



**WAVELENGTH
ELECTRONICS**

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 wired for Resistive Heater control



PID-1500 TEMPERATURE CONTROLLER

Figure 1
Pin Descriptions

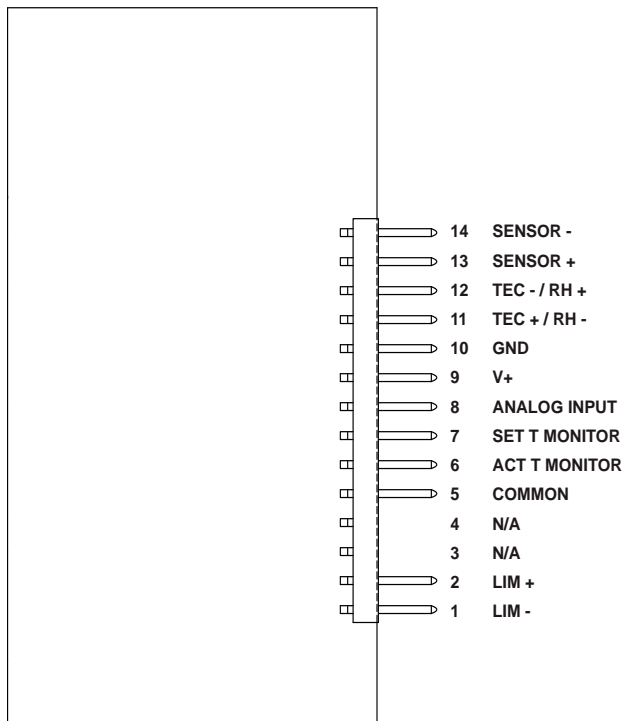
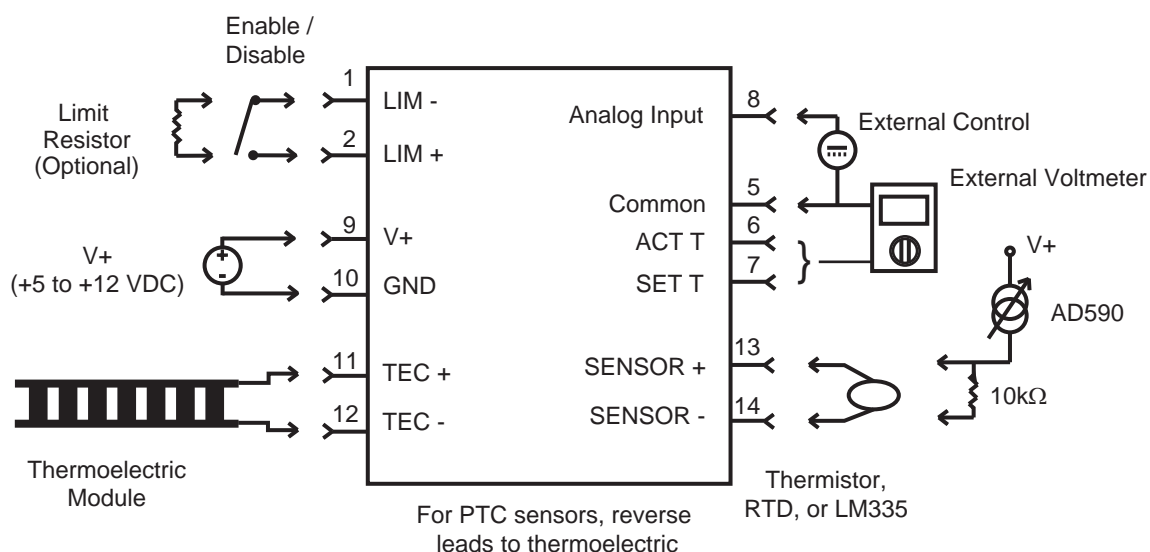


Figure 2
Quick Connect

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 datasheet before operating your thermoelectric with the PID-1500.



POWER SUPPLY & NOISE OPTIMIZATION

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 +5 V table top regulated switching power supply for easy initial operation.

