OVEN INDUSTRIES, INC.

OPERATING MANUAL

Model 5C7-362

THERMOELECTRIC MODULE

TEMPERATURE CONTROLLER

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FEATURES:

- INPUT VOLTAGE FROM 12 TO 28 VOLTS DCGENERAL DESCRIPTION
- SELF-CONTAINED, 0.1 TO 25 AMPERE LOAD RATING
- PC PROGRAMMABLE VIA RS232 COMMUNICATIONS PORT
- BI-DIRECTIONAL CONTROL FOR HEATING AND COOLING APPLICATIONS
- SOLID STATE "H" BRIDGE OPERATION
- CONTROL TEMPERATURE OF -20° TO 100°C WITH TS67 SERIES SENSORS
  -40° TO 70°C WITH TS141 SERIES SENSORS

- PROPORTIONAL (P), INTEGRAL (I), AND DERIVATIVE (D) CONTROL THAT CAN BE SELECTED AS P, PI, PD, OR PID; ON/OFF WITH AN ADJUSTABLE HYSTERESIS
- TEMPERATURE RESOLUTION OF 0.05°C.
- PULSE WIDTH MODULATION OF OUTPUT
  - SELECTABLE MODULATION FREQUENCY OF 675 Hz OR 2700 Hz
  - CONTROL STABILITY OF ±0.05°C.
- 1500 VAC ISOLATION OF RS232 COMMUNICATIONS INTERFACE
- CONTROLS UP TO 680 WATTS
- SET TEMPERATURE SELECTABLE
  - PC SET WITH CONTROLLER STAND-ALONE OPERATION
  - REMOTE USER SET TEMPERATURE POTENTIOMETER
  - 0 V TO 5 V ADJUSTABLE RANGE
  - 4 TO 20 MA CURRENT LOOP
  - DIFFERENTIAL TEMPERATURE CONTROL
- NO COMPUTER PROGRAMMING EXPERIENCE IS REQUIRED TO USE THE COMMUNICATIONS SOFTWARE PROGRAM
- COMMAND SET IS PROVIDED SO PROGRAMMERS MAY CREATE THEIR OWN SOFTWARE INTERFACE OR EMBEDDED CONTROLLER APPLICATIONS
- PC CONFIGURABLE ALARMS FOR 5 VOLTS DC AT 25 MA
- ALARM CANCEL: SELECTABLE VIA PC OR REMOTE CONTACTS
- NON-VOLATILE MEMORY RETENTION OF PARAMETERS

GENERAL DESCRIPTION

Model 5C7-362 is a bi-directional control for independent thermoelectric modules or in conjunction with auxiliary or supplemental resistive heaters for both cooling and heating applications. The “H” bridge configuration of the solid state MOSFET output devices allows for the bi-directional flow of current through the thermoelectric modules. Highly efficient N-channel output devices are used for this control mode.

This controller is PC programmable via an RS232 communication port for direct interface with a compatible PC. The RS232 communications interface has 1500 VAC isolation from all other electronic circuitry minimizing interference from noise or errant signals caused by common ground loops. The easily accessible communications link permits a variety of operational mode configurations. Field selectable parameters or data acquisition in a half duplex mode can be performed. This controller will accept a communications cable length in accordance with RS232 interface specifications.

Once the desired set parameters are established, the PC may be disconnected and Model 5C7-362 becomes a unique, stand-alone controller. All parameter settings are retained in non-volatile memory.

The user friendly, communications software requires no prior programming experience to establish operation. A command set is provided for qualified personnel to program a software interface or use as an embedded control.

Mechanically, the control printed circuit board is mounted to a metal bracket that is suitable for either horizontal or vertical orientation. Input and output connections are accessible via screw type terminal strips, fast-on terminals, and a .100 center connector.

TECHNICAL DESCRIPTION

Model 5C7-362 is capable of operating from an input supply voltage of 12 through 28 VDC, common to many available thermoelectric modules. The self-contained MOSFET output devices deliver load currents from 0.1 to 25 amperes (NOTE: consult appropriate installation instructions for power supply and heat sinking requirements for high current operation). This unit will control total load power up to 680 watts with a finite temperature resolution of 0.05°C.

The output signal to the thermoelectric module is Pulse Width Modulated and is PC selectable for either 675 Hz or 2700 Hz operation. Pulse Width Modulation averages the amount of energy provided to the module and reduces the extreme temperature excursions that are experienced with an “on / off” system. This tends to extend the life and reliability of the thermoelectric devices. The PWM control scheme affords control accuracy to within ±0.05°C. at the control sensor.

The controller tuning structure allows designation of a variety of control features. The computer set value provides for manual control of the output, either polarity, from 0% to 100% of load power. 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. In addition, a deadband control (on/off) with an adjustable hysteresis may be selected. Differential temperature control is offered when two input sensing thermistors are chosen.

