



PID-1500

Thermoelectric & Resistive Heater
Plug-n-Play Temperature Controller

GENERAL DESCRIPTION:

The PID-1500 Linear Bipolar, Thermoelectric Temperature Controller provides ultra-stable, low noise temperature control from a single output DC supply. 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. All inputs and outputs are accessed via a single 14-pin header on the base. These pins provide easy access for DC supply input, sensor, thermoelectrics or resistive heaters, external control, and measurements with an external voltmeter.

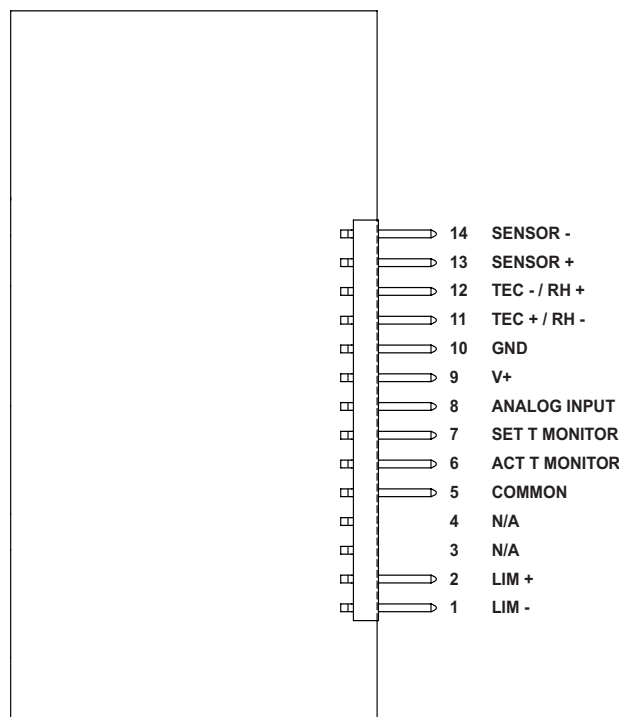
The rugged, compact design can be used in many environments and has a -20°C to +85°C operating range. The integral heatsink can be removed to mount the module to a system chassis.



FEATURES:

- Single supply operation: +5 V to +12 V
- Up to 1.5 A output current available
- < 0.005 °C stability (24-hour)
- Adjustable current limit
- Remote Analog Input to adjust Temperature Setpoint
- Supports Thermistors, IC Sensors, or RTDs
- Temperature Setpoint, Proportional Gain, and Current Limit are user adjustable
- Remotely Enable/Disable output
- Can be modified for Resistive Heater control

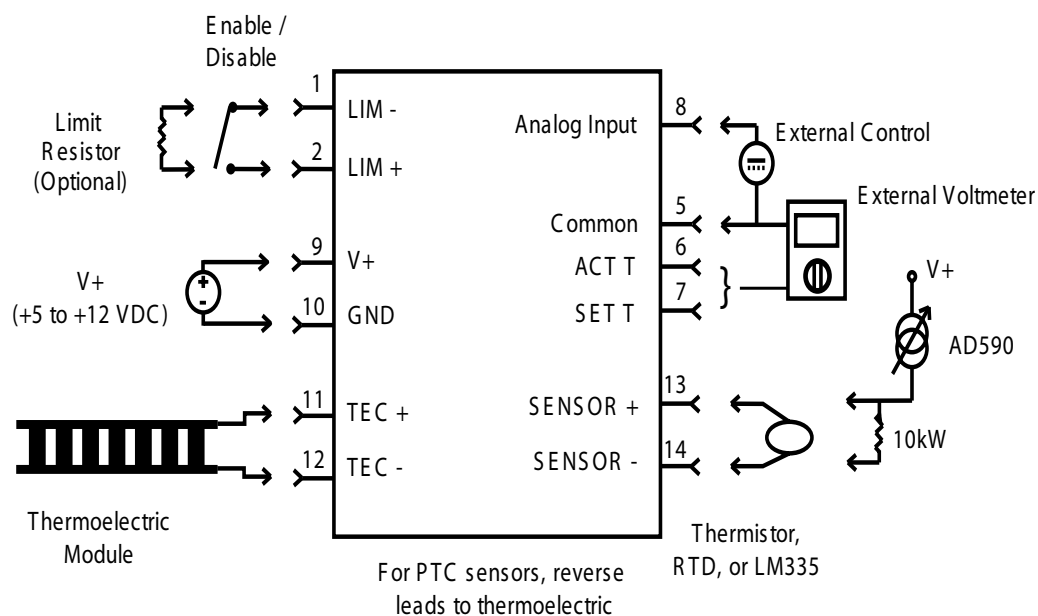
Figure 1
Pin Descriptions



QUICK START

EXTERNAL CONNECTIONS

The following is a sketch of the components required for operation of the PID-1500, and a rough connection diagram. The PIN DESCRIPTION section contains much greater detail. Please review the entire manual before operating your thermoelectric with the PID-1500.



OPTIMIZE YOUR PID-1500

POWER SUPPLY AND NOISE

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 PIDPCB evaluation kit plus the PWRPAK-5V +5V table top regulated switching power supply for easy initial operation.