ELECTRICAL AND OPERATING SPECIFICATIONS

| GENERAL SPECIFICATIONS DESCRIPTION | SYMBOL | VALUE | UNIT |
|---|---------------|------------------------------------|--------------|
| Power Requirements [1], [2] | 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 +125 | °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 [3] | | Range is sensor dependent | °C |
| Short Term Stability, 1 hour [4] | | < 0.003 | °C |
| Long Term Stability, 24 hours [4] | | < 0.005 | °C |
| OUTPUT | | | |
| Bipolar Output Current [2] | | ± 1.5 | Amps |
| Compliance Voltage | | See note [5] | |
| 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 | 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 | k Ω |
| 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 TE 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 k Ω thermistor at 100 μ A 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 k Ω sense resistor.

PIN DESCRIPTIONS

| PIN NO. | PIN NAME | DESCRIPTION | FUNCTION |
|---------|--------------|--|--|
| 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 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. |
| 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. |

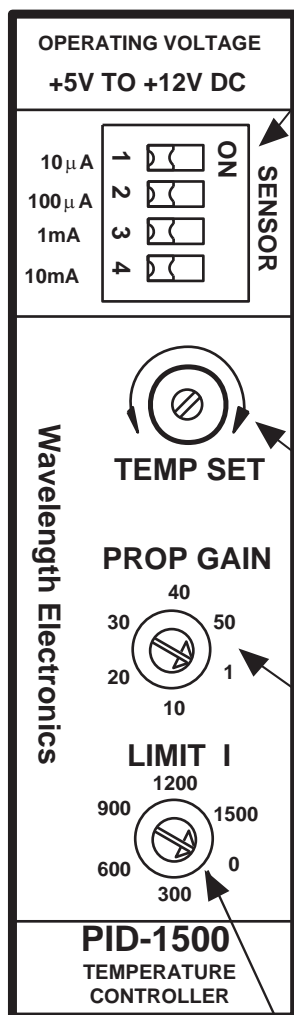


CAUTION: If you are operating the PID-1500 from a +5 V supply voltage, the output compliance voltage will be less than ± 5 V. A compliance voltage of ± 4 V will be obtained with +5 V input. 5 V operation will limit the setpoint voltage to 2.5-3.5 V, thus limiting the temperature range of the PID-1500.

PID-1500 TOP VIEW -- ADJUSTMENT DESCRIPTIONS

PID-1500 TEMPERATURE CONTROLLER

SELECTABLE ADJUSTMENTS



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 [pg. 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.

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).

Sensor (Pins 13 & 14)

Epoxy or otherwise affix 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.

Thermistors require 10 μ A or 100 μ A. 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 k Ω metal film resistor across pins 13 & 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.

Thermoelectric Module (Pins 11 & 12)

(Resistive Heater wiring is shown on page 8.)

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.

2. SET CURRENT LIMIT

Current Limit Adjust (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 k Ω) between pins 1 and 2, the new maximum limit current for the thermoelectric can be calculated given the following equations.

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

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

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

OPERATING INSTRUCTIONS -- THERMOELECTRICS (continued)**3. SET UP SETPOINT****Temp Setpoint Adjust
(Monitor with Pins 7 & 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 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 volts 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+.)

$$\text{MONITOR} = \text{ANALOG INPUT} \times 1.3$$

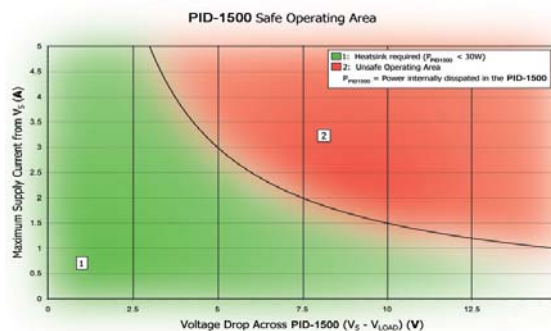
$$\text{ANALOG INPUT} = \text{MONITOR} / 1.3$$

4. SET 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. 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.

5. 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 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 at:

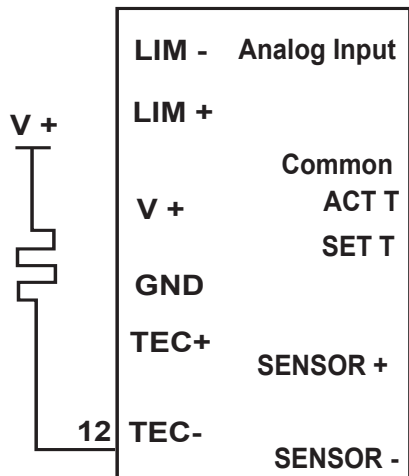
<http://www.teamwavelength.com/support/calculator/soa/soatc.php>

