

TEC 2000

INSTRUCTION MANUAL

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FEATURES

The TEC temperature controller offers many unique features. These include:

- Bipolar 2 Amps
- < 0.02°C stability
- Supports Thermistors, IC sensors or RTDs
- Current Limit for TE Cooler protection
- ± 8 to ± 15 VDC required
- Linear PID Control Loop
- Easily Configurable
- Temperature Setpoint, Current Limit, Proportional Gain, and Integral Time Constant user adjustable
- On-Board 12-turn trimpots
- External Booster Capability
- Compact package
- Heatsink included with 5 Amp version
- Two Year Warranty

The TEC 2000 offers the high stability and low noise of a full PID control loop in an inexpensive, compact package. The bipolar controller interfaces with thermistors, IC sensors, or RTDs, and achieves exceptional temperature control. The flexibility of this user configurable controller makes it useful for a wide variety of loads.

On-board twelve-turn trimpots control Temperature Setpoint, TE Current Limit, the Proportional Gain Constant, and the Integral Time Constant. For remote control, these trimpots can be replaced with external analog voltages or external trimpots. See page 11 for more detail.

CUSTOMER SERVICE / WARRANTY

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

Wavelength warrants this product 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 its 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 TEC

POWER SUPPLY AND NOISE:

These 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. To reduce power dissipation in the controller, separate power supplies can be used to provide power for the TE Cooler. The following table details power supplies from Power One that properly operate the TEC-2000. You can contact the California plant at 1-(800) 678-9445:

Module	$\pm 12V$ to $\pm 15V$
TEC-2000	HCC15-3-A

Depending on your requirements, you may be able to use a switching power supply. Each system's requirements must be evaluated individually because a switching power supply will affect noise, transient, and stability performance.

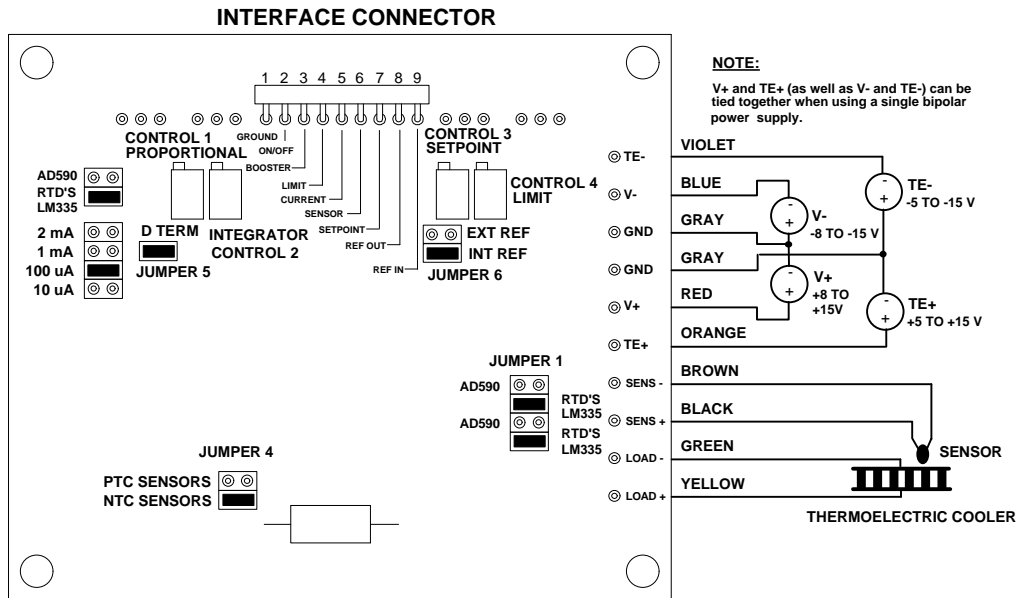
QUICK START

The following is a rough connection diagram for operating the TEC. Please review the jumper section to configure the unit for your sensor. Much more detail is included in the PIN DESCRIPTION section, and you should review the entire manual before operating your TE module with the TEC.

GROUNDING:



CAUTION: If you plan to operate any laser diode driver with a TEC, you may need to use separate power supplies. If the TE cooler or thermistor is tied to the laser diode, you must operate the TEC and Laser Diode Driver from separate power supplies and let each float independent of the other.



■ - Indicates the standard jumper configuration from the factory. This is the standard configuration for a 10 k Ω thermistor.

