so divide the set point by 1000 before using it in this equation.

Short the Connection at the End of the Cable

A second method, which does not require a DMM and can be done with just the **ComboSource**, is to short the anode and cathode wires at the end of the cable (nearest the laser diode), drive current through the cable and note the indicated voltage on the **ComboSource**. The resistance is found using a simpler version of the formula above:

$$Cable\ R = \frac{Vf}{I_{AMPS}}$$

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Note that the current is expressed in *amps*, not *milliamps*. The easiest way is to drive 1A of current. When I_{AMPS} equals 1A (1000mA), the displayed voltage is also the resistance of the cable.

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 **ComboSource** 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 above). 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 the Temperature Controller

TEC Control Modes

The ComboSource offers three TEC control modes: constant temperature mode (T Mode), and constant resistance mode (R Mode), and constant current mode (Ite Mode).

Changing the control mode is done through the TEC menu by changing the **Mode** parameter to **T Mode**, **R Mode**, or **Ite Mode**.

Constant temperature mode uses the sensor constants to calculate the resistance of the thermistor at the desired or actual temperature.

While most users will only need the temperature control mode, the constant resistance mode allows you to bypass the sensor equation and directly select the sensor set point. This can be useful when only the desired sensor value is known, or when the sensor-to-temperature conversion values are not available for your sensor.

Using the TEC Limits

All TEC limits are implemented in software, but due to the relatively slow nature of the TEC, software is typically adequate.

Both high and low temperature limits are available, and will turn the TEC output off unless this has been disabled (see *Using Advanced Settings* or TEC:ENABLE:OUTOFF command).

Likewise, the sensor limits define an upper and lower limit for the sensor, but unlike the temperature limits, the sensor limits will **not** turn the output off unless specifically enabled in the Advanced Settings menu or via the TEC:ENABLE:OUTOFF command.

Selecting the Fixture

The ComboSource has integrated support for many of the mounts offered by Arroyo Instruments, such as the **205 TEC Butterfly LaserMount**. To simplify operation when using these mounts, you can change the **Mount** setting in the menu to the mount type you are using. By selecting a mount, the current limit, temperature limits, default gain, and sensor settings are automatically adjusted to values appropriate to the mount, and menu settings limited to the capabilities

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of the mount. For example, when the **205** is selected, the **Sensor** setting is hidden from the menu, and the current limit is adjusted to the mount's rated limit to prevent damage to the mount's Peltier cooler.

Adjusting the **Mount** setting to *User Defined* removes all software limits, allowing unrestricted operation of the **ComboSource**.

Working With Thermistors

The **ComboSource** is designed to work with negative temperature coefficient (NTC) thermistors, such as the BetaTHERM 10K3A1 thermistor used in the **LaserMounts**. 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:
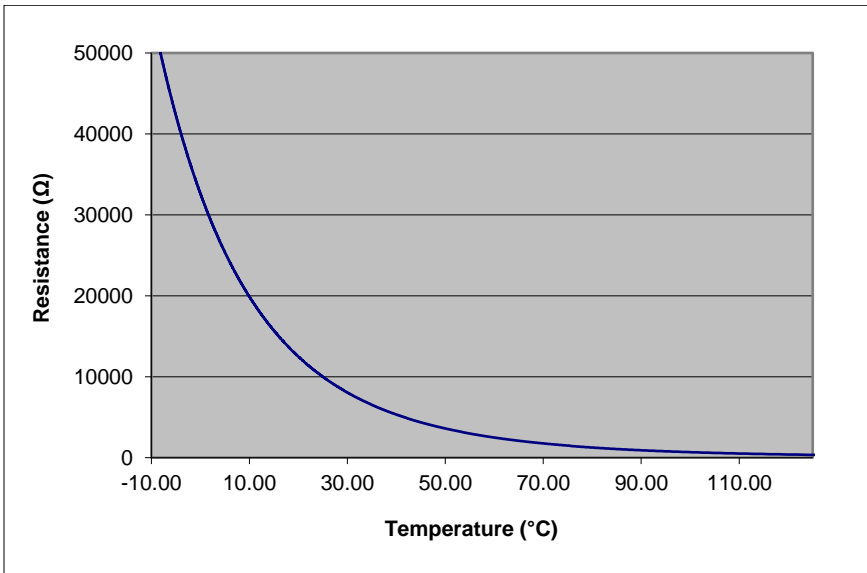
Typical Resistance vs. Temperature Graph

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 **ComboSource** supports operation using a 10μA or 100μA constant current source, which limits the upper control range to 450kΩ or 45kΩ, respectively. To minimize noise and maximize stability, you should select highest current while still allowing you full operation across your required temperature range. The typical setting is 100μA, but your application will determine the actual needs.

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 **ComboSource** defaults to the coefficients for the BetaTHERM 10K3A1 thermistor (A = $1.12924\text{x}10^{-3}$, B = $2.34108\text{x}10^{-4}$, C = $0.87755\text{x}10^{-7}$). You can change the coefficients under the **Sensor Coeffs** menu.

