

RHM-4000

RESISTIVE HEATER CONTROLLER INSTRUCTION MANUAL

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FEATURES

The RHM-4000 Resistive Heater Controller offers many unique features. These include:

- Single supply operation: +5V to +30V
- Up to 4 Amps
- < 0.008°C stability (24 hours)
- Voltage limit
- >+ 25V compliance with +30V input
- Linear Voltage Output with Voltage Limit
- Supports Thermistors, IC sensors or RTD's
- Temperature Setpoint, Proportional Gain, and Voltage Limit are user adjustable
- PID control loop
- Two year Warranty

The RHM-4000 Precision Linear Resistive Heater Controller provides ultra-stable, low noise temperature control from a single output DC supply. Featuring a unique voltage limit function, power to the load can be limited, decreasing the temperature ramp rate and protecting sensitive components. On-board 12-turn trimpots control coarse and fine temperature setpoint, proportional gain, and heater voltage limit. A single 10 pin connector provides easy access to the DC supply, sensor, resistive heater, and measurement hookups. The rugged, compact design can be used in low pressure environments and has a 0°C to +60°C operating range. It mounts with four 4-40 screws.

CUSTOMER SERVICE & WARRANTY

Our customer service begins with product shipment. If you have any questions or comments, please call our technical staff at (406) 587-4910. Our hours are 8:00a.m. to 5:00p.m. MT.

Wavelength warrants all products for 2 years against defects in materials and workmanship when used within published specifications. This warranty extends only to purchaser and not to users of purchaser's products. If Wavelength receives written notice of such defects during the warranty period, we will either repair or replace products which prove to be defective. It is purchaser's responsibility to determine the suitability of the products ordered for it's own use. Wavelength makes no warranty concerning the fitness or suitability of its products for a particular use or purpose; therefore, purchaser should thoroughly test any product and independently conclude its satisfactory performance in purchaser's application. No other warranty exists either expressed or implied, and consequential damages are specifically excluded.

All products returned must be accompanied by a Return Material Authorization (RMA) number obtained from the Customer Service Department. Returned product will not be accepted for credit or replacement without our permission. Transportation charges or postage must be prepaid. All returned products must show invoice number and date and reason for return.

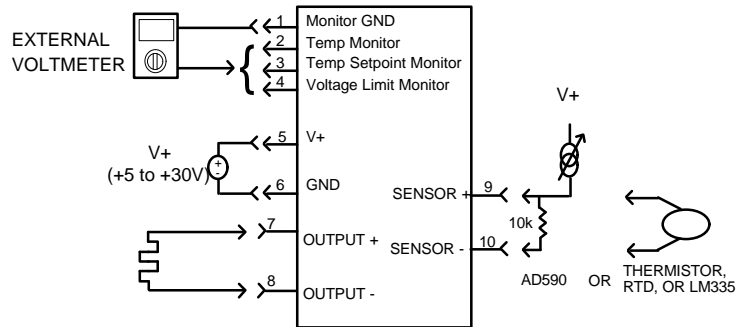
OPTIMIZE YOUR RHM-4000

POWER SUPPLY AND NOISE:

The control electronics are designed for low noise operation. The power supply you select will directly affect the noise performance of the controller. We recommend using regulated linear supplies for optimum performance. Depending on your requirements, you may be able to use a switching power supply. Each case must be evaluated as a switching power supply will affect noise, transient, and stability performance.

QUICK START

The following is a sketch of the components you will need to operate the RHM-4000, and a rough connection diagram. Much more detail is included in the PIN DESCRIPTION section, and you should review the entire manual before operating your resistive heater with the RHM-4000.