A control temperature range of –20°C to 100°C (TS67 series probe) or -40°C to 70°C (TS141 series probe) is standard when using an Oven Industries’ thermistor sensor probe for the PC’s primary set temperature. Additional external set temperature input types may be selected. They include a remote set temperature potentiometer, a 0 to 5 VDC signal, and a 0 to 20 ma current loop. These secondary inputs are used to define and “map” the secondary input to an adjustable temperature range. Differential set

temperature control may also be selected from this configuration menu. All temperatures may be consistently displayed in °C. or °F.

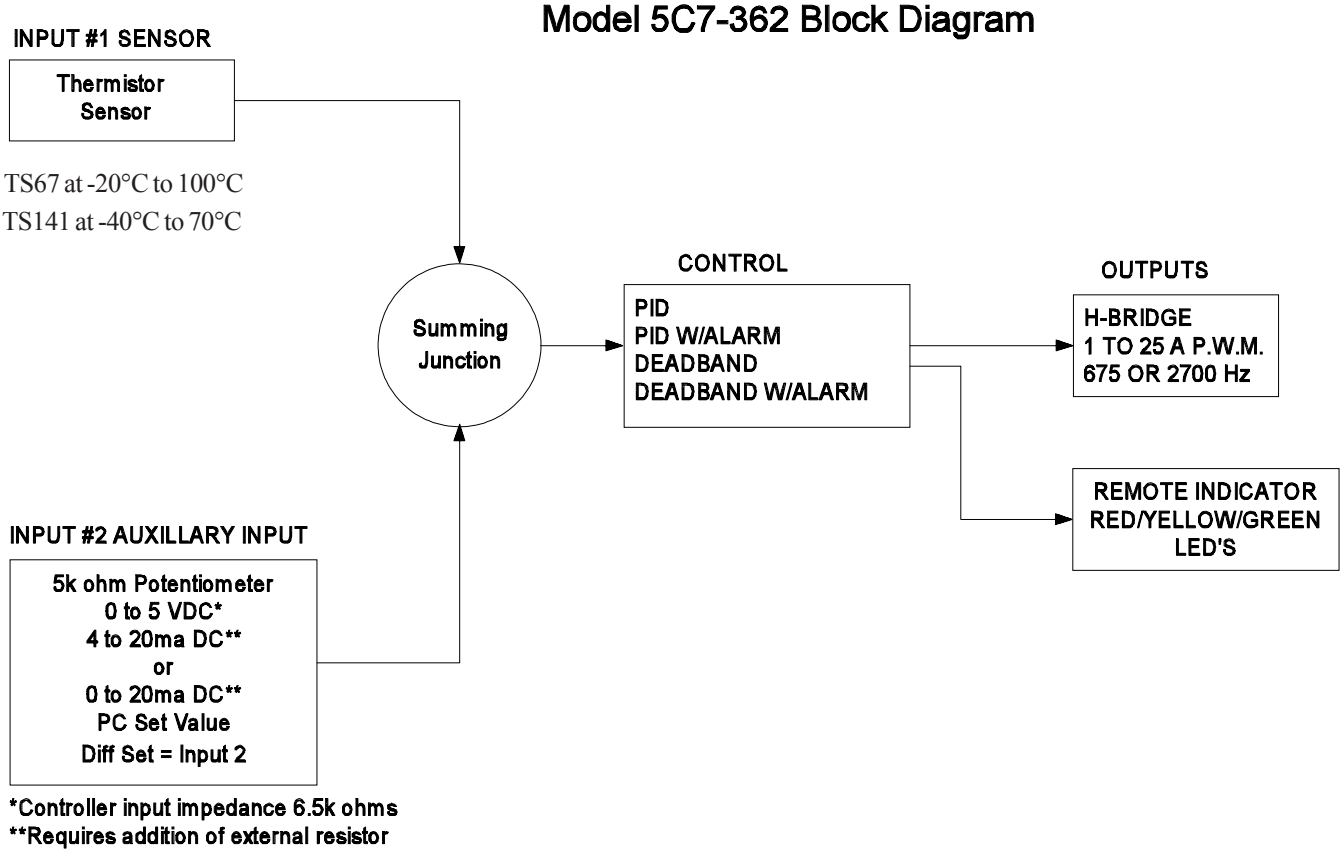
Differential control is accomplished by selecting the primary set temperature with the second thermistor input and establishing the offset with the computer set temperature. The unit will control the differential between Input 2 (reference temperature) and Input 1 (actual system temperature).

Two types of control output modes may be selected. This determines the direction of the current flow through the thermoelectric module during the heat cycle. 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.