Working With RTDs

Like thermistors, RTDs also function by converting temperature into resistance, but unlike thermistors, RTDs increase in resistance as temperature increases. RTDs are also a fairly linear device, meaning they can be used across a much broader temperature control range.

According to IEC751, the resistance/temperature relationship is determined using one of two equations, dependent on the temperature or resistance value being measured. For resistances above the R_0 value (resistance at 0°C, typically 100Ω) of the RTD, the following equation is used:

$$R = R_0(1 + AT + BT^2)$$

Below R_0, an additional term is added to the equation:

$$R = R_0[1 + AT + BT^2 + C(T-100)T^3]$$

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In both of these equations, R_0 is the resistance of the RTD at 0°C, and A, B, and C are the coefficients as defined by IEC751, through regression analysis, or by using the Callendar-van Dusen method. By default, the ComboSource uses the Laboratory standard coefficients for 100Ω RTD, which are for a 0.003926Ω/ Ω/°C curve (A = 3.9848×10^{-3}, B = -0.58700×10^{-6}, C = 4.0000×10^{-12}, and R_0 = 100).

The **ComboSource** automatically determines which equation to use based on the conditions at the time of the measurement.

2-Wire versus 4-Wire Measurements

One concern in using RTDs, particularly 100Ω RTDs, are their relatively low resistance (typically 100Ω at 0°C), and small Ω/°C. Because of these two factors, the resistance of the cable used to connect to the sensor can become a significant error in the sensor measurement. The **ComboSource** offers two RTD measurement modes: a conventional two wire measurement mode, which is subject to this error, and a four wire measurement mode that uses separate sensor and source lines to remotely sense the actual resistance of the RTD and eliminate the cable or connector resistances.

When using 4-wire measurement mode, you must select 'RTD (4-wire)' as the sensor type, and then connect the Sensor+ and Remote Sensor+ at one side of the RTD, and Sensor− and Remote Sensor− to the other side of the RTD. Make these connections as close to the sensor as possible.

The drawings below illustrate how 2-wire and 4-wire connections work. Note that 4-wire measurements require all four wires to be brought through the cable to the mount. The 1262 and 1263 cables carry this connection through to the mount, but the 1260 and 1261 cables do not.

RTD 2-wire Measurement

RTD 4-wire Measurement
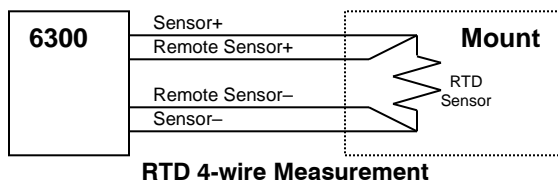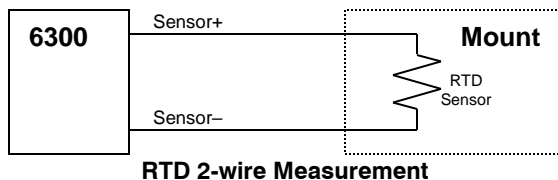
Working With AD590s and LM335s

Unlike thermistors and RTDs, an AD590 or LM335 is considered an "IC" sensor because it has an active transistor element that responds to changes in temperature by producing a current (AD590) or voltage (LM335).

Also unlike thermistors and RTDs, these IC sensors produce a linear response, making conversion to temperature a very straightforward calculation.

AD590 sensors produce 1μA/K, so that 0°C (which is equal to 273.15K) would produce 273.15 μA.

Similarly, LM335 sensors produce 10mV/K, so that 0°C would produce 2.7315V.

For both sensors, because the response is linear, the sensor coefficients default to a slope of 1 and an offset of zero, but can be adjusted to achieve higher accuracy.

The temperature correction formula for the AD590 or LM335 is:

$$T = MT_C + B$$

Where T_C is the temperature (in °C) calculated using the standard conversion value of 1°C/μA or 0.1°C/mV, as appropriate, and adjusted from Kelvin to Celsius.

External Fan Control

The **ComboSource** has a built-in user adjustable 4-12V DC power supply designed to provide up to 350mA to an external fan, such as those built into the **240 Series LaserMounts**. When using the **ComboSource** with mounts that require a fan, no additional external power supply is needed, however, the cable must include the wiring needed for the fan. The **1260B**, **1261B**, **1262**, and **1263** cables include the wiring.

Fan control is setup in the menu using the **Ext Fan**, **Ext Fan Pwr**, **Ext Fan Mode**, and **Ext Fan Off** settings.

Ext Fan can be set to *Off*, *Slow*, *Medium*, *Fast*, or *Custom*. When set to *Off*, the fan power is never turned on. *Slow*, *Medium*, and *Fast* correspond to 9V, 10.5V, and 12V. To select a different voltage, choose the *Custom* setting and then adjust the **Ext Fan Pwr** menu item to the desired voltage, from 4.0V to 12.0V.