RESISTIVE HEATER CONTROLLER ELECTRICAL SPECIFICATIONS

	RHM-4000	
RESISTIVE HEATER OUTPUT		GENERAL SPECIFICATIONS
Max. Output Current	+ 4 Amps	Power Requirements
Max. Output Voltage ❶	+ 25 Volts	+5 to +30 VDC (+32V MAX)
Maximum Output Power	100 Watts	Supply Current
Voltage Limit Range	+2.0 to +25 Volts	RHM's Maximum Output Current plus
Control Loop	PID	50 mA @ V+
TEMPERATURE CONTROL		Size (H x W x D)
Temperature Control Range ❷	Above Ambient	0.77" x 2.1" x 2.1"
Setpoint Repeatability	± 0.01°C	Weight
Short Term Stability ❸	< ± 0.005°C	4 oz.
Long Term Stability ❸	< ± 0.008°C	Operating Temperature
TEMPERATURE SENSOR TYPES		0 to +60°C
Thermistor Types (2 wire)	NTC	Storage Temperature
Thermistor Sensing Current	10 µA or 100 µA	-40 to +70°C
Thermistor Range	2 kΩ to 500 kΩ	Connector
IC Sensor Types ❹	AD590, LM335	10 pin friction lock
IC Sensor Bias (LM335)	1 mA	
RTD Types (2 wire)	>200 ohm	
RTD Sensor Current	1 mA	
Temp Setpoint Monitor vs. Temp Monitor Accuracy	< 5%	

- ❶ Maximum Output Voltage will vary depending on input voltage. A maximum compliance voltage of +25V will be obtained with +30V input.
- ❷ Temperature Range depends on the physical load, sensor type, and resistive heater used.
- ❸ Stability quoted for a typical 10kΩ thermistor at 100µA sensing current.
- ❹ AD590 requires an external bias voltage, and 10kΩ sense resistor.

PIN DESCRIPTIONS & ADJUSTMENTS

- 1. Common** This pin provides ground potential to be used with the monitor outputs, pins 2-4. This ground is starred with the circuit ground to provide the most accurate monitor measurement. This pin is at ground potential, but should not be used for anything other than the sensor current source return.
- 2. Temperature Monitor** This output is used to monitor the voltage, and therefore temperature, of the sensor. When controlled, the TEMP MONITOR voltage will closely match the voltage set at pin 3 (TEMP SETPOINT ADJUST).
- 3. Temperature Setpoint Adjust** This output is used in setting the temperature setpoint of the sensor. This voltage will range from 0-5 V and should match the voltage across the sensor when it is at the desired temperature. This voltage will be slightly less than 5V when using a +5V supply voltage.
- 4. Voltage Limit Adjust** This output is used in setting the maximum voltage to the resistive heater. This voltage is the maximum voltage between pins 7 and 8 (OUTPUT + and OUTPUT -).
- 5. V+** This pin along with pin 6 (GND) provides power to the control electronics and the output stage.
- 6. GND** This pin, along with pin 5 (V+) provides power to the control electronics and provides power to the resistive heater. This is the only ground connection designed as a high current return.
- 7. Output +** This pin sources the current to the resistive heater.
- 8. Output -** This pin sinks the current returned from the resistive heater.
- 9. Sensor +** This pin is used to source the thermistor, IC sensor, or RTD reference current through the temperature sensor. An internal jumper in the unit will select between a 10 μ A, 100 μ A, and 1 mA reference current.
- 10. Sensor - (GND)** 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.

TRIMPOT ADJUSTMENTS

VOLTAGE LIMIT ADJUST

This trimpot adjusts the resistive heater voltage limit. Turning the trimpot adjust clockwise increases the maximum voltage across the resistive heater.

PROPORTIONAL GAIN ADJUST

This trimpot adjusts the proportional gain for the PID control loop. Turning the trimpot adjust clockwise increases the PID dampening.

