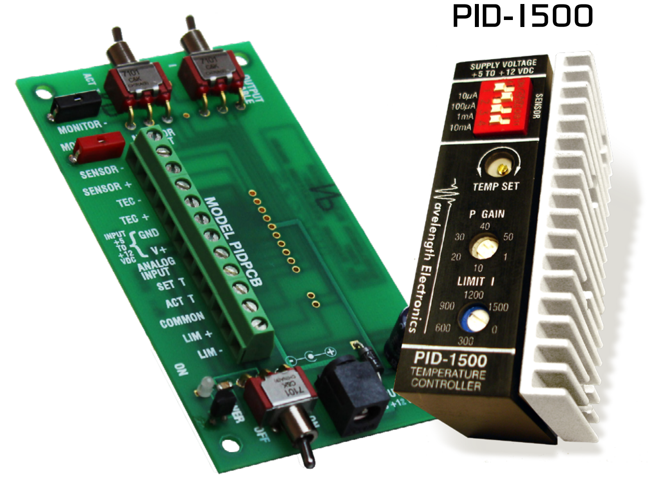
DATASHEET AND OPERATING GUIDE
PID-1500 & PIDEVAL PCB

High Stability Temperature Controller and Evaluation Board

PID-1500



PIDEVALPCB

FEATURES

- Plug-and-play packaging
- All controls and heatsink integrated
- Single Supply Operation: +5V to +12V
- Drive ±1.5A of TEC or RH current
- Package: 1.1" x 2.65" x 1.52"
- Heat and cool current limits
- Linear Stability: 0.003ºC
- Supports Thermistors, RTDs, IC sensors
- 14 Pin SIP PCB mount
- Monitor Actual and Setpoint Temperatures
- Adjustable current limit, setpoint temperature, and Proportional Gain
- Remote enable/disable output

RELIABILITY AND STABILITY

The robust circuitry of the PID-1500 achieves 0.003°C temperature stability with thermistors. Onboard controls make this package plug and play. The linear, PI control loop offers maximum stability while the bipolar current source has been designed for higher efficiency. The PID-1500 drives up to 1.5 A for either Thermoelectrics (bipolar) or Resistive Heaters (unipolar). An evaluation board simplifies prototyping: PIDEVALPCB. Heatsinking is already provided to support operation across a -20°C to +85°C operating range but can be removed if necessary.

The on-board, 12-turn Temperature Set trimpot sets the desired temperature. Single-turn trimpots control the proportional gain and current limit. A four-position Sensor Select jumper applies the proper bias current for thermistors, IC sensors, or RTDs.

LEADING EDGE APPLICATIONS

The PID-1500 has proven reliable in such diverse fields as spectroscopy, defense, and medical research.

EASY INTEGRATION

Use the PIDEVALPCB Evaluation Board to rapidly prototype a complete temperature control system using the PID-1500.

Onboard switches, connectors, and trimpots make configuration and operation simple. The PID-1500 Temperature Controller is not included. A 2.5 mm jack is compatible with the power supplies listed in the ordering information table.

CONTENTS

ORDERING INFORMATION

PART NO	DESCRIPTION
PID-1500	1.5 A Temperature Controller
PIDEVAL	Evaluation PCB for the PID-1500
PWRPAK-5V	Switching Power Supply 6A, 5V
PWRPAK-7V	Switching Power Supply 3A, 7.2V
PWRPAK-9V	Switching Power Supply 3A, 9V
PWRPAK-12V	Switching Power Supply 2.5A, 12V

RoHS Compliant

AD590 LM355 RTD R_T

406-587-4910
www.teamWavelength.com

Applies to Revision C and later

WAVELENGTH ELECTRONICS

QUICK CONNECT GUIDE

To ensure safe operation of the PID-1500, it is imperative that you determine that the unit will be operating within the internal heat dissipation Safe Operating Area (SOA).

Visit the Wavelength Electronics website for the most accurate, up-to-date, and easy to use SOA calculator:

https://www.teamwavelength.com/support/design-tools/soa-tc-calculator/

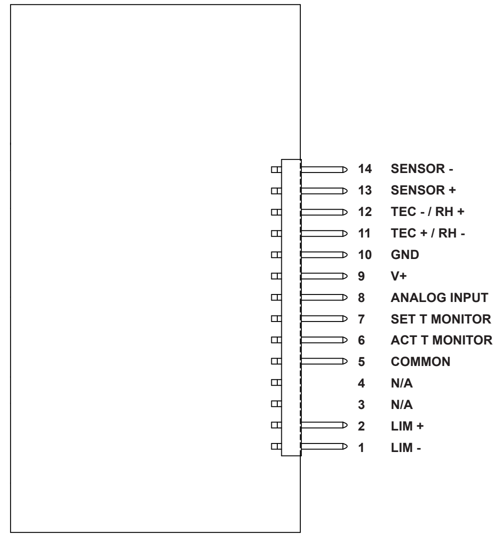


Figure 1. PID-1500 Pin Layout

Figure 1 shows the side view Pin Layout of the PID-1500.

Figure 2 shows connection diagram for PID-1500.

Figure 3 shows example test loads for the PID-1500.

Please review the entire datasheet before operating your themoelectric with the PID-1500.

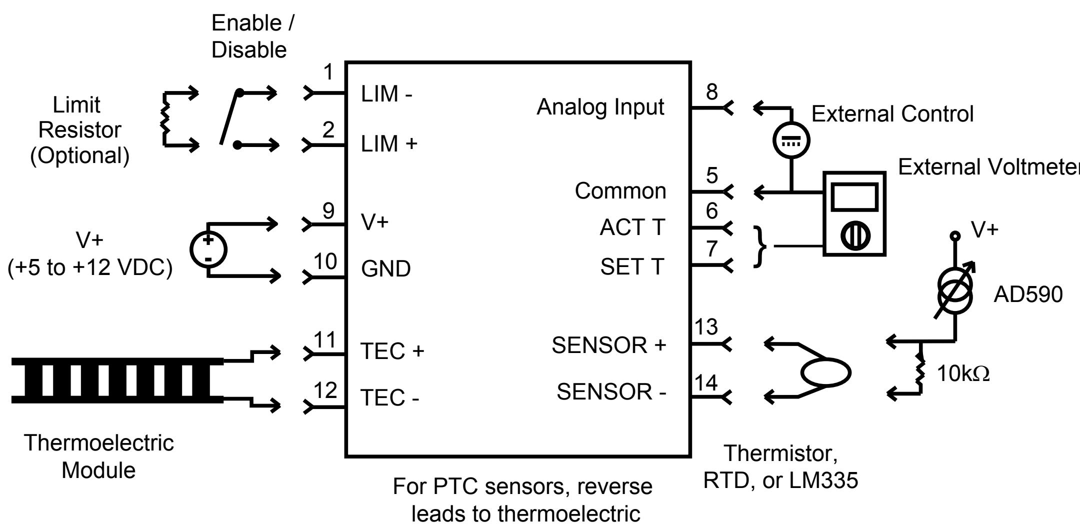


Figure 2. PID-1500 Quick Connect Diagram

RECOMMENDED TEST LOAD

For setup and configuration, we recommend using a test load in place of the TEC or resistive heater, connected directly to Pin 11 and Pin 12 (TEC+ and TEC-) on the controller, as shown in **Figure 3**.

Recommended test load:

- MP9100-1.00-1%. This resistor may need to be attached to a heatsink.

We also recommend using a test circuit to simulate a 10kΩ thermistor. An example is shown in **Figure 3**.