The fan on/off mode can be controlled using the **Ext Fan Mode** setting. There are five modes:

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Auto   Fan is turned on whenever the TEC output is on, and turns off when the TEC output is turned off.

On   Fan is always on.

Delay   Similar to the *Auto* mode, the fan is turned on whenever the TEC output is on, but when the TEC is turned off, the fan will remaining running for an addition number of minutes as defined by the **Ext Fan Off** setting.

Cool   Fan is turned on whenever the TEC output is on and cooling, off otherwise.

Heat   Fan is turned on whenever the TEC output is on and heating, off otherwise.

Resistive Heaters and Heat/Cool Only Modes

The **ComboSource** supports temperature control using resistive heaters instead of Peltier coolers. With resistive heaters, cooling is obviously not possible, and the **ComboSource** must be configured to not attempt to cool the output, or a run-away condition will occur when the cooling current actually causes additional heating.

If your application requires, you can also configure the **ComboSource** to operate in a cool-only mode. This is only possible with Peltier coolers, as resistive heaters will heat regardless of the direction of current.

To change the cooling mode, adjust the **H/C Mode** setting to *Heat/Cool*, *Heat Only*, or *Cool Only*, as appropriate.

Gain Control and the PID Loop

The **ComboSource** supports a fully configurable PID loop, allowing full customization of the PID control parameters. To simplify control, eight standard gain settings are also defined, and many applications can achieve acceptable performance with these predefined gain settings, eliminating the need to understand and adjust the PID loop.

The predefined gains are numbered *1* through *300*, and set using the **Gain** menu setting. Increasing the gain value will increase the speed of the control loop. For full access to the PID parameters, change the **Gain** setting to *PID*, and the individual P, I, and D values will be available as settings in the menu.

The PID parameters function within a mathematical formula as described below:

$$Output = P * \varepsilon + I * \sum \varepsilon dt + D * \frac{d\varepsilon}{dt}$$

Where ε is the error in the system, expressed as:

$$\varepsilon = \text{Target - Actual}$$

The controller can calculate ideal PID values using the AutoTune function, discussed in detail in the next section.

To manually adjust the PID, start by changing the I and D values to zero, and adjust the P value so that it reaches the set point as quickly as possible without overshooting the set point an unacceptable amount. Gradually increase the I value until the set point is achieved without oscillation. In many systems, the D term is not needed and may be left at zero.

For additional information on PID loop tuning, consult online resources such as Wikipedia (http://en.wikipedia.org/wiki/PID_controller) or search for terms such as "Ziegler-Nichols method", or "PID Loop".

Using the AutoTune Function

The **ComboSource** is capable of automatically determining PID parameters for most applications. Using a form of the Ziegler-Nichols method, the **ComboSource** will step through a process to determine the thermal response of the mount, which can then be used in a mathematical model to calculate the PID parameters.

The PID parameters generated by AutoTune are not necessarily the *ideal* PID parameters, and small improvements may be possible by further refining the results manually.

Before starting the AutoTune function, it is best to begin from ambient conditions, either with the TEC off and the mount stabilized at ambient, or the TEC on and the set point around 25°C. While this is not required, it can produce better results. AutoTune only functions in temperature mode. PID parameters must be manually determined for R mode.

Make sure the current and temperature limits are set prior to starting AutoTune. AutoTune will intentionally cause your mount to oscillate, so the temperature limit should be at least 5 to 10 degrees away from the test point to avoid tripping a limit during the process.

To start the AutoTune function, select the **AutoTune PID** menu entry from the TEC menu and press ENTER. If you wish to perform AutoTune remotely, see the following section for more information.

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The instrument displays the AutoTune test point. Use the knob to adjust the test point to your typical operating point. If you will be operating at two or more set points, you will usually want to select the set point furthest away from ambient. Once the temperature test point is selected, press ENTER.

The instrument asks for a final confirmation to start the AutoTune process. Press ENTER to start, or MENU to exit.

Once the AutoTune process starts, the display will indicate the present temperature, which step it is performing, and the word "AutoTune" will flash on the display.