ELECTRICAL SPECIFICATIONS -- THERMOELECTRICS

GENERAL SPECIFICATIONS DESCRIPTION	SYMBOL	VALUE	UNIT
Power Requirements [1]	V_{DD}	+5 to +12	Volts DC
Supply Current		PID Limit Current plus 100	mA
Operating Temperature	T_{OPR}	-20 to +85	°C
Storage Temperature	T_{STG}	-40 to +85	°C
Size		1.52 x 1.10 x 2.65	inches
		39 x 28 x 67	mm
Weight		4	ounces
Warm-up Time to rated accuracy		1	hour
TEMPERATURE CONTROL			
Temperature Control Range [2]		Range is sensor dependent	°C
Short Term Stability, 1 hour [3]		< 0.003	°C
Long Term Stability, 24 hours [3]		< 0.005	°C
OUTPUT			
Bipolar Output Current		± 1.5	Amps
Compliance Voltage		See note [4]	
Maximum Output Power		12	Watts
Maximum Internal Power Dissipation		9	Watts
Current Limit Range		0-1500	mA
Control Loop		PI	
Proportional Gain, adjustable		1-50	
Integrator Time Constant, fixed		1	seconds
TEMPERATURE SENSOR TYPES			
Thermistor Types, 2-wire		NTC	
Sensor Bias Currents		0.01, 0.100, 1.0 and 10.0	mA
Thermistor Range		1-500	k Ω
IC Sensor Types [5]		AD590, LM335	
IC Sensor Bias (LM335)		1	mA
RTD Types, 2-wire		100-1000	Ω
ANALOG INPUT TRANSFER FUNCTION		1.3 / 1	Volts
SET T versus ACT T Accuracy		< 1	%

[1] +12.5 V MAXIMUM

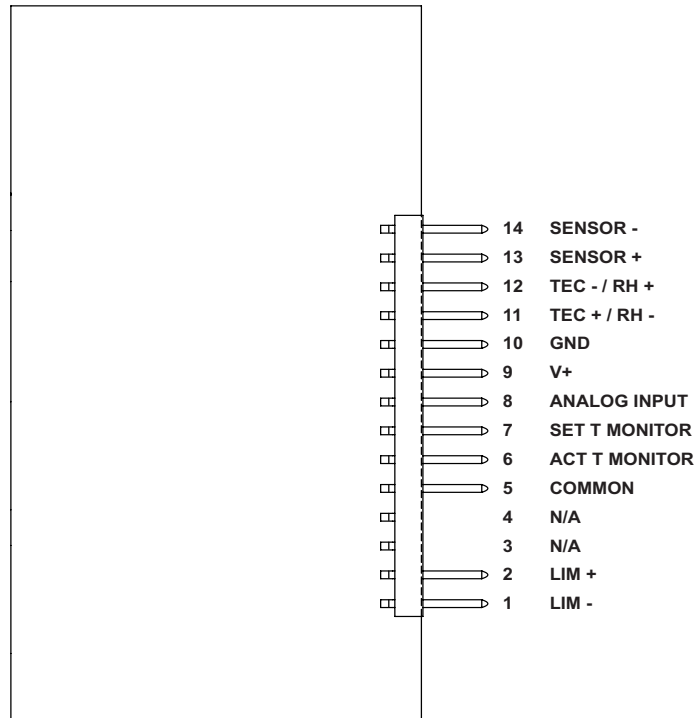
[2] Temperature range depends on the physical load, sensor type, and TE module used.

[3] Stability quoted for a typical 10 k Ω thermistor at 100 μ A sensing current.

[4] Compliance Voltage varies with power supply voltage. A maximum compliance voltage of ± 10.5 V will be obtained with a +12 V input. A minimum compliance voltage of ± 4 V will be obtained with +5 V input. 5V operation will limit the Setpoint Voltage to 2.5-3.5 V, thus limiting the temperature range of the PID-1500.

[5] AD590 requires an external bias voltage and 10 k Ω sense resistor.

PIN DESCRIPTIONS



CAUTION: If you are operating the PID-1500 from a +5V supply voltage, the setpoint monitor voltage will be less than 5V (2.5-3.5 V), limiting the temperature range of the PID-1500.

PINS 1 & 2 LIM- & LIM+

These pins can be used to enable or disable the PID-1500 output using a simple SPST switch. The maximum output current can also be fixed by placing a resistor across these pins.

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. (*Reference page 9 for Resistive Heaters.*)

For thermoelectrics:

$$\text{MAX TE I} = \left(\frac{45.9375 \cdot R}{200 + 30 \cdot R} \right) \text{ Amps}$$

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

$$R = \left(\frac{200 \cdot I_{\text{TEMAX}}}{45.9375 - 30 \cdot I_{\text{TEMAX}}} \right) \text{ k}\Omega$$

PINS 3 & 4 Not Used

PIN 5 Common

This is a low current return for pins 6, 7, and 8 only. This pin provides ground potential to be used with the monitor outputs and analog input (pins 6, 7, 8). This ground is internally started with the circuit ground to provide the most accurate monitor measurement. Internally, it is connected to pin 10.