OPERATING INSTRUCTIONS -- RESISTIVE HEATERS

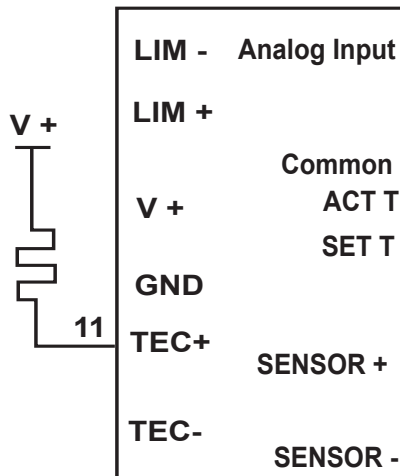
THIS DATASHEET APPLIES TO REVISIONS C AND LATER.

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

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

REVISION B DIFFERENCES

THE PARAGRAPHS BELOW DESCRIBE FEATURES FOR REVISIONS A & B.

NOTE: This assumes that the Resistive Heater is hooked between pins 11 & 12.

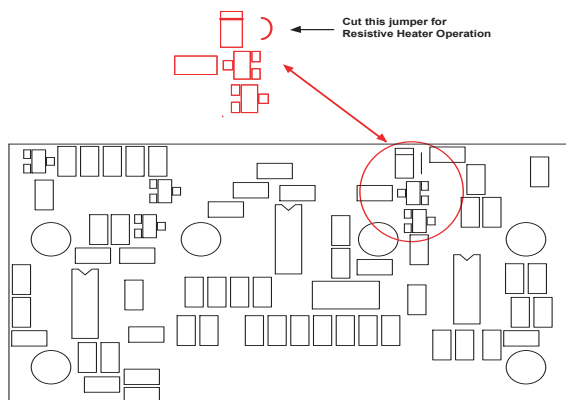
ELECTRICAL SPECIFICATIONS -- THERMOELECTRICS & RESISTIVE HEATERS

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 ± 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.