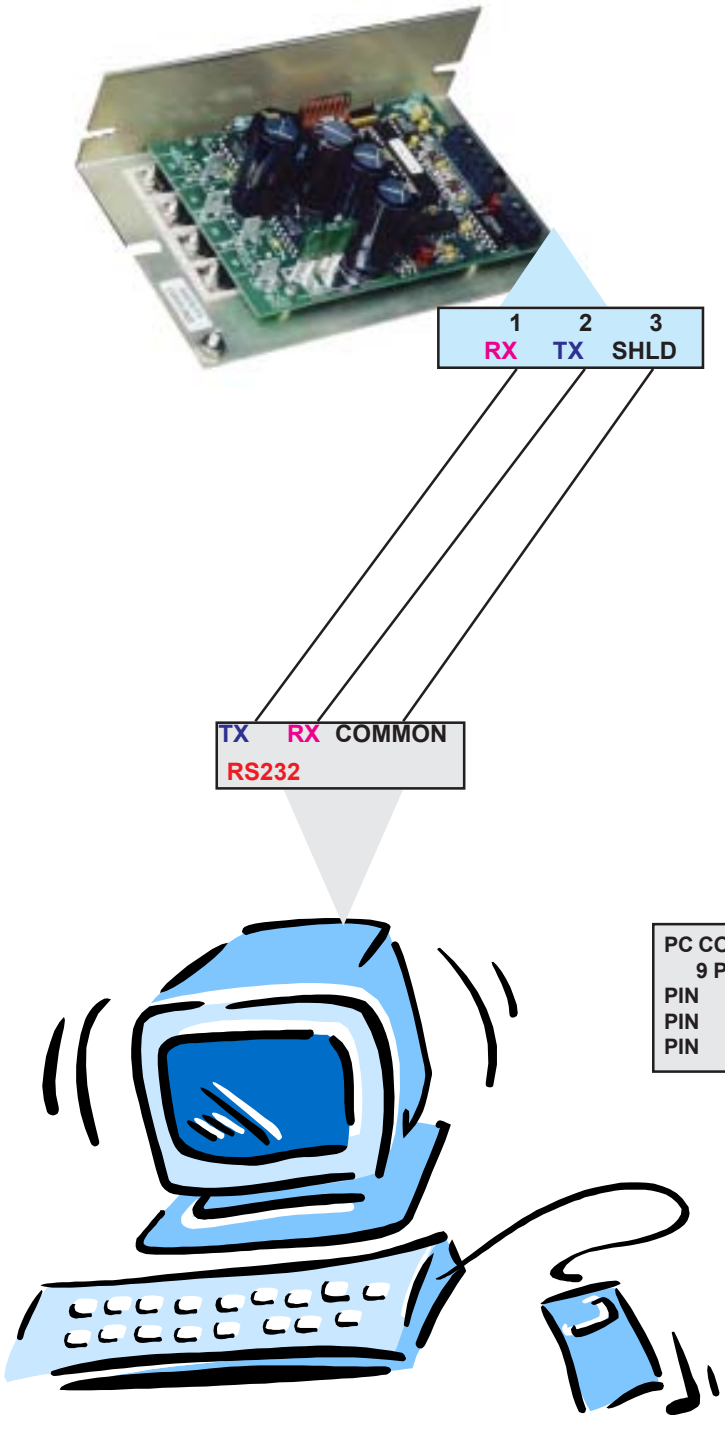
Several alarm types may be selected which provide a 5 VDC output, rated for 25 ma of current. They consist of no alarm function, tracking alarm, and fixed value alarm. Alarm set temperature values are entered in the setup menu. The computer-controlled selection is available for additional embedded controller 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 module or auxiliary heater. Power may be maintained during an alarm condition or the main power may be shut down.