The typical temperature profile of an AutoTune process is shown in the graph below. The first step, which is the calculation of the P and D parameters, completes at around 68 seconds, then the mount is allowed to stabilize with the new P and D parameters,. Then the second step begins, which is the determination of the I term. This completes around 200 seconds into the test, and then the output stabilizes with the calculated set of PID parameters for the remaining portion of the graph.
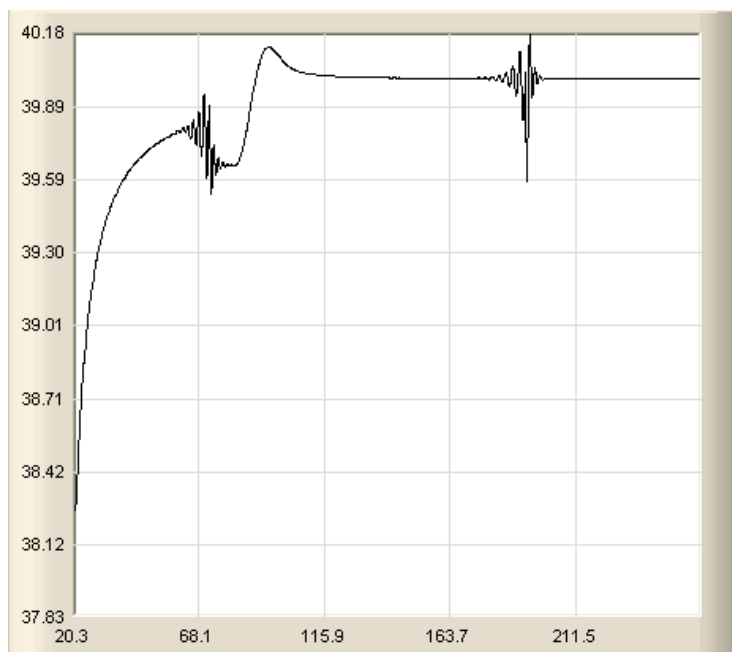
Once the AutoTune process is complete, the output will remain on and the display will show "AutoTune Successful". The three PID parameters will also be displayed. The **Gain** setting will be changed to *PID*.

If the AutoTune process fails, the instrument will display an E-436 AutoTune Failed error message and turn the output off. Any of the following can cause the AutoTune to fail:

- Noisy temperature measurements, which make it difficult to accurately measure oscillations
- Any condition that causes the output to turn off (temperature limits, sensor limits, etc.)
- Systems with very low P or I terms

In the Auto-Tune fails due to thermal system limitations, you will need to manually modify the PID parameters as described in the section above or select factory gain setting.

You can turn the output off at any time to cancel the AutoTune process, and the PID parameters will remain unchanged (an E-436 will also be displayed).

Using the AutoTune Function Remotely

The AutoTune function can be done remotely, and works essentially the same as local operation. The TEC:AUTOTUNE command starts the process, and requires one parameter, which is the AutoTune temperature test point.

The command will immediately put the instrument into AutoTune mode, and the display will indicate progress in the same way as local operation. The TEC:AUTOTUNE? query can be used to monitor the process of AutoTune. A response of 1 indicates AutoTune is in progress. Once complete, the instrument will respond with a 2 if AutoTune failed or a 3 if AutoTune succeeded. A response of 0 is returned if the instrument has never started an AutoTune process.

Turning the output off remotely will cancel the AutoTune process and generate an E-436 error.

More details on the use of the command can be found in the *Computer Interfacing Manual*.

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Compensating for TEC Cable Resistance

Because the high currents the **ComboSource** can drive through the Peltier, the voltage loss through the cable and connectors of the system can significantly affect the TEC voltage measurement. In most cases, accurate voltage measurements are not needed, and the default compensation of the instrument is sufficient. To improve the compensation, the **Cable R** setting in the menu allows you to specify the cable resistance, which is then used to dynamically subtract the voltage drop by simply using the formula $V = I * R$ to calculate the voltage loss, where I is the TEC ITE current, and R is the **Cable R** setting. This value is then removed from the voltage measurement to display an accurate TEC voltage measurement.

The safest method of calculating cable resistance is to short the ITE+ and ITE− connections, making sure whatever you are using to short the terminals is not itself adding resistance to the circuit. Use short, heavy gauge wires, preferably soldered onto the terminals to minimize any resistance the short might add. Place the short as close to the Peltier as is reasonable. A simple approach is to unplug the cable from the mount and place a shorting plug on the mount end of the cable, which is easily made from a male DB15 connector and a soldering iron to solder the ITE+ and ITE− pins together. Make sure the Peltier is disconnected to protect it from current overloading during the test.

Change the instrument to ITE mode and set the current to 5A. Depending on your setup, you may first need to change the Mount to User Defined and adjust the limit to 5A. Turn on the output and after the voltage has stabilize, make a note of it and turn the output off. Enter the measured voltage into the following equation to calculate **Cable R**:

$$\text{Cable R} = \text{Voltage} / 5$$

Enter the resulting values into the **Cable R** menu entry and return the instrument to its original configuration. Typical values for **Cable R** are 0.008 to 0.040, but depend on your actual configuration.

Field Calibration (User Cal)

The **ComboSource** is typically calibrated annually, and calibration can be done one of two ways: the instrument can be returned to the factory for a full recalibration, or the **User Cal** menu can be used for simpler slope/offset calibration.

CAUTION

Because user calibration directly affects the performance of the instrument, it must be performed by a qualified technician with sufficiently accurate meters and test loads to properly measure the actual performance of the instrument. Failure to do so could significantly degrade the performance of the instrument or damage your device.

Factory calibration has the benefit of a full multi-point calibration and verification of instrument performance against NIST-traceable instrumentation, using equipment and test loads designed specifically for the application. However, field (or user) calibration is possible, and often desirable, as it allows the user to meet certification or calibration requirements not available through a factory calibration.