PIN 6 ACT T Monitor

This output and pin 5 are used to monitor the voltage, and therefore the actual temperature of the sensor. The ACT T MONITOR voltage will closely match the voltage set at pin 7 (SET T MONITOR) by the 12-turn TEMP SET trimpot.

PIN 7 SET T Monitor

This output and pin 5 are 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.

PIN DESCRIPTIONS -- continued

PIN 8 Analog Input

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

PIN 9 V+ (+5V to +12 VDC, +12.5 VDC MAXIMUM)

This pin along with pin 10 (GND) provides power to the control electronics and the thermoelectric output.

PIN 10 GND

This pin along with pin 9 (+V) provides power to the control electronics and the thermoelectric output.

PINS 11&12 TEC+ (RH-) & TEC- (RH+)

These pins source the control current to the thermoelectric or resistive heater load.

PIN 13 Sensor +

This pin is used to source the thermistor, IC sensor, or RTD reference current through the temperature sensor. The Sensor Select switch on the top will select between a 10 μ A, 100 μ A, 1 mA, or 10 mA reference current. Selection of the proper reference current will allow the optimal temperature range of the sensor selected.

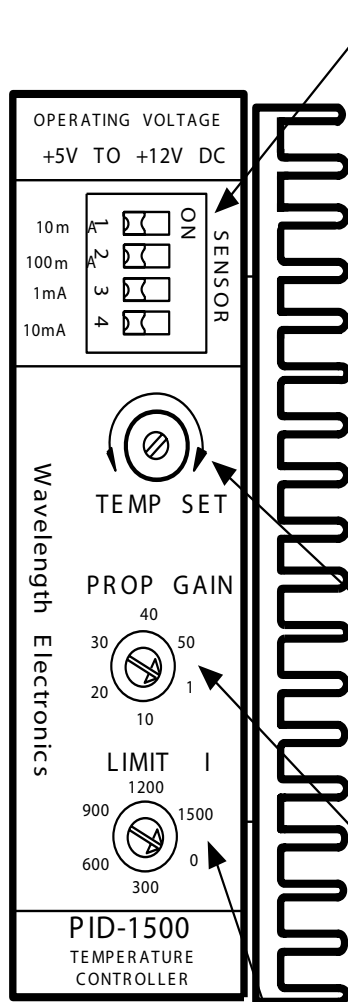
PIN 14 Sensor -

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 +5V supply voltage, the output compliance voltage will be less than $\pm 5V$ (± 2.5 to ± 3.5 V), limiting the output power of the PID-1500. (See also page 9, *Operating Instructions -- Resistive Heaters.*)

PID-1500 TOP VIEW ADJUSTMENT DESCRIPTIONS



SENSOR SELECT

This switch selects the appropriate current for the sensor used with the PID-1500. The sensor output currents can be 10 mA, 100 mA, 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 V and 5 V in order to be used in the control loop. The 10 mA and 100 mA ranges are used with thermistors. The 1 mA range is used with the LM335 IC sensor and 500 or 1000 W RTDs. The 10 mA range is used with 100 or 200 W RTDs for higher sensitivities. For AD590s, set all switches to OFF and make the connections shown in the Quick Start Section [pg. 3].

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 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 (I_{MAX}) before power is applied to the PID-1500. Turning the trimpot clockwise increases the maximum output current from 0 to 1.5 Amps when configured for thermoelectrics. 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.

OPERATING INSTRUCTIONS THERMOELECTRICS

1. CONNECT DC POWER, SENSORS, & THERMOELECTRIC MODULE

Power (Pins 9 & 10)

The PID-1500 operates from a single +5 to +12 V power supply. 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 (TE current limit setting plus 100 mA) for the requirements of the load and control circuitry.

Sensor (Pins 13 & 14)

Epoxy or otherwise affix the temperature sensor to the device being cooled or heated in your application. 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.

Thermistors require 10 μ A or 100 μ A. Use the LM335 with the 1 mA setting. 500 and 1000 Ω RTDs also require the 1 mA setting. 100 and 200 Ω RTDs require the 10 mA setting for added sensitivity. When connecting the AD590, place a 10 k Ω metal film resistor across pins 13 and 14 and apply V+ to the sensor as shown in the Quick Start diagram (page 2). Set all switches to OFF when using the AD590 sensor.

Thermoelectric Module or Resistive Heater (Pins 11 & 12)

Connect the thermoelectric module or resistive heater to pins 11 and 12. Ensure that the thermoelectrics are adequately connected to a heatsink. Properly transferring heat from the thermoelectric device is absolutely necessary for stable temperature control. Ensure that the heatsink is rated to remove the heat generated by the temperature load and thermoelectric. 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.

2. SET CURRENT LIMIT, OPERATING TEMPERATURE, & PROPORTIONAL GAIN

Current Limit Adjust

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 amps when configured for thermoelectrics. 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+).

OPERATING INSTRUCTIONS -- continued THERMOELECTRICS

Temp Setpoint Adjust (Monitor with Pins 7 and 5)

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

$$V_{\text{SETPOINT}} = I_{\text{BIAS}} \times R$$

(I_{BIAS} in amps, R in Ω),

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

LM335 & AD590

$$V_{\text{SETPOINT}} = 2.730 + (0.010\text{V}/^{\circ}\text{C} \times T_{\text{DESIRED}})$$

(in volts),

where T_{DESIRED} is the setpoint temperature in $^{\circ}\text{C}$.