Model 5C7-362 Block Diagram



RS232 COMMUNICATIONS CONNECTIONS FOR MODEL 5C7-362

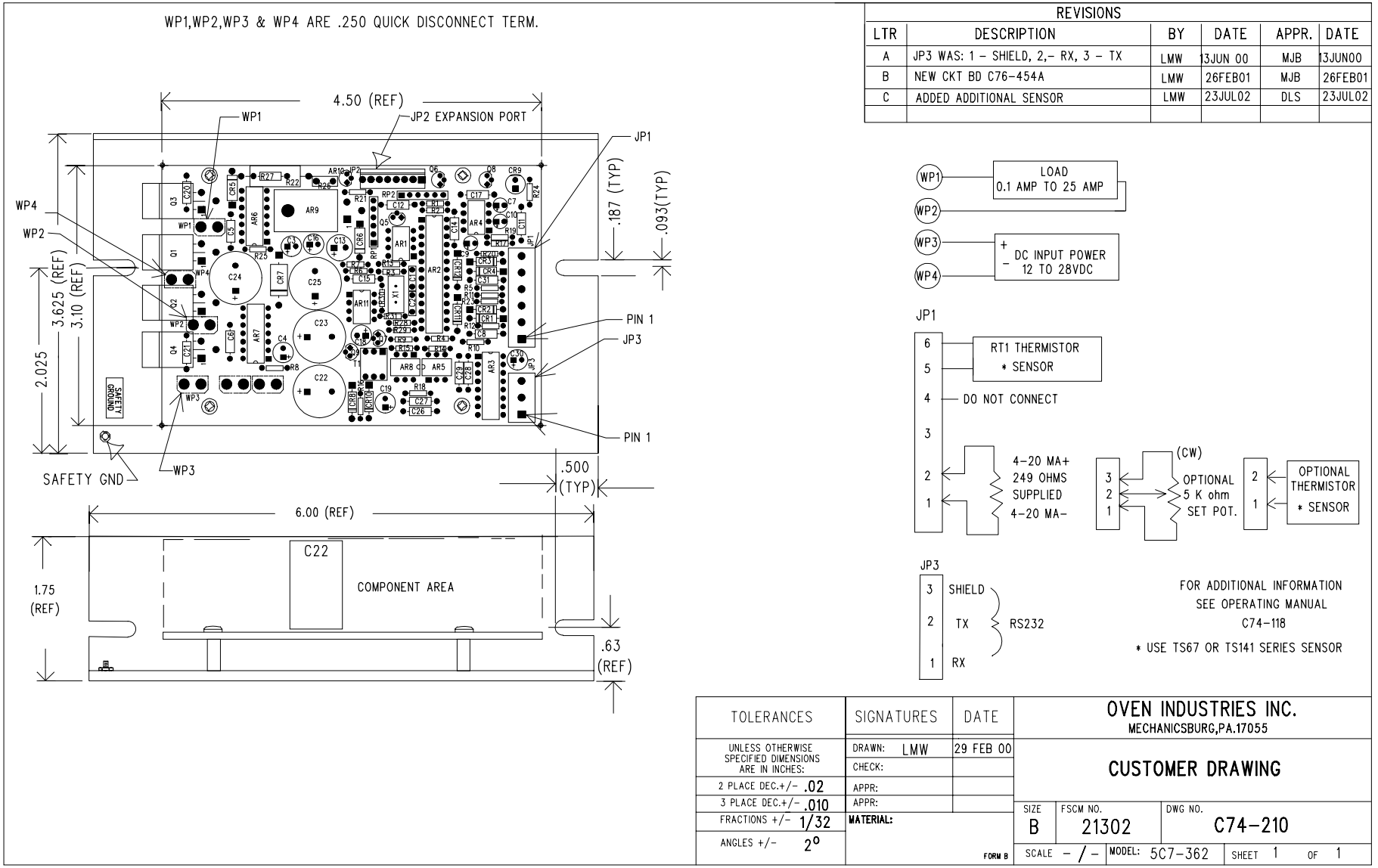


PC CONNECTION TABEL

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

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

MECHANICAL PACKAGE DRAWING



REVISIONS					
LTR	DESCRIPTION	BY	DATE	APPR.	DATE
A	JP3 WAS: 1 – SHIELD, 2,– RX, 3 – TX	LMW	13JUN 00	MJB	13JUN00
B	NEW CKT BD C76–454A	LMW	26FEB01	MJB	26FEB01
C	ADDED ADDITIONAL SENSOR	LMW	23JUL02	DLS	23JUL02

TOLERANCES	SIGNATURES	DATE
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES:	DRAWN: LMW	29 FEB 00
	CHECK:	
2 PLACE DEC.+/– .02	APPR:	
3 PLACE DEC.+/– .010	APPR:	
FRACTIONS +/– 1/32	MATERIAL:	
ANGLES +/– 2°		