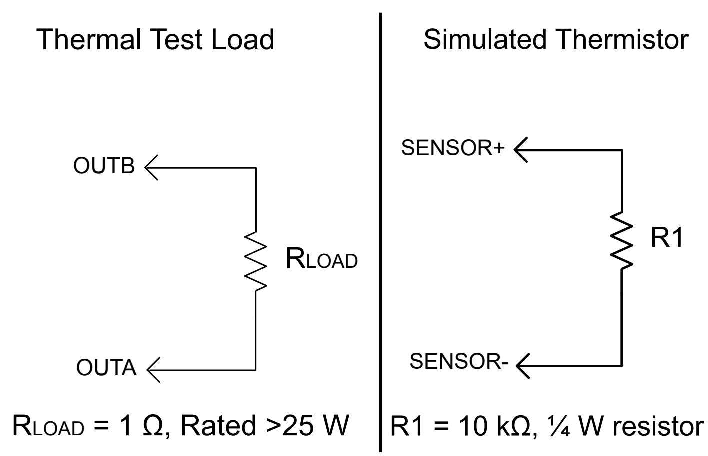


Figure 3. PID Test Load

SELECTABLE ADJUSTMENTS

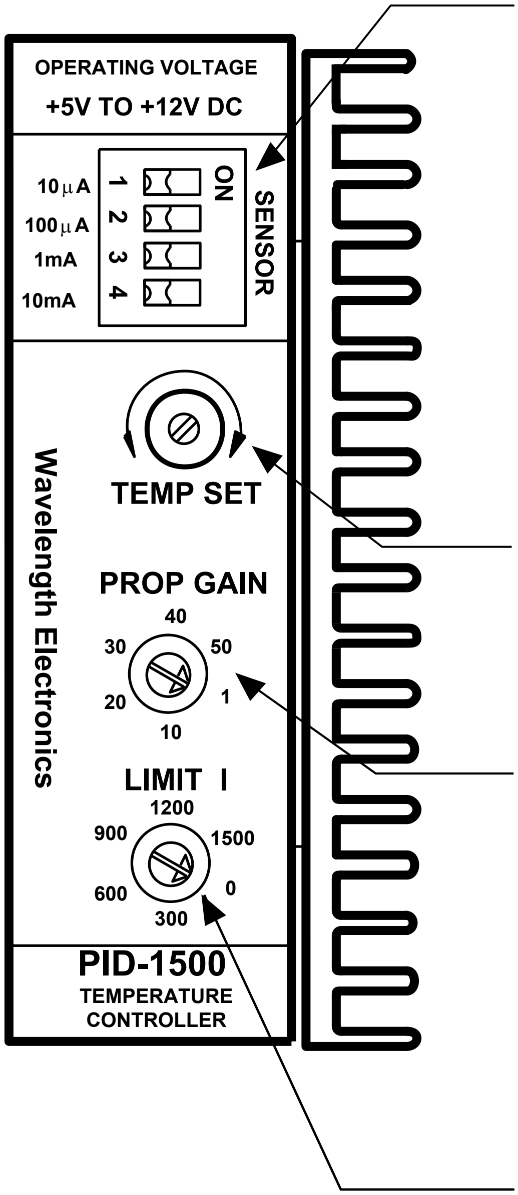


Figure 4. PID Top View Descriptions

SENSOR SELECT

This switch selects the appropriate current for the sensor used with the PID-1500. The sensor output currents can be 10 µA, 100 µA, 1 mA, or 10 mA.

WARNING: Only one switch can be in the ON position for proper operation. All remaining switches must be in the OFF position.

The resistance of the sensor you choose, in conjunction with the sensor current, must produce a voltage between 0.2 V and V+ minus 2 V in order to be used in the control loop. The 10 µA and 100 µA ranges are used with thermistors. The 1 mA range is used with the LM335 IC sensor and 500 or 1000 Ω RTDs. The 10 mA range is used with 100 or 200 Ω RTDs for higher sensitivities. For AD590s, set all switches to OFF and make the connections shown in the Quick Connect Section (**page 2**).

TRIMPOT ADJUSTMENTS

TEMPERATURE SET

This 12-turn trimpot adjustment varies the temperature setpoint (measured from Pin 7, SET T Monitor). Turning the trimpot adjust clockwise increases the temperature setpoint from 0 to 5 V. Set this voltage to match sensor voltage at the desired operating temperature.

PROPORTIONAL GAIN

This single-turn trimpot adjusts the proportional gain for the PI control loop. Turning the trimpot adjust clockwise increases proportional gain from 1 to 50. The numbers surrounding the trimpot are approximations and should be used as reference points when setting the proportional gain. The arrow on the trimpot indicates the setting. When adjusting the proportional gain, remove V+ momentarily to reset the Integrator. Making adjustments after the temperature has stabilized will not affect the system stability until V+ has been removed to reset the PI control loop.

LIMIT I

This single-turn trimpot adjusts the maximum output current. The LIMIT I should be set below the maximum current of your thermoelectric (IMAX) before power is applied to the PID-1500. Turning the trimpot clockwise increases the maximum output current from 0 to 1.5 A. The numbers surrounding the trimpot are approximations and should be used as reference points when setting the limit current. The arrow on the trimpot indicates the setting.

PIN DESCRIPTION

Table 1. Pin Descriptions

PIN LABEL	PIN #	NAME	PIN DESCRIPTION
1 2	LIM- LIM+	Output Current Limit / Enable / Disable	An SPST switch across these pins enables or disables the PID-1500 output. OPEN = Enabled CLOSED / Shorted = Disabled The maximum output current can also be fixed by placing a resistor across Pin 1 and Pin 2.
3	NC	Not Used	This pin is not used.
4	NC	Not Used	This pin is not used.
5	COM	Common	**This is a low current return for Pins 6, 7, and 8 only.** This ground is internally starred with the circuit ground to provide the most accurate monitor measurement. Internally, it is connected to Pin 10.
6	ACT T MON	Actual Temperature Monitor	This pin is used to monitor the voltage, and therefore the actual temperature of the sensor. After settling, the ACT T MONITOR voltage will closely match the voltage set at Pin 7 (SET T MONITOR) by the 12-turn TEMP SET trimpot.
7	SET T MON	Setpoint Temperature Monitor	This pin is used in setting the temperature setpoint of the sensor. This voltage will range from 0 - 5 V and will closely match the voltage across the sensor when it is at the desired temperature.
8	ANALOG IN	Setpoint Analog Input	This input is used to control the temperature setpoint remotely. The control voltage input range is 0.2 V to V+ minus 2 V and the input sums directly with the TEMP SET trimpot. The transfer function relative to ACT T MONITOR (Pin 6) is 1.3 V / 1 V. Damage threshold: < -0.5 V or > V+.
9	V+	Voltage Supply In	**(+5 V to +12 VDC, +12.5 VDC MAXIMUM)** This pin along with Pin 10 (GND) provides power to the control electronics and the thermoelectric output.
10	GND	Ground	This pin along with Pin 9 (V+) provides power to the control electronics and the thermoelectric output
11	TEC+	Thermoelectric Positive	This pin sources the control current to the thermoelectric or resistive heater load. It connects to the positive terminal of TECs when using NTC sensors.
12	TEC-	Thermoelectric Negative	This pin sources the control current to the thermoelectric or resistive heater load. It connects to the negative terminal of TECs when using NTC sensors.
13	SENSOR+	Sensor Positive Terminal	This pin is used to source reference current through the temperature sensor (thermistor, IC sensor, or RTD). The Sensor Select switch on the top will select between a 10 µA, 100 µA, 1 mA, or 10 mA reference current. Selection of the proper reference current will allow the optimal temperature range of the attached sensor.
14	SENSOR-	Sensor Negative Terminal	This pin is used as the thermistor, IC sensor, or RTD current source return pin. This pin is at ground potential but should not be used for anything other than the sensor current source return.

CAUTION: If you are operating the PID-1500 from a +5 V supply voltage, the output compliance voltage will be less than ±5 V. A compliance voltage of ±4 V will be obtained with +5 V input. 5 V operation will limit the setpoint voltage to 2.5 - 3.5 V, thus limiting the temperature range of the PID-1500.

ELECTRICAL SPECIFICATIONS

PARAMETER	SYMBOL	VALUE	UNIT
GENERAL SPECIFICATIONS DESCRIPTION			
Power Requirements [1] [2]	V_{DD}	+5 to +12	Volts DC
Supply Current		PID Limit Current Plus 100	mA
Maximum Internal Power Dissipation		9	Watts
Operating Temperature	T_{OPR}	-20 to +85	ºC
Storage Temperature	T_{STG}	-40 to +125	ºC
Size		1.52 x 1.10 x 2.65 39 x 28 x 67	Inches mm
Weight		4	Ounces

PARAMETER	VALUE	UNIT
TEMPERATURE CONTROL		
Temperature Control Range [3]	Range is sensor dependent	ºC
Short Term Stability, 1 hour [4]	< 0.003	ºC
Long Term Stability, 24 hours [4]	< 0.005	ºC
Warm-up Time to Rated Accuracy	1	Hour
OUTPUT		
Bipolar Output Current [2]	± 1.5	Amps
Compliance Voltage	See note [5]	
Maximum Output Power	12	Watts
Current Limit Range	0 - 1500	mA
Control Loop	PI	
Proportional Gain, adjustable	1 - 50	A / V
Integrator Time Constant, fixed	1	Second
TEMPERATURE SENSOR TYPES		
Thermistor Types, 2-wire	NTC or PTC	
Sensor Bias Currents	0.01, 0.10, 1.0, and 10.0	mA
Thermistor Range	1 - 500	kΩ
IC Sensor Types [6]	AD590, LM335	
IC Sensor Bias (LM335)	1	mA
RTD Types, 2-wire	100 - 1000	Ω
TRANSFER FUNCTION (ANALOG IN TO MONITOR)	1.3 / 1	V / V
SET T versus ACT T Accuracy	< 1	%

[1] +12.5 V Maximum

[2] At V_{DD} = 5 VDC, maximum bipolar output current is ±1.25 A.