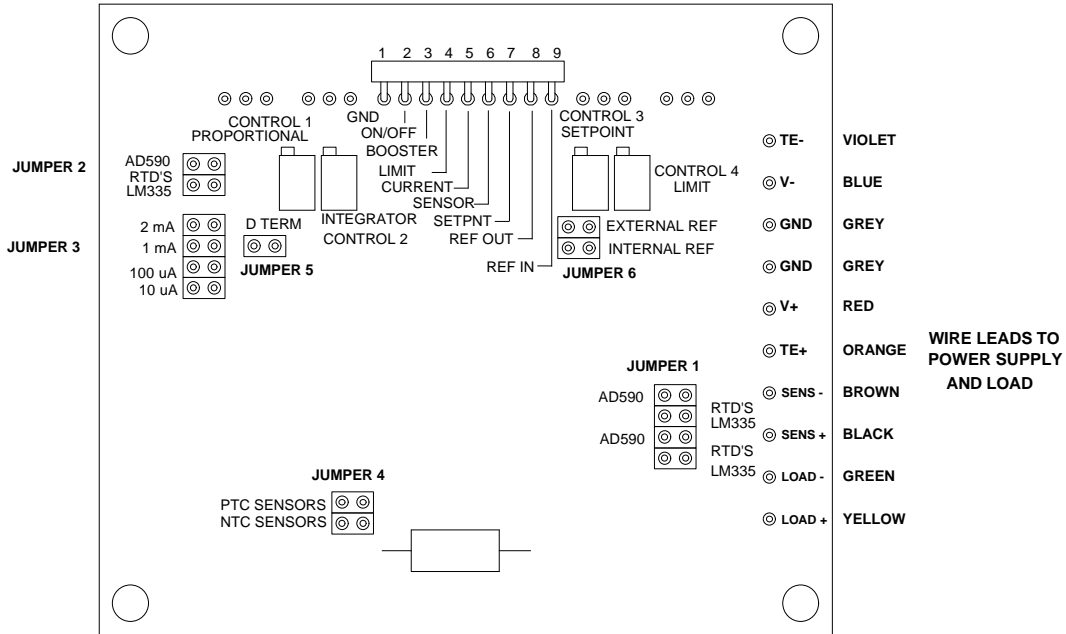
TEC TEMPERATURE CONTROLLER ELECTRICAL SPECIFICATIONS

MODEL NUMBER	TEC 2000
Temperature Control	
Temp. Control Range, ①	-99 to +150°C
Short Term Stability, 10 min. ②	< 0.005°C
Long Term Stability, 24 hr. ②	< 0.02°C
Proportional Gain Range	2 to 50
Integrator Time Constant Range	10 to 1000 msec
Internal Reference Voltage	5 Volts
Internal Reference Voltage Drift	50 ppm/°C
TEC Output	
Bipolar Output Current	± 2 Amps
Compliance Voltage ③	± 8 Volts
Maximum Output Power	16 Watts
Current Limit Range (± 2%FS Accuracy)	50-2000 mA
Control Loop	PI / PID
Temperature Sensors	
Thermistor Types (2 wire)	NTC
Thermistor Sensing Current	10 µA & 100 µA
Thermistor Range	1 kΩ - 500 kΩ
IC Sensor Types	AD590, LM335
Bias Current (LM335)	1 mA
RTD Types (2 wire)	100, 500 or 1000Ω
RTD Sensor Current	1 mA , 2 mA
Power Supply	
Control Supply Voltage V+ & V-	±8 to ±15 VDC
Maximum Control Supply Current (V+ & V-)	±100 mA
Current Source Supply Voltage (TE+ & TE-)	±5 to ±15 VDC
Maximum TE Supply Current (TE+ & TE-)	2.2 Amps
Setpoint vs. Monitor Accuracy	< 5 %

TEC GENERAL SPECIFICATIONS		
Size (H x W x D)	Connectors	Storage Temperature Range
TEC-2000 4.0" x 3.5" x 1.0"	9 pin right angle and flying leads	-50°C to +85°C
Weight	Operating Temperature Range	Warm-up
TEC-2000 6 oz.	0°C to +50°C	1 hour to rated accuracy

- ① Temperature Range depends on the physical load, sensor type and TE module used.
- ② Stability quoted for a typical 10 kΩ thermistor at 100 µA sensing current.
- ③ Compliance Voltage will vary depending on input voltages. A maximum compliance voltage of ± 8 volts will be obtained with ±15 volts input.