This field or user calibration is accessible through the **User Cal** menus, or via the **LASER:USERCAL or TEC:USERCAL** commands over the computer interface.

For calibration of the instrument from the front panel, the **User Cal** menu is located under the **Advanced** menu of either the Laser to TEC menus. From there, you can view the various calibration entries, but editing can only be done by changing **Edit Cal** to *Yes*. Once enabled, the calibration entries can be adjusted just like any other menu setting. You can also reset the user calibration data for all elements by changing the **Reset Cal** to *Yes*.

For each set point or measurement, there is a corresponding slope and offset calibration:

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Laser User Calibration Entries

Menu Entry	Description
I Set LoM	Io set point, low range, slope
I Set LoB	Io set point, low range, offset (mA)
I Set HiM	Io set point, high range, slope
I Set HiB	Io set point, high range, offset (mA)
Im Set M	Im set point, slope
Im Set B	Im set point, offset (μA)
V Set M	Vf local sense set point, slope
V Set B	Vf local sense set point, offset (V)
V Set Rm M	Vf remote sense set point, slope
V Set Rm B	Vf remote sense set point, offset (V)
I LoM	Io measurement low range, slope
I LoB	Io measurement low range, offset (mA)
I HiM	Io measurement high range, slope
I HiB	Io measurement high range, offset (mA)
Im M	Im measurement, slope
Im B	Im measurement, offset (μA)
V M	Vf local sense measurement, slope
V B	Vf local sense measurement, offset (V)
V Rem M	Vf remote sense measurement, slope
V Rem B	Vf remote sense measurement, offset (V)

TEC User Calibration Entries

Menu Entry	Description
ITE Set M	ITE set point, slope
ITE Set B	ITE set point, offset (A)
ITE M	ITE measurement, slope
ITE B	ITE measurement, offset (A)
VTE M	VTE measurement, slope
VTE B	VTE measurement, offset (V)
Th 10μA M	10μA Thermistor measurement, slope
Th 10μA B	10μA Thermistor measurement, offset (kΩ)
Th 100μA M	100μA Thermistor measurement, slope
Th 100μA B	100μA Thermistor measurement, offset (kΩ)
LM335 M	LM335 measurement, slope
LM335 B	LM335 measurement, offset (mV)
AD950 M	AD590 measurement, slope
AD590 B	AD590 measurement, offset (μA)
RTD M	100Ω RTD measurement, slope
RTD B	100Ω RTD measurement, offset (Ω)
RTD4 M	100Ω RTD 4-wire measurement, slope
RTD4 B	100Ω RTD 4-wire measurement, offset (Ω)
1K RTD M	1kΩ RTD measurement, slope
1K RTD B	1kΩ RTD measurement, offset (Ω)
1K RTD4 M	1kΩ RTD 4-wire measurement, slope
1K RTD4 B	1kΩ RTD 4-wire measurement, offset (Ω)

When the slope is 1 and the offset is zero, this is considered an "uncompensated" measurement. If you change either the slope or offset, the

value becomes "compensated" based on these values. The compensation formula (a linear equation) is very simple:

$$\text{Compensated} = \text{Slope} * \text{Uncompensated} + \text{Offset}$$

The short form for Slope is typically 'm', and the short form for offset is typically 'b', which is why you see these letters used in the instrument menu (you will often see a similar version of the equation above written as y=mx+b).

Depending on how you wish to calibrate, a simple offset calibration may be sufficient, where only the offset value is adjusted and the slope is left at 1. This level of calibration can be done using a single measurement, and if absolute accuracy is only critical at a single point, this may be sufficient. For a slope and offset calibration, you will need at least two points to compute the slope and offset, and greater than two points can be used in a least-squares-fit algorithm.

Single Point Offset Calibration

Let's say that you want to precisely calibrate the laser drive current at 300mA, and you are using a **6305** in high range. You set the instrument at 300mA, observe that the actual current is 298.6mA and the current measured by the **6305** is 301.2mA.

To correct the set point, you need to adjust the offset value for the high range lo set point, which is the **I Set HiB** menu entry. Considering that you need to *raise* the set point by 1.4mA, then the **I Set HiB** menu entry should be adjusted to +1.4mA (the **I Set HiM** menu entry should be set to 1.000). This will compensate the set point by *increasing* it 1.4mA and bring it close to 300.0mA.

The measurement adjustment is similar, but in this case, you need to adjust the **I HiB** menu entry to −1.2mA to bring *down* the measurement to 300mA.

Multi-Point Calibration

Multiple point calibration is mathematically more complex but improves calibration to operate across a range of values rather than at a single point. This addresses a downside of single point offset calibration where it can cause the instrument to no longer be in calibration at points away from the single calibration point. To keep the math simple in our example, we will only do a two point calibration, but a higher number of points are possible, and the slope can be calculated using a least-squares-fit algorithm (offset calculation is the same in either case).