[3] Temperature range depends on the physical load, sensor type, and TEC module used. 5 V operation will limit the Setpoint Voltage to 2.5 - 3.5 V, thus limiting the temperature range of the PID-1500.

[4] Stability quoted for a typical 10 kΩ thermistor at 100 μA sensing current.

[5] Compliance Voltage varies with power supply voltage. A maximum compliance voltage of ±10.5 V will be obtained with a +12 V input. A compliance voltage of ±4 V will be obtained with +5 V input.

[6] AD590 requires an external bias voltage and 10 kΩ sense resistor.

SAFETY INFORMATION

SAFE OPERATING AREA — DO NOT EXCEED INTERNAL POWER DISSIPATION LIMITS

Before attempting to operate the PID-1500, it is imperative that you first determine that the unit will operate within the *Safe Operating Area* (SOA). Operating outside of the SOA may damage the load and the product. Operating outside of the SOA will void the warranty.

To determine if the PID-1500 will be operating in the safe range in your application, consult the instructions for calculating the Safe Operating Area online:

www.teamwavelength.com/support/design-tools/soa-tc-calculator/

SOA charts are included in this datasheet for quick reference (**page 12**), but we recommend you use the online tools instead.

To ensure safe operation of the PID-1500, it is imperative that you determine if the unit is going to be operating within the internal heat dissipation Safe Operating Area (SOA).

If you have any questions about the Safe Operating Area calculator, call the factory for free and prompt technical assistance.

PREVENT DAMAGE FROM ELECTROSTATIC DISCHARGE

Before proceeding, it is critical that you take precautions to prevent electrostatic discharge (ESD) damage to the controller and the load. ESD damage can result from improper handling of sensitive electronics, and is easily preventable with simple precautions.

For more information regarding ESD, see Application Note *AN-LDTC06: Basics: Electrostatic Discharge (ESD).*

We recommend that you always observe ESD precautions when handing the PID-1500.

THEORY OF OPERATION

The PID-1500 is a linear temperature controller that delivers bidirectional current to Peltier Effect thermoelectric coolers (TEC), or unidirectional current to resistive heaters.

The fundamental operating principle is that the controller adjusts the TEC drive current in order to change the temperature of the sensor that is connected to the thermal load.

The goal is to make the voltage across the sensor match the setpoint voltage, and then keep them equal in spite of changes to ambient conditions and variations in thermal load.

The controller measures the load temperature by driving a current through the temperature sensor and measuring the voltage drop across it. It may be useful to remember that you do not directly adjust the setpoint temperature. Rather, you adjust a voltage signal that represents the sensor voltage at the desired temperature setpoint.

While the output is enabled the controller continuously compares the setpoint voltage and the actual sensor voltage. If there is a difference between the two signals the controller adjusts the output current—thereby driving the TEC or heater to change temperature—until the difference is zero.

Once the actual sensor voltage equals the setpoint voltage, the controller makes minor adjustments to the output current in order to keep the difference at zero. If the ambient temperature changes, for example, the controller will adjust the drive current accordingly.

The controller includes features that help protect the load from damage, and also make it more versatile in a wide array of applications. These features are explained in detail in **Operating Instructions — Standalone on page 7**.

- **Current limit**: the adjustable current limit must be set correctly in order to avoid over-driving and damaging the TEC or heater.
- **External and Onboard temperature setpoint control**: for prototyping and benchtop applications the temperature setpoint can be adjusted with the onboard trimpot. When the controller is integrated into an automated control system, the temperature setpoint can be adjusted by external voltage signal.
- **Remote Enable and Local Enable**: the controller can be configured to use a remote signal to enable the output, or it can be configured so that the output is always on whenever power is applied to the unit.
- **Control loop**: the controller employs a smart Proportional Integrating control loop to adjust the drive current. The proportional term is user-adjustable, and when properly configured will quickly settle the load to temperature with minimal overshoot and ringing.

OPERATING INSTRUCTIONS — STANDALONE

The PID-1500 requires minimal external electronics. If you are using the controller on the benchtop or for prototyping your laser control system, we recommend purchasing the PID Evaluation Board.

We recommend using a test load until you are familiar with operation of the controller. Refer to **page 2** for test load schematics.

NECESSARY EQUIPMENT

The following equipment is the minimum necessary to configure the PID-1500 for basic operation:

- PID-1500
- Digital Voltmeter, 4-½ digit resolution recommended
- Test load for configuring the controller [optional]
- Thermoelectric or Resistive Heater
- Connecting wires
- Power Supply
- Thermistor or other sensor

SYSTEM DESIGN DECISIONS

Before the PID-1500 can be configured, several decisions must be made:

- What sensor is being used?
- What bias current is needed?
- What is the operating maximum current and maximum voltage?
- Will the system, as designed, fit within the Safe Operating Area (SOA)?

POWER SUPPLY REQUIREMENTS

The PID-1500 is designed for low noise operation. The power supply you select will directly affect the noise performance of the controller. Wavelength Electronics recommends using a regulated linear supply for optimum performance. Depending on your requirements, you may be able to use a switching power supply.

Each case must be evaluated individually, as a switching power supply will affect noise, transient, and stability performance. The PID-1500 can be purchased with the PIDEVALPCB evaluation kit plus the PWRPAK-5V +5V table top regulated switching power supply for easy initial operation.

STEP 1 - CONNECT POWER (PINS 9 & 10)

Use Pins 9 and 10 to connect a single +5 to +12 V power supply to the PID-1500. Connect the positive voltage to V+ (Pin 9) and common to GND (Pin 10). Check the power supply specifications to ensure that it has sufficient current capacity (TEC current limit setting plus 100 mA).

STEP 2 - SELECT THE SENSOR (PINS 13 & 14)

Epoxy or otherwise attach the temperature sensor to the device being cooled or heated. Connect the sensor to Pins 13 and 14. For sensors where polarity is important, Pin 13 is Sensor + and Pin 14 is Sensor -. Select the appropriate current on the Sensor Select switch for the sensor chosen.

WARNING: Only one switch can be in the ON position for proper operation. All remaining switches must be in the OFF position.

The resistance of the sensor over the application temperature range, in conjunction with the sensor bias current, must produce a voltage between 0.2 V and V_{DD} minus 2 V. To calculate the voltage drop across the sensor use the following equation:

$$V_{SENSOR} = R_{SENSOR} \times I_{BIAS}$$

Select the bias current according to the equation above so that the sensor voltage does not exceed the maximum voltage (V_{DD} - 2 V). Thermistors require 10 µA or 100 µA. Use the LM335 with the 1 mA setting. The 1 mA setting is used for 500 Ω and 1000 Ω RTDs. 100 and 200 Ω RTDs require the 10 mA setting for added sensitivity. When connecting the AD590, place a 10 kΩ metal film resistor across Pins 13 and 14 and apply V+ to the sensor as shown in the Quick Connect diagram (**page 2**). Set all switches to OFF when using the AD590 sensor.

STEP 3 - CONNECT THE THERMOELECTRIC MODULE (PINS 11 & 12)

Connect the thermoelectric module to Pins 11 and 12. Ensure that the thermoelectric is adequately connected to a heatsink. Properly transferring heat from the thermoelectric device is absolutely necessary for stable temperature control. The heatsink must be rated to remove the total heat generated. If heat is not adequately removed, the temperature-controlled load can go into thermal runaway and might be damaged. **NOTE**: The default factory loop direction is set up for NTC sensors (thermistors). While cooling, it flows from TEC+ (Pin 11) to TEC- (Pin 12). If using a PTC sensor (LM335, AD590, or RTDs), reverse the cooler leads between Pins 11 and 12. Current will flow from TEC- to TEC+, so TEC- will connect to the positive wire of the cooler, and vice versa.

For operation with a resistive heater see **page 13** for instructions.

STEP 4 - SET THE CURRENT LIMIT (PINS 1 & 2)

Set the LIMIT I trimpot for the maximum current necessary to control the thermal load and below the maximum current ratings for your thermoelectric or resistive heater. Excessive current can damage your thermoelectric. Turning the trimpot clockwise increases the maximum output current from 0 to 1.5 A. The numbers surrounding the trimpot are approximations and should be used as reference points when setting the limit current. The maximum limit current will be reduced when a resistor is placed between Pin 1 (LIM-) and Pin 2 (LIM+).