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

Analog Input (Pins 8 and 5)

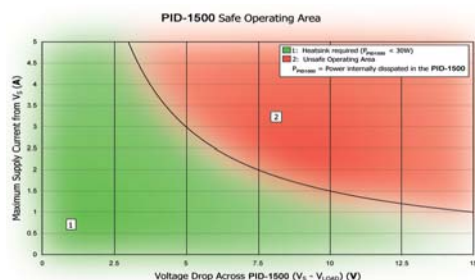
This input and pin 5 are used to control the temperature setpoint remotely. The control voltage input range is 0 volts to +5V and the input sums directly with the TEMP SET trimpot. The transfer function for this input is 1.3V / 1V. (Input maximum is V+.)

Proportional Gain

The factory setting for the proportional gain is 33. This gain can be adjusted from 1 to 50 to optimize the system for overshoot and settling time. Turning this potentiometer clockwise increases the gain and dampens the output. When adjusting the proportional gain, it is recommended to disable the PID-1500 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 PID control loop.

Cooling the PID-1500 Heatsink

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's heatsink at an acceptable temperature. Measure the PID-1500 heatsink temperature. If the temperature exceeds 75 $^{\circ}\text{C}$, then use a fan to cool the PID-1500.



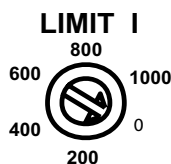
CAUTION: To operate this controller safely, use the Safe Operating Area design tool online at:
www.teamwavelength.com

OPERATING INSTRUCTIONS RESISTIVE HEATERS

The PID-1500 can be configured to operate with resistive heaters. When configured for this mode, only thermistor temperature sensors (or NTC) can be used. The limit current is reduced to 1 amp in this mode of operation.

To limit the output current with a fixed resistor --
The LIMIT I trimpot should be turned fully clockwise 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 resistive heaters can be calculated given the following equations:

Calibrate the LIMIT I trimpot range to the following scale:



$$\text{MAX RH I} = \left(\frac{30.625 \cdot R}{200 + 30 \cdot R} \right) \text{ Amps}$$

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

$$R = \left(\frac{200 \cdot I_{RH \text{ MAX}}}{30.625 - 30 \cdot I_{RH \text{ MAX}}} \right) \text{ k}\Omega$$

Please contact the factory if voltage operation of greater than +12 V is necessary.

ELECTRICAL SPECIFICATIONS -- RESISTIVE HEATERS

GENERAL SPECIFICATIONS DESCRIPTION	SYMBOL	VALUE	UNIT
Power Requirements [1]	V _{DD}	+5 to +12	Volts DC
Supply Current		PID Limit Current plus 100	mA
Operating Temperature	T _{OPR}	-20 to +85	°C
Storage Temperature	T _{STG}	-40 to +85	°C
Size		1.52 x 1.10 x 2.65 39 x 28 x 67	inches mm
Weight		4	ounces
Warm-up Time to rated accuracy		1	hour
TEMPERATURE CONTROL			
Temperature Control Range [2]		(ambient+10) to +250	°C
Short Term Stability, 1 hour [3]		< 0.003	°C
Long Term Stability, 24 hours [3]		< 0.005	°C
OUTPUT			
Bipolar Output Current		± 1.5	Amps
Compliance Voltage		See note [4]	
Maximum Output Power		12	Watts
Maximum Internal Power Dissipation		9	Watts
Current Limit Range		0-1500	mA
Control Loop		PI	
Proportional Gain, adjustable		1-50	
Integrator Time Constant, fixed		1	seconds
TEMPERATURE SENSOR TYPES			
Thermistor Types, 2-wire		NTC	
Sensor Bias Currents		0.01, 0.1, 1.0 and 10.0	mA
Thermistor Range		1-500	kΩ
IC Sensor Types [5]		AD590, LM335	
IC Sensor Bias (LM335)		1	mA
RTD Types, 2-wire		100-1000	Ω
ANALOG INPUT TRANSFER FUNCTION			
SET T versus ACT T Accuracy		< 1	%

[1] +12.5 V MAXIMUM

[2] Temperature range depends on the physical load, sensor type, and TE module used.

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

[4] Compliance Voltage varies with power supply voltage. A maximum compliance voltage of ± 10.5 V will be obtained with a +12 V input. A minimum compliance voltage of ± 4 V will be obtained with +5 V input. 5V operation will limit the Setpoint Voltage to 2.5-3.5 V, thus limiting the temperature range of the PID-1500.

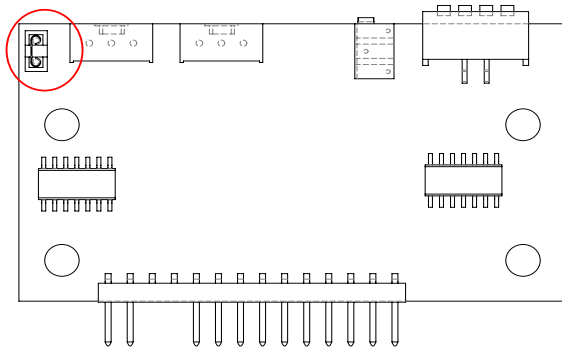
[5] AD590 requires an external bias voltage and 10 kΩ sense resistor.