Coarse TEMPERATURE ADJUST

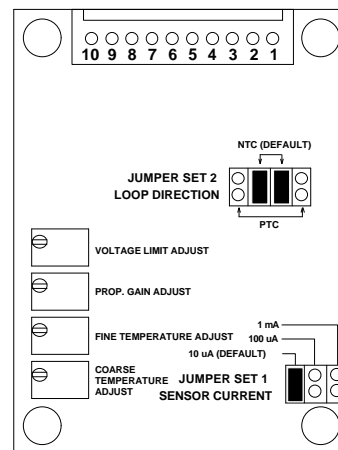
This trimpot adjustment varies the temperature setpoint coarsely. Turning the trimpot adjust clockwise decreases the setpoint voltage.

Fine TEMPERATURE ADJUST

This trimpot adjustment fine tunes the temperature setpoint. Turning the trimpot adjust clockwise decreases the setpoint voltage.

SELECTABLE ADJUSTMENTS

Several jumpers are used to configure the system to the application. These jumpers select Sensor Type and the Sensor Current. The lid must be removed to access the jumpers.



Sensor Current (Jumper Set 1): The resistance of the sensor you choose, in conjunction with the sensor current, must produce a voltage between 200 mV and 5 V in order to be used in the control loop. Based on this jumper setting, the sensor current will be 10 μ A, 100 μ A, or 1mA. (Default factory setting is 10 μ A.)

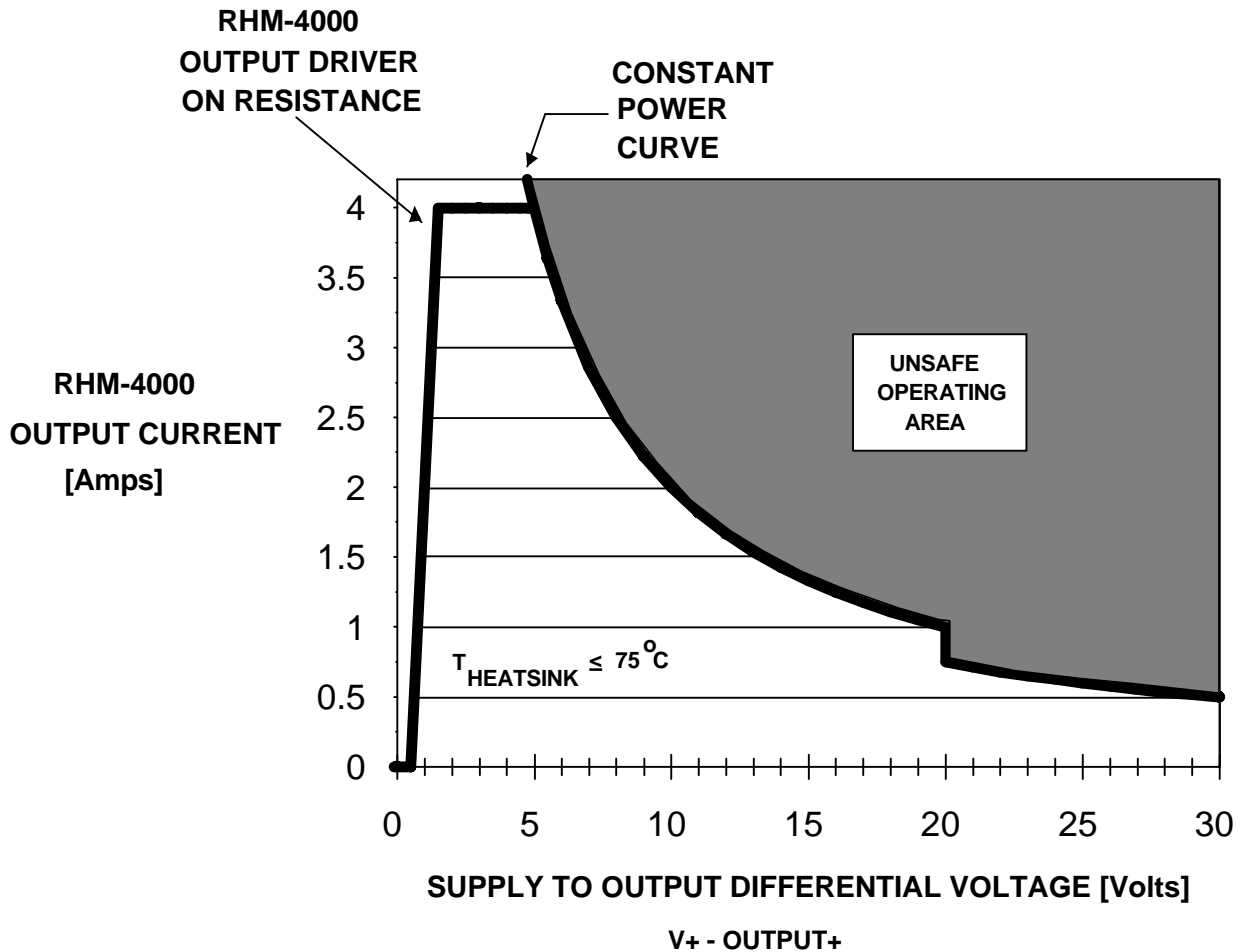
Loop Direction (Jumper Set 2): This jumper is used to accommodate both positive and negative temperature coefficient sensors. It is also used in adapting the RHM-4000 for use with thermoelectrics. (Default factory setting is for NTC sensors with resistive heaters.)

