Operation Manual
For
Model TC-36-25 RS232
Thermoelectric Cooler
Temperature Controller

April 17, 2007
Drawing #4637 Rev. B

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Notice: Improper tuning of this temperature controller (or any temperature controller) can lead to excessive thermal cycling and/or overheating of the thermoelectric device, either of which are known to reduce the lifetime of any thermoelectric device. Care should be taken to prevent the temperature of the thermoelectric device from going beyond the range specified by the device manufacturer. Care should also be taken so that any thermal cycling of the thermoelectric device is a result of changes in the controller's set-point temperature and not instability at a given set point due to improper selection of the tuning variables.

In no event shall TE Technology, Inc. be liable for any damages whatsoever (including without limitation, damage for loss of business profits, business interruption, loss of business information, or any other pecuniary loss) arising out of the use or inability to use this TE Technology, Inc. product, even if TE Technology, Inc. has been advised of the possibility of such damages.

Features

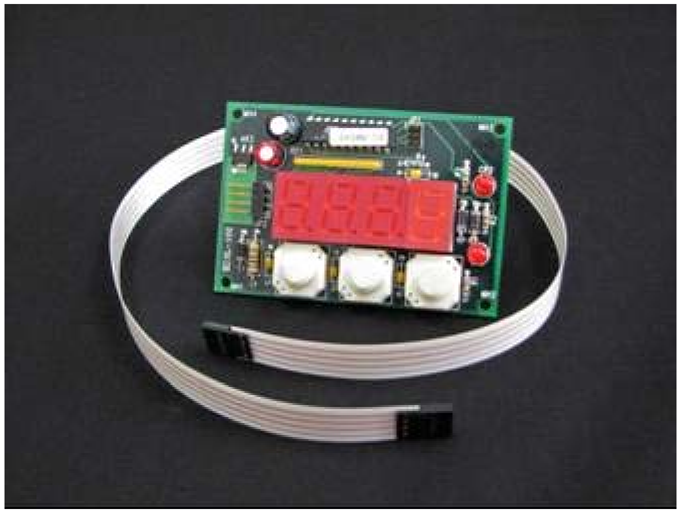
- RoHS compliant
- Operates as a stand-alone controller or with a computer monitor
- Bi-directional, solid-state H-bridge operation for both heating and cooling
- Can be configured to control both high and low voltage thermoelectric (TE) devices:
  - ✓ Single power supply configuration for TE devices with an input voltage range from (12 to 36) VDC
  - ✓ Dual power supply configuration for TE devices with an input voltage range is less than 12 VDC:
    - Controller-circuitry input voltage range from (12 to 36) VDC
    - TE device (H-Bridge) input voltage range from (0 to 36) VDC
  - Maximum 25 A current rating, controls up to 900 W
- Soft-start features turns the output on slowly, over a one second period
- Over current shutdown that can be set in 2.5 A increments
- Open sensor and shorted sensor output shutdown with automatic restart
- Low Voltage shutdown protects the H-bridge when the control circuitry voltage is less than 12 VDC
- Pulse width modulation of output at 2700 Hz
- Computer programmable via RS232 communications port
- Control temperature of –20 °C to +100 °C using thermistor supplied with controller
- Control temperature of –40 °C to +250 °C using optional thermistors
- Proportional (P), Integral (I) and Derivative (D) control that can be selected as P, PI, PD or PID; or Deadband (on/off) with an adjustable hysteresis
- Temperature resolution of 0.01 °C or 0.01 °F
- Control stability of ±0.01 °C or ±0.01 °F (best case, when controlling a cold plate)
- Set temperature adjustable by several options:
  - Computer set via software/RS-232 communication
  - Remote potentiometer (customer supplied)
  - 0 mA to 20 mA current loop
  - 0 VDC to 5 VDC adjustable range
  - Differential temperature control (allows control to a programmable temperature difference above or below the temperature of the second thermistor, if used)
  - MP-2986 Display and Keypad (optional accessory)
- No computer programming experience required to use the communications software program
  (Supplied software is compatible with Windows 95/98/XP/NT)
- Command set is provided so programmers can create their own software interface or embedded controller applications
- Versatile alarm system:
  - Computer configurable alarms for 25 mA, with a compliance voltage up to 11 VDC
  - Alarm cancel: selectable via computer-software communication or remote contact closure
  - The second sensor input is configurable as a heat-sink over-temperature shut-down
- Non-volatile memory retention of parameters (1,000,000 write cycles maximum; see command #31 in Appendix C for further details.)
- Operating temperature range of 0 °C to 60 °C, storage temperature range of -55 °C to +105 °C

General Description

The TC-36-25 RS232 provides bi-directional (heating and cooling) temperature control for thermoelectric devices. Resistive heaters can also be controlled. An H-bridge configuration is used for the power output stage. The output stage is made from solid-state N-channel MOSFETs (no relays or mechanical components are used). These transistors are highly efficient and allow for the bi-directional flow of current through the thermoelectric coolers. Their high efficiency reduces the waste heat generated by the controller and allows for a compact design.

This controller is programmable via the RS232 communication port for direct interface with a compatible computer. Field selectable parameters or data acquisition in a half duplex mode can be performed. The supplied software is compatible with Windows 95/98/XP/NT. The software provides a graphical user interface for setting control parameters and receiving feedback from the temperature sensor. However, the command set is also provided so that qualified personnel can use the controller as an embedded control, or they can create a custom program interface using LabView, for example. The software can also be used to instruct the TC-36-25 RS232 to save the desired control parameters to the controller's non-volatile memory. This allows the controller to be disconnected from the computer and operated as a stand-alone controller. When operating as a stand-alone controller, the controller can be set to always control to the stored set point or it can be set up to accept a proportional signal to vary the set point as required.

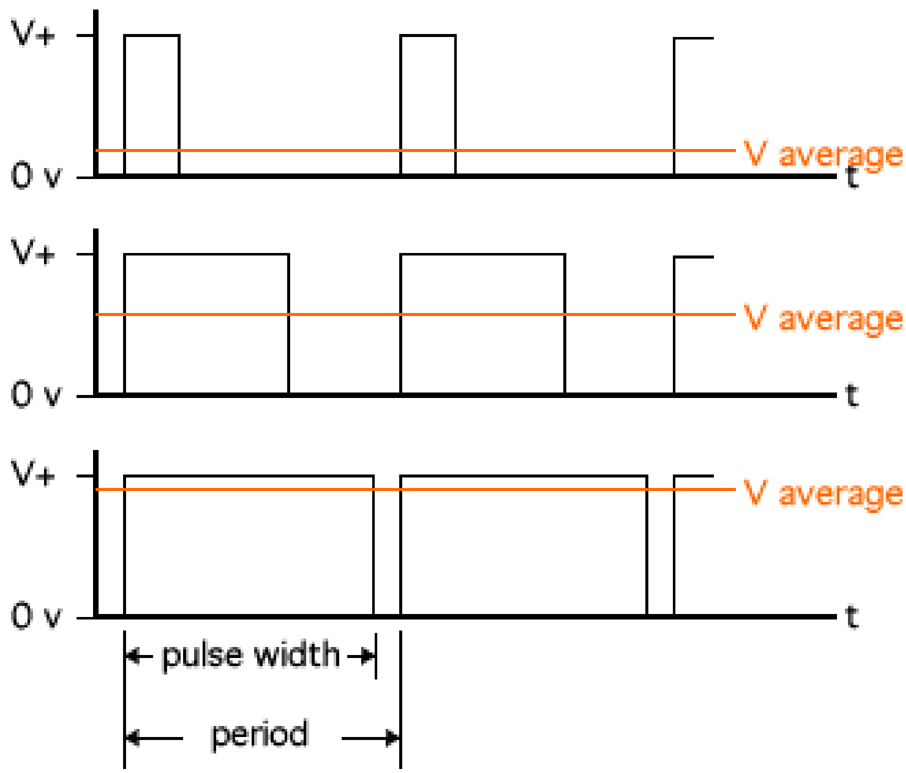
The MP-2986 Display and Keypad, shown below, is an optional accessory that can be purchased separately. It provides a convenient way of showing and adjusting the temperature set point or showing the actual temperature being sensed when the TC-36-25 RS232 is operating as a stand-alone controller. See the MP-2986 manual for further information.



Mechanically, the controller's printed circuit board is mounted to a metal bracket that is suitable for either horizontal or vertical orientation. The controller can operate in ambient temperatures from 0 °C to 60 °C without generally requiring additional heat sinking.

Technical Description

The TC-36-25 RS232 requires a constant-voltage power supply to provide power for a thermoelectric (TE) device such as a TE cooling assembly or a Peltier (TE) module. The controller regulates the power to the TE device using a method called pulse-width modulation (PWM). With PWM, the power is rapidly switched “ON” and “OFF” at constant frequency (2700 Hz for this controller). This creates a square-wave “pulse” of power to the thermoelectric device. The “ON” time, or pulse width, can be varied to create an average output voltage (Vaverage) that is required by the TE device to maintain the set temperature.



How Pulse-width Modulation Works

The important advantage to PWM is that it does not cause the extreme temperature excursions that are experienced with a thermostatic control system. This helps to extend the life and reliability of the TE devices. Added benefits are that the controller does not generate a large amount of waste heat and it does not require a large heat sink.

Depending on the input voltage required for the TE device, the TC-36-25 RS232 can be used with either one or two separate power supplies. When using one power supply, an input supply voltage ranging anywhere from (12 to 36) VDC is required to power both the controller and the TE device. The output voltage during the “ON” time is approximately equal to the input voltage.

When using two power supplies, one power supply, ranging anywhere from (12 to 36) VDC, can be used to power the controller itself; and a second power supply, ranging anywhere from (0 to 36) VDC, can be connected to the H-bridge of the controller. This second power supply allows the controller to control TE devices that must operate at a voltage less than 12 V. The self-contained H-bridge output transistors can deliver load currents from (0.1 to 25) A. (NOTE: consult appropriate installation instructions for power supply and heat sinking requirements for high current operation).

The controller tuning structure allows designation of a variety of control features:
1) The Computer Set Value provides for manual control of the output from 0% to ±100% of load power. This allows a remote device or computer to designate what output % the controller should deliver.
2) Proportional bandwidth (P) in degrees, Integral reset (I) in repeats per minute, and the Derivative rate (D) in minutes may be configured for P, PI, PD, or PID control.
3) Deadband control (on/off) with an adjustable hysteresis may also be selected. However, this control mode is not generally recommended with TE devices.
4) Differential temperature control is provided when two input sensing thermistors are used. The unit will control the differential between Input 2 (reference temperature) and Input 1 (actual system temperature).

A control temperature range of –20 °C to +100 °C is standard when using TE Technology's supplied thermistor sensor probe (MP-2996) for the primary sense temperature. Other temperature ranges are available with optional thermistors.

The set point of the controller can be changed in a variety of ways by using either a computer, a remote set-temperature potentiometer, a (0 to 5) VDC signal, a (0 to 20) mA current loop, or the MP-2986 Display and Keypad accessory. A secondary thermistor can also be used for differential control (or it could be used for alarm condition sensing). All temperatures may be consistently displayed in °C or °F.

Two types of control output modes may be selected. This determines the direction of the current flow through the thermoelectric when heating is desired. This current flow may be from Wire Point WP1+ to Wire Point WP2-. Alternatively, this current flow may be reversed from WP2+ to WP1- as selected in the configuration menu.

Several alarm settings may be selected, some of which provide an output current of 25 mA for alarm signaling. The settings can be selected for no alarm function, tracking alarm, and fixed-value alarm. Alarm temperature values can be entered in the setup menu using the supplied software. The computer-controlled selection is available for additional embedded controller input/output options. The alarm setup menu also provides for selection of an alarm latching condition. The alarm sensor may be either the control temperature sensor or a secondary thermistor sensor.

The various alarms have the ability to determine the status of the output power to the thermoelectric cooler or auxiliary heater. The main output power may be maintained during an alarm condition or shut down, depending on the user's setting.

Setup Instructions

1.0 Initial Setup

NOTE: the maximum allowable ambient temperature for the controller is 60 °C. Furthermore, the maximum allowable temperature of the controller base (underneath the transistor-mounting area) is 90 °C.

Portions of the temperature controller (the aluminum frame near the output transistors, for example) can exceed 60 °C during normal operating conditions.

Temperatures greater than 60 °C can result in a hazard to the user. Use caution! Protect against accidental contact with hot surfaces.

If the temperature controller is to be used under conditions such that it's surface temperatures could possibly exceed 60 °C test the surface temperatures under the worst-case operating conditions of maximum ambient temperature and highest output current and voltage. If any portion of the temperature controller exceeds 60 °C place adequate guards around the temperature controller to prevent contact with any hot surfaces.

1.1 The TC-36-25 RS232 can run as a stand-alone controller, meaning that it can operate without the use of a computer. However, a computer is required initially to set up various operating parameters.

Make sure the computer is **OFF** and the controller is **UN-POWERED**. Connect the RS232 Communications Port from the controller (JP4) to the RS232 input (Serial Communications Port) on the computer. Pin 1 of JP4 is the controller's RX, Pin 2 of JP4 is the controller's TX, and Pin 3 of JP4 is the controller's shield.

When using the supplied RS-232 cable, connect the wires to JP4 as follows (see "*RS232 Communications Connections*" for further information):

JP4-1: clear wire
JP4-2: red wire
JP4-3: black wire

1.2 Attach the thermistor to the temperature-control location.

Generally, attaching the thermistor to the cold side of the TE device provides better control stability than locating it at the object, liquid, or air that is to be cooled/heated. However, in doing so, there will be a temperature difference between the TE device and the object, liquid, or air that is to be cooled/heated. The temperature set point can be adjusted to compensate for this temperature difference if necessary.