OPERATING INSTRUCTIONS RESISTIVE HEATERS

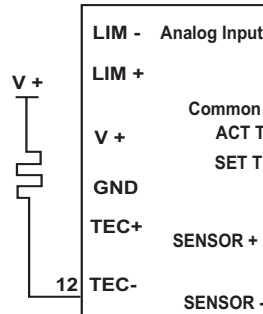
THIS DATASHEET APPLIES TO REVISIONS C AND LATER.

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

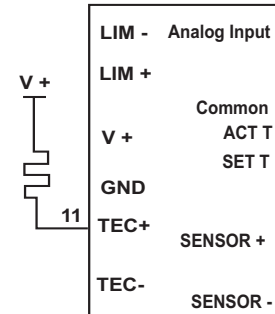
Remove Jumper JP1 for unipolar operation with resistive heaters:



Connect Resistive Heater to pin 12 & V+ when using PTC Sensor



Connect Resistive Heater to pin 11 & V+ when using NTC Sensor



The diagram above illustrates the wiring for resistive heaters based on the type of sensor used. Much more detail is included in the PIN DESCRIPTION section. Please review the entire manual before operating your resistive heater with the PID-1500.

REVISION B EXCEPTIONS

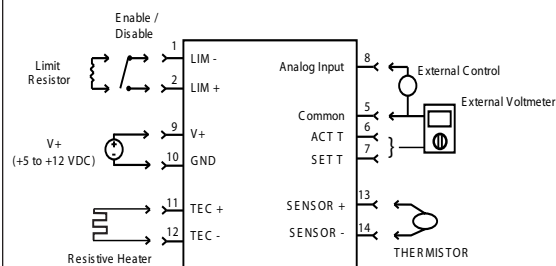
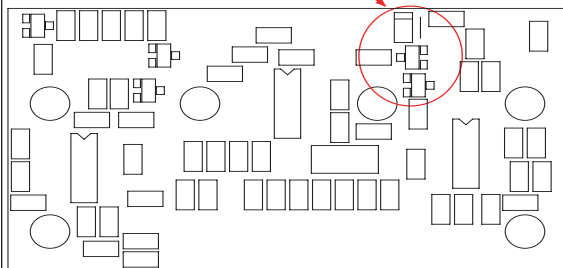
THE PARAGRAPHS BELOW DESCRIBE FEATURES FOR REVISIONS A & B.

ELECTRICAL SPECIFICATIONS -- THERMOELECTRICS & RESISTIVE HEATERS

Short Term Stability, 1-hour < 0.005 °C
Long Term Stability, 24-hour < 0.008 °C

Compliance Voltage will vary depending on power supply voltage. A maximum compliance voltage of ± 8V will be obtained with a +12V input. A minimum compliance voltage of ± 2.0V will be obtained with +5V input. 5V operation will limit the Setpoint Voltage to 2.5-3.5V, thus limiting the temperature range of the PID-1500.

RESISTIVE HEATER QUICK START



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 at left. Reassemble the electronics in the enclosure and attach the heatsink to the mount.

The lower sketch illustrates the components required to operate the PID-1500 with resistive heaters, and a rough connection diagram. Much more detail is included in the PIN DESCRIPTIONS section. Please review the entire manual before operating your resistive heater with the PID-1500.

OPERATING INSTRUCTIONS PIDPCB with PWRPAK-5V

Monitor Setpoint and Actual Temperature: These can be monitored via the screw lock connector (SET T & ACT T) or a DVM can be connected to these two monitor jacks and the switch used to choose between Actual & Setpoint Temperature

Output Enable / Disable: Even if DC power is applied, the output current can only be enabled by setting this switch to the | position
Enable = |
Disabled = 0