FORM B

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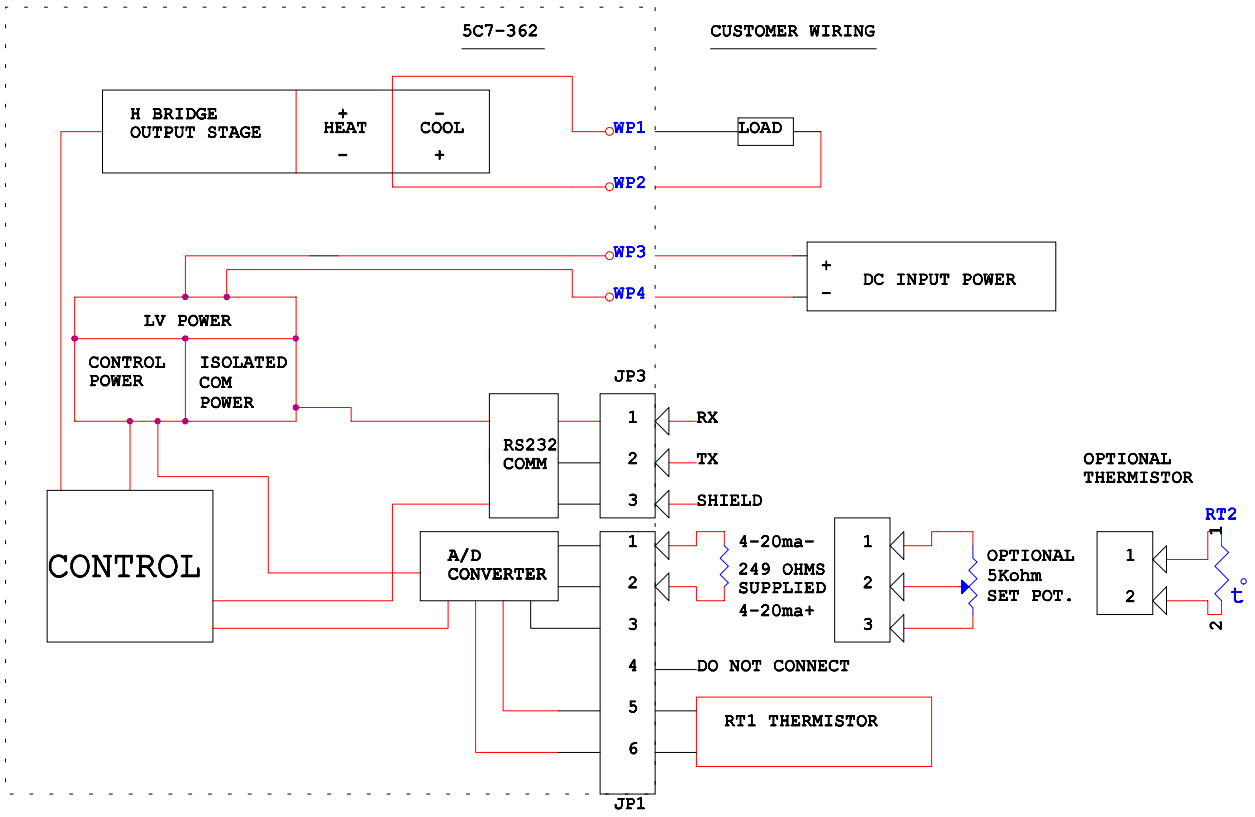
MECHANICSBURG,PA.17055