INTERFACE CONNECTOR



CONNECTIONS TO TE COOLER, TEMPERATURE SENSOR, AND POWER SUPPLY

Wire leads for the TE cooler, temperature sensor, and power supply are color coded and labeled on the printed circuit board.

Violet, TE- This is the negative power supply input for the TE current source.

Blue, V- This is the negative power supply input for the loop control electronics.

Grey, Ground There are two ground connections provided. One ground can be used for the TE current source supply and one for the loop control electronics for more stable operation.

Red, V+ This is the positive power supply input for the loop control electronics.

Orange, TE+ This is the positive power supply input for the TE current source.

Brown and Black, Sensor - and Sensor +
These are the connections for feedback from the temperature sensor.

Green and Yellow, LOAD- and LOAD+ TE current flows from LOAD+ connection to the LOAD- connection when the TE cooler is connected.

INTERFACE CONNECTOR (9 pin friction lock)

1. **Ground** This is ground potential for the TE controller. It is starred to increase the accuracy of measurements on pins 4 through 9.
2. **ON / OFF** This input is used to enable or disable the TEC current source. If the input is high (>3V), the current source is reduced to a standby current of less than 50mA. If the input is low or left floating, the TEC current source is enabled.
3. **Booster** This output is the sum of the P, I, and D terms and is before the current limit circuit. This signal can be used to drive higher current power amplifiers.
4. **Limit** This output corresponds to the TE Limit Current setting. It can be set between 0 and the maximum current of the TE controller. The transfer function for this monitor is 1 A / V.
5. **Current** This output corresponds to the actual current through the TE cooler. The transfer function for this monitor is 1 A / V.
6. **Sensor** This output is used to monitor the voltage, and therefore temperature, of the sensor. When controlled, the sensor voltage will equal the voltage set at pin 7.
7. **Setpoint** This output is used in setting the temperature setpoint of the sensor. Depending on the type of sensor used, this voltage can range from 0-5V and should match the voltage across the sensor when it is at the desired temperature.
8. **REF Out** This output is the 5V reference used in the temperature controller. It is provided for use with an A/D or D/A controller.
9. **REF In** This input can be used to provide the control electronics with a more stable reference voltage. A reference voltage of 5V may be applied.

JUMPERS

Jumper 1, Jumper 2. Sensor Type Select

These three jumpers select the type of temperature sensor used.

Jumper 3. Sensor Current Setting This jumper is used to select which reference current is to be used with the resistive temperature sensors (thermistor, RTD). Choices are 2mA, 1mA, 100 μ A, and 10 μ A. The 2mA is typically used to bias the LM335.

Jumper 4. PTC/NTC Loop Configuration This jumper sets the correct loop control direction based on whether the temperature sensor is Positive Temperature Coefficient (PTC) or Negative Temperature Coefficient (NTC). Thermistors are NTC sensors. Platinum RTDs, LM335s, and the AD590 are PTC sensors.

Jumper 5. D Term When this jumper is installed, the control loop includes a D term to make it a true PID loop with derivative control. The D term helps reduce settling time but may increase the noise coefficient.

Jumper 6. Reference Selection This jumper determines whether an internal or external voltage reference is used in the PID control loop.

TRIMPOT ADJUSTMENTS

Four trimpots are positioned along the top of the circuit board. These are twelve-turn trimpots. The setpoint and limit potentiometers may be removed and analog voltages can be substituted (see page 11). If the proportional gain and integral time constants are known, these potentiometers can be removed and replaced with fixed resistor values. The following details the controls:

Control 1. Proportional Gain Adjust This 12 turn trimpot adjusts the proportional gain term from 1 to 50. The gain of the loop increases as the trimpot is turned clockwise.

Control 2. Integral Time Constant Adjust This 12 turn trimpot adjusts the integral time constant from 10 to 1000 msec. The time constant decreases as the trimpot is turned clockwise.

Control 3. Temperature Setpoint Adjust This sets the temperature the controller will maintain at the load. This is sensor dependent. The setpoint voltage increases as the trimpot is turned clockwise. The potentiometer can be replaced with an analog input voltage ranging from 0 to 5V.

Control 4. TE Current Limit Adjust This 12 turn trimpot sets the maximum current through the TE cooler. The potentiometer can be replaced with an analog input voltage ranging from 0 to 5V. Since the maximum current depends on the model selected, the transfer function between voltage and current varies with the model.