If providing your own DC power, use pins 9 and 10 on the screw lock connector

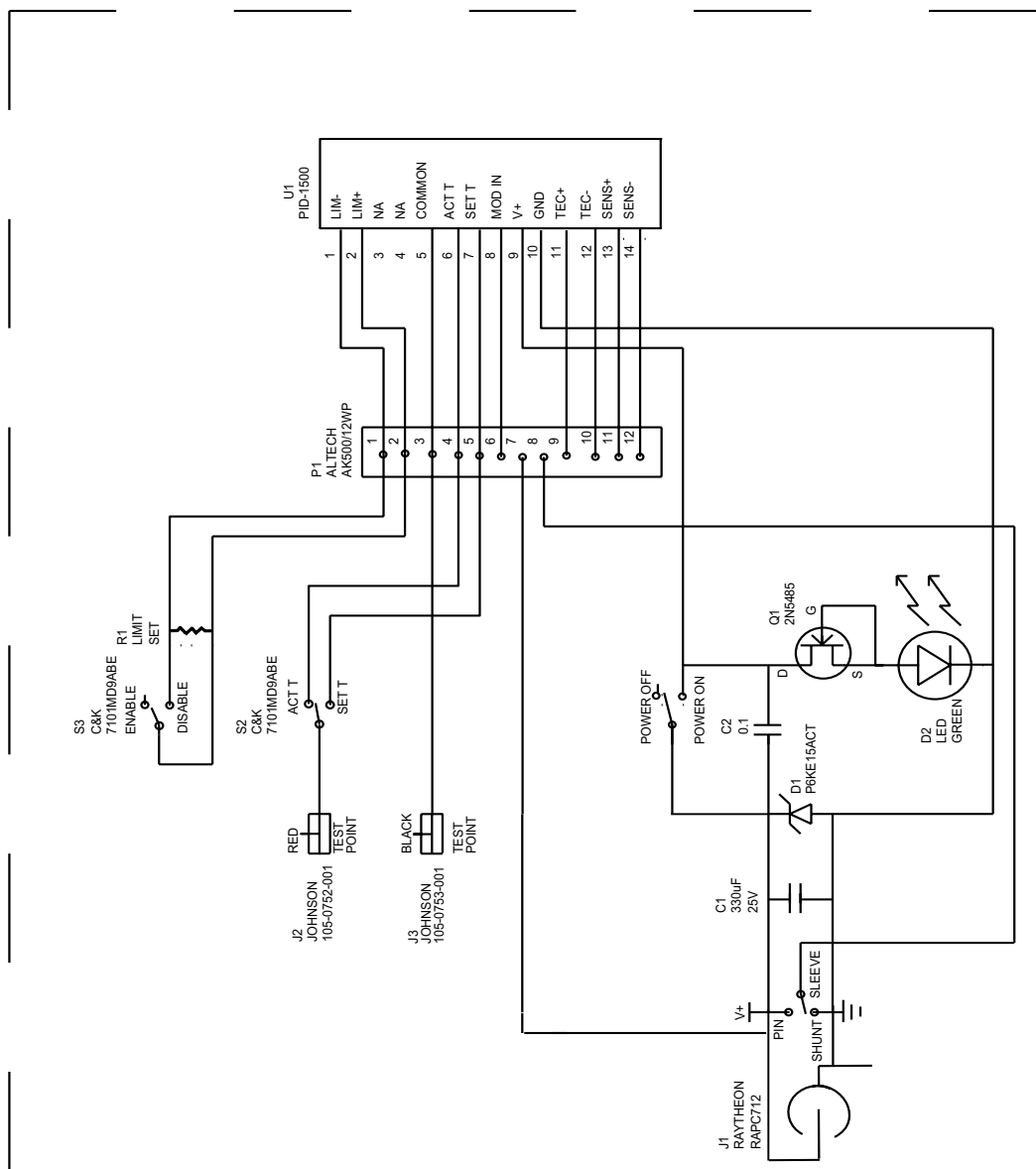
We recommend 22 AWG wire minimum for connections to the screw lock connector.

The GREEN LED will light when DC power is applied

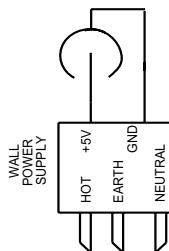
DC Power: This switch applies DC power to the PID-1500. Note that if the output is not also enabled, no output current will flow.

DC Power Input: Two inputs are available. If using a 2.5mm circular connector (such as provided with the POWERPAK-5V) use the DC input next to the Power Switch