RESISTIVE HEATER QUICK START

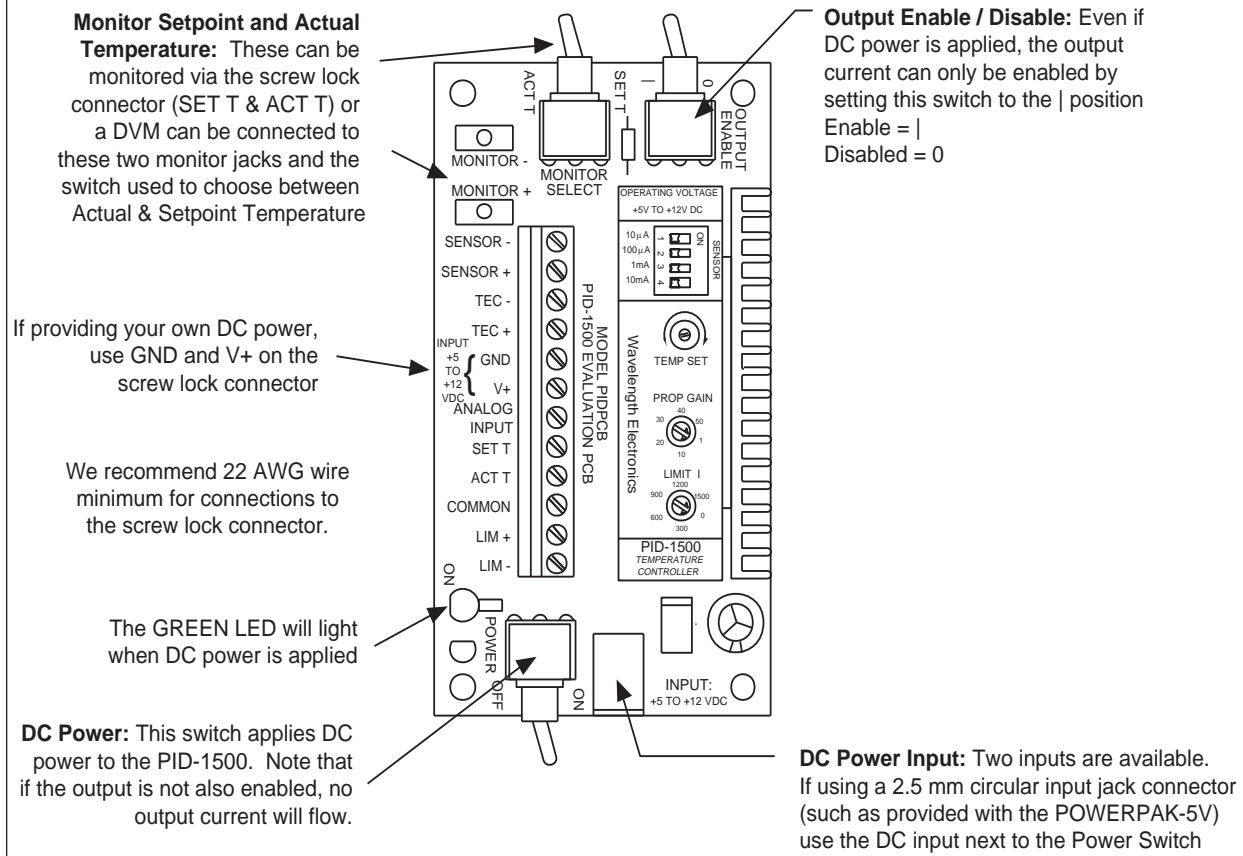


FOR UNIPOLAR OPERATION:

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.

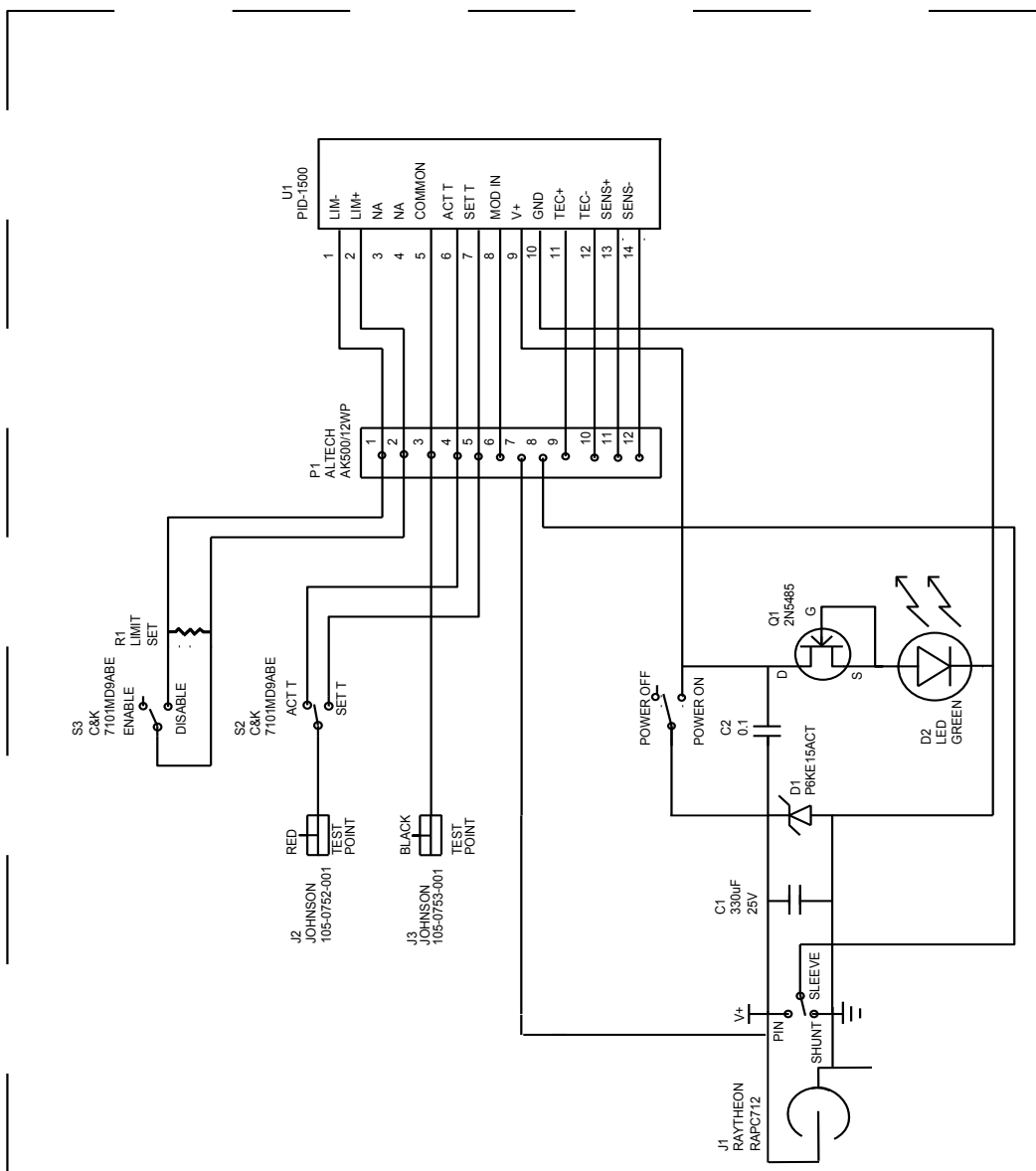
First, remove two phillips head screws that hold the PID-1500's heatsink to the internal mount. On the same side as the heatsink, notice two slotted head nylon screws. Remove these screws and gently slide the electronic assembly down and out of the plastic enclosure. With the surface mount component 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.