OPERATING INSTRUCTIONS

Please note that these instructions are sequential. Performing them out of order may damage the thermoelectric cooler. First time operation will proceed faster if you read through the procedure first and complete all the calculations before working with the hardware.

CONFIGURING THE JUMPERS

The first step in operating a thermoelectric module with the TEC system is to configure the TEC. Jumpers must be in place on the board to determine the operating mode. The following sections detail several choices you have about operating mode. Set each jumper or jumper pair according to your needs.

Jumper Set 1 and Jumper Set 2. Sensor Type Select

Choose a sensor that allows control over the required range. Once a sensor type has been selected, set Jumper 1 and Jumper 2 accordingly. For AD590's, install the jumpers as labeled on the circuit board. For all other temperature sensors, install the jumpers on the locations marked "RTD's/LM335".

Jumper 3. Sensor Current Setting The resistance of the sensor you choose, in conjunction with the sensor current, must produce a voltage between 0 and 5V in order to be used in the control loop. Install a jumper on one of the locations marked "10 μ A", "100 μ A", "1mA", or "2mA" based on the sensor you will use.

Jumper 4. PTC / NTC Loop Configuration Thermistors are Negative Temperature Coefficient (NTC) devices. Install the jumper on the location marked "NTC Sensors" when using a thermistor. The LM335 and AD590 are linear Positive Temperature Coefficient (PTC) devices. Install a jumper on the location marked "PTC Sensors" when using either the LM335 or AD590. Platinum RTD's are extremely linear resistive temperature devices and also have a Positive Temperature Coefficient. Install the jumper on the location marked "PTC Sensors" when using a platinum RTD.

Jumper 5. D Term If your application requires fast settling times, then install this jumper. The derivative term should only be used when the noise component is not a critical design parameter.

Jumper 6. Reference Selection If your application requires better temperature stability or temperature coefficient than the published specification, an external reference can be used to enhance the stability. Install the jumper on the location marked "External Ref" if you will provide the reference voltage. Otherwise install the jumper on the "Internal Ref" jumper location. The external reference can also be used with A/D and D/A systems. The reference voltage determines all the transfer functions for the TEC.

CONNECTING POWER, SENSOR, AND THERMOELECTRIC MODULE

Power

The TEC can be configured to operate from either one or two bipolar supplies. When using one bipolar supply, connect the **Blue** and **Violet** leads to the negative terminal of the supply, the supply ground to the **Grey** leads, and the **Red** and **Orange** leads to the positive supply terminal.

For applications that require a simpler power supply connection, remove the **Blue** and **Red** leads, and one of the **Grey** leads. Solder jumpers in the locations next to the **Violet** and **Orange** leads. These short the TEC- and V- points together, and the TEC+ and V+ points together.

Using two separate bipolar supplies improves the performance of the TEC. A regulated bipolar supply can be used to power the control electronics through the **Red** and **Blue** leads. A separate unregulated bipolar supply can be used to power the TE current source with the **Violet** and **Orange** leads.

Sensor

Epoxy or otherwise fix the temperature sensor to the cooling plate in your application. Connect the sensor to the **Brown** and **Black** leads on the TEC. For sensors where polarity is important, the **Brown** lead is Sensor -, and the **Black** lead is Sensor +.

TE Cooler

Connect the thermo-electric cooler to the **Yellow** and **Green** leads on the TEC. Make sure it is adequately connected to the cooling plate and heat sink. Properly transferring heat from the device is imperative. Make sure your heat sink is rated to remove the amount of heat required for your application. If enough heat is not removed from the device, it can go into thermal runaway where it cannot cool and might be damaged.

SETTING UP THE TEMPERATURE CONTROLLER

TE Limit Current Adjust (Control 4) Turn Control 4 fully CCW. Calculate the voltage setting from the maximum current allowed through the thermo-electric cooler with this equation:

$$V_{LIMIT} = I_{LIMIT}$$

I_{LIMIT} is in amps and V_{LIMIT} is in volts.

Monitor this setting on **pin 4** (relative to pin 1) of the interface connector. Increase the voltage by rotating the control potentiometer clockwise to the proper limit setpoint.

Temperature Setpoint Adjust (Control 3)

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

Thermistors and RTD's: $V_{SETPOINT} = I_{REF} * R$

I_{REF} is in amps and R is in ohms. "R" equals the resistance value of the sensor at the desired operating temperature. The reference current (I_{REF}) is based on the setting of **Jumper 3**.