Consider the following two data points, where 'actual' is what you are measuring with your meter, and 'measured' is the measured current as displayed by the **6305**:

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Set point	Actual	Measured
100	101.5	100.6
300	298.6	301.2

As stated above, correction is done using a linear equation, and we need to calculate the slope and offset. Slope must be calculated first, and is calculated using the following formula:

$$\text{Slope} = (y_2 - y_1) / (x_2 - x_1)$$

For the set point calibration, 'x' is the actual current and 'y' is the set point. For the measurement calibration, 'x' is the measurement and 'y' is the actual current. Make sure to note how the actual current changes position depending on what you are calibrating.

The offset is equally simple to calculate:

$$\text{Offset} = y_1 - \text{Slope} * x_1$$

So for the set point calibration, you would have the following two calculations:

$$\text{Slope} = (300 - 100)\,(298.6 - 101.5) = 200 / 197.1 = 1.0147 \text{ (slightly rounded)}$$
$$\text{Offset} = 100 - 1.0147 * 101.5 = -2.9934$$

You can validate your calculations by applying the formula to one or both of the data points to confirm the compensation is correct. Consider the 300mA set point … if we apply the values just calculated, we should get a compensation that increases the set point by slightly over 1.4mA to bring it up to 300mA. Let's check:

$$300\text{mA test point} = 1.0147 * 300 - 2.9934 = 301.4166\text{mA} - \text{check!}$$

Likewise, the 100mA set point should be *lowered* by slightly more than 1.5mA:

$$100\text{mA test point} = 1.0147 * 100 - 2.9934 = 98.4766\text{mA} - \text{check!}$$

You can make the same tests of the measurement side. By using the multiple point calibration, you benefit from the calibration across a much wider operating range. When choosing your two data points, you can either calibrate specifically for your application, where the upper point should be the maximum current you plan to operate, and the lower data point near the minimum current you plan to operate (but above zero). Alternatively, you can take two generalized data points of 80% of the range of the instrument as the upper point and 20% of the range as the lower point… this latter approach provides a more generated calibration that will function across the full range of the instrument.

Accuracy Requirements

When calibrating the instrument, we recommend that the accuracy of your meter is four times greater than the accuracy you are trying to achieve with the instrument. For example, if you want to calibrate the laser current to within 0.1mA, then your meter would have an accuracy of 0.025mA or better. Using lower accuracy meters could actually degrade the accuracy of the instrument rather than improving it.

Considerations for Calibrating the Laser Current

For current calibration, more meters have poor current measurement performance. A better approach is to measure the voltage across a known resistor value. However, this introduces two measurement errors: the measurement error of the resistance of the current sense resistor, and the measurement error of the voltage across the current sense resistor, so both much be considered when determining the overall accuracy of your measurement system.

Considerations for Calibrating the TEC Sensors

For calibration of resistance sensors (thermistor and RTD), it is best to use a selection of precisely measured fixed resistors, then connect them to the sensor input on the instrument.

For LM335, the sensor is biased with a 1mA current source, so using an appropriately ranged fixed resistor (2kΩ to 4kΩ) will generate a voltage in the operating range of the sensor which can be measured by your meter.

For AD590 calibration, the sensor is biased with a ~4.5V source. Like the LM335, you can use a precisely known fixed resistor to create a known amount of current flowing through the sensor. By using the $I = V / R$ calculation, you can determine the amount of current flowing through the resistor by measuring the voltage across the resistor.

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Specifications

Description	Laser Specifications							
	6301		**6305**		**6310**		**6340**	
LASER								
SETPOINT	Low Range	High Range	Low Range	High Range	Low Range	High Range	Low Range	High Range
LASER CURRENT								
Range (mA)	50	100	250	500	500	1000	2000	4000
Max Resolution (mA)	0.002	0.005	0.01	0.02	0.02	0.05	0.1	0.2
Accuracy (±[% set+mA])	0.025% + 0.02	0.025% + 0.03	0.025% + 0.08	0.025% + 0.12	0.025% + 0.12	0.025% + 0.3	0.025% + 0.5	0.05% + 0.8
Stability (ppm, time)	< 10, 1 hour							
Temperature Coeff (ppm/°C)	50							
Noise/Ripple (µA rms)	< 1	< 1	< 1.2	< 1.5	< 1.5	< 2.5	< 35	< 40
Transients (µA)								
Compliance Voltage (V)	10		10		10		4	
PHOTODIODE CURRENT								
Range (µA)	2 – 5,000							
Resolution (µA)	0.1							
Accuracy (±[% set+µA])	0.05% + 1							
Stability (ppm, time)	< 200, 24 hours							
Temperature Coeff (ppm/°C)	< 200							
PD Bias (V)	0 to -5V, programmable							
LASER VOLTAGE								
Range (V)	0 – 10		0 – 10		0 – 10		0 – 4	
Resolution (V)	0.001							
Accuracy (±[% set+V])	0.05% + 0.005							
Stability (ppm, time)	< 50, 1 hour							
Temperature Coeff (ppm/°C)	< 100							
EXTERNAL MODULATION								
Input Range	0 – 10V, 10kΩ							
Modulation Bandwidth (kHz)	325		325		200		150	
MEASUREMENT								
LASER CURRENT								
Resolution (mA)	0.002	0.005	0.01	0.02	0.02	0.05	0.1	0.2
Accuracy (±[% set+mA])	0.025% + 0.02	0.025% + 0.03	0.025% + 0.08	0.025% + 0.12	0.025% + 0.12	0.025% + 0.3	0.025% + 0.5	0.05% + 0.8
LASER VOLTAGE								
Resolution (V)	0.001							
Accuracy (±[% read+V])	0.05% + 0.005							
PHOTODIODE CURRENT								
Resolution (µA)	0.1							
Accuracy (±[% read+µA])	0.05% + 0.5							
LIMITS								
LASER CURRENT								
Resolution (mA)	1							
Accuracy (±mA)	2		5		10		40	
LASER VOLTAGE								
Resolution (V)	0.1							
Accuracy (±% FS)	2.5%							