NOTE: When possible, it is recommended that at least 50 mm of the thermistor's wire be thermally connected to the cold side of the TE device. This can be accomplished by placing aluminum tape over the thermistor wires and adhering the wires and tape to the cold side of the cooler. If this is not done, the thermistor wires will be at a different temperature than the cold side and they will add or remove heat in the region of the thermistor, making the temperature reading **significantly less accurate** and thermal response time slower.

The standard thermistor supplied with the TC-36-25 RS232 is the MP-2996. Appendix D "*Thermistor Styles for TC-36-25 RS232*" shows dimensional data on the MP-2996 and other thermistor styles readily available as well as the corresponding temperature-resistance data. If you are using the MP-2996, it is recommended that you use thermal grease (such as TE Technology TP-1) between the thermistor and the surface to which it is mounted.

See also section 2.11 for further details on using thermistors with different resistance-temperature curves than the standard thermistor.

1.3 Connect the thermistor wire leads to terminals JP2-5 and JP2-6. The thermistor is non-polarized, so it does not matter which particular lead goes to which terminal. (See "*Controller Wiring Diagram*" for reference. The thermistor is indicated in the diagram as the 'primary thermistor'.) You can lengthen the wire leads if necessary. The gauge of the wire is generally not important since the resistance of the wire is insignificant to the resistance of the thermistor.

1.4.0 The TC-36-25-RS232 can be used with two separate power supplies which allows for the control of TE devices whose nominal operating voltage is less than 12 V. In this case, one power supply is for the TE device, and the other power supply is for the controller itself (the microprocessor and associated electronics). Of course, just one power supply can be used for powering both the controller and the TE device provided that the TE device's nominal operating voltage is within (12 to 36) V.

When using one power supply for the controller and the TE device, the power supply input voltage is passed directly through the controller to the TE device during the "ON" pulse. The user should choose an input voltage that is at least 12 V yet is also no greater than the rated input voltage for the TE device.

When using two power supplies, the controller input power supply must be within a (12 to 36) V range, 150 mA minimum. The TE device power supply input voltage should be no greater than the rated input voltage for the TE device or no greater than 36 V, whichever is less.

The TE device current rating should be no more than 25 A at the supplied input voltage regardless of whether you are using one power supply or using two independent power supplies. *NOTE: the maximum allowable ambient temperature for the controller is 60 °C. The maximum allowable temperature of the controller base (underneath the transistor-mounting area) is 90 °C. The controller might need additional heat sinking, depending on ambient conditions and how much current is being drawn by the TE device.*

Note: when making a cooling system from a single TE module, the maximum operating voltage for that *system* is usually no more than 75% of the rated Vmax of the TE module. The 75% rule is based on the TE module being thermally connected to a "good" heat sink; system modeling should be done to verify this rule is applicable though. If multiple TE modules are used in a series or series-parallel combination, the Vmax of the system will be approximately 75% of the rated Vmax of each TE module multiplied by the number of modules in series.

1.4.1 One Power Supply Operation:

a) Install jumper across JP6-1 and JP6-2 (default setup)

b) Connect the constant DC voltage power supply (12 to 36) V to the controller:

Positive power supply terminal to WP3

Negative power supply terminal to WP4

c) Do **NOT** connect the TE device to the controller at this time.

d) See the "*Controller Wiring Diagram (Single Power Supply Setup)*" for further details.

1.4.2 Two Power Supplies Operation:

a) Remove jumper across JP6-1 and JP6-2

b) Connect the constant DC voltage controller power supply (12 to 36) VDC, 150 mA minimum to the controller:

Positive power supply terminal to JP6-2

Negative power supply terminal to JP6-3

Note: JP6 is a Molex connector, part number 22-23-2031

c) Connect the constant DC voltage TE device power supply (0 to 36) VDC to the controller:

Positive power supply terminal to WP3

Negative power supply terminal to WP4

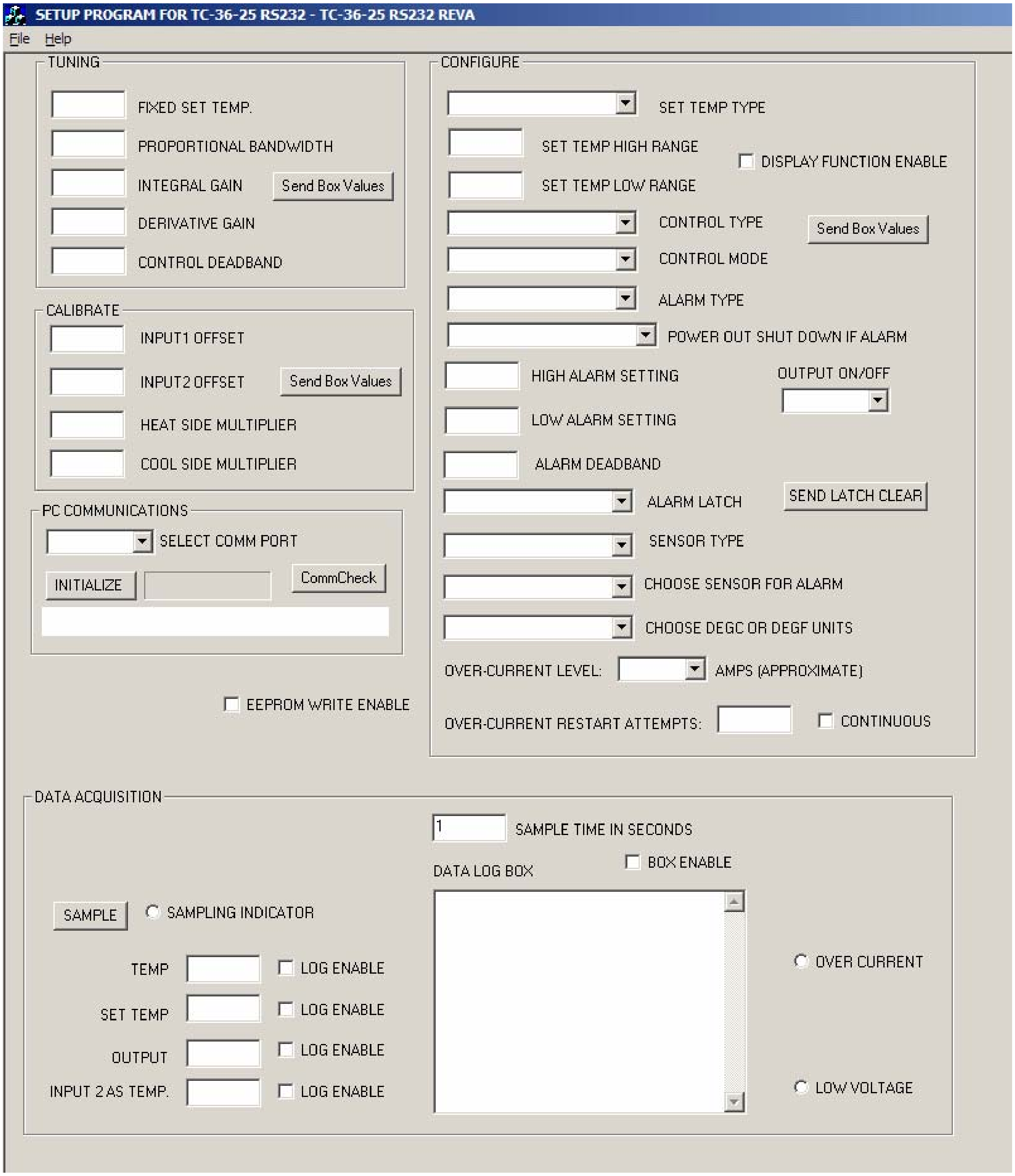
d) Do **NOT** connect the TE device to the controller at this time.

e) See the "*Controller Wiring Diagram (Two Power Supplies Setup)*" for further details.

1.5 Turn power on to both the computer and the power supply(s) (which in turn powers up the controller). The on-board green LED will flash at a steady rate to indicate that the controller is energized correctly.

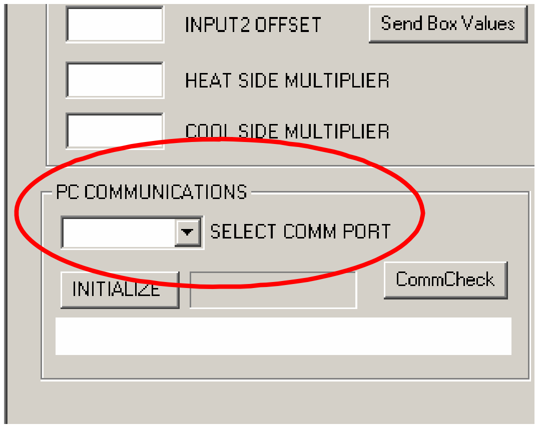
1.6 Insert the TC-36-25 RS232 software CD into the computer CD drive. To run the software from the CD, select START, RUN from your Windows Desktop and then enter D:\TC-36-25 RS232.exe (CD drive letter may vary). This will load the software into your computer's RAM. Alternatively, (and preferably) copy the TC-36-25 RS232.exe file to your hard-disk drive and run the program from there.

1.7 The Main Menu screen will appear on your computer monitor. All selections are made from this menu screen.



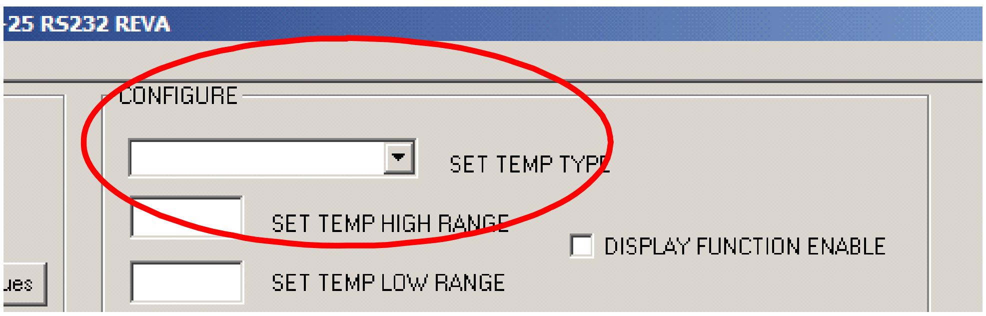
1.8 In the PC COMMUNICATIONS section, select the RS232 communications port (COM1 through COM8) to which the controller is connected by using the SELECT COMM PORT menu key. After making this selection, click on the INITIALIZE button.

NOTE: If you receive an error message, please refer to Appendix A "*Troubleshooting Communications Port.*"



2.0 Configuration Setup

2.1 In the CONFIGURE section of the software, the various selections below are used to establish the custom operating criteria for the controller.



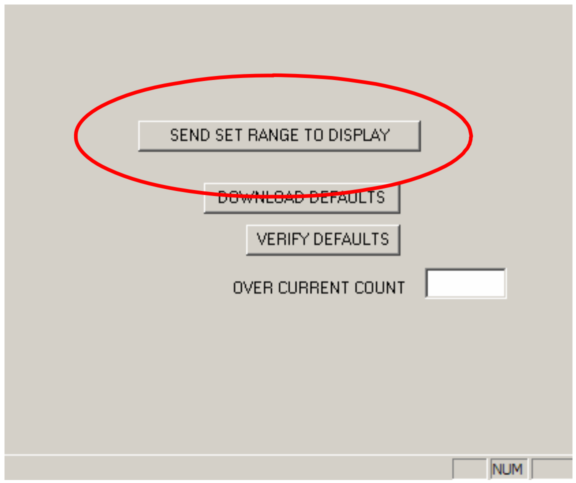
2.2 SET TEMP TYPE menu key:

a) COMPUTER SET VALUE: temperature set point is determined from software input

b) POTENTIOMETER SET, 0 TO 5vdc SET, or 0 TO 20 mA SET: temperature set point is determined by remote input. Refer to the "*Controller Wiring Diagram*" and the "*Block Diagram*" for additional information. If you intend to use one of these options, you will need to enter the SET TEMP HIGH RANGE and SET TEMP LOW RANGE values. These values are used to linearly scale the temperature range (or fixed percentage output power) that you are controlling within to the full range of the external input. The set limit values must be within the temperature range that the TC-36-25 RS232 is capable of controlling. For example, suppose you are using a (0 to 5) VDC external input to control the set point. If you then enter -20 for the SET TEMP LOW RANGE and +100 for the SET TEMP HIGH RANGE, this will create a linear scale of 5 V per 120 degrees or 0.0417 V/degree. So, to control to 10 °C, for example, you would set the external input voltage to 1.25 V.

c) DIFF.SET=INP2+FIXED SET: actual set temperature is the sum of the temperature sensed by the optional, secondary thermistor input sensor and the temperature entered as the FIXED SET TEMP value. This allows the controller to maintain a constant temperature difference between the primary thermistor temperature and the secondary thermistor.

d) JP3 DISPLAY SET VALUE: the temperature set point is determined by the set point entered with the MP-2986 Display and Keypad accessory. The DISPLAY FUNCTION ENABLE check box must be checked as well to enable the MP-2986. The allowable set temperature range for the MP-2986 can be set to the limits indicted by the values entered in the SET TEMP HIGH RANGE and the SET TEMP LOW RANGE boxes. However, to send these values to the display, the SEND SET RANGE TO DISPLAY button must be clicked. This button is located in the lower right-hand corner of the software. See the MP-2986 manual for further details.