LM335 & AD590:

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

$T_{DESIRED}$ is the setpoint temperature in $^{\circ}C$. Monitor this setting on **pin 7** (relative to pin 1) of the interface connector. Increase the voltage by rotating the setpoint potentiometer clockwise slowly. Watch the **Temp Monitor - pin 6** (relative to pin 1) voltage increase with a time lag to approach the Setpoint voltage. Once the load is stabilized at the proper temperature, continue with this procedure.

The Integrator Time Constant Adjust and Proportional Constant Adjust are factory preset for most normal load configurations and should not be adjusted except to optimize for your specific application after the unit has been operating. If optimizing is required, follow these steps:

Integrator Time Constant Adjust (Control 2)

This potentiometer resistance (R_I) can be measured using a resistance meter and measuring between the holes marked CW and W at the external integrator pot hookup. After initial operation, adjust the Integrator Time Constant control until you reach an acceptable temperature stability.

$$\text{Time Constant} = (R_I + 10) \text{ msec}$$

where R_I is the integral potentiometer resistance in k Ω .

Proportional Constant Adjust (Control 1)

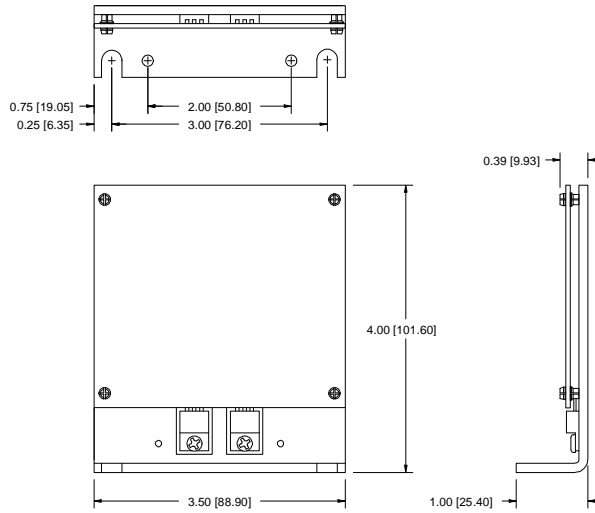
This potentiometer resistance (R_P) can be measured between the holes marked CW and W at the external proportional pot hookup. After initial operation, adjust the gain until you reach an acceptable temperature stability. Typically, a gain of 30 is appropriate for standard loads.

$$\text{Proportional Gain} = 250 / (R_P + 5)$$

where R_P is the proportional potentiometer resistance in k Ω .

MECHANICAL DIMENSIONS

TEC2000



Precision thermistors for various temperature ranges are offered with detailed R-T charts for quick system integration:

SELECTION GUIDE

MODEL	DESCRIPTION
TEC2000	2 Amp Temperature Controller

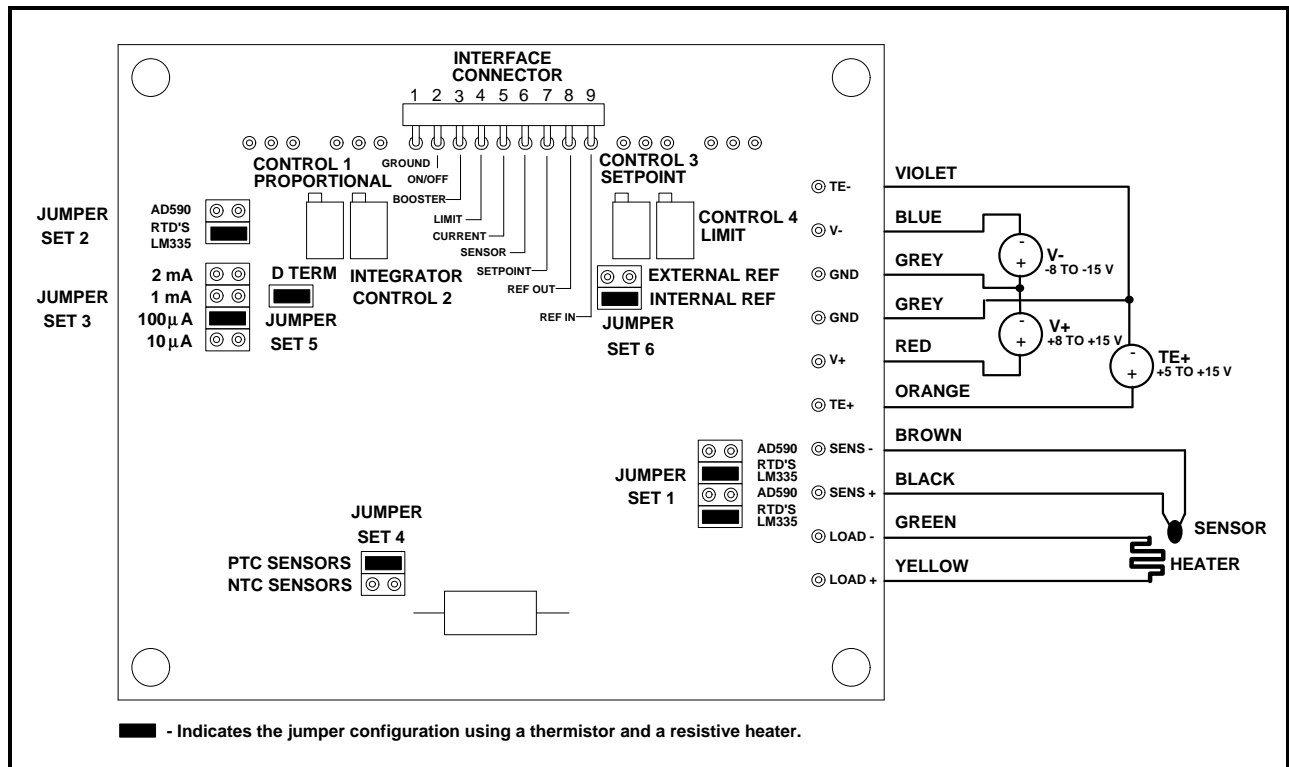
THERMISTOR SELECTION GUIDE

MODEL	R @ 25°C	10 μA RANGE	100 μA RANGE
TCS-602	2.252 kΩ	-60°C to -12°C	-33°C to +15°C
TCS-605	5 kΩ	-55°C to -2°C	-20°C to +33°C
TCS-610	10 kΩ	-45°C to +13°C	-8°C to +50°C
TCS-620	20 kΩ	-35°C to +28°C	+6°C to +69°C
TCS-650	50 kΩ	-18°C to +49°C	+25°C to +92°C
TCS-651	100 kΩ	-6°C to +67°C	+41°C to +114°C

USING THE TEC 2000 TEMPERATURE CONTROLLERS WITH RESISTIVE HEATERS

The TEC 2000 temperature controller will control resistive heaters. The figure below is a connection diagram using a thermistor and resistive heater. Most power supplies have higher current capacity on the positive supply rails than on the negative supply rails; therefore the connection diagram is set up for a positive supply. Notice that only the TE+ current source supply is connected to operate the heater. With TE+ connected as shown, JUMPER SET 4 must be configured for PTC (positive temperature coefficient) sensors. If RTD's or IC sensors are used then JUMPER SET 4 must be configured for NTC (negative temperature coefficient) sensors.

If your power supply has a negative supply with enough current capacity for the heater, the heater can be supplied by connecting the TE- current source supply and grounding TE+. JUMPER SET 4 then correlates to the sensor being selected.