OPERATING INSTRUCTIONS

1. VERIFY MAXIMUM POWER DISSIPATION OF RHM-4000 IS NOT EXCEEDED

The SOA (Safe Operating Area) curve combines the effects of current, voltage, and power limitations for the RHM-4000. This curve illustrates the unsafe operating area where the RHM-4000 can be damaged due to thermal stress on the output power stage. Figure 1 shows the SOA curve for the RHM-4000 when the heatsink temperature is less than 75°C. This curve assists in selecting a resistive heater, power supply, and determining the voltage limit setting. **CAUTION:** Never allow the heatsink temperature to exceed 75°C.

FIGURE 1:



DRAWING LOAD LINES

First calculate the current (I_{max}) necessary to generate the desired power (P_{max}) in the resistive heater using Equation 1. To draw a load line on the SOA curve, draw a horizontal line from the y-axis at I_{max} . Next, calculate the difference between the voltage generated by the maximum current through the heater ($I_{max} \times R$ [resistance of the heater]) and the supply voltage and draw a vertical line from the x-axis at this value. Draw a line from the intersection of these two lines to the supply voltage value on the x-axis.

Equation 1 -
$$I_{max} = \sqrt{\frac{P_{max}}{R}}$$
 where I_{max} is the current necessary to generate P_{max} for a resistive heater with resistance R .

EXAMPLE 1: Figure 2 [following page] shows a load line for a flexible Kapton resistive heater with $R = 6.4 \Omega$ and $P_{max} = 12 \text{ W}$ using a +15 Volt supply. From equation 1 we find $I_{max} = 1.37 \text{ Amps}$ and draw a horizontal line from this value. The voltage across the RHM-4000 is calculated as $15 - (1.37 \times 6.4)$ or 6.23V. A vertical line is drawn at the value. The load line is drawn from the intersection of these lines to the x-axis at the value of the supply voltage (+15V). To limit P_{max} to 12 Watts (for device safety, etc.), adjust the VOLT LIMIT ADJUST trimpot until the voltage limit monitor measures (1.37×6.4) or 8.77V.

The load line also assists in determining the maximum power dissipated in the RHM-4000. First find the location on the load line that is closest to the SOA's constant power curve (before it breaks at 20V). In this example, this is near 1 Amp (see Figure 2). Draw a vertical line from the intersection of the 1 Amp line and the load line to the x-axis to determine the voltage drop across the RHM-4000. In Figure 2 this is 8.8V. The power dissipated in the RHM-4000 is 1 A x 8.8 V or 8.8 Watts. Use this power value to determine the heatsink capacity required to operate the RHM-4000.