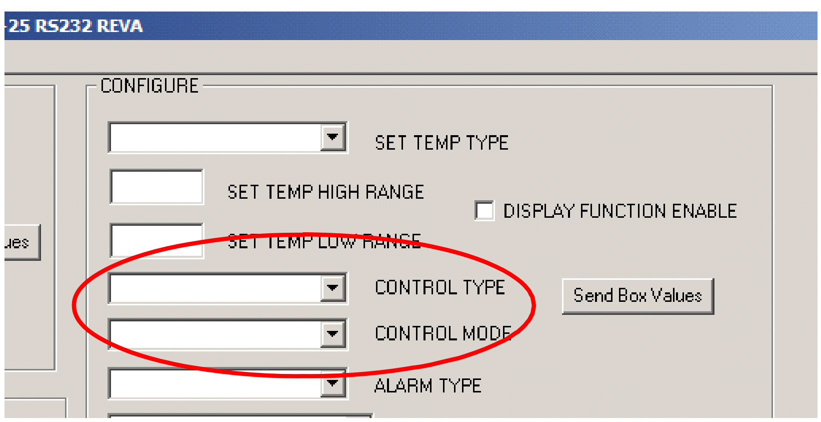


2.3 CONTROL TYPE menu key:

a) DEADBAND CONTROL: selects on/off control mode. However, DEADBAND CONTROL should not be used unless care is taken to prevent the TE device from being damaged by excessive thermal cycling.

b) PID CONTROL: selects proportional/integral/derivative control mode.

c) COMPUTER CONTROL: enables the user to select a constant, fixed-duty-cycle output (a fixed percentage output, see section 3.2 for further details.)



2.4 CONTROL MODE menu key:

HEAT WP1+ AND WP2- or HEAT WP2+ AND WP1-. This selection establishes the polarity for the heating mode of the thermoelectric cooler. It allows you to reverse the current flow in the TE device without having to change the wiring.

NOTE**: For TE Technology's standard products, the TE+ (red) wire should be attached to* WP2 *and the TE- (black) wire should be attached to* WP1 *as shown in the "Controller Wiring Diagram." The* CONTROL MODE *should then be set to* HEAT WP1+ and WP2-. *Again though, do* ***NOT *connect the TE device at this time.*

2.5 ALARM TYPE menu key:

a) NO ALARMS PICKED: no alarm condition will be monitored.

b) SET TRACKING ALARMS: allows an alarm to be set with respect to the set temperature. It will move accordingly with a change of the temperature setting. This option can be used for a high alarm, low alarm, or both settings.

c) FIXED VALUE ALARMS: permits the setting of a fixed, absolute temperature either above or below the set point temperature or both.

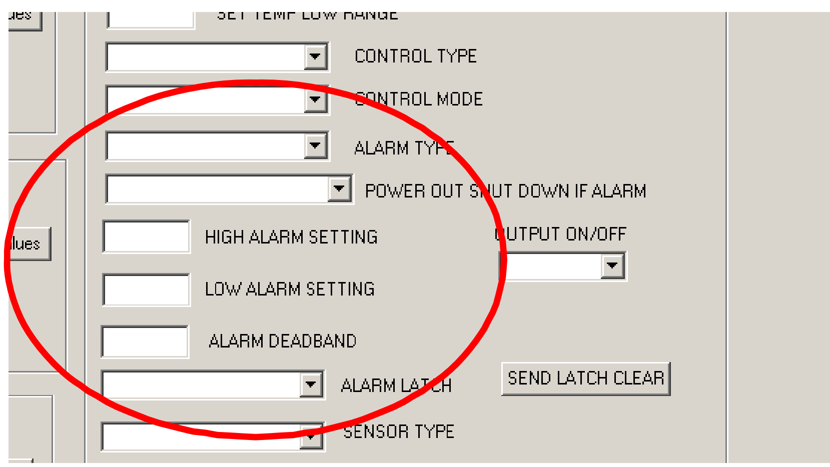
d) COMPUTER CONTROLLED ALARM: provides for user activation of the alarm relay via the computer software. The "*Expansion Connector Wiring Diagram*" shows how customer-supplied LED's can be installed to signal various alarm conditions.

Associated with the ALARM TYPE configuration are the HIGH ALARM SETTING box, LOW ALARM SETTING box, and the ALARM DEADBAND box. If an alarm type has been selected, enter the desired high and low temperature values that you want to have trigger an alarm condition. The ALARM DEADBAND option sets the hysteresis of the alarm values from 0.1 degrees to 100 degrees.

2.6 POWER OUT SHUT DOWN IF ALARM menu key:

a) NO SHUT DOWN IF ALARM: controller will continue to supply power to the TE device regardless of alarm condition.

b) MAIN OUT SHUTDOWN IF ALARM: shuts off power output to the TE device when an alarm condition exists.



2.7 ALARM LATCH menu key:

a) ALARM LATCH OFF: controller will automatically reset to a non-alarm state if the alarm condition self-corrects.

b) ALARM LATCH ON: controller will maintain the alarm condition until it is manually cleared. If an alarm condition exists, the alarm latch can be reset by clicking the SEND LATCH CLEAR button or by electrically shorting the Alarm Cancel pin, JP2-5 to the circuit ground pin, JP2-4.

2.8 SENSOR TYPE menu key:

The available options correspond to various temperature-resistance curves for thermistors as shown in "*Temperature-Resistance Curves*" in the Appendix. Select the sensor type having the same temperature-resistance curve as the thermistor you intend to use with the controller:

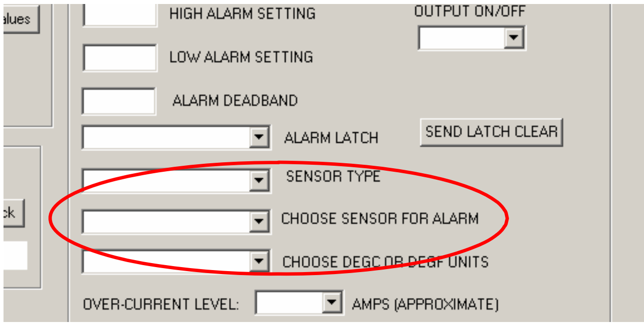
a) TS-141 5K, control temperature range: -40 °C to +70 °C
b) TS-67, TS132 15K, control temperature range: -20 °C to +100 °C
c) TS-91 10K, control temperature range: -20 °C to +85 °C
d) TS-165 230K, control temperature range: +25 °C to +250 °C
e) TS-104 50K, control temperature range: 0 °C to 150 °C
f) YSI H TP-53, control temperature range: -15 °C to +80 °C

NOTE: Select **TS-67, TS132 15K** when using the standard **MP-2996** sensor or other sensors listed in Appendix D *"Thermistor Styles for TC-36-25 RS232."* This will provide a control range of -20 °C to +100 °C. However, remember that depending on the type of cooler you have, the cooler itself might not be suitable for operation at temperatures greater than 70 °C.

If you have an existing 10 kOhm thermistor, the TS-91 10K or YSI H TP-53 might be equivalent. The TS-91 10K is equivalent to the 10 kOhm thermistor, curve "B" from YSI Temperature, Inc. The YSI H TP-53 is equivalent to the 10 kOhm thermistor curve "H" from YSI Temperature, Inc.

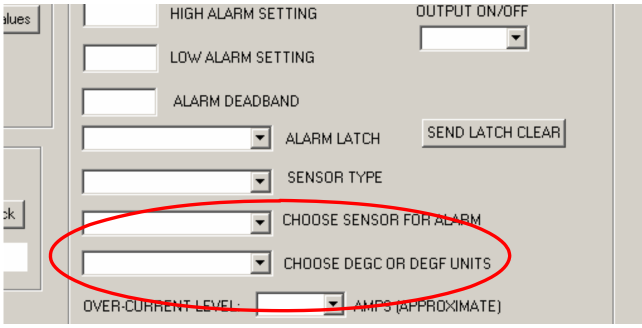
2.9 CHOOSE SENSOR FOR ALARM menu key:

a) CONTROL SENSOR: the primary sensor temperature is monitored for alarm conditions
b) INPUT 2 SENSOR: a secondary thermistor (see "*Controller Wiring Diagram*") can be attached to the heat sink or other object in order to detect over-temperature conditions. (Note: the INPUT 2 SENSOR secondary thermistor cannot be used if you are using a potentiometer or voltage/current levels to control the set point.)



2.10 CHOOSE DEGC OR DEGF menu key:

a) DEG F: all temperatures are read/interpreted in degrees Fahrenheit.
b) DEG C: all temperatures are read/interpreted in degrees Celsius.



2.11 OVER CURRENT LEVEL menu key:

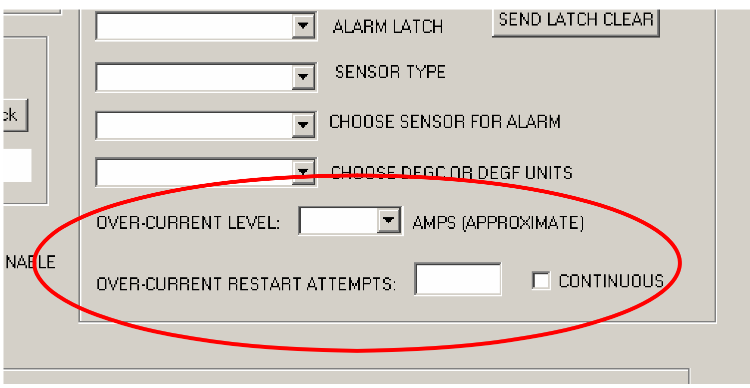
This selects the level at which the over-current protection for the TE device shuts the output off. This level is adjustable in 2.5 A increments, and the allowable levels range from 0 A to 40 A. The controller will automatically attempt to restart the output (either continuously or a fixed number of times) per the conditions set as described in section 2.12. During the restart attempts, the output will still be shut down each time if the over-current level is reached again. If a fixed limit of attempts is reached the output will be disabled until a "latch clear" signal is sent (see section 2.7) or the controller is turned off and then on again.

NOTE: THIS IS NOT AN ANALOG CURRENT LIMIT FEATURE!

The over-current value is approximate; the actual current value the controller shuts off at may differ by 3 A or more from the selected over-current level. Also, it is normal to have an output current surge when the direction of current flow is instantaneously reversed to a TE device that has a temperature difference established across it. When this happens, the "apparent electrical resistance" of the TE device is lower because the Seebeck back-voltage does not immediately reverse polarity. The reversal of current will eventually reverse the temperature difference across the TE device (and then its Seebeck back-voltage will likewise change polarity). As the temperature difference reverses, the current will revert back down to a steady-state level.

2.12 OVER-CURRENT RESTART ATTEMPTS / CONTINUOUS boxes:

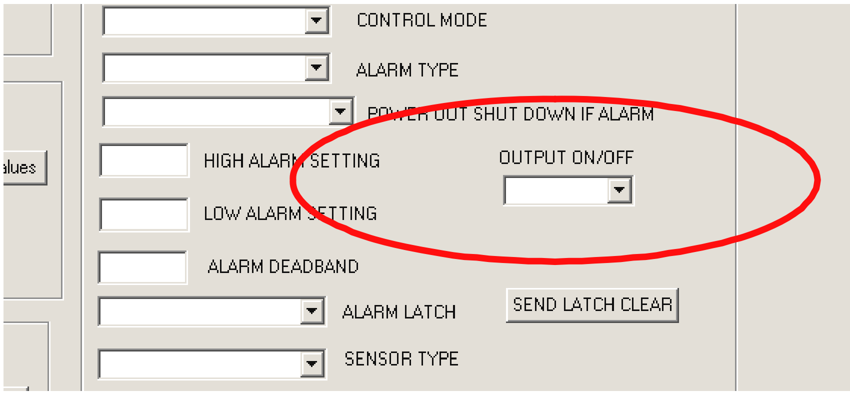
This sets the number of restarts the controller will attempt. Selecting the CONTINUOUS box provides an infinite number of restarts. If a fixed limit of attempts is reached, the output will be disabled until a "latch clear" signal is sent or the controller is turned off and then on again.



2.13 OUTPUT ON/OFF menu key:

a) OFF: output power to the TE device is shut off

b) ON: output power to the TE device is enabled and the controller will begin controlling to the set point temperature (if possible)



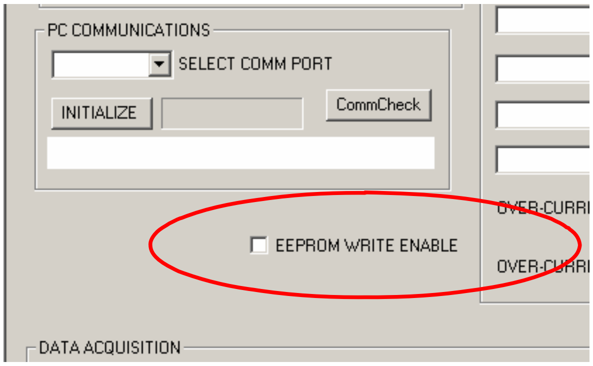
NOTE: Select OFF for the initial setup. This will ensure that the controller will not begin controlling the TE device to a temperature that might inadvertently cause damage if the controller were not yet completely set up.

2.14 EEPROM WRITE ENABLE check box:

Upon a power-up or reset condition, the controller performs an initialization of all command variables that have write commands. The controller transfers the last values stored in non-volatile memory (EEPROM) to appropriately referenced static RAM locations. This action is performed so that the controller can run faster (RAM is faster than ROM). This also allows the controller to run as a stand-alone controller, separate from the computer.

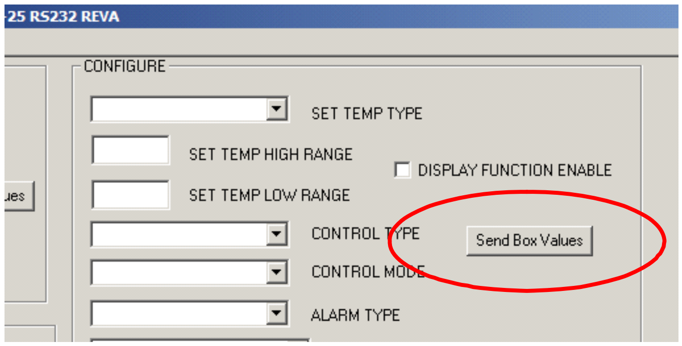
a) EEPROM WRITE ENABLE is checked: any changes in the run-time values of the command variables are stored in EEPROM as well in RAM and thus will be recalled upon a power-up or reset condition.

b) EEPROM WRITE ENABLE is un-checked: run-time values are stored only in RAM. No settings are saved to EEPROM. This setting gives you the ability to change run-time values without changing your desired power-up settings. This also allows the user to send unlimited write commands to the controller without exceeding the maximum number of writes to an EEPROM location (1,000,000).