CUSTOMER DRAWING

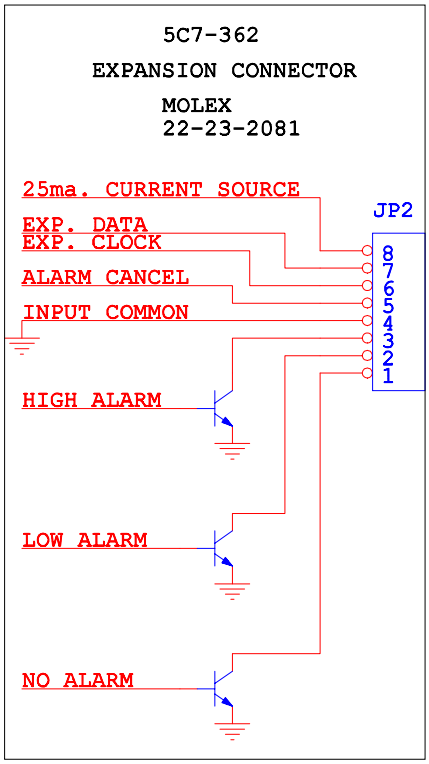
SIZE	FSCM NO.	DWG NO.
B	21302	C74–210

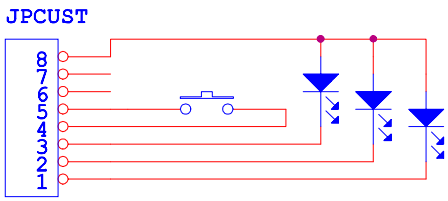
SCALE – / – MODEL: 5C7–362 SHEET 1 OF 1

CUSTOMER HOOK-UP DRAWING



EXPANSION CONNECTOR WIRING DIAGRAM

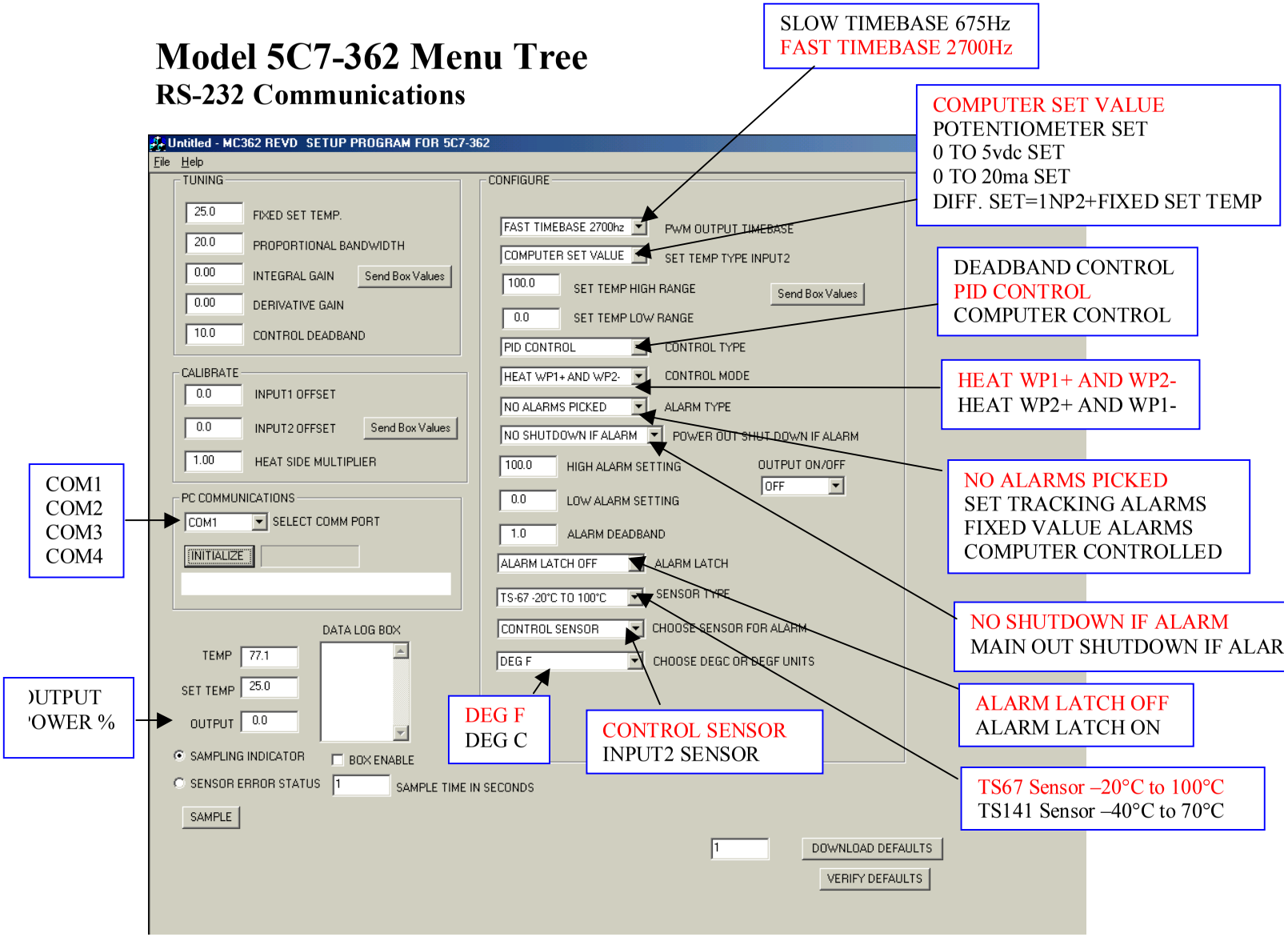




PINS 6 & 7 FUNCTIONALLY NOT DEFINED
PLEASE DO NOT CONNECT

Model 5C7-362 Menu Tree

RS-232 Communications



NOTE: THE FACTORY DEFAULT VALUES ARE SHOWN IN RED.

SET-UP INSTRUCTIONS FOR MODEL 5C7-362, THERMOELECTRIC MODULE, PC PROGRAMMABLE, TEMPERATURE CONTROLLER

1. Connect the appropriate DC power (12 to 28 volts) to the controller between WP3 (+) and WP4 (-) and the thermoelectric module between WP1 and WP2 in accordance with the customer hook-up drawing. *Note: the DC power supply must also match the voltage and current ratings of the thermoelectric module configuration. (Reference Application Note 351).*

2. Connect the RS232 Communications Port from the controller (JP3) to the RS232 input on the PC. Pin 1 of JP3 is the controller's RX, Pin 2 of JP3 is the controller's TX, and Pin 3 of JP3 is the controller's Shield.

3. Turn power on to both the PC and controller. The on-board green LED will flash at a steady rate to indicate the controller is energized correctly.

4. Insert the 5C7-362 software disk into the computer A:\ drive. To install the software from the floppy disk, select "START", "RUN" from your Windows Desktop and then enter A:\Oi362.exe and OK. This will load the PC interface into your computer's RAM.