If the load line passes through the unsafe area of operation for this device then the designer can do one of the following:

- 1) Select a resistive heater with a larger resistance or use two similar resistive heaters in series.
- 2) Place a power dissipating resistor in series with the resistive heater to reduce the slope of the load line.
- 3) Lower the power supply voltage.
- 4) Reduce the limit voltage.

Example 2: In this example an RHM-4000 is used in a system with an available +24 Volt power supply. The load being heated needs 10 Watts of power to maintain it at 55°C with an ambient temperature of 25°C. Two resistive heater load curves are shown in Figure 3. Both resistive heaters have the same effective area. The first resistive heater has a resistance of 6.8 Ω. While this resistive heater can produce 10 Watts of heating power, the load line crosses into the unsafe operating area for the RHM-4000, and therefore would damage the RHM. In order to use this resistive heater, no more than 1.1 Amps could be used, so the voltage limit for the RHM-4000 must be set at (1.1 x 6.8) or 7.48V. With this voltage, it cannot provide the desired 10 Watts.

The second resistive heater has a resistance of 14.9 Ω. Its load line remains in the safe operating area for the RHM-4000. Using this resistive heater reduces the amount of power dissipated in the RHM-4000; therefore it reduces the amount of heatsinking required for the controller. To limit the power to 10 Watts the RHM-4000's voltage limit should be set at (0.82 x 14.9) or 12.2V for this resistive heater.

Assuming the 14.9 Ω resistive heater is chosen for this application, then the maximum power dissipated by the RHM-4000 can be determined using its load line. The load line crosses closest to the constant power curve at 0.82 Amps. This corresponds to a 11.8 V drop across the RHM-4000. The maximum power dissipated by the RHM-4000 will be (0.82 x 11.8) or 9.7 Watts. The heatsink must maintain the RHM-4000 at or below 75°C while dissipating this power.

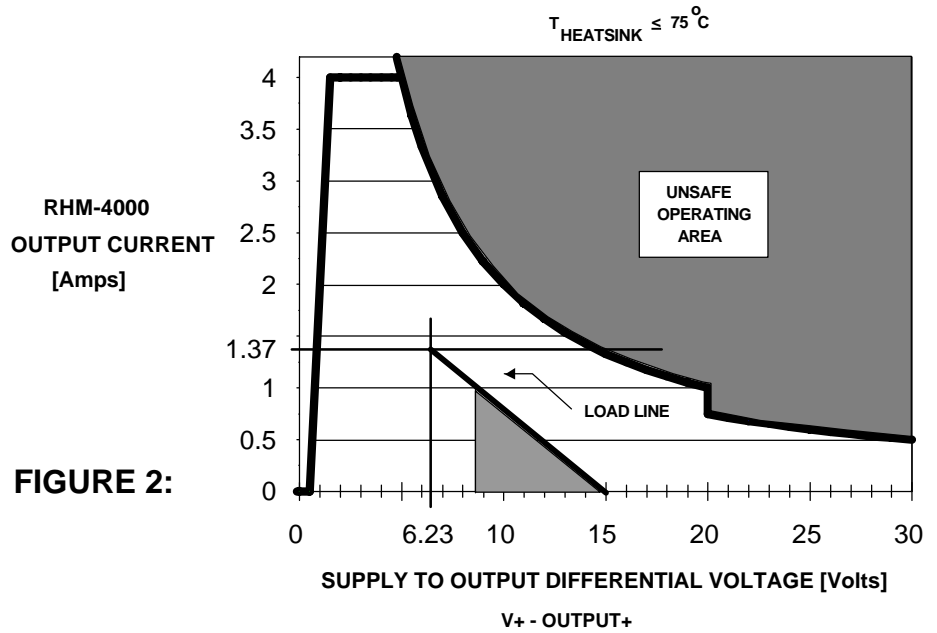


FIGURE 2:

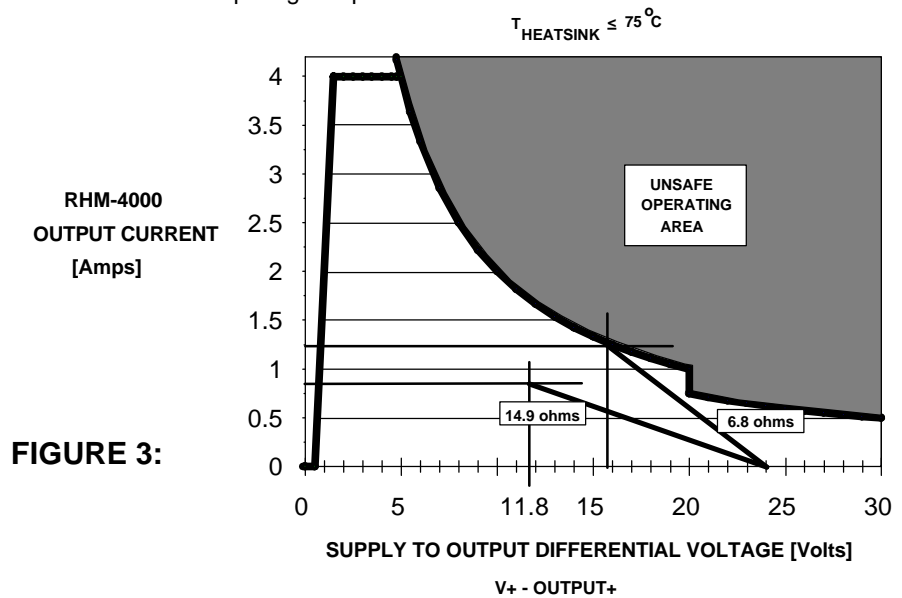


FIGURE 3:

2. ESTABLISH THERMAL CONTROL

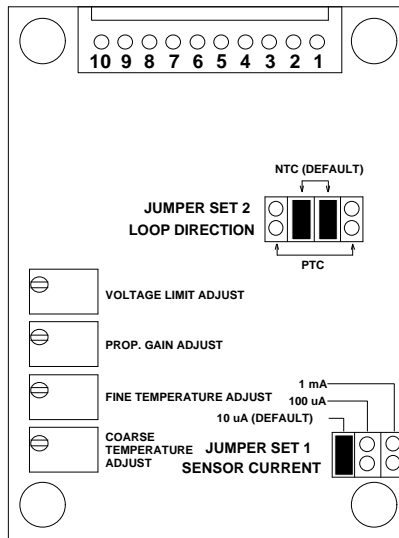
When the RHM-4000 must dissipate more than 4 Watts of power, a heat sink must be properly attached to the base plate. Thermally conductive grease should be used between the heatsink and the module for optimum performance.

Use the SOA curves to determine the maximum power dissipated in the unit. Calculate the allowed rate of temperature increase with:

$$\text{RATE} = \frac{50}{P_{\text{UNIT}}} \text{ where Rate is in } ^\circ\text{C/W.}$$

For example, if P_{UNIT} is 10 W, RATE is 50/10 or 5°C/W. Adding a safety factor, you should select a heatsink with 4°C/W rating.

3. CONFIGURING THE JUMPERS



Sensor Current (Jumper Set 1)

The resistance of the sensor you choose, in conjunction with the sensor current, must produce a voltage between 200 mV and 5 V in order to be used in the control loop. Install a jumper on one of the locations marked "10μA", "100μA", or "1mA" based on the sensor you will use. Bias an LM335 using the 1mA sensor current. Once a sensor type has been selected, set Jumper 1 accordingly. For AD590's, remove all jumpers from the Jumper 1 connector and use the connections shown in the Quick Setup Section.

Loop Direction (Jumper Set 2)

The RHM-4000's loop direction can be modified to accommodate both positive and negative coefficient sensors, PTC and NTC respectively. When using NTC sensors [typically thermistors] place the shorting jumpers on the two inside jumper locations. When using PTC sensors, move the shorting jumpers to the two outside jumper locations.