Description	Laser Specifications			
	6310-QCL		**6340-QCL**	
	Low Range	High Range	Low Range	High Range
LASER				
SETPOINT				
LASER CURRENT				
Range (mA)	500	1000	2000	4000
Max Resolution (mA)	0.02	0.05	0.1	0.2
Accuracy (±[% set+mA])	0.025% + 0.12	0.025% + 0.3	0.025% + 0.5	0.05% + 0.8
Stability (ppm, time)	< 10, 1 hour			
Temperature Coeff (ppm/°C)	50			
Noise/Ripple (µA rms)	< 1.5	< 2.5	< 35	< 40
Transients (µA)				
Compliance Voltage (V)	18		15	
PHOTODIODE CURRENT				
Range (µA)	2 – 5,000			
Resolution (µA)	0.1			
Accuracy (±[% set+µA])	0.05% + 1			
Stability (ppm, time)	< 200, 24 hours			
Temperature Coeff (ppm/°C)	< 200			
PD Bias (V)	0 to -5V, programmable			
LASER VOLTAGE				
Range (V)	0 – 18		0 – 15	
Resolution (V)	0.001			
Accuracy (±[% set+V])	0.05% + 0.005			
Stability (ppm, time)	< 50, 1 hour			
Temperature Coeff (ppm/°C)	< 100			
EXTERNAL MODULATION				
Input Range	0 – 10V, 10kΩ			
Modulation Bandwidth (kHz)	200		150	
MEASUREMENT				
LASER CURRENT				
Resolution (mA)	0.02	0.05	0.1	0.2
Accuracy (±[% set+mA])	0.025% + 0.12	0.025% + 0.3	0.025% + 0.5	0.05% + 0.8
LASER VOLTAGE				
Resolution (V)	0.001			
Accuracy (±[% read+V])	0.05% + 0.005			
PHOTODIODE CURRENT				
Resolution (µA)	0.1			
Accuracy (±[% read+µA])	0.05% + 0.5			
LIMITS				
LASER CURRENT				
Resolution (mA)	1			
Accuracy (±mA)	10		40	
LASER VOLTAGE				
Resolution (V)	0.1			
Accuracy (±% FS)	2.5%			

Description	TEC & General Specifications
TEC	
SETPOINT	
TEMPERATURE	
Range (ºC)[1]	-99 to 250
Resolution (ºC)	0.01
Therm Accuracy (± ºC)[2]	0.05[3]
AD560 Accuracy (± ºC)[2]	0.05
LM335 Accuracy (± ºC)[2]	0.05
100Ω RTD Accuracy (± ºC)[2]	0.33
1kΩ RTD Accuracy (± ºC)[2]	0.40
Stability (1hr) (± ºC)[4]	0.004
Stability (24hr) (± ºC)[4]	0.01
CURRENT	
Range (A)	5
Compliance Voltage (V)	12
Max Power (W)	60
Resolution (A)	0.01
Accuracy (±[% set+mA])	0 + 30
Noise/Ripple (mA, rms)	< 5
MEASUREMENT	
CURRENT	
Resolution (mA)	10
Accuracy (±[% read+mA])	0 + 30
VOLTAGE	
Resolution (mV)	10
Accuracy (±[% read V])	0 + 0.05
10μA THERMISTOR	
Range (kΩ)	0.2 – 450
Resolution (kΩ)	0.01
Accuracy (±[% read+kΩ])	0.05 + 50
100μA THERMISTOR	
Range (kΩ)	0.02 – 45
Resolution (kΩ)	0.001
Accuracy (±[% read+kΩ])	0.05 + 5
LM335	
Bias (mA)	1
Range (mV)	1730 – 4730
Resolution (mV)	0.1
Accuracy (±[% read+mV])	0.3 + 1
AD590	
Bias (V)	4.5
Range (μA)	173 – 473
Resolution (μA)	0.01
Accuracy (±[% read+ μA])	0.03 + 0.1
100Ω RTD	
Range (Ω)	20 – 192
Resolution (Ω)	0.01
Accuracy (±[% read+Ω])	0.03 + 0.1

[1] Software limits. Actual range dependent on sensor type and system dynamics
[2] Accuracy figures are the additional error the 6300 adds to the measurement and does not include the sensor uncertainties.
[3] 25°C, 100μA thermistor
[4] Stability measurements done at 25°C using a 10kΩ thermistor on the 100μA setting. The number is ½ the peak-to-peak deviation from the average over the measurement period.