5. NOTE: Refer to the Model 5C7-362 Menu Tree in this manual for factory default settings.

6. The Menu Tree screen will appear on your PC monitor.

7. NOTE: If you receive an error message, please refer to Appendix A.

8. All selections are made from this menu screen. In the PC COMMUNICATIONS box, select the "COMM PORT" (1 through 4) which will be your communications link to the controller. After making this selection, click on the INITIALIZE button.

9. In the CONFIGURE box, the various menu selections are used to establish the custom operating criteria for the controller. *NOTE: To avoid damage to the thermoelectric module, confirm that the OUTPUT ON/OFF is in the OFF position prior to proceeding!!*

10. First, click on the PWM OUTPUT TIMEBASE (pulse width modulated) menu key, options for "SLOW TIMEBASE 675Hz" or "FAST TIMEBASE 2700Hz" will appear. Select the option that is appropriate for your thermoelectric module(s).

11. Next, click on the SET TEMP TYPE INPUT 2 menu key to reveal the options available. COMPUTER SET VALUE is to be set for the desired control set temperature. The other selections, POTENTIOMETER SET, 0 to 5 vdc SET, and 0 to 20 ma SET, are for external set temperature adjustments. The controller default setting for these options is the full range of the thermistor input sensor. The DIFF.SET=INP2+COMPSET establishes an actual set temperature that is the sum of the optional thermistor input sensor and the temperature selected as the COMPUTER SET VALUE.

12. Associated with the external set temperature adjustments are the SET TEMP HIGH RANGE and SET TEMP LOW RANGE selections. These permit the selection of limitations on the temperature range of the external adjustments. Enter the desired values for these settings. These set limit values must be within the -20°C and 100°C (TS67 Probe) or -40°C and 70°C (TS141 Probe) range specified for the controller.

13. Now, click on the CONTROL TYPE menu key and select which type is appropriate for your application. The DEADBAND CONTROL is an on/off control and PID CONTROL is a proportional/integral/derivative control. The COMPUTER CONTROL acts like an electronic variac in that a fixed percentage of power may be applied to the load.

14. Clicking on the CONTROL MODE menu key permits the selection of either HEAT WP1+ and WP2- or HEAT WP2+ and WP1-. This selection establishes the polarity for the heating mode of the thermoelectric module. (i.e. If the positive side of the module is connected to WP1 and the negative side to WP2, the module will heat when power is applied to the module, and vice versa if the wiring is reversed.) This selection allows you to reverse the current flow in the thermoelectric module without changing the wiring.

15. The ALARM TYPE setting permits the selection of available alarm options with this controller. The drop down menu allows for four selections. NO ALARM PICKED indicates that no alarm parameters are desired. SET TRACKING ALARMS allows an alarm to be set with respect to the set temperature and will move, accordingly, with a change of the temperature setting. This option can be used for a high alarm, low alarm, or both settings. FIXED VALUE ALARMS permits the setting of a fixed, absolute temperature either above or below the set point temperature or both. COMPUTER CONTROLLED ALARM is not an actual alarm, but a user activation of the alarm relay via the PC.

16. The POWER OUT SHUT DOWN IF ALARM menu key provides two selections. NO SHUT DOWN IF ALARM which will let the power output stage of the controller to continue to function or MAIN OUT SHUTDOWN IF ALARM which disables the power output stage under an alarm condition.

17. Associated with the ALARM TYPE configuration are the HIGH ALARM SETTING, LOW ALARM SETTING, and the ALARM DEADBAND selections. If an alarm type has been selected, enter the desired high and low temperature values. The ALARM DEADBAND option is to set the hysteresis of the alarm values from 0.1°F. to 100°F.

18. The ALARM LATCH option permits the selection of an ALARM LATCH OFF where the controller will automatically reset if the alarm condition is self-correcting or ALARM LATCH ON which will maintain that an alarm condition existed and must be manually cleared.

19. The CHOOSE SENSOR FOR ALARM option allows for the selection of either the thermistor CONTROL SENSOR or the INPUT 2 SENSOR be used for the alarm.

20. The CHOOSE DEG C OR DEG F menu key permits the selection of displaying DEG F or DEG C.

21. Review all of your controller configuration selections. If all the configuration selections are correct for your application, select the Send Box Values button to download these settings to the controller.

22. You are now ready to tune the controller. All selections for this portion will occur in the menu tree TUNING box displayed on the monitor.

23. The various constants required by the controller to optimize the system performance are entered in this section.

24. NOTE: Refer to the Menu Tree in this manual for the factory default settings for the following parameters.

25. The FIXED SET TEMP is the set temperature value entered in degrees. This temperature is one within the range of the input sensor or the limits of low and high set ranges from the controller configuration setup. The COMPUTER CONTROL selection in the CONTROL TYPE configuration provides a fixed percentage of power to the load. This power resolution with an entry of 0.0 is equal to 0% power and +12.0 equals 100% power and -12.0 equals -100% power.