OPERATING INSTRUCTIONS -- PIDEVALPCB with PWRPAK-5V

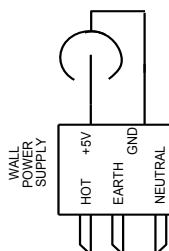


OPERATING INSTRUCTIONS -- PIDEVALPCB EVALUATION BOARD SCHEMATIC

PID-1500 TEMPERATURE CONTROLLER

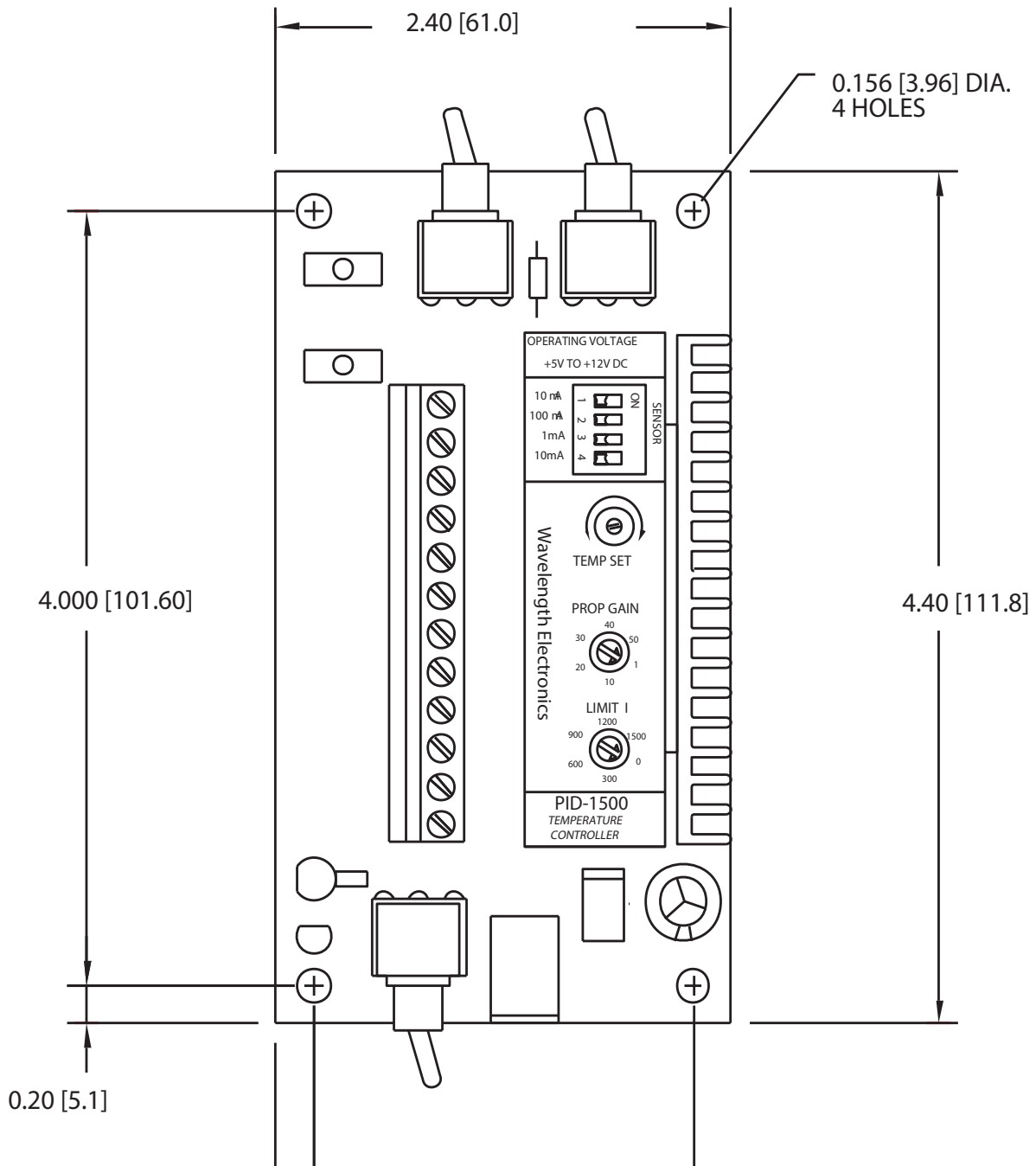


PWRPAK-5V



MECHANICAL SPECIFICATIONS -- PIDEVALPCB

PID-1500 TEMPERATURE CONTROLLER



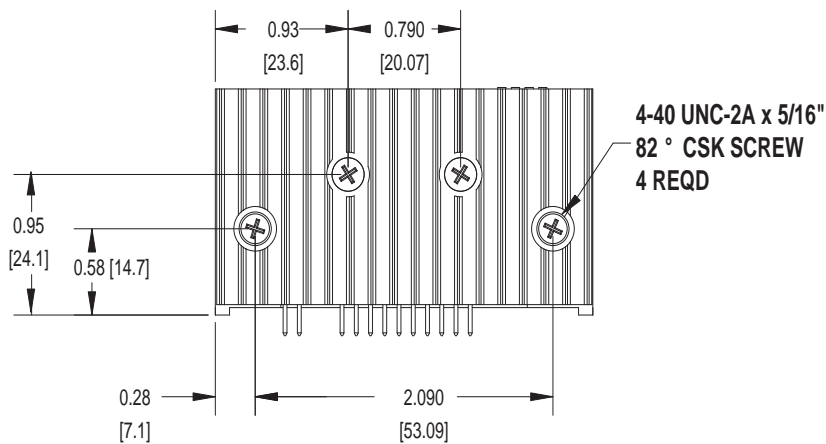
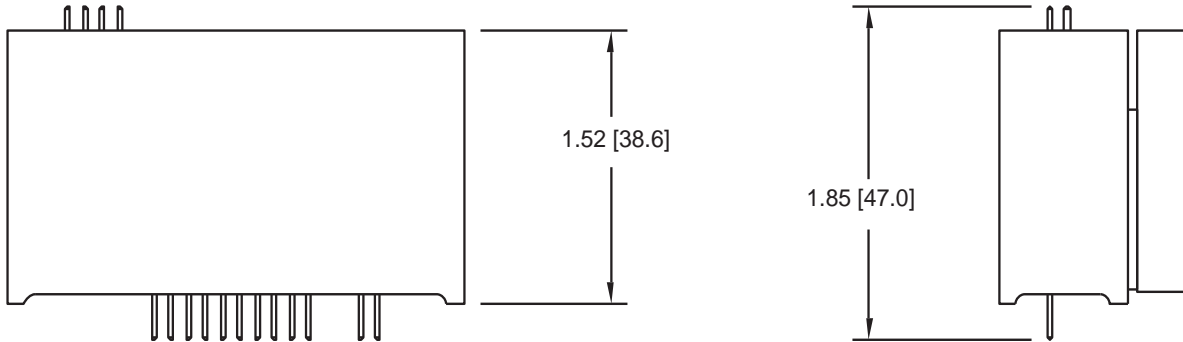
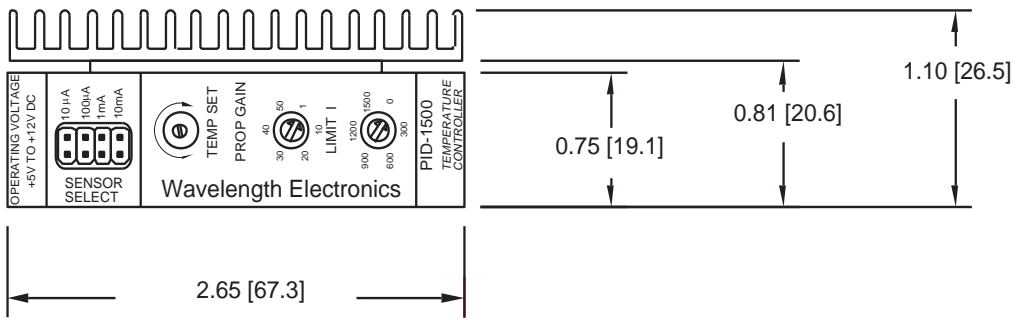
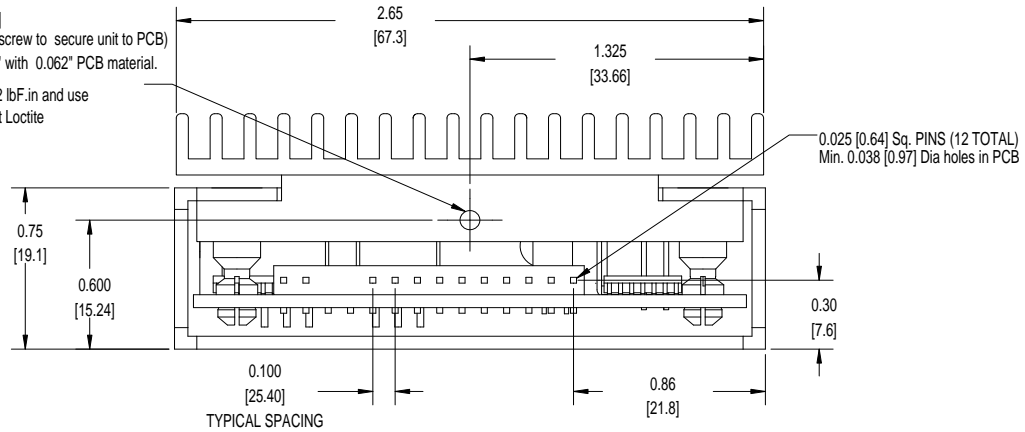
**All dimensions are inches [mm].
All tolerances are ±5 %.**

MECHANICAL SPECIFICATIONS -- PID-1500

PCB LAYOUT PATTERN -- BOTTOM VIEW

Ø 0.125 [3.18]
 (in PCB for #4 screw to secure unit to PCB)
 Use 4-40 x 1/4" with 0.062" PCB material.

Torque to 1.5-2 lbF.in and use
 non-permanent Loctite



**All dimensions are inches [mm].
 All tolerances are ±5 %.**

CERTIFICATION AND WARRANTY

CERTIFICATION:

Wavelength Electronics, Inc. (Wavelength) 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.

REVERSE ENGINEERING PROHIBITED:

Buyer, End-User, or Third-Party Reseller are expressly prohibited from reverse engineering, decompiling, or disassembling this product.



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SAFETY:

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

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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 product can be reasonably expected to cause failure of the life support device or to significantly affect its safety or effectiveness. Wavelength will not knowingly sell its products for use in such applications unless it receives written assurances satisfactory to Wavelength that the risks of injury or damage have been minimized, the customer assumes all such risks, and there is no product liability for Wavelength. 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 |
| REV. J | 13-Sep-10 | Added detail to mechanical drawing |
| REV. K | 18-Apr-11 | Updated torque spec |
| REV. L | 5-Feb-13 | Updated Max Bipolar Output Current spec |

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.