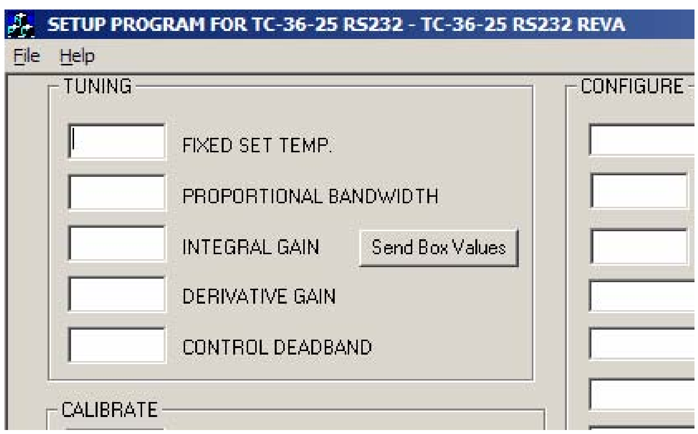
2.15 Review all of your controller configuration selections. If all the configuration selections are correct for your application, click the SEND BOX VALUES button in the CONFIGURE section to download these settings to the controller.

NOTE: Remember to click the SEND BOX VALUES button to update the controller any time CONFIGURE variables have changed.



3.0 Tuning Parameter Description

3.1 In the TUNING section of the software, the various selections below are used to establish the set point and the variables affecting set point stability.



3.2 FIXED SET TEMP. box:

a) Enter the set temperature value in degrees. This temperature must be within both the range of the selected input sensor and the limits of low and high set ranges from the controller configuration setup. Also, verify that the cooler is capable of safely operating at the entered set temperature. This is particularly important if you are heating. While you can control to +100 °C using the standard thermistor, many TE devices are only rated for at most 80 °C.

b) If you selected COMPUTER CONTROL in the CONTROL TYPE menu key under the CONFIGURE section, the values that can be entered in the FIXED SET TEMP box range from –5.11 to +5.11. This corresponds linearly to a fixed percentage of power output where –5.11 equals –100% power and +5.11 equals +100% power. If you selected HEAT WP+1 and WP2- under the

CONTROL MODE menu key under the CONFIGURE section, then -5.11 corresponds to full-power cooling. The value is adjustable in 0.01 unit increments.

3.3 PROPORTIONAL BANDWIDTH:

The acceptable bandwidth values that may be entered are (1 to 100) degrees.

The proportioning bandwidth is the temperature span over which the output power is proportioned from -100% to +100%. The bandwidth is centered about the temperature set point, and once set the proportional output will vary as the actual temperature moves through the bandwidth range. That is, the controller output is +100% at the end of the bandwidth range above the set point, it decreases to 0% power as it reaches the set point, and then reverses to -100% as it reaches the end of the bandwidth range below the set point.

For example, suppose the controller is being operated in the cooling mode, the set point is 10.0 °C, and the bandwidth is set to 5 °C (with INTEGRAL GAIN and DERIVATE GAIN both set to zero). The controller will be at +100% output until the temperature cools to 12.5 °C. Power then starts to proportionally decrease as the sensor temperature is cooled below 12.5°C. The power will be reduced to 0% when the sensor is at 10.0 °C. Finally, the power will reverse polarity and proportionally increase to -100% if the sensor temperature decreases to 7.5°C.

If the bandwidth is set too narrow, the temperature will oscillate around the set point. If the bandwidth is too wide, the controller will be slow to respond or may never reach set point.

3.4 INTEGRAL GAIN:

The acceptable values that may be entered are (0.00 to 10) repeats per minute.

With just proportional control, the controller's output is, by definition, 0% when the actual temperature reaches the set temperature. Because some non-zero output power level is almost always required to reach the set point, using ***only*** proportional control will not allow the controller to maintain a desired set point. Therefore, introducing an integral gain allows for an output amount other than 0% when the actual temperature reaches the set temperature. It essentially shifts the output power to the average level required to maintain the desired set point.

For example, suppose the set temperature is 10.0 °C, the bandwidth is set to 5 °C, and the controller settled to a constant 11.2 °C (corresponding to 48% power with only the proportional bandwidth active).

- In this case the "error", or difference in temperature between the set point and actual temperature, is 1.2 °C.
- From the example in section 3.3 we know that the proportional output will change by 40% for every 1 °C change in the error (this is bandwidth gain of 40 % per °C).
- Let's assume the integral gain is activated by changing its setting from "0" to "1 per minute".

The integral function will now ramp the output at a rate determined by the error signal, the proportional bandwidth gain, and the integral gain. The rate is determined by multiplying the error, the bandwidth gain, and the integral gain. In this case, if the integral control is set to 1 repeat per minute, the controller will increase the output power at a rate of 48% per 1 minute.

$$\frac{40\%}{°C} * 1.2°C * \frac{1}{minute} = 48\% \ / \ minute$$

This output % is updated continuously. Of course, the maximum output is limited to +100% and the minimum is limited to -100%.

If the integral gain is set too high, the temperature will oscillate. If integral control is set too low, it will take a long time for the temperature to settle to steady state.

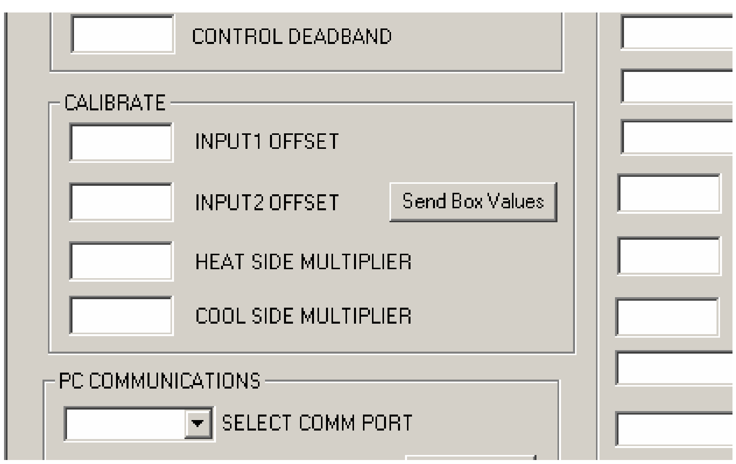
3.5 DERIVATIVE GAIN:
The acceptable values that may be entered are (0.00 to 10) cycles per minute.

The derivative gain senses the rate of change of the temperature and allows the controller to anticipate the power needed to compensate for rapid changes in system loading. This term is generally used only on very sluggish systems or where very quick response is necessary. It works in a way similar to the integral gain, but acts upon change in error signal and not the actual error signal.

3.6 CONTROL DEADBAND:
The controller can be set to turn on and off by either rising or falling temperatures where no heating or cooling takes place. This band is expressed in degrees, and the acceptable values that may be entered are 0.1 to 100. This setting is only utilized when CONTROL TYPE is set to DEADBAND CONTROL.

4.0 Calibration Parameter Description

4.1 The CALIBRATE section provides additional variables that can be used to fine tune your system's operation. You may want to try controlling with the initial settings prior to entering values in this section.



4.2 INPUT 1 OFFSET is a manual method of compensating for a temperature difference between the sensor 1 temperature and actual control temperature.

4.3 INPUT 2 OFFSET is a manual method of compensating for a temperature difference between the sensor 2 temperature and actual temperature.

4.4 HEAT SIDE MULTIPLIER is a 0.01 to 2.00 numerical multiplier that compensates for the non-symmetrical response of the thermoelectric cooler between the heat and cool modes. When the controller is in heating mode it takes the computed PID output power value and multiplies it by this multiplier to derive the actual output level. Setting the value to 0 makes the controller a "cool only" controller.

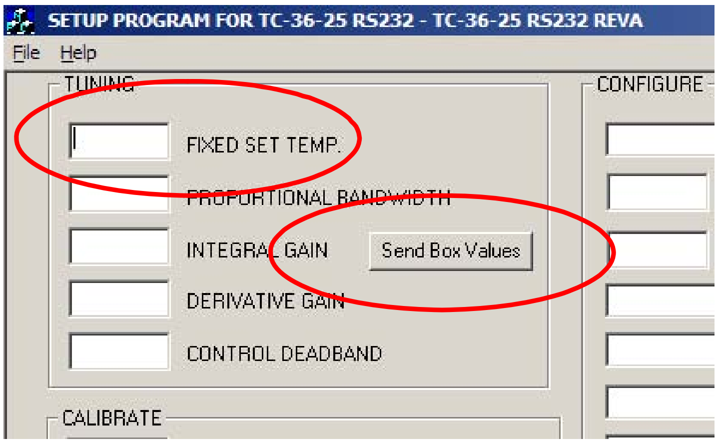
4.5 COLD SIDE MULTIPLIER is a 0.01 to 2.00 numerical multiplier that compensates for the non-symmetrical response of the thermoelectric cooler between the heat and cool modes. When the controller is in cooling mode it takes the computed PID output power value and multiplies it by this multiplier to derive the actual output level. Setting the value to 0 makes the controller a "heat only" controller.

4.6 If you have entered values in the CALIBRATE section and they are desired settings, click the SEND BOX VALUES button to download these constants to the controller.

5.0 Final Setup—Controller Tuning

5.1 Enter the desired control set point in the FIXED SET TEMP. box of the TUNING section. Then click the SEND BOX VALUES in the TUNING section to enter the set point temperature into the controller RAM.

NOTE: Remember to click the SEND BOX VALUES button to update the controller anytime TUNING variables have changed.

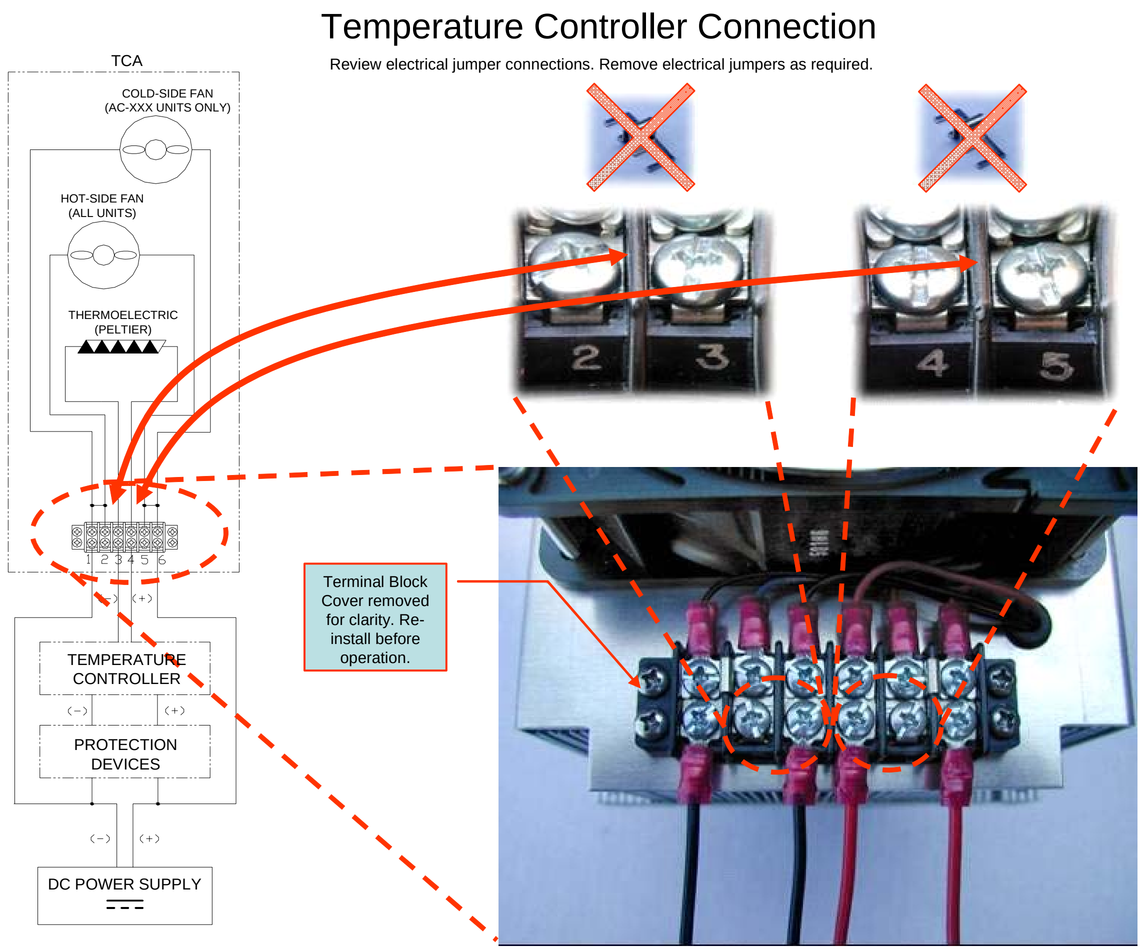


5.2 Connect **ONLY** the TE device to the controller:

Positive TE device terminal to WP2

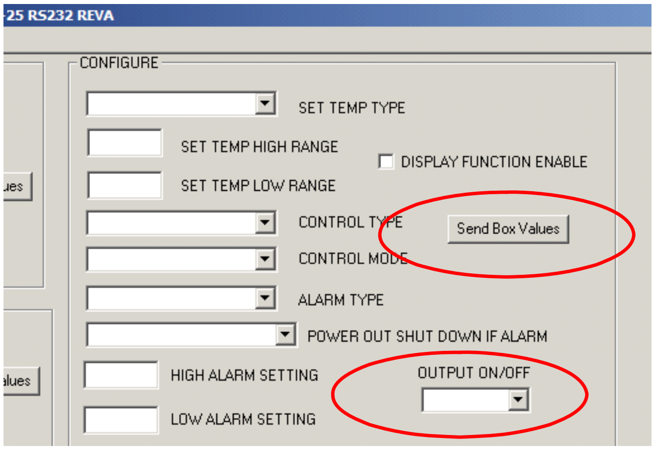
Negative TE device terminal to WP1

TE Technology's standard thermoelectric cooling assemblies (TCA) have at least one fan on the heat sink. The standard configuration has the thermoelectric modules and fan(s) wired to a terminal block with jumpers across the terminals so that the fans and modules are connected in parallel. However, this configuration is applicable only when applying power directly from the power supply. When using the TCA with the temperature controller, the jumpers **MUST** be removed so that the controller is controlling power only to the thermoelectric modules. There must be no electrical connection between the fans and the modules; fans must be connected directly to the power supply, not to the controller. *The controller will be damaged if this is not followed*. See the cooler manual for further details, but the picture below shows the basic setup.