26. PROPORTIONAL BANDWIDTH is the temperature band in which 0% to 100% power will be applied to the load. The acceptable bandwidth values that may be entered are 1° to 100°.

27. INTEGRAL GAIN shifts the proportional bandwidth with respect to the set point to compensate for droop. This value is expressed in repeats per minute and the acceptable values that may be entered are .01 to10 repeats per minute.

28. DERIVATIVE GAIN senses the rate of rise or fall of the system temperature and adjusts the cycle time of the controller to minimize overshoot or undershoot. This value is expressed in cycle rates per minute and the acceptable values that may be entered are .01 to 10 cycles per minute.

29. CONTROL DEADBAND is the temperature band where the controller is turned on and off by either rising or falling temperatures where no heating or cooling takes place. This band is expressed in °F. and the acceptable values that may be entered are 0.1°F. to 100°F.

30. Review the tuning parameters for correctness and then select the Send Box Values button to download these constants to the controller.

31. The CALIBRATE box 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.

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

33. INPUT 2 OFFSET is a manual method for compensating for the sensor 2 temperature and actual temperature.

34. HEAT SIDE MULTIPLIER is a 0.01 to 2.00 numerical multiplier that compensates for the non-symmetrical response of the thermoelectric module between the heat and cool modes.

35. If you have entered values in the CALIBRATE box and they are the desired settings, select the Send Box Values button to download these constants to the controller.

36. Initial set-up of your Model 5C7-362 controller is complete.

APPENDIX A

Troubleshooting Communications Port

Error Message	Cause	Solution
Comm Port Timeout	No power to 5C7-362	Apply power to 5C7-362, review Customer Drawing for proper hookup.
Comm Port Timeout	Wrong Comm Port Selected	Check Computer hardware settings and set to the correct Comm Port.
Comm Port Timeout	Incorrect wiring of the Comm Port to the Computer.	Check for the correct wiring from JP3 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.

APPLICATION NOTE 353

5 Minutes to PID Tuning of the 5C7-362 Controller

Tuning the Model 5C7-362 temperature controller involves three variables. (P)ropotional bandwidth, (I)ntegral action, and (D)erivative rate.

The control algorithm sums the three values of these terms to determine the output power.

P + I + D = % Power Applied

Most applications work satisfactorily with only the "P" and "I" values used.

Start the tuning process by setting the Integral and Derivative functions to zero.

Proportional Bandwidth is defined as the temperature range around the setpoint where the controller modulates (proportions) the output power. In a heating application, if the temperature is above the proportional band, the controller output is OFF. If the temperature is below the proportional band, the controller output is ON.

Each thermal system has its own time constants determined by the thermal mass of the components and the placement of the sensor relative to the load. To tune the system the bandwidth must be wide enough that the controller can sense a change and react to it before the temperature drifts outside the bandwidth. If the bandwidth is too small the output will oscillate above and below the setpoint, never settling into control.

The bandwidth range of the 5C7-362 is 1° to 100°. The units are shipped with a default setting of 20°.

Assuming the controller is configured for your requirements, start the tuning process by applying power with the default settings and observing the system's response. If the system comes into the proportional band and maintains a steady

temperature near setpoint, without over shoot, the bandwidth setting is satisfactory or too large. Reduce the bandwidth setting 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, record the period of oscillation for use in determining the Integral Reset setting. To set the proportional bandwidth, multiply the current bandwidth setting by 1.5 and use it as your new bandwidth setting. The system should come into control and maintain a steady temperature near the setpoint.

Integral Reset monitors the difference between the set point and the actual temperature. Its function is to slowly change the output power until the delta between actual temperature and set temperature is zero.

The function works by integrating the error signal at fixed intervals. These intervals are expressed in repeats/minute. The acceptable range for the 5C7-362 is 0.01 to 10 repeats /minute. Start with a setting determined by the following formula.

Integral Reset = 1/ 2(period)

Note: Period is expressed in minutes.

Example: The system‘s period of oscillation with narrow bandwidth was 75 seconds. Therefore the suggested Integral Rate is

Integral Reset = 1/ 2(1.25 minutes)

Integral Reset = 0.625 repeats/minute

For slower response reduce the number of repeats per minute.

NOTE: DERIVATIVE RATE IS DIFFICULT TO APPLY. IF YOU ARE NOT EXPERIENCED IN PROCESS CONTROL, ASK FOR HELP NOW!

Derivative Rate senses the rate of change of the temperature and allows the controller to anticipate 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. The acceptable range for the 5C7-362 is 0.01 to 10 cycles/ minute.

To determine an appropriate derivative rate, use the following formula.

Derivative Rate = Integral Reset / 10

For the example above the Derivative Rate would be .06 cycles per minute.

The Derivative function is difficult to use and often causes more trouble than it is worth!

NOTES:

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