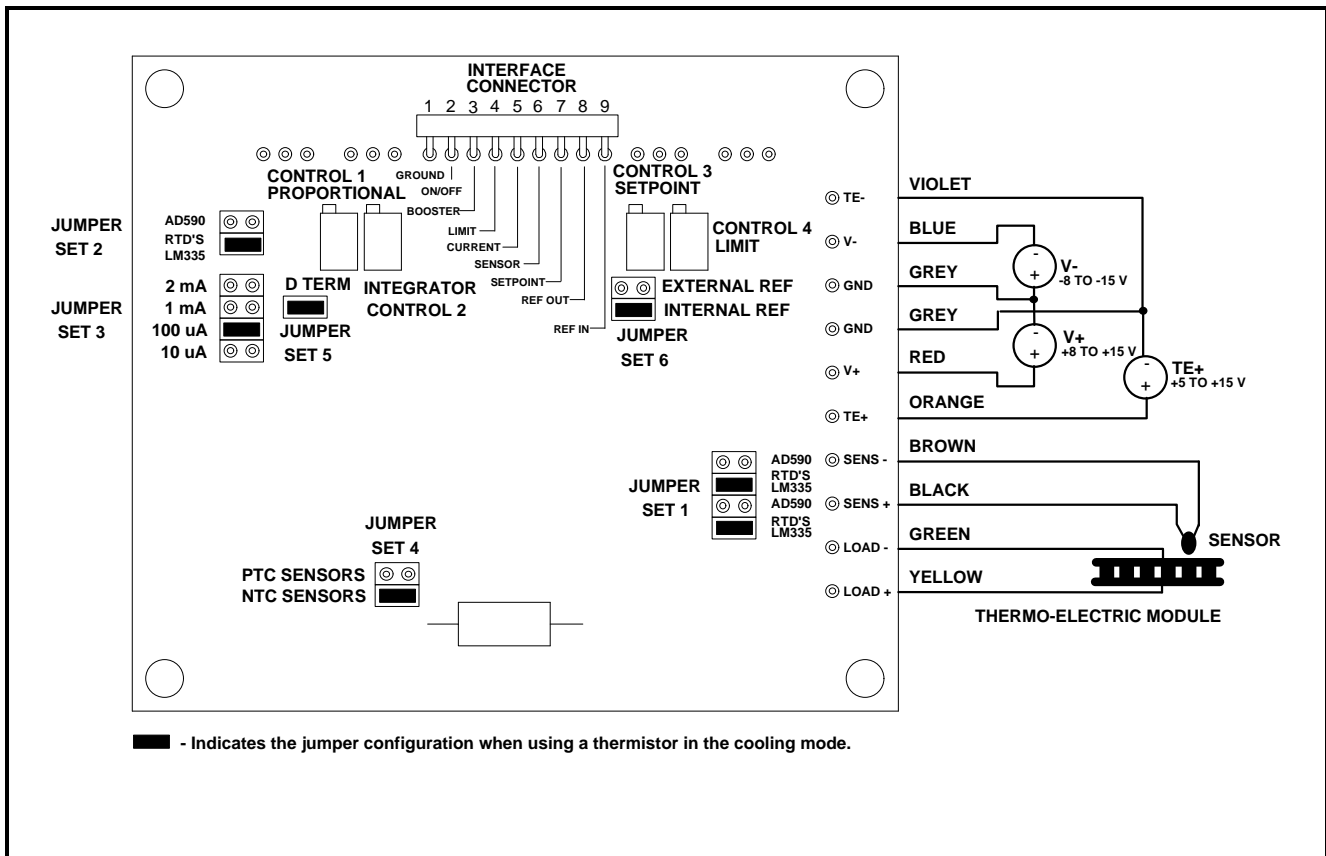


- Contact the factory for available thermistor values when using a resistive heater.

USING THE TEC 2000 TEMPERATURE CONTROLLER WITH A SINGLE SIDED HIGH CURRENT SUPPLY

COOLING MODE

Cooling loads below ambient temperature is easily done using only one side of the TEC 2000 temperature controller current source. Most power supplies have higher current capacity on their positive supply rails than on their negative supply rails; therefore, the connection diagram is set up for a positive supply. Notice that only the TE+ current source supply is connected to operate the thermo-electric module.