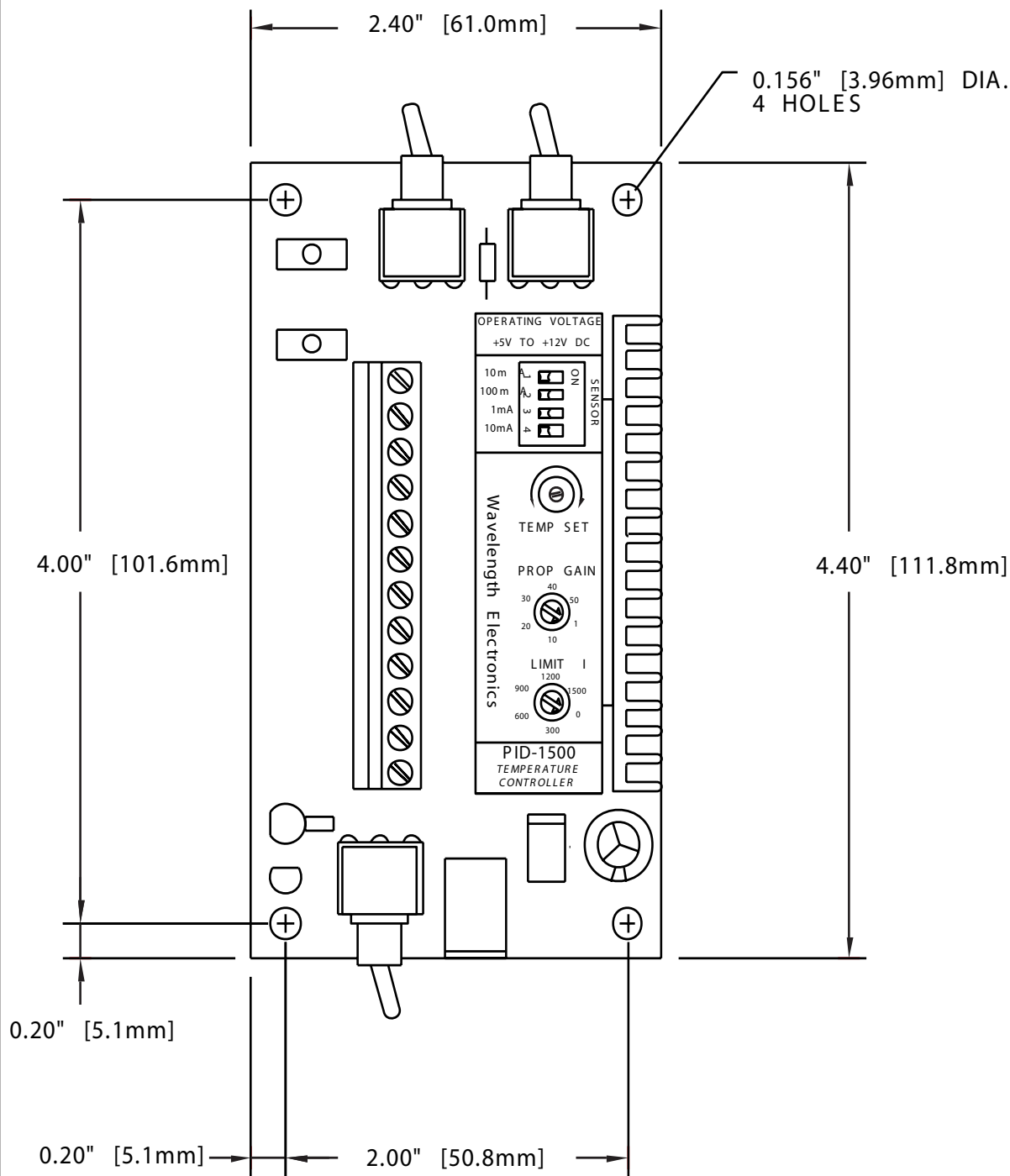
OPERATING INSTRUCTIONS -- PIDPCB EVALUATION BOARD SCHEMATIC



PWRPAK-5V



MECHANICAL DIMENSIONS

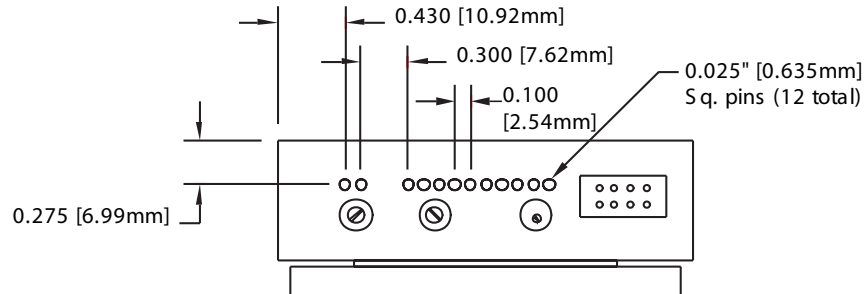


All tolerances are $\pm 5\%$.