To Enable/Disable the output - Connect a switch between the pins. If the switch is open, the output is enabled. Shorting the switch contacts disables the output current.

To limit the output current with a fixed resistor - the LIMIT I trimpot should be turned fully clockwise (CW) when using the fixed resistor to limit the output current. By connecting a resistor with resistance R (in kΩ) between Pins 1 and 2, the new maximum limit current for the thermoelectric can be calculated given the following equations.

$$\text{MAX TEC I} = \left(\frac{45.9375*R}{200 + 30*R}\right)\text{ Amps} \qquad (1)$$

To calculate the desired resistance, given the maximum limit current, use the following equation:

$$R = \left(\frac{200*I_{TECMAX}}{45.9375 - 30*I_{TECMAX}}\right)\ \text{k}\Omega \qquad (2)$$

STEP 5 - SET UP THE SETPOINT (PINS 5 & 7)

Use Pins 5 (Common) and 7 (SET T) to monitor the setpoint temperature. The desired setpoint voltage will depend on the sensor selected. Use one of the following equations based on the sensor type you will be using.

THERMISTORS AND RTDS:

$$V_{SETPOINT} = I_{BIAS} \times R \qquad (3)$$

where R equals the resistance value (in Ω) of the sensor at the desired operating temperature and I_{BIAS} is in Amps. The sensor bias current (I_{BIAS}) will be 10 mA, 1 mA, 100 µA, or 10 µA.

LM335 & AD590:

$$V_{SETPOINT} = 2.730 + (0.010\ \text{V/°C} \times T_{DESIRED}) \qquad (4)$$

where $T_{DESIRED}$ is the setpoint temperature in ºC.

Monitor the temperature setpoint on Pin 7. To decrease the setpoint voltage, rotate the TEMP SET adjust trimpot counter-clockwise (CCW). After the power supply voltage is applied and PID-1500 is enabled, check the Actual Temperature Monitor (ACT T MONITOR, Pin 6). The ACT T MONITOR voltage should approach setpoint voltage with time.

ANALOG INPUT (PINS 8 & 5):

This input referenced to Pin 5 is used to control the temperature setpoint remotely. The control voltage input range is 0 V to +5 V, and the input sums directly with the TEMP SET trimpot. The transfer function for this input is 1.3 V / 1 V. (Input maximum is V+.)

MONITOR = ANALOG INPUT * 1.3
ANALOG INPUT = MONITOR / 1.3

STEP 6 - SET THE PROPORTIONAL GAIN

Adjust the proportional gain from 1 to 50 to optimize the system for overshoot and settling time. The factory setting for the gain is 33. Turning this potentiometer clockwise increases the gain. When adjusting the proportional gain, it is recommended to cycle power to the PID-1500 momentarily to restart the Integrator. Making adjustments after the temperature has stabilized will not affect the system stability until V+ has been removed to reset the PID control loop.

STEP 7 - ATTACH THE HEATSINK (IF NEEDED)

The PID-1500 can dissipate a large amount of power depending on the power supply voltage being used and the current required to maintain temperature on the load. In some instances, an external fan may be required to keep the PID-1500 heatsink at an acceptable temperature. Measure the PID-1500 heatsink temperature. If the temperature exceeds 75ºC, then use a fan to cool the PID-1500.

OPERATING INSTRUCTIONS WITH EVAL BOARD

PID-1500 WITH PIDEVALPCB

Operate the PID-1500 quickly using the PIDEVALPCB. Simply solder the controller onto the evaluation board as illustrated in **Figure 5**, and **Table 2** shows the label descriptions of the PIDEVALPCB.

NECESSARY EQUIPMENT

The equipment is the same as on **page 7** with the addition of the PIDEVALPCB board.

SYSTEM DESIGN DECISIONS

Before the PID-1500 can be configured with the PIDEVALPCB, several decisions must be made:

- What sensor is being use?
- What bias current is needed?
- What is the operating maximum current and maximum voltage?
- Will the system, as designed, fit within the Safe Operating Area (SOA)?

Table 2. PIDEVALPCB Label Descriptions

PIDEVALPCB LABEL	DESCRIPTION
Monitor Setpoint and Actual Temperature	The setpoint and actual temperature can be monitored via the screw lock connector (SET T & ACT T) or a DVM can be connected to these two monitor jacks. The Monitor Select Switch can be used to choose between monitoring the Actual or Setpoint temperature with the monitor jacks.
Terminal Block	The terminal block allows for easy screw lock connections to the designated pins on the PID-1500 for power supply input, TEC connections, sensor connections, and monitoring capabilities.
Green LED Power Indicator	The green LED will light when DC power is applied.
Power Switch	The DC Power switch applies DC power to the PID-1500. Note that if the output is not also enabled, no output current will flow.
Output Enable/ Disable	Even if DC power is applied, the output current can only be enabled by setting this switch to the '|' position. Enable = | Disable = 0
DC Power Input	Two inputs are available. If using the 2.5 mm circular input jack connector (such as the one provided with the POWERPAK-5V) use the DC input next to the Power Switch. The power supply can also be connected to the terminal block (V+ & GND). Only use one input to power the controller. The input jack connector is a Switchcraft RAPC712X 2.50 mm ID, 5.50 mm OD.

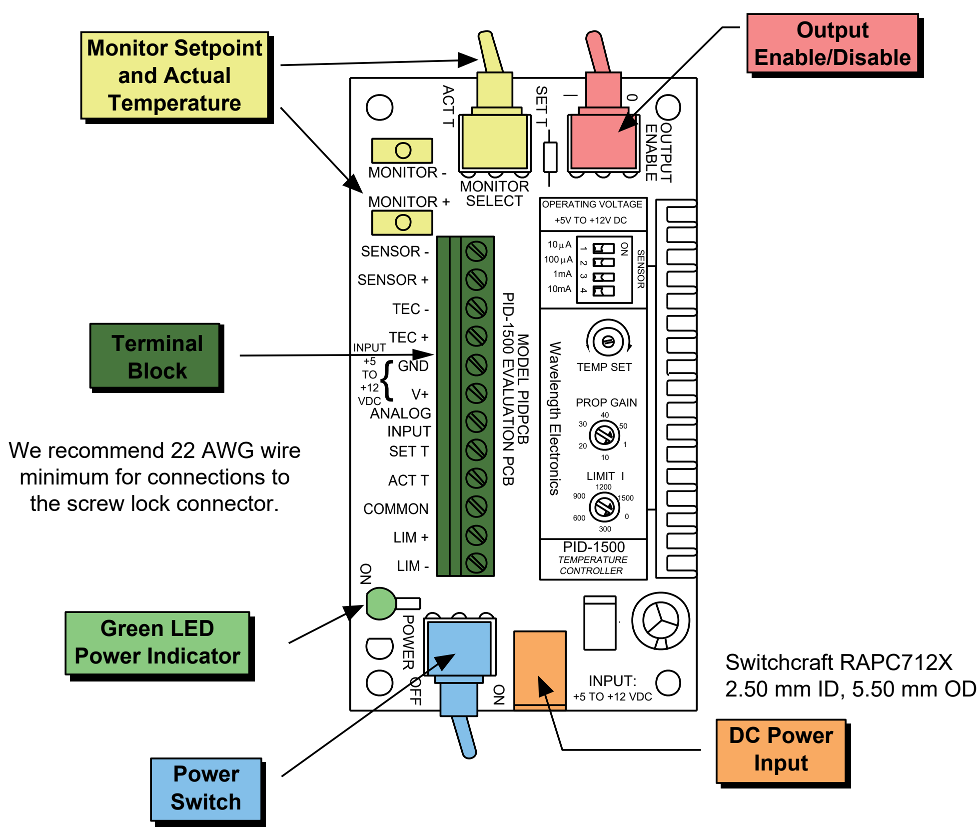


Figure 5. PIDEVALPCB Board Top View (with PID-1500 attached)

STEP 1 - INSTALL THE PID-1500 ON THE PIDEVALPCB BOARD

Align the pins on the PID-1500 controller to the 12 hole positions on the PIDEVALPCB board. **Figure 5** shows the orientation of the controller on the evaluation board. Solder the pins to the board. **NOTE**: Do not exceed 700ºF soldering temperature for more than 5 seconds on any pin.

STEP 2 - CONFIGURE THE SWITCHES

Connect a power supply by either the DC Power Input connector or the terminal block connections V+ and GND. Use the Power Switch to enable or disable the power to the EVAL board. The green LED will light when power is applied.