NOTE: Generally there is approximately a 0.5 to 1.3 V drop from the power supply to the TE device. You might need to adjust the power supply accordingly to ensure full power is delivered to the TE device when needed.

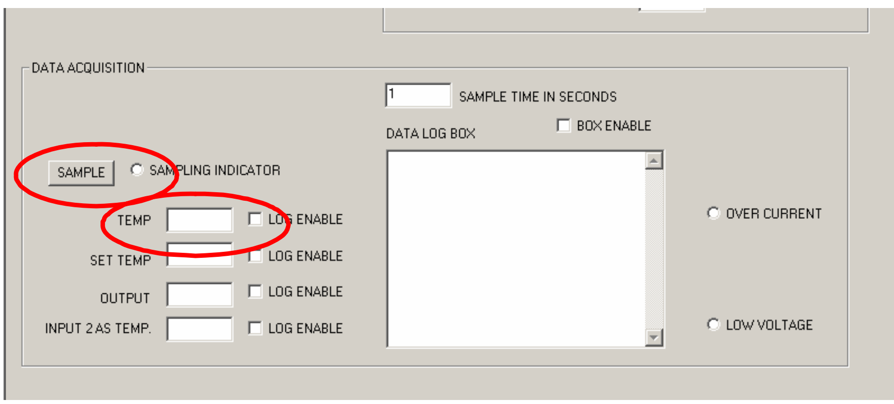
Next, select ON in the OUTPUT ON/OFF menu key in the CONFIGURE section. Then click SEND BOX VALUES in the CONFIGURE section. The controller will begin to send output power to the TE device.



5.3.0 Enter the following parameters:
PROPORTIONAL BANDWIDTH: 20
INTEGRAL GAIN: 0
DERIVATIVE GAIN: 0

NOTE: whenever a tuning parameter is entered in the box, you must click the SEND BOX VALUES button in the TUNING section in order to download the values to the controller.

5.3.1 Click the SAMPLE button to monitor the actual temperature being sensed. The sensed temperature will be shown in the TEMP box.



5.3.2 Allow the TE device to reach steady state. Incrementally reduce the bandwidth setting, allowing the controller to reach steady-state at each increment, until the system just begins to oscillate. At this point, the bandwidth is too small. Note the bandwidth setting that just caused the system to oscillate and note the time period of oscillation in minutes. The time period will be used later for determining the integral gain and derivative gain settings.

NOTE: The system temperature will likely begin to oscillate before reaching the set point temperature. This is normal.

5.3.3 Multiply the current proportional bandwidth setting by 2.2, and enter it as your new PROPOROTIONAL BANDWIDTH setting. Be sure to click “SEND BOX VALUES” after entering new parameters. The system should come into control and maintain a steady temperature near the set point.

5.3.4 The integral gain is calculated as follows: I = 0.54/T where I is the integral gain, and T is the time period, in minutes, determined in section 6.3.2. Enter this value into the INTEGRAL GAIN.

For example, suppose the system’s period of oscillation with the appropriately set proportional bandwidth was 75 seconds (1.25 minutes). The suggested integral gain is therefore:

I = 0.54/1.25 minutes = 0.43 repeats/minute

5.3.5 The derivate gain is often times difficult to apply and might cause more trouble than it is worth. If you are not experienced in process control, you may be better off leaving the DERIVATIVE GAIN set to zero.

If you decide to use derivative gain, the other values should be adjusted first.

a) Instead of multiplying the initial bandwidth setting by 2.2, multiply it by 1.7, and enter this as the new PROPORTIONAL BANDWIDTH setting.

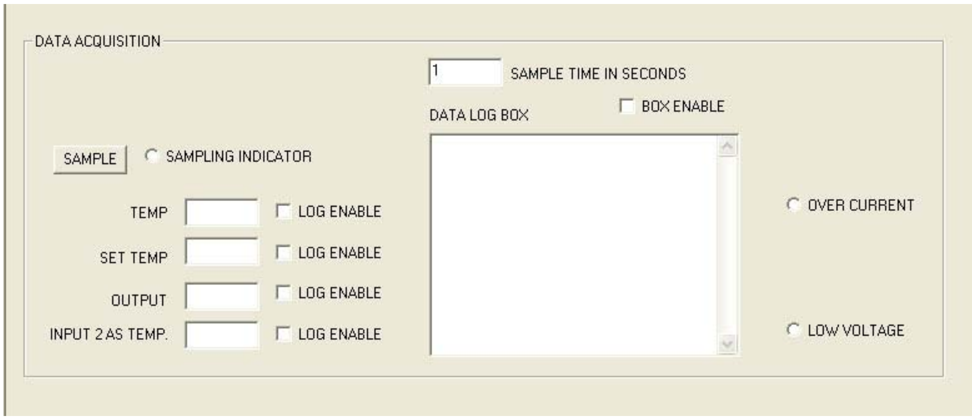
b) Calculate the integral gain as follows: I = 1.2/T, and enter this into the INTEGRAL GAIN setting.

c) Calculate the derivative gain as follows: D = 0.075 x T, and enter this into the DERIVATIVE GAIN setting.

5.4 Setup of the TC-36-25 RS232 is now complete. However, the proportional, integral, and derivative settings are approximate settings and might need further minor adjustments.

You might also want to save your settings to EEPROM for future recall (see section 2.14)

6.0 Data Acquisition Features



6.1 SAMPLE button:
Clicking the sample button instructs the controller to report the controller operating conditions for TEMP, SET TEMP, OUTPUT, INPUT2 AS TEMP, and OVER CURRENT COUNT.

6.2 SAMPLE TIME IN SECONDS box:
Enter the time, in seconds. This sets the controller update interval for the various operating conditions.

6.3 TEMP box:
This shows the temperature currently being sensed by the primary thermistor.

6.4 SET TEMP box:
This simply reports what was entered in the FIXED SET TEMP. box.

6.5 OUTPUT box:
This indicates the percentage of power (duty cycle) being applied to the TE device.

6.6 INPUT2 AS TEMP box:
This shows the temperature of the secondary thermistor if it is installed.

6.7 LOG ENABLE check box:
If the box is unchecked, the controller will not save any previous data reported to software.
If the box is checked, the controller will report the data to the DATA LOG BOX before updating at the next sample time interval.

6.8 DATA LOG BOX:
If any of the sample boxes have the LOG ENABLE box checked, the data from those boxes will be recorded to the DATA LOG BOX at each time interval. Be sure that the BOX ENABLE box is checked. The data does scroll down and off of the screen. However, you can cut and paste it into a spreadsheet if necessary.

6.9 OVER CURRENT indicator:

This indicator shows when the controller has shut the output off because of an over current condition.

6.10 LOW VOLTAGE Indicator:

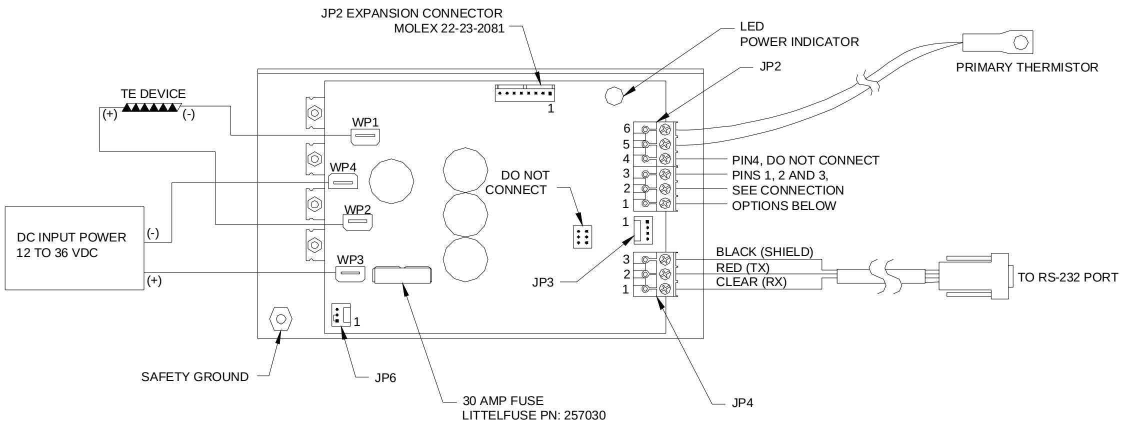
This indicator shows when the output driver circuitry has turned the output MOSFETs off due to a low controller circuit voltage. The output will be turned off if the controller circuit voltage drops below approximately 11.0 to 11.2 volts. The output will automatically restart when the voltage increases to approximately 11.4 volts.

7.0 Custom Software

The controller does not specifically have to be used with the software that is provided. You can create your own control programs using commercial software such as LabView from National Instruments. This might be useful if you wanted to control a specific temperature profile over a particular amount of time. This is accomplished by communicating through the RS-232 port of the computer using the command set for the controller. The command set is given in Appendix B "*Serial Communications*."

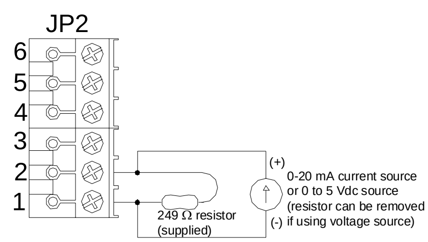
TE Technology has developed some LabView programs for internal use. We would be happy to share them for use as a starting point for your custom software application. Please email the company if you are interested in this option.

Controller Wiring Diagram: One Power Supply Setup

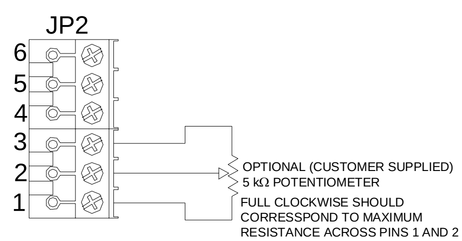


NOTE: 1) WP1, WP2, WP3, AND WP4 ARE 6.35 mm (.25 inch) QUICK CONNECT TERMINALS.
2) SINGLE POWER SUPPLY OPTION: INSTALL JUMPER ON PINS 1 AND 2 OF JP 6 (DEFAULT CONDITION)

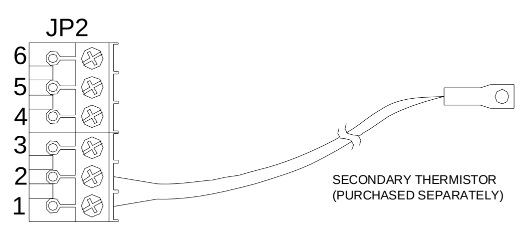
OPTION 1
Proportional Signal for Adjusting Set Point



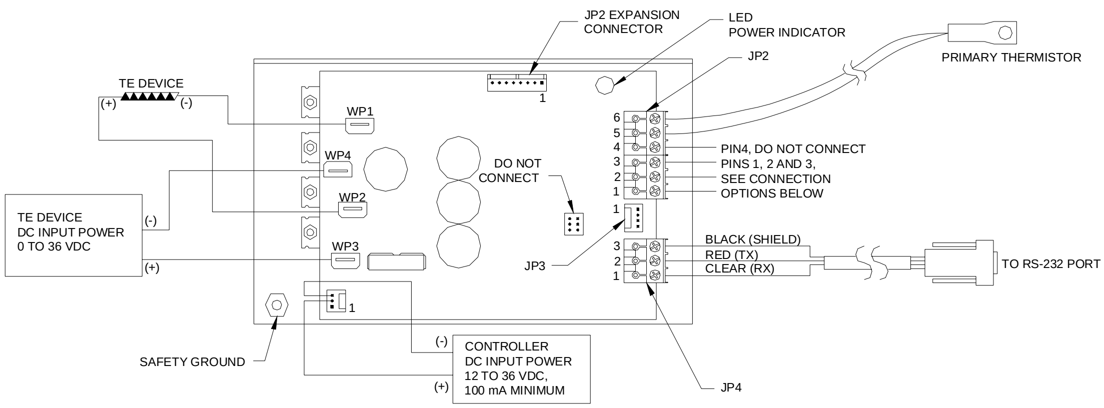
OPTION 2
Variable Resistance for Adjusting Set Point



OPTION 3
Second Thermistor for Differential Control or for Sensing Over-temperature Condition

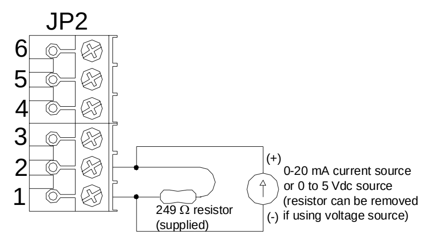


Controller Wiring Diagram: Two Power Supplies Setup

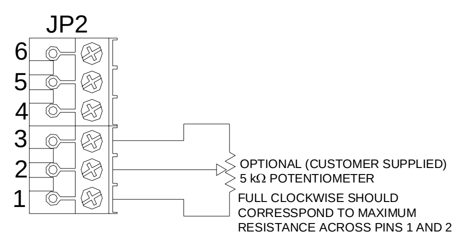


NOTE: 1) WP1, WP2, WP3, AND WP4 ARE 6.35 mm (.25 inch) QUICK CONNECT TERMINALS
2) TWO POWER SUPPLIES SETUP: A) TE DEVICE POWER SUPPLY CONNECTS TO WP3(+) AND WP4(-)
B) CONTROLLER POWER SUPPLY CONNECTS TO JP6-2(+) AND JP6-3(-) (REMOVE JUMPER FROM JP6)
JP6: MOLEX PN: 22-23-2031