MECHANICAL DIMENSIONS

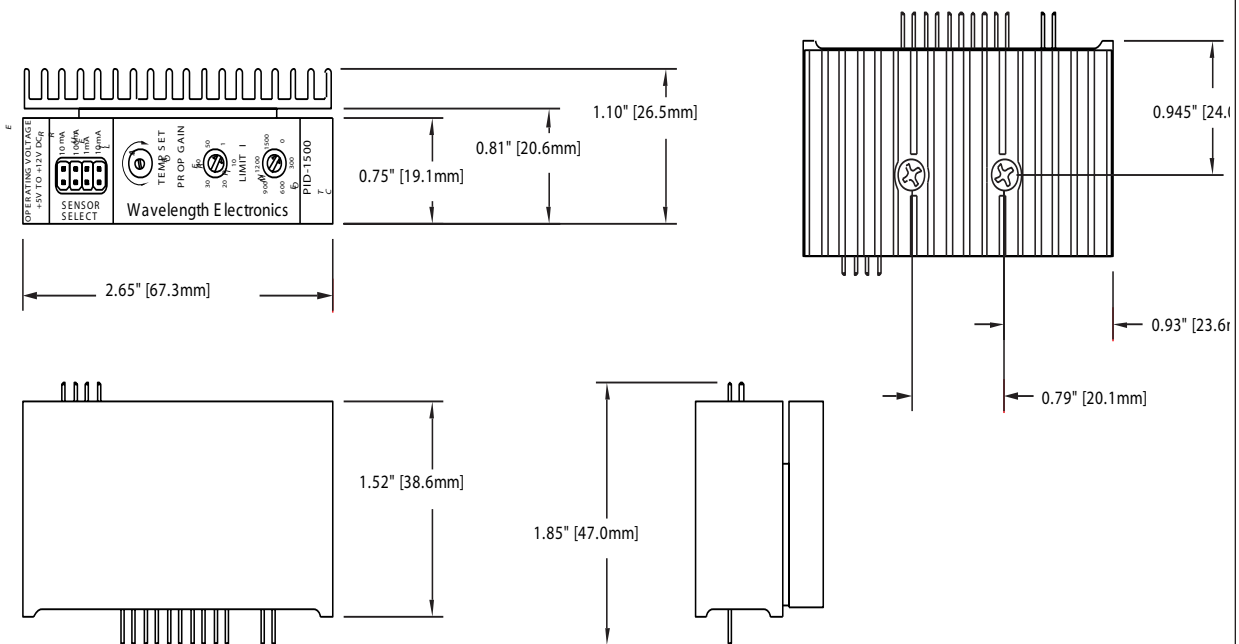
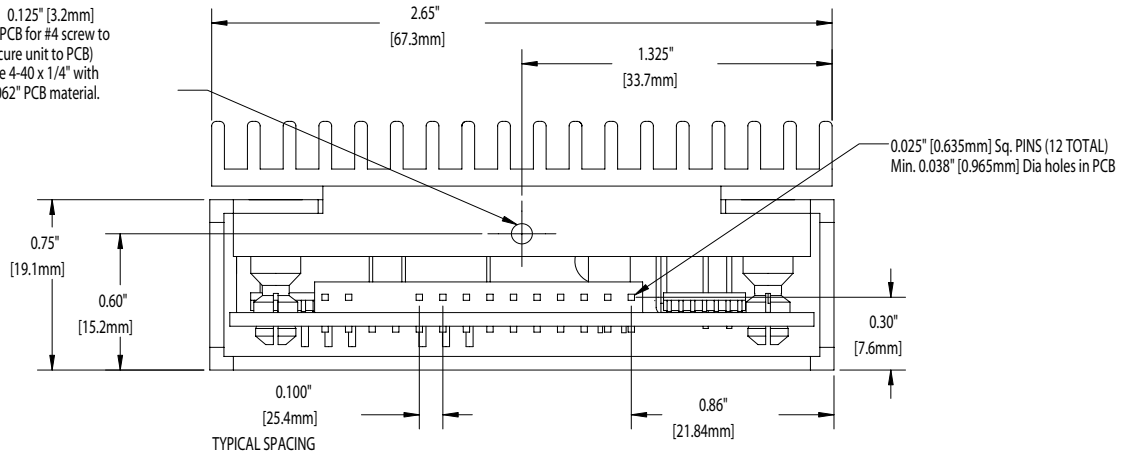
PCB LAYOUT PATTERN -- TOP VIEW

PCB LAYOUT PATTERN - TOP VIEW



PCB LAYOUT PATTERN -- BOTTOM VIEW

Ø 0.125" [3.2mm]
(in PCB for #4 screw to secure unit to PCB)
Use 4-40 x 1/4" with 0.062" PCB material.



All tolerances are ± 5%.

CERTIFICATION:

Wavelength Electronics (WEI) certifies that this product met it's 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.

WARRANTY:

This Wavelength product is warranted against defects in materials and workmanship for a period of 90 days from date of shipment. During the warranty period, Wavelength will, at its option, either repair or replace products which prove to be defective.

WARRANTY SERVICE:

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.

LIMITATIONS OF WARRANTY:

The warranty shall not apply to defects resulting from improper use or misuse of the product or operation outside published specifications.

No other warranty is expressed or implied. Wavelength specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

EXCLUSIVE REMEDIES:

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

APPLICABLE PID1500 REVISIONS

This Datasheet applies to PID1500 Rev C and higher. Revision is indicated in the third digit of the lot number of the unit.
 Example: 00C081001 = Rev C.
 Paragraphs applicable to earlier revisions are indicated in the text.

NOTICE:

The information contained in this document is subject to change without notice. Wavelength will not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material. No part of this document may be photocopied, reproduced, or translated to another language without the prior written consent of Wavelength.

SAFETY:

There are no user serviceable parts inside this product. Return the product to Wavelength Electronics for service and repair to ensure that safety features are maintained.

LIFE SUPPORT POLICY:

As a general policy, Wavelength Electronics, Inc. does not recommend the use of any of its products in life support applications where the failure or malfunction of the Wavelength Electronics, Inc. product can be reasonably expected to cause failure of the life support device or to significantly affect its safety or effectiveness. Wavelength Electronics, Inc. will not knowingly sell its products for use in such applications unless it receives written assurances satisfactory to Wavelength Electronics, Inc. that the risks of injury or damage have been minimized, the customer assumes all such risks, and there is no product liability for Wavelength Electronics, Inc. Examples of devices considered to be life support devices are neonatal oxygen analyzers, nerve stimulators (for any use), auto transfusion devices, blood pumps, defibrillators, arrhythmia detectors and alarms, pacemakers, hemodialysis systems, peritoneal dialysis systems, ventilators of all types, and infusion pumps as well as other devices designated as "critical" by the FDA. The above are representative examples only and are not intended to be conclusive or exclusive of any other life support device.

REVISION HISTORY		
REVISION	DATE	NOTES
REV. F	27-Dec-00	Initial release
REV. H	21-Nov-03	Updated to coincide with product configuration C upgrade
REV. I	18-Jun-08	Added details, diagrams



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