Enable or disable output current by using the Output Enable/ Disable switch.

Change the measurement you are monitoring, when a voltmeter is connected to the Monitor (+ and -) jacks by using the Monitor Select Switch. This will toggle the measurement between ACT T and SET T. You can also monitor the SET T and ACT T by using the screw lock connector (SET T, ACT T, and COMMON) with a Digital Voltmeter.

STEP 3 - SET THE PROPORTIONAL GAIN

Adjust the proportional gain from 1 to 50 to optimize the system for overshoot and settling time. The factory setting for the gain is 33. Turning this potentiometer on the PID-1500 controller clockwise increases the gain. When adjusting the proportional gain, it is recommended to cycle power to the PID-1500 momentarily to restart the Integrator. Making adjustments after the temperature has stabilized will not affect the system stability until V+ has been removed to reset the PID control loop.

STEP 4 - ATTACH A THERMOELECTRIC

Connect the thermoelectric module to TEC- and TEC+. Ensure that the thermoelectric is adequately connected to a heatsink. Properly transferring heat from the thermoelectric device is absolutely necessary for stable temperature control. The heatsink must be rated to remove the total heat generated. If heat is not adequately removed, the temperature-controlled load can go into thermal runaway and might be damaged. **NOTE**: The default factory loop direction is set up for NTC sensors (thermistors). While cooling, it flows from TEC+ to TEC-. If using a PTC sensor (LM335, AD590, or RTDs), reverse the cooler leads between TEC+ and TEC-. Current will flow from TEC- to TEC+, so “TEC-” will connect to the positive wire of the cooler, and vice versa.

For operation with a resistive heater see **page 13** for instructions.

STEP 5 - SELECT THE SENSOR

Epoxy or otherwise attach the temperature sensor to the device being cooled or heated. Connect the sensor to SENSOR- and SENSOR+ with correct polarity if necessary. Select the appropriate current on the Sensor Select switch for the sensor chosen.

WARNING: ONLY ONE SWITCH CAN BE IN THE ON POSITION FOR PROPER OPERATION. ALL REMAINING SWITCHES MUST BE IN THE OFF POSITION.

The resistance of the sensor over the application temperature range, in conjunction with the sensor bias current, must produce a voltage between 0.2 and V_{DD} minus 2 V. To calculate the voltage drop across the sensor use the following equation:

$$V_{SENSOR} = R_{SENSOR} \times I_{BIAS}$$

Select the bias current according to the equation above so that the sensor voltage does not exceed the maximum voltage (V_{DD} - 2 V). Thermistors require 10 µA or 100 µA. Use the LM335 with the 1 mA setting. The 1 mA setting is used for 500 Ω and 1000 Ω RTDs. 100 and 200 Ω RTDs require the 10 mA setting for added sensitivity. When connecting the AD590, place a 10 kΩ metal film resistor across SENSOR- and SENSOR+ and apply V+ to the sensor as shown in the Quick Connect diagram (**page 2**). Set all switches to OFF when using the AD590 sensor.

STEP 6 - SET THE CURRENT LIMIT

Set the LIMIT I trimpot for the maximum current necessary to control the thermal load and below the maximum current ratings for your thermoelectric or resistive heater. Excessive current can damage your thermoelectric. Turning the trimpot clockwise increases the maximum output current from 0 to 1.5 A. The numbers surrounding the trimpot are approximations and should be used as reference points when setting the limit current. The maximum limit current will be reduced when a resistor is placed between LIM- and LIM+.

To limit the output current with a fixed resistor - the LIMIT I trimpot should be turned fully clockwise (CW). By connecting a resistor with resistance R (in kΩ) between LIM- and LIM+, the new maximum limit current for the thermoelectric can be calculated given the following equations.

$$\text{MAX TEC I} = \left(\frac{45.9375*R}{200 + 30*R}\right) \text{Amps} \qquad (1)$$

To calculate the desired resistance, given the maximum limit current, use the following equation:

$$R = \left(\frac{200*I_{TECMAX}}{45.9375 - 30*I_{TECMAX}}\right) \text{k}\Omega \qquad (2)$$

STEP 7 - SET THE SETPOINT INPUT

Use the monitor jacks or Common and SET T on the screw lock connector to monitor the setpoint temperature. The desired setpoint voltage will depend on the sensor selected. Use one of the following equations based on the sensor type you will be using.

THERMISTORS AND RTDS:

$$V_{SETPOINT} = I_{BIAS} \times R \qquad (3)$$

where R equals the resistance value (in Ω) of the sensor at the desired operating temperature. The sensor bias current (I_{BIAS}) will be 10 mA, 1 mA, 100 µA, or 10 µA.

LM335 & AD590:

$$V_{SETPOINT} = 2.730 + (0.010\ V/^{o}C \times T_{DESIRED}) \qquad (4)$$

where $T_{DESIRED}$ is the setpoint temperature in ºC.
Monitor the temperature setpoint on monitor jacks or SET T and COMMON. To decrease the setpoint voltage, rotate TEMP SET adjust trimpot counter-clockwise (CCW). After the power supply voltage is applied and PID-1500 is enabled, check the Actual Temperature Monitor using the monitor jacks or ACT T and MONITOR. The ACT T MONITOR voltage should approach setpoint voltage with time. Use the Monitor Select Switch to select which temperature to monitor: setpoint or actual temperature.

ANALOG INPUT (PINS 8 & 5):
This input referenced to ANALOG INPUT is used to control the temperature setpoint remotely. The control voltage input range is 0 V to +5 V and the input sums directly with the TEMP SET trimpot. The transfer function for this input is 1.3 V / 1 V. (Input maximum is V+.)

MONITOR = ANALOG INPUT * 1.3
ANALOG INPUT = MONITOR / 1.3

ADDITIONAL TECHNICAL INFORMATION

SAFE OPERATING AREA

The Safe Operating Area of the PID-1500 is determined by the amount of power that can be dissipated within the output stage of the controller. If that power limit is exceeded permanent damage can result.

DO NOT EXCEED THE SAFE OPERATING AREA (SOA). EXCEEDING THE SOA VOIDS THE WARRANTY.

Refer to the Wavelength Electronics website for the most up-to-date SOA calculator for our products. The online tool is fast and easy to use, and also takes into consideration operating temperature.

www.teamwavelength.com/support/design-tools/soa-tc-calculator/

SOA charts are included in this datasheet for quick reference, however we recommend you use the online tools instead.

An example SOA calculation for the PID-1500 is shown in **Figure 6** where:

V_{DD}= 12 Volts (Point C) V_{LOAD} = 5 Volts
I_{LOAD} = 1 A (Point B) V_{DROP} = 12 - 5 = 7 Volts (Point A)

Follow these steps to determine if the controller will be operating within the SOA.

- Refer to the laser datasheet to find the maximum voltage (V_{LOAD}) and current (I_{LOAD}) specifications
- Calculate the voltage drop across the controller: $V_{DROP} = V_{DD} - V_{LOAD}$ (V_{DD} is the power supply voltage)
- Mark V_{DROP} on the X-axis, and extend a line upward
- Mark I_{LOAD} on the Y-axis, and extend a line (Line BB) to the right until it intersects the V_{DROP} line
- On the X-axis, mark the value of V_{DD}
- Extend a diagonal line from V_{DD} to the intersection of the V_{DROP} and I_{LOAD} lines; this is the Load Line
- If the Load Line crosses the Safe Operating Area line at any point, the configuration is not safe

If the SOA Calculator indicates the PID-1500 will be outside of the Safe Operating Area, the system must be changed so that less power is dissipated within the controller. See Wavelength Electronics Application Note *AN-LDTC01: The Principle of the Safe Operating Area* for information on shifting the Load Line.