Description	TEC & General Specifications
1kΩ RTD	
Range (Ω)	100 – 4500
Resolution (Ω)	0.1
Accuracy (±[% read+Ω])	0.05 + 1
LIMITS	
CURRENT	
Resolution (mA)	10
Accuracy (mA)	40
GENERAL	
Display Type	2x20 VFD
Laser Connector	DB-9, female
TEC Connector	DB-15, female
Fan Supply	4 – 12V, 350mA max
Computer Interface	USB 2.0 Full Speed (Type B), RS-232 (DB-9, male)
Power (50/60 Hz)	100V / 120V / 230V, 150W
Size (H x W x D) [inches (mm)]	3.47 (89) x 8.5 (215) x 12 (305)
Weight (lbs [kg])	7.8 (3.5)
Operating Temperature	+10°C to +40°C
Storage Temperature	-20°C to +60°C

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-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-402	Sensor open, output turned off	A sensor open circuit was detected and the output was turned off.
E-403	Module open, output turned off	A Peltier module open circuit was detected and the output was turned off.
E-404	I limit, output turned off	A current limit was detected and the output was turned off.
E-405	V limit, output turned off	A voltage limit was detected and the output was turned off.
E-406	Thermistor resistance limit, output turned off	The thermistor resistance limit (high or low) was exceeded and the output was turned off.

E-407	Temperature limit, output turned off	The temperature limit (high or low) was exceeded and the output was turned off.
E-409	Sensor changed, output turned off	The sensor type was changed, causing the output to be turned off.
E-410	Temperature was out of tolerance, output turned off	The temperature went out of tolerance and the output was turned off.
E-415	Sensor short, output turned off	A sensor short circuit was detected and the output was turned off.
E-416	Cal failed	An error occurred during calibration that caused the calibration to fail. The unit is no longer in calibration mode.
E-419	TEC not stable	The TEC is considered stable if the temperature has changed less than 0.02°C for more than 20 seconds.
E-433	Not a TEC	The TEC:CHAN command attempted to select a non-TEC channel
E-434	Ite limit exceeds cable rating	The cable plugged into the unit is not rated to carry the current as set by the current limit. Use a 1262 cable, 1263 cable, or custom cable with ID pin connected to analog ground, or reduce the current limit below 5A.
E-435	Mode Change	A mode change occurred when the output was on, forcing the output off.
E-436	AutoTune failed	The AutoTune process failed. See the "Using the AutoTune Function" for more information.
E-437	AutoTune in T mode only	The AutoTune process is only available in T (temperature) mode. In R mode, the PID parameters must be determined manually.
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-508	TEC off disabled output	The laser output was turned off because the TEC was off 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	A change in the operating mode of the ComboSource while the output was on shutdown the output.
E-516	Incorrect configuration for calibration to start	The ComboSource 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-521	TEC temperature limit disabled output	The laser output was turned off because the TEC temperature limit was exceeded corresponding bit in the OUTOFF register was set.
E-534	Po mode selected with PD Response set to zero	Attempted to select Po mode and PD Response was zero, or ComboSource 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 shut down 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.
W-800	Remote voltage sense is low	When in remote voltage sense mode, the ComboSource 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.
E-998	Command not supported	A command was recognized but not supported by the ComboSource.
E-999	Non-specific error	A non-specific error was encountered.

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Maintenance and Service

Maintenance

The **ComboSource** 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, 2A, 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 **ComboSource** 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.

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EC Declaration of Conformity

EC Declaration of Conformity

C E

I/We

Arroyo Instruments

of

1201 Prospect Street
San Luis Obispo, CA
USA

declare that

6300 Series ComboSource Laser Diode Controller

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 6**300 Series
ComboSource Laser Diode Controller** 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   June 1, 2011
(TITLE OF AUTHORIZED PERSON)   (DATE OF ISSUE)

UK Declaration of Conformity

UK Declaration of Conformity

UK CA

I/We

Arroyo Instruments

of

1201 Prospect Street
San Luis Obispo, CA 93401
USA

declare that

6300 Series ComboSource Laser Diode Controller

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 **6300 Series
ComboSource Laser Diode Controller** 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   September 27, 2022
(TITLE OF AUTHORIZED PERSON)   (DATE OF ISSUE)

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NOTES:

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