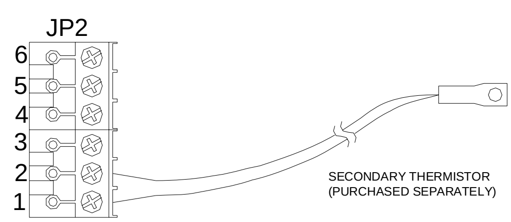
OPTION 1
Proportional Signal for Adjusting Set Point



OPTION 2
Variable Resistance for Adjusting Set Point

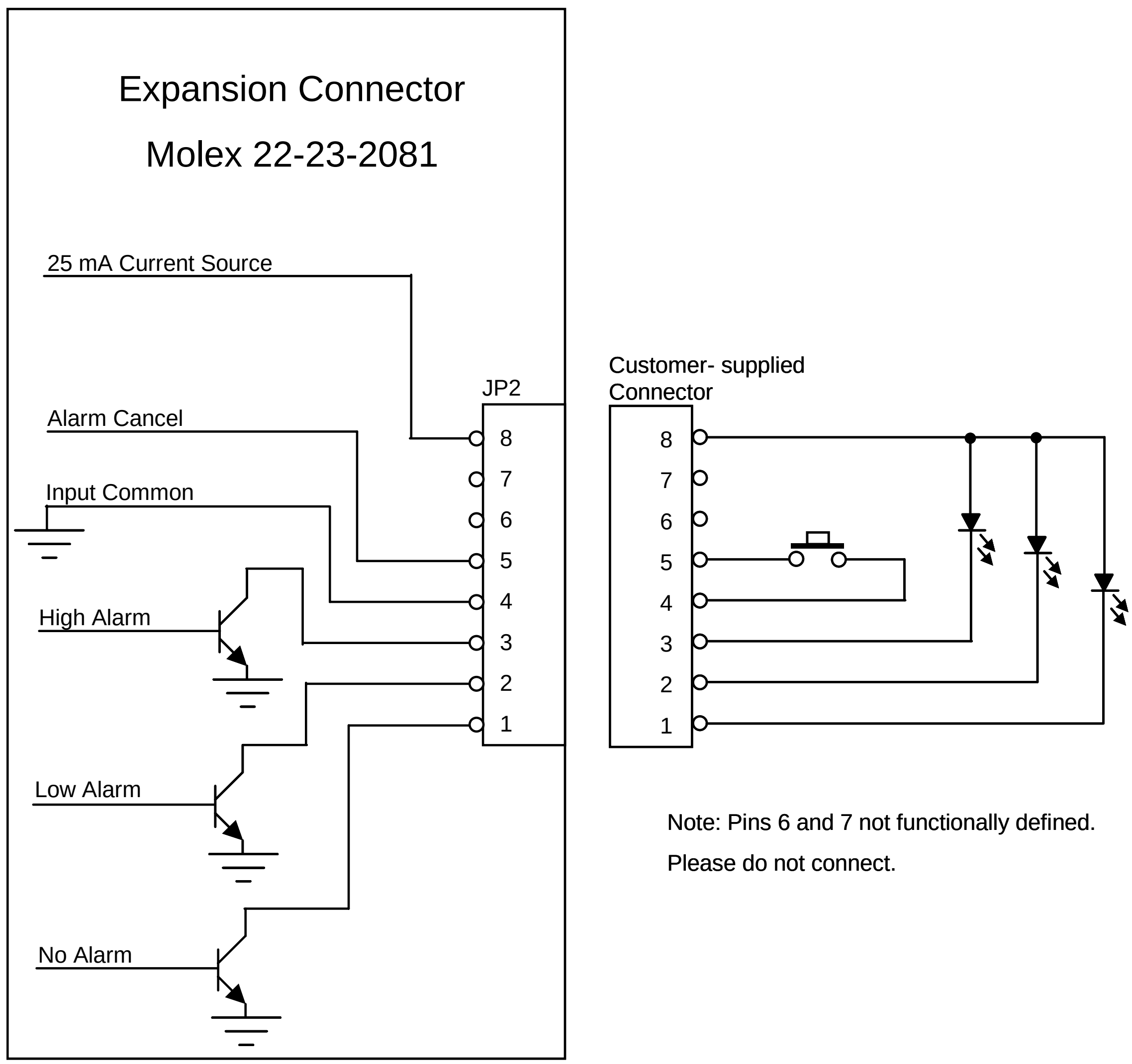


OPTION 3
Second Thermistor for Differential Control or
for Sensing Over-temperature Condition

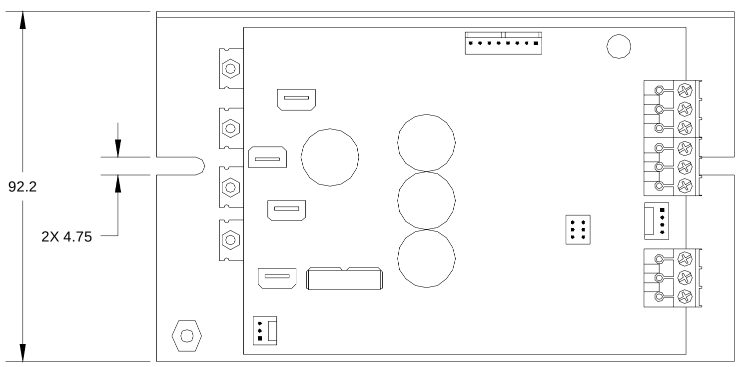


Expansion Connector Wiring Diagram

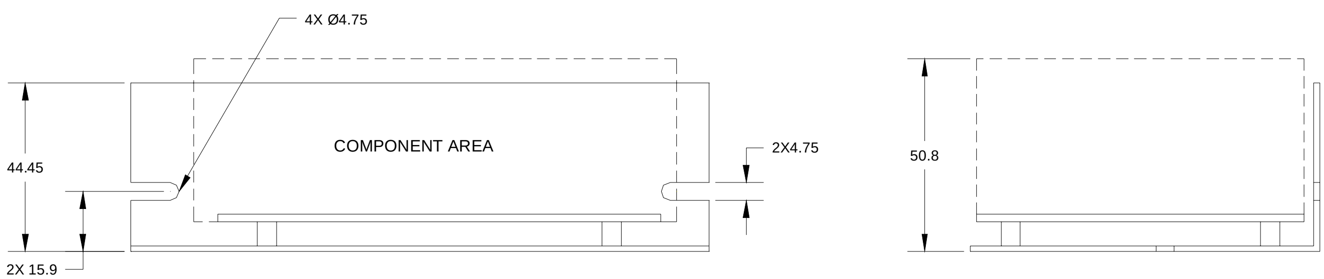
Note: The 25 mA current source is a true current source. Maximum compliance voltage is approximately V+, the input voltage to the temperature controller. No external current limit resistors are needed for the LED. The LED must be capable of being driven with a 25 mA continuous current.



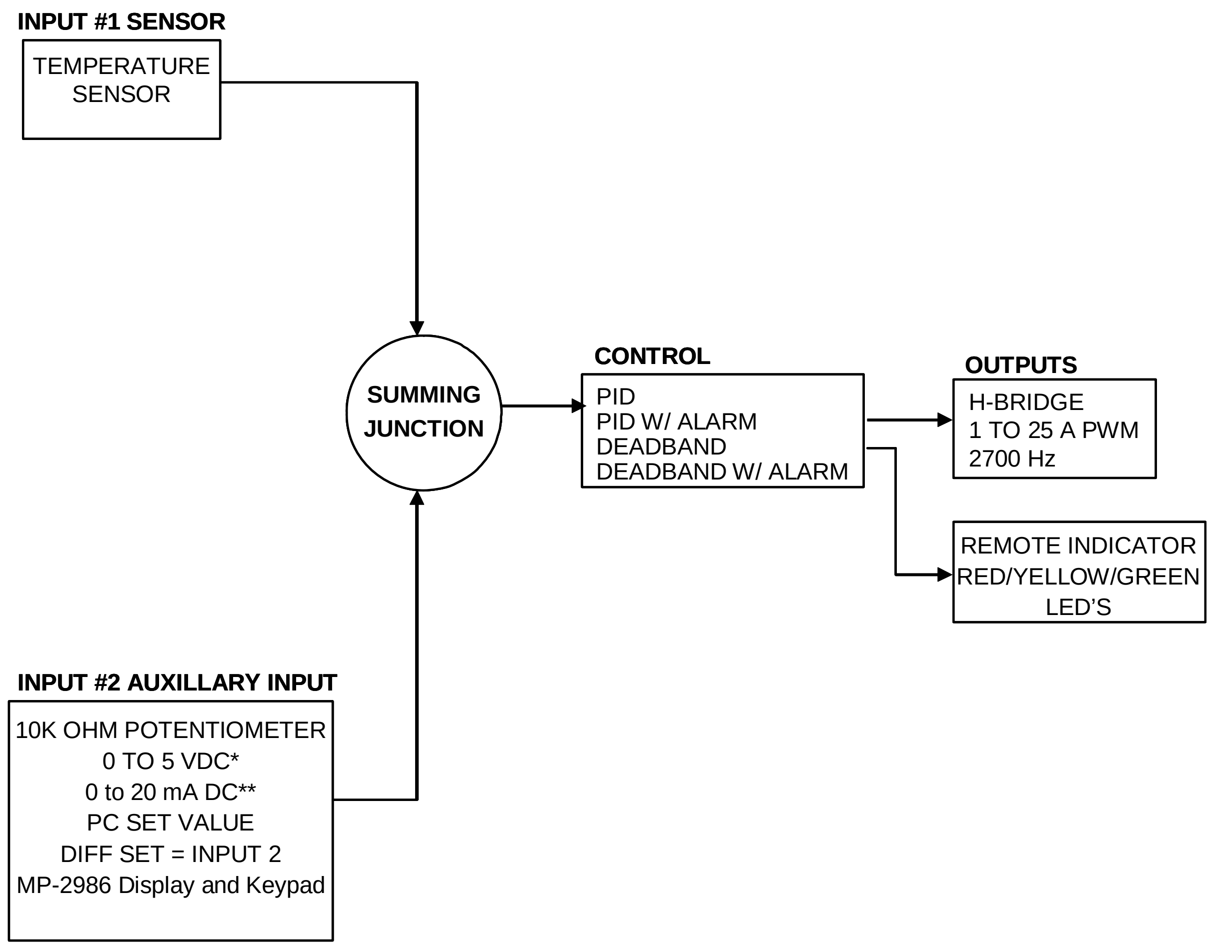
Mechanical Package Drawing



DIMENSIONS IN MILLIMETERS



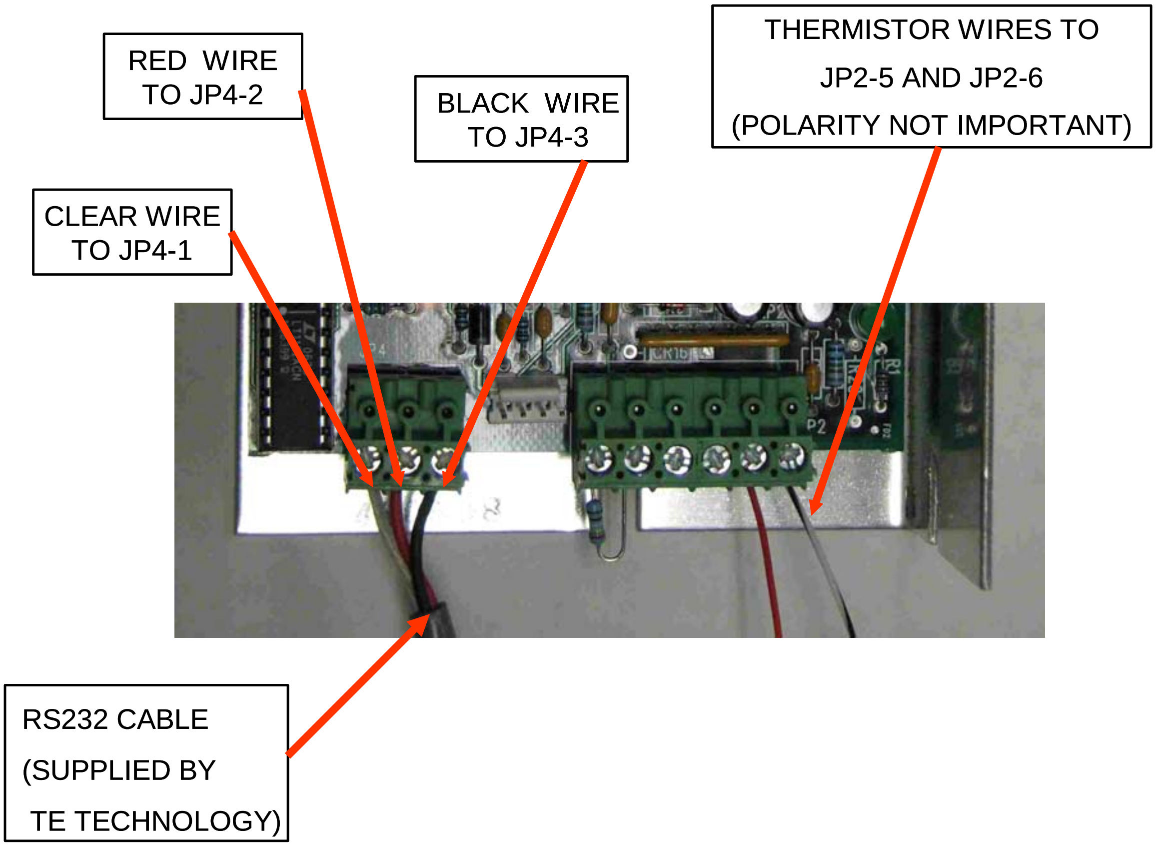
Block Diagram



*CONTROLLER INPUT IMPEDANCE 6.5K OHMS

**REQUIRES ADDITION OF EXTERNAL RESISTOR

RS232 Communications Connections



PC CONNECTION TABLE

PC CONNECTOR	9 PIN	25 PIN	PC FUNCTION*	CONTROLLER
PIN	**2**	**3**	**RECEIVE (RX)**	**TRANSMIT (TX) JP4-2**
PIN	**3**	**2**	**TRANSMIT (TX)**	**RECEIVE (RX) JP4-1**
PIN	**5**	**7**	**COMMON**	**SHIELD JP4-3**

***Functions normally assigned to pins.**
Check your PC manual to confirm

APPENDIX A Troubleshooting Communications Port

You can perform a quick check of the communications port (without having to initialize variables) by clicking the "CommCheck" button in the PC COMMUNICATIONS section of the software screen. You should have the controller connected to a communications port and the controller powered up when performing the communications check. A "COMM ERROR!" message will show if there is no hookup. If the connection is good a "COMM OKAY" message will appear.