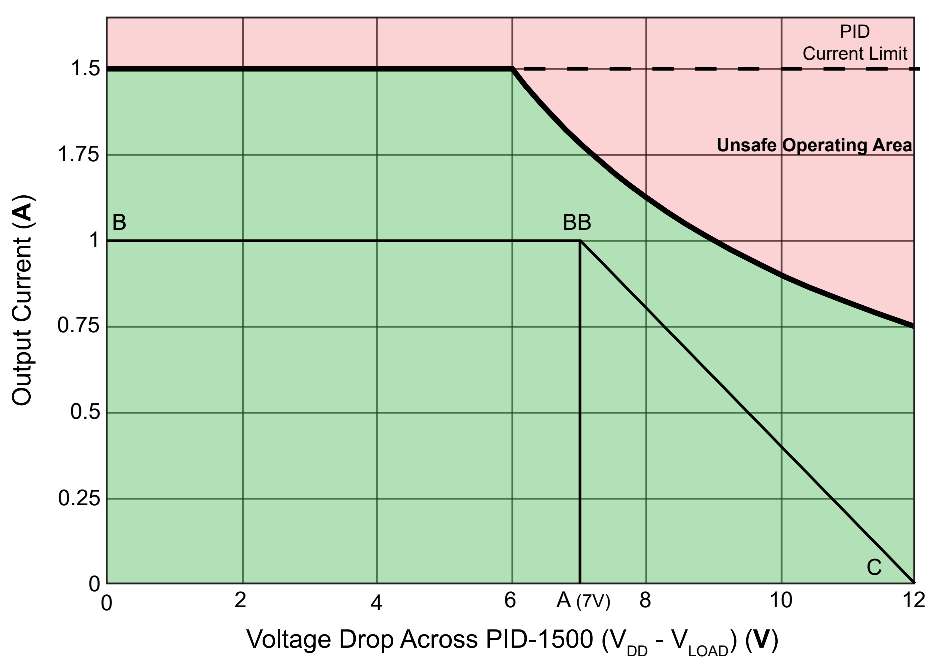


Figure 6. Product SOA

OPERATION WITH RESISTIVE HEATERS

This Datasheet applies to revisions C and later.

Revision is indicated in the third digit of the lot number of the unit. Example: 00C081001 = Rev C.

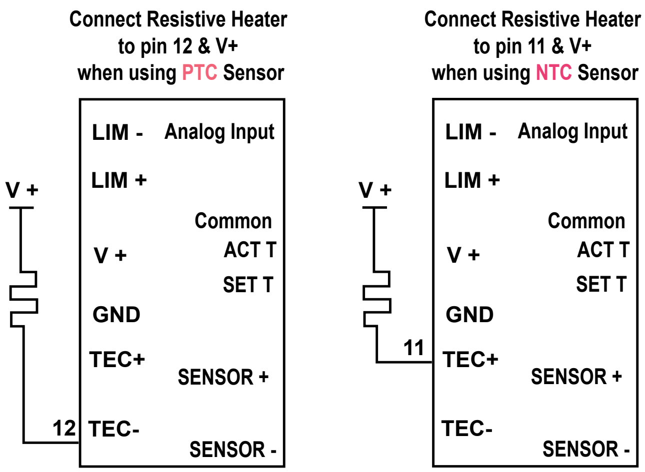


Figure 7. Resistive Heater Connections

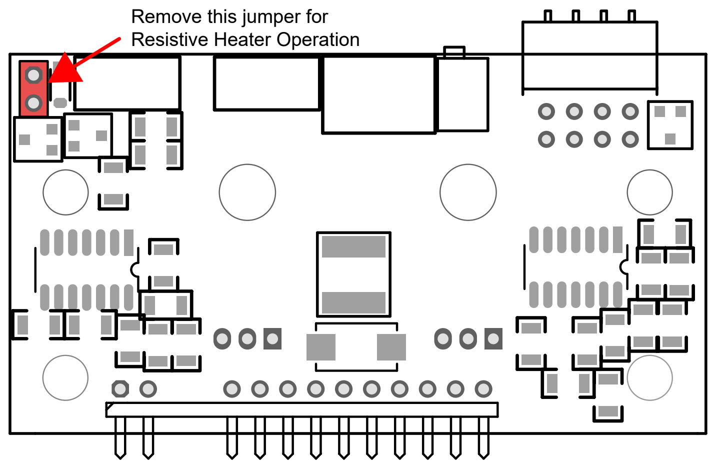


Figure 8. Resistive Heater Operation (Revision C)

Figure 7 illustrates the wiring for resistive heaters based on the type of sensor used. Please review the entire datasheet before operating your resistive heater with the PID-1500.

Figure 8 illustrates the location of the jumper on the top of the PCB that must be removed to operate the PID-1500 controller (Revision C) with resistive heaters or in unipolar mode.

REVISION HISTORY

The paragraphs below describe features for **Revisions A & B**.

ELECTRICAL SPECIFICATIONS — THERMOELECTRICS & RESISTIVE HEATERS

NOTE: This assumes that the resistive heater is hooked between Pins 11 & 12.

Short Term Stability, 1-hour < 0.005ºC
Long Term Stability, 24-hour < 0.008ºC
Compliance Voltage will vary depending on power supply voltage. A maximum compliance voltage of ±8 V will be obtained with a +12 V input. A minimum compliance voltage of ± 2.0 V will be obtained with +5 V input.

FOR UNIPOLAR OPERATION

A small phillips-head screwdriver, a small slotted head screwdriver, and a pair of wire cutters are required to convert the PID-1500 to resistive heater operation.

First, remove two phillips-head screws that hold the PID-1500's heatsink to the internal mount. On the same side as the heatsink, notice two slotted head nylon screws. Remove these screws and gently slide the electronic assembly down and out of the plastic enclosure. With the surface mount component side of the electronic assembly facing you and the leads of the device facing down, cut the jumper as shown in **Figure 9**. Reassemble the electronics in the enclosure and attach the heatsink to the mount.

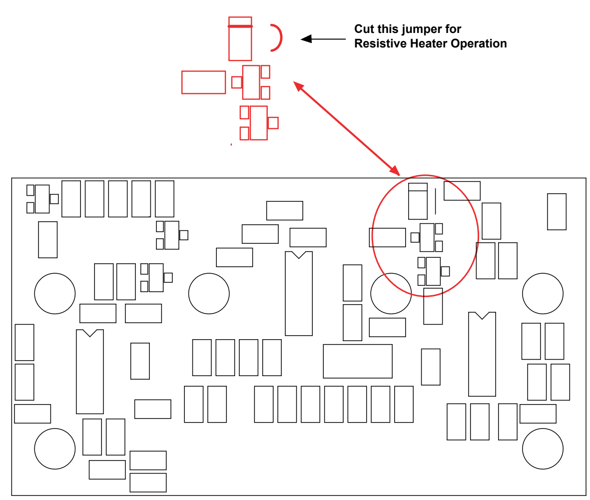
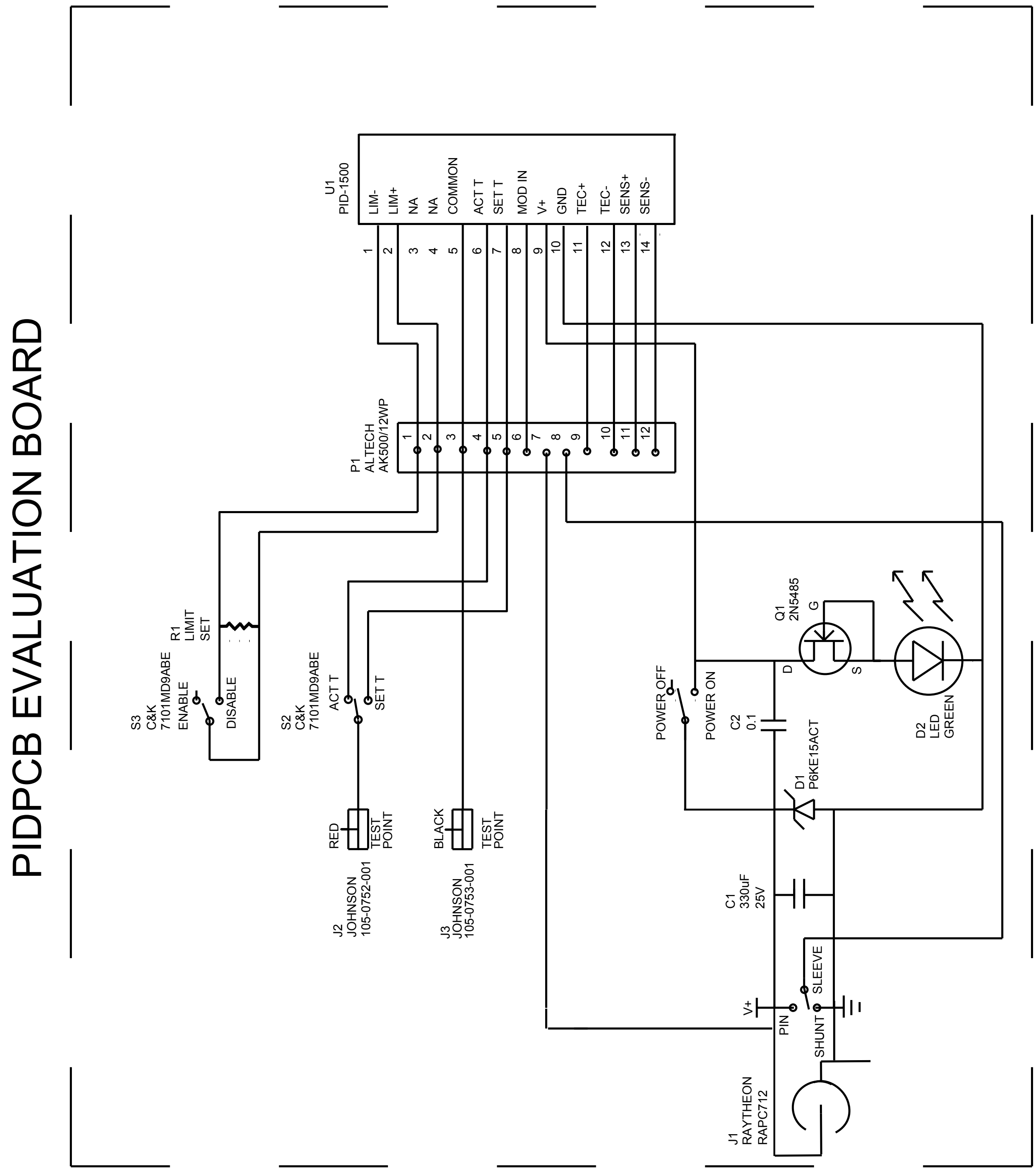
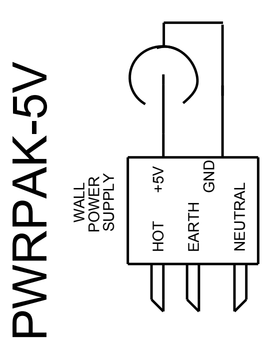