Using Thermoelectrics for Cooling

The RHM-4000 is also suitable for driving thermoelectrics. The loop direction must be properly set. When using NTC sensors place the shorting jumpers on the two outside jumper locations. When using PTC sensors move the shorting jumpers to the inside jumper locations. [This reverses the standard setting.] The thermoelectric module positive lead connects to Output + and the negative lead connects to Output -.

Using Thermoelectrics for Heating

To use the RHM-4000 with thermoelectrics for heating applications, the leads from the thermoelectrics must be connected correctly to the unit. The OUTPUT+ connection must be connected to the thermoelectric module's negative lead. Similarly, the OUTPUT- connection must be connected to the thermoelectric module's positive lead. The loop direction must also be properly set. When using NTC sensors, place the shorting jumpers on the two inside jumper locations. When using PTC sensors move the shorting jumpers to the outside jumper locations.

4. CONNECTING POWER, SENSOR, AND RESISTIVE HEATER

Power (Pins 5 and 6)

The RHM-4000 operates from a single power supply. Connect a positive voltage to V+ (pin 5) and GND (pin 6). Insure the power supply has sufficient current capacity for the requirements of the load.

Sensor (Pins 9 and 10)

Epoxy or otherwise fix the temperature sensor to the device being heated in your application. Connect the sensor to pins 9 and 10. For sensors where polarity is important, pin 9 is Sensor+, and pin 10 is Sensor-. When connecting a 100 Ω RTD, add a 1kΩ metal film resistor in series with the Sensor output. This biases the sensor signal to 1 V, well above the ground floor, and provides better performance. This technique can be used with other sensors when required.

Resistive Heater (Pins 7 and 8)

Connect the resistive heater to pins 7 and 8. Make sure it is adequately connected to the heatsink. NOTE: The default factory loop direction is set up for NTC sensors (thermistors). Current always flows from OUTPUT+ to OUTPUT-.

5. SETTING UP THE VOLTAGE LIMIT, OPERATING TEMPERATURE, AND PROPORTIONAL GAIN

Voltage Limit Adjust (Pin 4)

First turn the coarse and fine temperature adjust trimpots fully CCW when using NTC sensors, and fully CW when using PTC sensors (heating), perform the opposite when using thermoelectrics to cool. Turning the voltage limit adjust trimpot CW increases the maximum allowable voltage between OUTPUT+ and OUTPUT-. The voltage limit measurement on pin 4 can be adjusted from 0V to 90% of V+. The lowest actual voltage limit on the output will be 2V. Note: When using a variable power supply, the voltage limit must be adjusted to compensate for increases or decreases in the supply voltage.

The maximum output current will be limited by the voltage limit divided by the resistance of the resistive heater.

The voltage limit can be utilized to reduce the temperature ramp rate of the load by restricting the amount of power supplied to the resistive heater. Experiment with the voltage limit adjust to keep the temperature ramp rate below the maximum allowable rate for the device being heated.

Temp Setpoint Adjust (Pin 3)

This voltage will depend on the sensor selected. Use one of the following equations based on the sensor type you will be using.

Thermistors and RTD's

$$V_{SETPOINT} = I_{REF} \times R \quad (I_{REF} \text{ in amps, } R \text{ in ohms})$$

"R" equals the resistance value of the sensor at the desired operating temperature. The reference current (I_{REF}) will be 1mA, 100μA, or 10μA.

LM335 & AD590

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

where T_{DESIRED} is the setpoint temperature in °C.

Monitor this setting on pin 3. Decrease the voltage by rotating either the coarse or fine temperature adjust potentiometer clockwise. Watch the Temp Monitor (pin 2) voltage approach the setpoint voltage with a time lag.

Proportional Gain

The factory setting for the proportional gain is a gain of 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.

MECHANICAL DIMENSIONS