When you initialize, an error message might show up if there are any additional problems. The following table offers possible solutions corresponding to a particular error:

Error Message	Cause	Solution
Comm Port Timeout	No power to TC-36-25 RS232 unit	Apply power to TC-36-25 RS232, review customer drawing for proper hookup.
Comm Port Timeout	Wrong Comm Port selected	Check computer hardware setting and set to the correct Comm Port.
Comm Port Timeout	Incorrect wiring of Comm Port to the computer.	Check for correct wiring from JP4 to the computer.
Comm Port Open Error	No Comm Port available at this port setting.	Check computer hardware setting and set to the correct Comm Port.

Note: See Appendix B, Section III RS232 Communications Parameters regarding the insertion of a delay between sending characters if you are using your own software program.

APPENDIX B Serial Communications

I. Definitions:

<u>All numeric values are in hexadecimal format.</u>

<u>Use lowercase ASCII characters.</u>

(stx)	Start of text character (*) or 2a hex.
(etx)	End of text character (carriage return) or 0d hex.
(ack)	Acknowledge character (^) or 5e hex.
AA	Address characters are ASCII characters from 0 through 9 or a through f. **However, 00 is the only address that should be used for the TC-36-25 RS-232.**
CC	Command characters are ASCII characters from 0 through 9 or a through f.
DDDDDDDD	Hex two's-complement return or send value. 1d = 00000001 -1d=ffffffff
SS	The 8-bit (modulo 256) checksum of characters sent to/from the controlling computer. This is represented as 2 ASCII hex characters. The checksum calculation excludes the characters (stx), SS, (etx). *The TC-36-25 RS232 sums (in an 8-bit register) the ASCII values of the characters sent to/from the controlling computer. Any overflow is truncated, leaving the 8-bit (modulo 256) checksum. When the controller is receiving data, this number (as represented by two hex characters) is compared to the two ASCII character hex checksum sent by the controlling computer. The TC-36-25 RS232 will respond as shown below depending on whether or not the checksums match. When the controlling computer is receiving data the checksum sent by the controller can be used to make sure the data has not been received with an error. Remember, when finding the ASCII value for a hex number (a, b, c, d, e, and f) be sure to use lower case letters.*

To write a command to a controller, the controlling computer must send the following ASCII characters:

(stx)AACCDDDDDDDDSS(etx)

If the temperature controller receives the command and the checksum is correct, the temperature controller will respond by sending back the "send value" and the checksum of those eight ASCII characters:

(stx)DDDDDDDDSS(ack)

To query a controller, there is no send value so the controlling computer only needs to send the following ASCII characters:

(stx)AACCSS(etx)

If the temperature controller receives the query and the checksum is correct, the temperature controller will respond by sending back a "return value" and the checksum of those eight ASCII characters:

(stx)DDDDDDDDSS(ack)

If the checksum for a command or query is not correct the temperature controller will respond with eight upper case X's and then c0, which is the checksum of these eight X's:

(stx)XXXXXXXXc0(ack)

Remember, AA = 00 is the universal address for the TC-36-25 RS232. If the address is not correct, then the controller will not respond to any requests.

II. Examples:

Set the controller at address 00 to control via a computer programmable set point.

1. The controller address, AA, is by definition 00.
2. The write command, CC, for "SET TYPE DEFINE" is 29 hex.
3. A data value of "0" selects a computer communicated set value, so the eight-character send value DDDDDDDD is 00000000.
4. Compute the checksum (SS) by adding the ASCII values of the following characters: 0, 0, 2, 9, 0, 0, 0, 0, 0, 0, 0, and 0:

ASCII Character:	Hex Value:
0	30 hex
0	30 hex
2	32 hex
9	39 hex
0	30 hex
0	30 hex
0	30 hex
0	30 hex
0	30 hex
0	30 hex
0	30 hex
0	30 hex
Sum	**024b hex**

The 8-bit checksum is the 8 least significant binary bits of the sum, represented as 4b in hex.

5. Combining all of these characters in one string we send: (stx)0029000000004b(etx).
6. If the temperature controller receives the command and the checksum is correct, it will send back: (stx)0000000080(ack). If the checksum is not correct the temperature controller will send back: (stx)XXXXXXXXc0(ack).

Send the set temperature of 10.00 to the controller at address 00.

1. The controller address, AA, is by definition 00.
2. The control command, CC, for "FIXED DESIRED CONTROL SETTING" is 1c.
3. Multiply the desired set-point temperature by 100 (10.00 converts to 1000d).
4. Convert 1000d to hex (03e8h) and add on leading zeros to make the eight-character send value DDDDDDDD (000003e8).
5. Compute the checksum (SS) by adding the ASCII values of the following characters: 0, 0, 1, c, 0, 0, 0, 0, 0, 3, e, and 8:

ASCII Character:	Hex Value:
0	30 hex
0	30 hex
1	31 hex
c	63 hex
0	30 hex
0	30 hex
0	30 hex
0	30 hex
0	30 hex
3	33 hex
e	65 hex
8	38 hex
Sum	**02b4 hex**

   The 8-bit checksum is the 8 least significant binary bits of the sum, represented as b4 in hex.
6. Combining all of these characters in one string we send: (stx)001c000003e8b4(etx).
7. If the temperature controller receives the command and the checksum is correct, it will send back: (stx)000003e8c0(ack). If the checksum is not correct the temperature controller will send back: (stx)XXXXXXXXc0(ack).

Read the actual temperature of the control thermistor (INPUT1) from the controller at address 00.

1. Let us assume the actual temperature is 2.50 °C, and the working units have been defined as °C. This means that the controller will return a value in °C.
2. The controller address, AA, is by definition 00.
3. The control command, CC, for "INPUT1" is 01 hex.
4. There is no send value, so we can just calculate the checksum (SS) by adding the ASCII values of the following characters: 0, 0, 0, and 1:

ASCII Character:	Hex Value:
0	30 hex
0	30 hex
0	30 hex
1	31 hex
Sum	**00c1 hex**

   The 8-bit checksum is the 8 least significant binary bits of the sum, represented as c1 in hex.
5. Combining all of these characters in one string we send: (stx)0001c1(etx).
6. If the temperature controller receives the command and the checksum is correct, it will send back: (stx)000000fae7(ack). The e7 at the end of the string is the checksum of "000000fa". The value "000000fa" hex converts to 250 in decimal. This number,

when divided by 100 is 2.50, and it is the temperature in °C. As in the other examples, if the checksum from the query were not correct the temperature controller would send back: (stx)XXXXXXXXc0(ack).

III. RS232 Communications Parameters (JP4 connector on controller board)

A. Baud Rate 9600
B. No Parity
C. 1 Start Bit 1 Stop Bit

NOTE if you are using communications software* different *from the one supplied with the controller: *The demands of temperature control require a relatively large portion of the processing power of the onboard microcontroller. It is possible for a host computer to send data too quickly for the controller to receive and update. TE Technology recommends adding a delay between each character sent to allow the controller sufficient time to process the information. One millisecond might be a good delay time to use initially, but the exact time will vary depending on the host computer's hardware and the particular demands on the controller at the moment.*

IV. Commands

1. INPUT1 (controlled input value) (reads the temperature of the primary thermistor)
   Write Command: NA
   Read Command: 01 hex
   Interpret: Divide returned fixed-point temperature value by 100.0 and convert to °F/°C decimal value.
   Example:
   Receive 10.00 °F temp from unit (sensor type = 1).
   Send: *00010000000042(etx)
   Receive *000003e8c0^
   Convert hex 000003e8 returned to decimal = (1000)
   Divide by 100.0 = (10.00 °F)

2. DESIRED CONTROL VALUE (set value)
   Write Command: NA
   Read Command: 03 hex
   Interpret: This command returns the set value determined by Input2 or as a fixed value set by communications (see INPUT1 command above for interpretation).

3. POWER OUTPUT
   Write Command: NA
   Read Command: 02 or 04 hex
   Interpret: -511 represents –100% output.
   0 returned is 0% output.
   511 represents 100% output.

4. ALARM STATUS
   Write Command: NA

Read Command: 05 hex

Interpret: 0 returned means no alarms.
Bit 0 = 1 means HIGH ALARM.
Bit 1 = 1 means LOW ALARM.
Bit 2 = 1 means COMPUTER CONTROLLED ALARM.
Bit 3 = 1 means OVER CURRENT DETECTED.
Bit 4 = 1 means OPEN INPUT1.
Bit 5 = 1 means OPEN INPUT2.
Bit 6 = 1 means DRIVER LOW INPUT VOLTAGE.

5. INPUT 2

Write Command: NA

Read Command: 06 hex

Interpret: Input 2 reading as a secondary thermistor temperature sensor.

6. OUTPUT CURRENT COUNTS

Write Command: NA

Read Command: 07 hex

Interpret: Output current detection in A/D counts.

7. ALARM TYPE

Write Command: 28 hex

Read Command: 41 hex

Interpret: 0 sent or returned means no alarms.
1 sent or returned means Tracking Alarm Mode.
2 sent or returned means Fixed Alarm Mode.
3 sent or returned means Computer Controlled Alarm Mode (see write command ALARM LATCH ENABLE).

8. SET TYPE DEFINE (the desired control temperature or "set temp" input definition)

Write Command: 29 hex

Read Command: 42 hex

Interpret: This function tells the controller how the set-point temperature will be communicated.
0 sent or returned means computer communicated set value.
1 sent or returned means Potentiometer Input.
2 sent or returned means 0 to 5 V Input.
3 sent or returned means 0 to 20 mA Input.
4 sent or returned means "Differential set": Desired Control Value = Temp2 + Computer Set.
The range of values is settable via the commands HIGH ALARM SETTING and LOW ALARM SETTING.
5 sent or returned means set value is from optional MP-2986 Display and Keypad accessory.

9. SENSOR TYPE

Write Command: 2a hex

Read Command: 43 hex
Interpret:
0: TS141 5K
1: TS67 OR TS136 15K
2: TS91 10K
3: TS165 230K
4: TS104 50K
5: YSI H TP53 10K

10. CONTROL TYPE
Write Command: 2b hex
Read Command: 44 hex
Interpret:
0 is deadband control.
1 is PID control.
2 is computer control. With this setting, the output power sent to the cooler is determined by sending a write command to INPUT1. The range of values then becomes -511 = -100% output power to +511 = +100% output power.

11. CONTROL OUTPUT POLARITY
Write Command: 2c hex
Read Command: 45 hex
Interpret:
0 is HEAT WP1+ and WP2-.
1 is HEAT WP2+ and WP1-.

12. POWER ON/OFF
Write Command: 2d hex
Read Command: 46 hex
Interpret:
0 is off.
1 is on.

13. OUTPUT SHUTDOWN IF ALARM
Write Command: 2e hex
Read Command: 47 hex
Interpret:
0 is no shutdown upon alarm.
1 is to shutdown main output drive upon alarm.

14. FIXED DESIRED CONTROL SETTING
Write Command: 1c hex
Read Command: 50 hex
Interpret:
When writing, multiply the desired control temperature by 100 and convert to hex. This becomes the "send value."
When reading, convert the "return value" to decimal and divide by 100 to convert to °F/°C.

15. PROPORTIONAL BANDWIDTH
Write Command: 1d hex
Read Command: 51 hex
Interpret:
Fixed-point temperature bandwidth in °F/°C.

Multiply desired bandwidth by 100.
1 °F/°C bandwidth would be 100 decimal.
20 °F/°C bandwidth would be 2000.

16. INTEGRAL GAIN

Write Command:	1e hex
Read Command:	52 hex
Interpret:	Fixed-point gain in repeats/min. Multiply desired integral gain by 100. 0.01 rep/min would be 1 decimal. 1.00 rep/min would be 100 decimal.

17. DERIVATIVE GAIN

Write Command:	1f hex
Read Command:	53 hex
Interpret:	Fixed-point gain in minutes. Multiply desired derivative gain by 100. 0.01 min would be 1 decimal. 1.00 min would be 100 decimal.

18. LOW EXTERNAL SET RANGE

Write Command:	20 hex
Read Command:	54 hex
Interpret:	Value mapped to zero voltage of Input2.

19. HIGH EXTERNAL SET RANGE

Write Command:	21 hex
Read Command:	55 hex
Interpret:	Value mapped to 5 volt or maximum voltage of Input2.

20. ALARM DEADBAND

Write Command:	22 hex
Read Command:	56 hex
Interpret:	Temperature Input1 must move to toggle alarm output.