Figure 9. Resistive Heater Quick Start (Rev A & B)

PID EVALUATION BOARD SCHEMATIC





TROUBLESHOOTING

<table>
<tr><th>PROBLEM</th><th>POTENTIAL CAUSES</th><th>SOLUTIONS</th></tr>
<tr><td rowspan="2">Output will not enable
–OR–
Output will not disable</td><td>Improperly configured Pins 1 & 2 on the PID-1500 unit</td><td>Connect a switch between the pins. If the switch is open, the output is enabled. Shorting the switch contacts disables the output current.</td></tr>
<tr><td>Improperly configured the Output Enable/Disable switch on the PIDEVALPCB</td><td>The output current can only be enabled by setting this switch to the ‘|’ position. The ‘0’ position will disabled the output current. Also ensure that the DC Power switch is set to ON.</td></tr>
<tr><td>Temperature is decreasing when it should be increasing
–OR–
Temperature is increasing when it should be decreasing</td><td>The TEC may be connected backwards to the PTC</td><td>The convention is that the red wire on the TEC module connects to TEC+ (Pin 11) and the black wire to TEC- (pin 12). If your TEC is connected in this manner and the problem persists, the TEC module itself may be wired in reverse. Switch off power to the system, reverse the connections to the PTC, and then try again to operate the system.

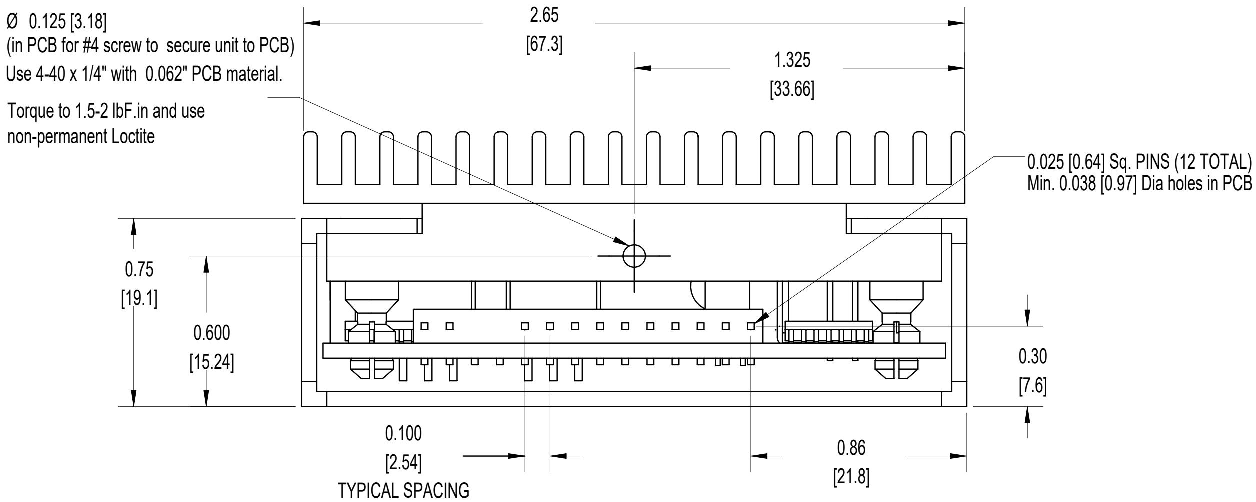
TEC wiring polarity is dependent on temperature sensor type (NTC vs. PTC). Verify that the polarity is correct for the sensor type you are using</td></tr>
<tr><td rowspan="2">Temperature increases beyond setpoint and will not come down</td><td>The heatsink may be inadequately sized to dissipate the heat from the load and the TEC module, and now the system is in thermal runaway</td><td>Increase the size of the heatsink, add a fan to blow air over the heatsink, and/or reduce the ambient air temperature around the heatsink.</td></tr>
<tr><td>The TEC and heatsink are not adequately sized for the thermal load</td><td>The heat being generated by the load may be too great for the TEC to pump to the heatsink; a larger TEC may be needed. Consult our Technical Note TN-TC01: Optimizing Thermoelectric Temperature Control Systems and Application Note AN-TC09: Specifying Thermoelectric Coolers.</td></tr>
<tr><td rowspan="4">Temperature does not stabilize very well at the setpoint</td><td>There may be poor thermal contact between components of the thermal load</td><td>Use thermal paste or washers between the load / TEC and the TEC / heatsink interfaces. Ensure the temperature sensor is in good thermal contact with the load</td></tr>
<tr><td>Unit may be operating outside the ideal region of the temperature sensor</td><td>The sensor type and bias current should be selected to maximize sensitivity at the target temperature. Thermistors provide the best performance, particularly for applications where a single setpoint temperature must be accurately maintained. For example, at 25ºC a 10 kΩ thermistor has a sensitivity of 43 mV / ºC, whereas an RTD sensor has a sensitivity of 4 mV / ºC.</td></tr>
<tr><td>Proportional control term may be set too high</td><td>Reduce the value of the proportional term. For more information, reference our Technical Note TN-TC01: Optimizing Thermoelectric Temperature Control Systems.</td></tr>
<tr><td>Heatsink may not be sized correctly or may not have adequate airflow</td><td>Ambient temperature disturbances can pass through the heatsink and thermoelectric and affect the device temperature stability. Choosing a heatsink with a larger mass and lower thermal resistance will improve temperature stability. Adding a fan across the thermoelectric’s heatsink may be required.</td></tr>
<tr><td rowspan="3">Temperature does not reach the setpoint</td><td>Current driven to the TEC or heater may be insufficient</td><td>Increase the current limit - but DO NOT exceed the specifications of the TEC or heater.</td></tr>
<tr><td>The controller may not have sufficient compliance voltage to drive the TEC or heater</td><td>Increase the power supply voltage; be certain to verify that the controller is within the Safe Operating Area with Wavelength’s Temperature Controller SOA calculator: www.teamwavelength.com/support/design-tools/soa-tc-calculator/</td></tr>
<tr><td>The sensor may not have good contact with the heatsink and load</td><td>Use thermal paste or washers between the load / TEC and the TEC / heatsink interfaces. Contact the thermoelectric manufacturer for their recommended mounting methods.</td></tr>
</table>