HEATING MODE

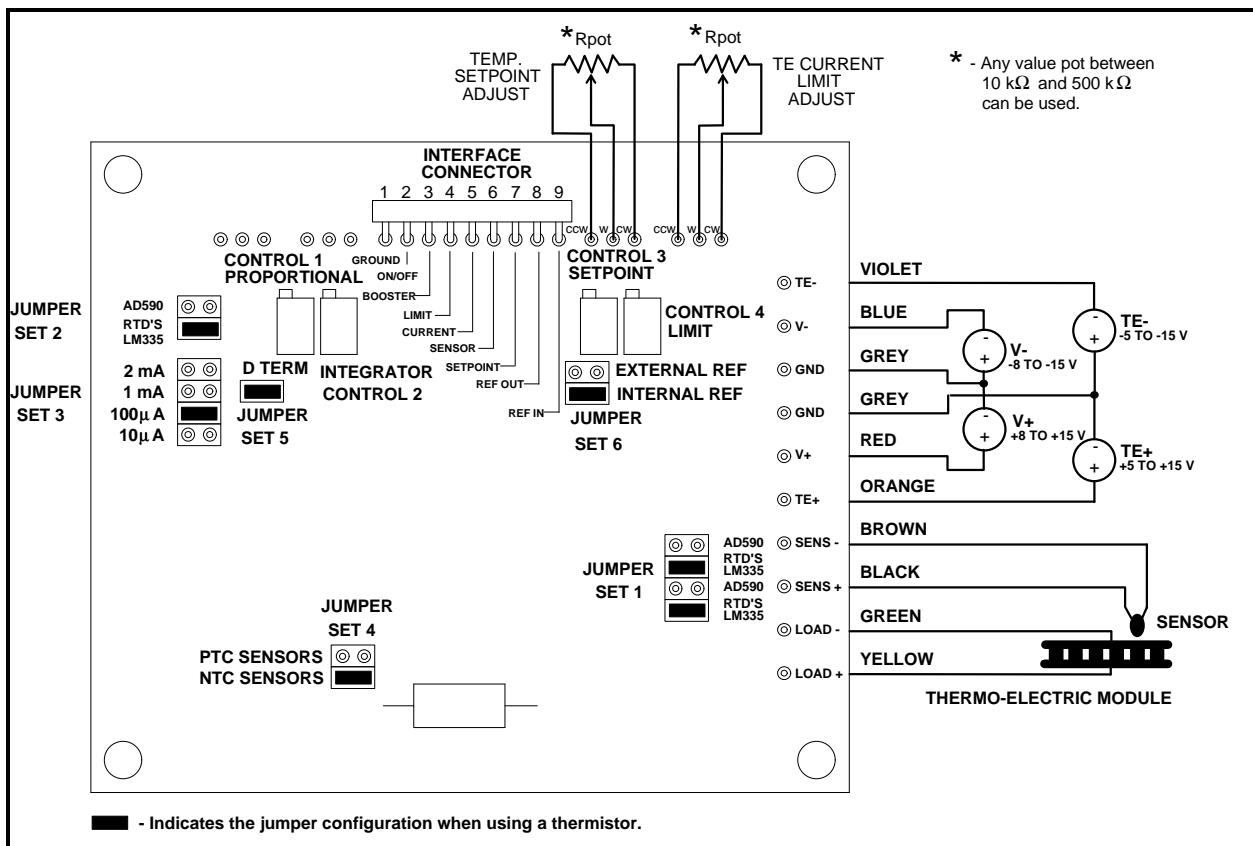
When heating a load above ambient temperature the TEC can again be configured to use a single high current supply. First, configure JUMPER SET 4 to the opposite setting (i.e. PTC SENSORS if you are using a NTC thermistor). Next, switch the YELLOW (LOAD+) and GREEN (LOAD-) lead connections to the thermo-electric module.

- Contact the factory for available thermistor values.

CONTROLLING THE TEC 2000 WITH EXTERNAL POTENTIOMETERS OR EXTERNAL VOLTAGES

EXTERNAL POTENTIOMETER CONTROL

The TEMP SETPOINT ADJUST and TE CURRENT LIMIT ADJUST controls can be set externally using potentiometers connected to the CW, W, and CCW solder pads above each control trimpot. The figure below is a connection diagram for this type of control. These trimpots can be removed completely or left in place by adjusting the on-board trimpots to their half scale setting. To adjust the trimpot to its half scale setting, place an ohmmeter between the CW and W connections and adjust the trimpot until the ohmmeter measures approximately 50 kΩ. Precision wirewound trimpots provide the best stability and noise performance but any type can be used in this application. The PROPORTIONAL GAIN ADJUST and INTEGRATOR TIME CONSTANT ADJUST also can be controlled using external potentiometers. To add external potentiometers to these adjustments, the on-board trimpots must be removed.



Recommended potentiometers: Digikey part # 73JA203-ND or Newark part # 09F1857

EXTERNAL VOLTAGE CONTROL

The TEMP SETPOINT ADJUST and TE CURRENT LIMIT ADJUST can be controlled externally using voltages connected to the W and CCW solder pads above each control trimpot. The figure below is a connection diagram for this type of control. These trimpots can be removed completely or left in place by adjusting the on-board trimpots to their half scale setting. To adjust the trimpot to its half scale setting, remove jumper from jumper set #6 (Internal / External REF), place an ohmmeter between the CW and W connections and adjust the trimpot(s) until the ohmmeter measures approximately 50 k Ω , re-install jumper to set #6. D/A converters are shown in this diagram but any type of voltage input in the range of 0 to 5 Volts will control the TEMP. SETPOINT and TE CURRENT LIMIT. The PROPORTIONAL GAIN ADJUST and INTEGRATOR TIME CONSTANT ADJUST **CANNOT** be controlled using external voltages. External potentiometers can be added to these adjustments when the on-board trimpots are removed.