21. HIGH ALARM SETTING

Write Command:	23 hex
Read Command:	57 hex
Interpret:	Temperature reference to compare against Input1 for high alarm output.

22. LOW ALARM SETTING

Write Command:	24 hex
Read Command:	58 hex
Interpret:	Temperature reference to compare against Input1 for low alarm output.

23. CONTROL DEADBAND SETTING

Write Command: 25 hex
Read Command: 59 hex
Interpret: Temperature or count span Input1 must move to toggle control output.

24. INPUT1 OFFSET
    Write Command: 26 hex
    Read Command: 5a hex
    Interpret: Value to offset Input1 by in order to calibrate external sensor if desired.

25. INPUT2 OFFSET
    Write Command: 27 hex
    Read Command: 5b hex
    Interpret: Value to offset Input2 by in order to calibrate external sensor if desired.

26. HEAT MULTIPLIER
    Write Command: 0c hex
    Read Command: 5c hex
    Interpret: This multiplies the heater percentage of power to offset its effectiveness.
    100 is a multiplier of 1.00
    1 is a multiplier of 0.01

27. COOL MULTIPLIER
    Write Command: 0d hex
    Read Command: 5d hex
    Interpret: This multiplies the cooling percentage of power to offset its effectiveness.
    100 is a multiplier of 1.00
    1 is a multiplier of 0.01

28. OVER CURRENT COUNT COMPARE VALUE
    Write Command: 0e hex
    Read Command: 5e hex
    Interpret: This is the count compare value which determines an over-current condition. Current is approximately 2.5 per count.

29. ALARM LATCH ENABLE
    Write Command: 2f hex
    Read Command: 48 hex
    Interpret: 1 is latching enabled.
    0 is latching disabled.
    If ALARM TYPE is equal to 3 then
    1 is Computer Alarm On.
    0 is Computer Alarm Off.

30. COMMUNICATIONS ADDRESS (reserved command, do not use)

31. ALARM LATCH RESET

Write Command:	33 hex
Read Command:	NA
Interpret:	Send this command to reset the alarm latches.

32. CHOOSE SENSOR FOR ALARM FUNCTION

Write Command:	31 hex
Read Command:	4a hex
Interpret:	0 is for the Control Sensor Input. 1 is for the Input2 Secondary Input.

33. CHOOSE °C or °F TEMPERATURE WORKING UNITS

Write Command:	32 hex
Read Command:	4b hex
Interpret:	0 is °F 1 is °C

34. EEPROM WRITE ENABLE

Write Command:	34 hex
Read Command:	4c hex
Interpret:	0 is disable EEPROM writes 1 is enable EEPROM writes
Function Description:	Upon a power-up or reset condition, the controller performs an initialization of all command variables that have write commands by transferring the last values stored in non-volatile memory (EEPROM) to appropriately referenced static RAM locations. This action is performed so that the controller can run faster (RAM is faster than ROM). When the “EEPROM WRITE ENABLE” is enabled, any changes in the run-time values of the command variables are also stored in EEPROM as well in RAM and thus will be recalled upon a power-up or reset condition. When the “EEPROM WRITE ENABLE” is disabled, run-time values are stored only in RAM. This setting gives you the ability to change run-time values without changing your desired power-up settings. This will also alleviate a possible problem since the maximum number of writes to an EEPROM location is 1,000,000.

35. OVER CURRENT CONTINUOUS

Write Command:	0x35
Read Command:	0x4d
Interpret:	1 is continuous retry when over current detected. 0 allows the RESTART ATTEMPTS value to be used.

36. OVER CURRENT RESTART ATTEMPS

Write Command:	0x0f

Read Command: 0x5f
Interpret: Range of value 0 to 30000
This is the amount of times the controller will attempt to restart the output after an over current condition is detected.

37. JP3 DISPLAY ENABLE
Write Command: 0x36
Read Command: 0x4e
Interpret: 1 display function enabled.
0 display function disabled.

V. ASCII Reference Table

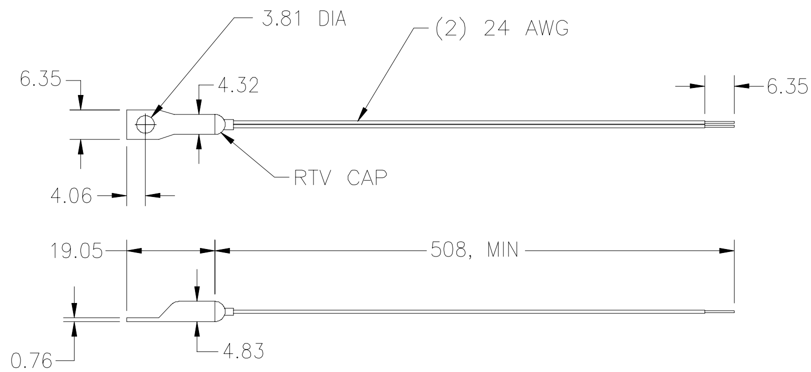
```
Dec   Oct   Hex   Binary          Description

000   000   00    00000000   ^@ ^` NULL NUL null c-@ c-`
001   001   01    00000001   ^A ^a SOH GTL c-A c-a start-of-heading
002   002   02    00000010   ^B ^b STX c-B c-b start-of-text
003   003   03    00000011   ^C ^c ETX c-C c-c end-of-text
004   004   04    00000100   ^D ^d EOT SDC end-of-transmission c-D c-d ..._._
005   005   05    00000101   ^E ^e ENQ PPC c-E c-e enquiry
006   006   06    00000110   ^F ^f ACK c-F c-f acknowledge
007   007   07    00000111   ^G ^g BELL BEL bell c-G c-g \a
008   010   08    00001000   ^H ^h BS GET backspace c-H c-h \b
009   011   09    00001001   ^I ^i TAB TCT HT tab c-I c-i \t
010   012   0A    00001010   ^J ^j LF lf linefeed c-J c-j \n
011   013   0B    00001011   ^K ^k VT vertical-tab c-K c-k \v
012   014   0C    00001100   ^L ^l FF ff formfeed page \f c-L c-l
013   015   0D    00001101   ^M ^m CR cr carriage-return c-M c-m \r
014   016   0E    00001110   ^N ^n SO c-N c-n shift-out
015   017   0F    00001111   ^O ^o SI c-O c-o shift-in

016   020   10    00010000   ^P ^p DLE c-P c-p data-link-escape
017   021   11    00010001   ^Q ^q DC1 LLO go XON xon c-Q c-Q
018   022   12    00010010   ^R ^r DC2 c-R c-r
019   023   13    00010011   ^S ^s DC3 stop XOFF xoff c-S c-s
020   024   14    00010100   ^T ^t DC4 DCL c-T c-t
021   025   15    00010101   ^U ^u NAK PPU negative-acknowledge c-U c-u
022   026   16    00010110   ^V ^v SYN c-V c-v synchronous-idle
023   027   17    00010111   ^W ^w ETB end-of-transmission-block c-W c-w
024   030   18    00011000   ^X ^x CAN SPE c-X c-x cancel
025   031   19    00011001   ^Y ^y EM SPD c-Y c-y end-of-medium
026   032   1A    00011010   ^Z ^z SUB suspend c-Z c-z substitute
027   033   1B    00011011   ^[ ^{ ESC escape c-[ c-{ m-
028   034   1C    00011100   ^\ ^| FS field-separator c-\ c-|
029   035   1D    00011101   ^] ^} GS group-separator
030   036   1E    00011110   ^^ ^~ RS record-separator c-^ c-~
031   037   1F    00011111   ^_ ^DEL unit-separator US c-_ c-DEL

032   040   20    00100000   SPC space spc
033   041   21    00100001   ! exclamation-point
034   042   22    00100010   " straight-double-quotation-mark
035   043   23    00100011   # number-sign
036   044   24    00100100   $ @@ dollar-sign
```

037	045	25	00100101	% percent-sign
038	046	26	00100110	& ampersand
039	047	27	00100111	' apostrophe
040	050	28	00101000	(left-parenthesis
041	051	29	00101001	) right-parenthesis
042	052	2A	00101010	* asterisk star
043	053	2B	00101011	+ addition-sign
044	054	2C	00101100	, comma
045	055	2D	00101101	- subtraction-sign minus hyphen negative dash
046	056	2E	00101110	. period dot decimal
047	057	2F	00101111	/ right-slash
048	060	30	00110000	0
049	061	31	00110001	1
050	062	32	00110010	2
051	063	33	00110011	3
052	064	34	00110100	4
053	065	35	00110101	5
054	066	36	00110110	6
055	067	37	00110111	7
056	070	38	00111000	8
057	071	39	00111001	9
058	072	3A	00111010	: colon
059	073	3B	00111011	; semicolon
060	074	3C	00111100	< less-than
061	075	3D	00111101	= equals
062	076	3E	00111110	> greater-than, right-chevron
063	077	3F	00111111	? question-mark, query
064	100	40	01000000	@ at-symbol, at-sign
065	101	41	01000001	A
066	102	42	01000010	B
067	103	43	01000011	C
068	104	44	01000100	D
069	105	45	01000101	E
070	106	46	01000110	F
071	107	47	01000111	G
072	110	48	01001000	H
073	111	49	01001001	I
074	112	4A	01001010	J
075	113	4B	01001011	K
076	114	4C	01001100	L
077	115	4D	01001101	M
078	116	4E	01001110	N
079	117	4F	01001111	O
080	120	50	01010000	P
081	121	51	01010001	Q
082	122	52	01010010	R
083	123	53	01010011	S
084	124	54	01010100	T
085	125	55	01010101	U
086	126	56	01010110	V
087	127	57	01010111	W
088	130	58	01011000	X
089	131	59	01011001	Y
090	132	5A	01011010	Z
091	133	5B	01011011	[left-bracket, open-square
092	134	5C	01011100	\ left-slash, backslash bash
093	135	5D	01011101	] right-bracket, close-square
094	136	5E	01011110	^ hat, circumflex, caret, up-arrow

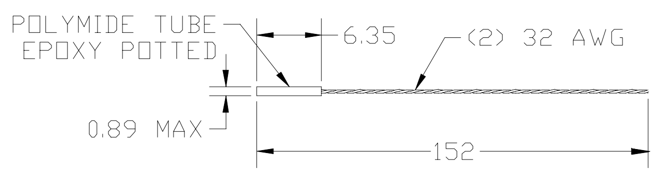
095	137	5F	01011111	_ UNT, underscore, underbar
096	140	60	01100000	` accent-grave, backprime, backquote
097	141	61	01100001	a
098	142	62	01100010	b
099	143	63	01100011	c
100	144	64	01100100	d
101	145	65	01100101	e
102	146	66	01100110	f
103	147	67	01100111	g
104	150	68	01101000	h
105	151	69	01101001	i
106	152	6A	01101010	j
107	153	6B	01101011	k
108	154	6C	01101100	l
109	155	6D	01101101	m
110	156	6E	01101110	n
111	157	6F	01101111	o
112	160	70	01110000	p
113	161	71	01110001	q
114	162	72	01110010	r
115	163	73	01110011	s
116	164	74	01110100	t
117	165	75	01110101	u
118	166	76	01110110	v
119	167	77	01110111	w
120	170	78	01111000	x
121	171	79	01111001	y
122	172	7A	01111010	z
123	173	7B	01111011	{ left-brace begin
124	174	7C	01111100	| logical-or vertical-bar
125	175	7D	01111101	} right-brace end
126	176	7E	01111110	~ similar
127	177	7F	01111111	^? DEL rubout delete

APPENDIX C Thermistor Styles for TC-36-25 RS232

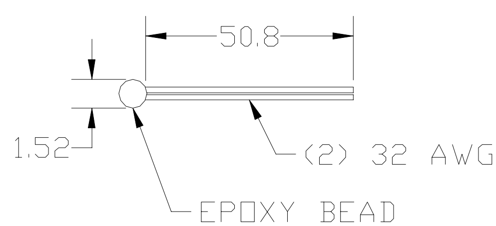
Note: all dimensions in millimeters



MP-2996



MP-2444



MP-2542

TS-67 Temperature (°C) versus Resistance (ohms) Data
for MP-2996, MP-2444, and MP2542 Thermistors

-20	146735	1	46709	22	17136	43	7075	64	3227	85	1601
-19	138447	2	44397	23	16388	44	6801	65	3115	86	1551
-18	130677	3	42213	24	15676	45	6539	66	3008	87	1503
-17	123390	4	40150	25	15000	46	6289	67	2905	88	1457
-16	116554	5	38199	26	14356	47	6049	68	2806	89	1412
-15	110138	6	36354	27	13744	48	5820	69	2711	90	1369
-14	104113	7	34608	28	13161	49	5600	70	2620	91	1328
-13	98454	8	32957	29	12606	50	5391	71	2532	92	1288
-12	93137	9	31394	30	12078	51	5190	72	2448	93	1250
-11	88138	10	29914	31	11574	52	4997	73	2367	94	1212
-10	83438	11	28512	32	11095	53	4813	74	2288	95	1176
-9	79016	12	27183	33	10637	54	4637	75	2213	96	1142
-8	74855	13	25925	34	10202	55	4467	76	2141	97	1108
-7	70938	14	24731	35	9786	56	4305	77	2072	98	1076
-6	67249	15	23600	36	9389	57	4150	78	2005	99	1045
-5	63773	16	22526	37	9011	58	4001	79	1940	100	1014
-4	60498	17	21508	38	8650	59	3858	80	1878		
-3	57410	18	20541	39	8306	60	3721	81	1818		
-2	54498	19	19623	40	7976	61	3590	82	1761		
-1	51750	20	18751	41	7662	62	3464	83	1705		
0	49157	21	17923	42	7362	63	3343	84	1652		

Note: Tolerance is ±650 Ω, corresponding to ±1 °C
over a 0 °C to 100 °C range.

Note: For TS-141, TS-91, TS-165, TS-104 and YSI-H temperature-resistance Curves, contact TE Technology for further information.