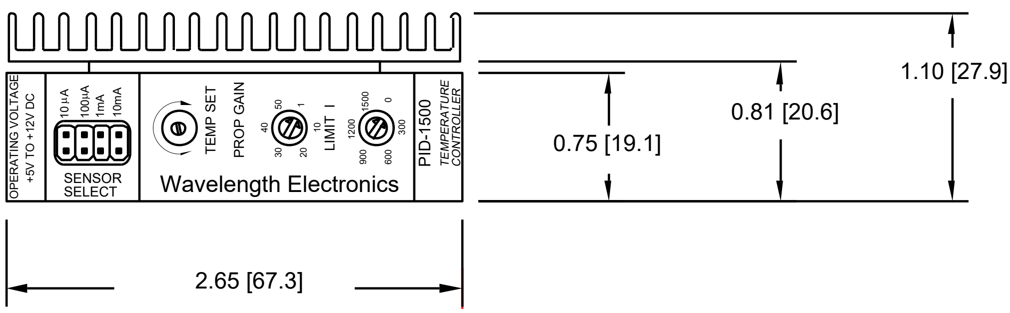
TROUBLESHOOTING, CONTINUED

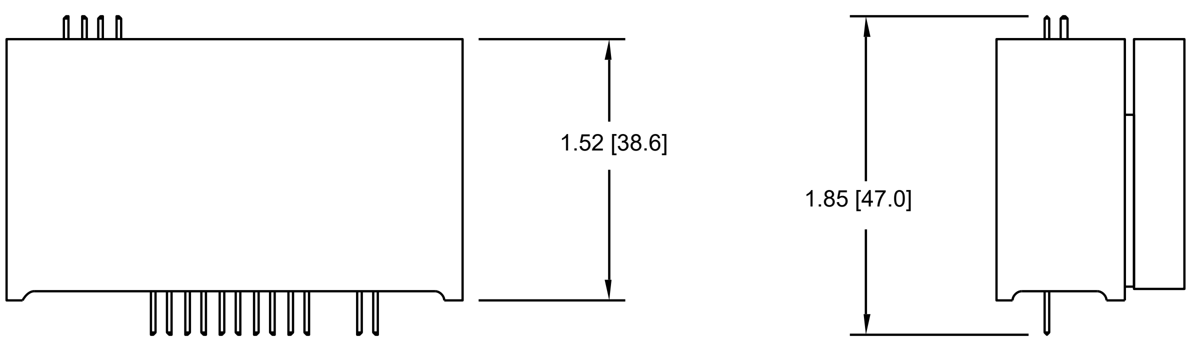
Temperature is slow to stabilize and is not within the specifications using Resistive Heaters	Setpoint temperature is set close to the ambient temperature	Set the temperature at least 10ºC above ambient when using a resistive heater. A resistive heater is unable to precisely maintain temperatures near ambient because once the temperature overshoots the setpoint, the controller turns off and relies on ambient temperature to cool the load. If setting the temperature 10ºC or more above ambient is not possible, then choose a thermoelectric controller, which can alternately heat and cool the load to maintain a more precise setpoint temperature.

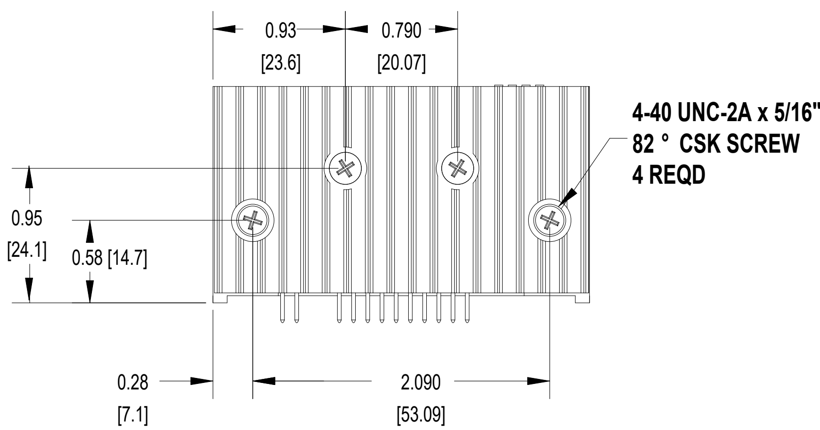
MECHANICAL SPECIFICATIONS – PID-1500

All dimensions are inches [mm]
All dimensions are ±5%



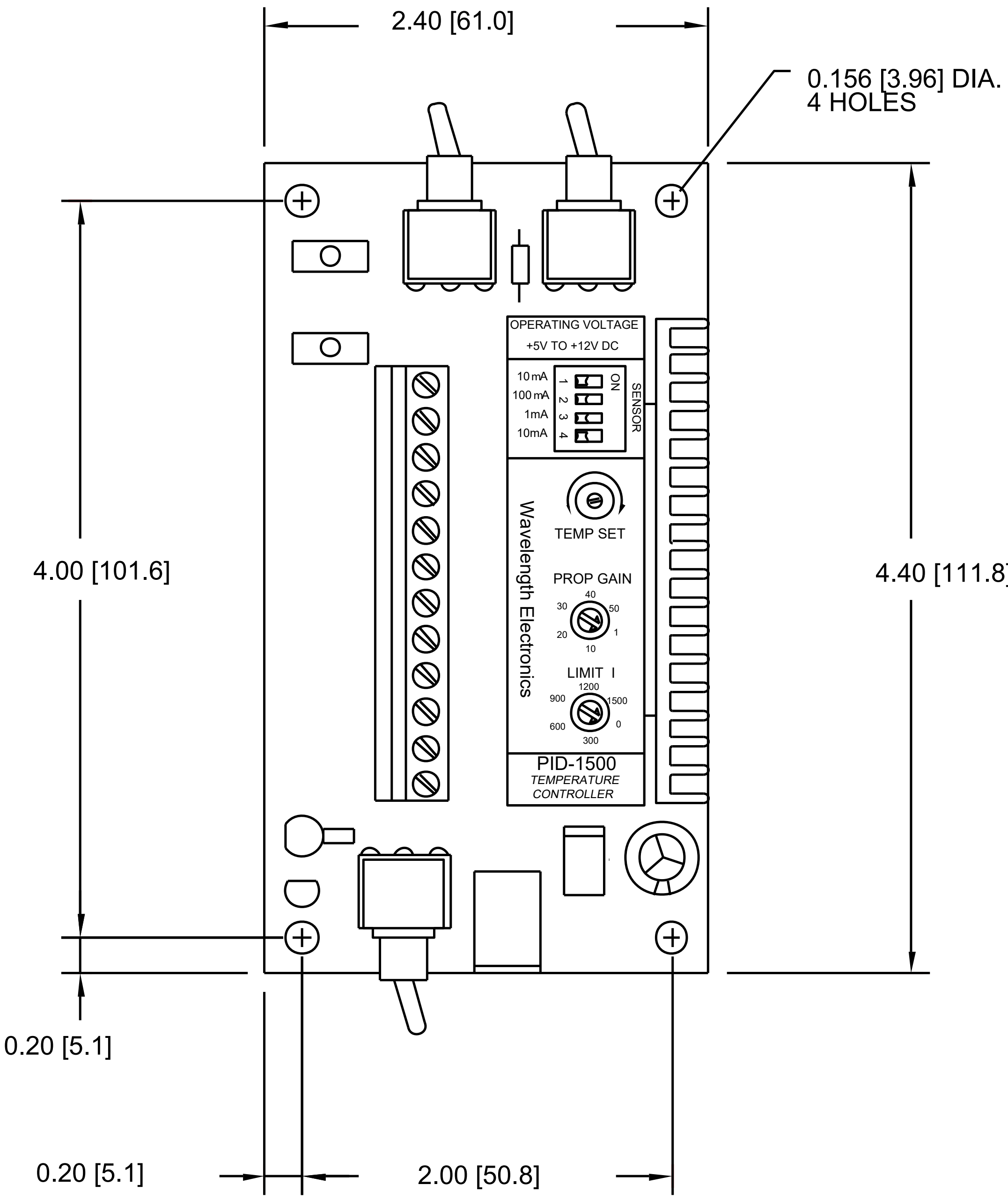






MECHANICAL SPECIFICATIONS – PIDEVALPCB

All dimensions are inches [mm]
All dimensions are ±5%



CERTIFICATION AND WARRANTY

CERTIFICATION
Wavelength Electronics, Inc. (Wavelength) certifies that this product met its published specifications at the time of shipment. Wavelength further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, to the extent allowed by that organization's calibration facilities, and to the calibration facilities of other International Standards Organization members.

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For warranty service or repair, this product must be returned to the factory. An RMA is required for products returned to Wavelength for warranty service. The Buyer shall prepay shipping charges to Wavelength and Wavelength shall pay shipping charges to return the product to the Buyer upon determination of defective materials or workmanship. However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to Wavelength from another country.

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REVISION HISTORY
DOCUMENT NUMBER: PID-1500-00400

REV.	DATE	CHANGE
J	Sept. 2010	Added detail to mechanical drawings
K	Apr. 2011	Updated torque specifications
L	Feb. 2013	Updated Max Bipolar Output Current specification
M	May 2021	Updated to new format

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