OVEN INDUSTRIES, INC.

OPERATING MANUAL

Model 5C7-361

THERMOELECTRIC MODULE TEMPERATURE CONTROLLER

Table of Contents

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FEATURES

- INPUT VOLTAGE FROM 12 TO 28 VOLTS DC
- SELF-CONTAINED, 0.1 TO 25 AMPERE LOAD RATING
- PC PROGRAMMABLE VIA RS-485 COMMUNICATIONS PORT
- BI-DIRECTIONAL CONTROL FOR HEATING AND COOLING APPLICATIONS
- FULLY, SOLID STATE "H" BRIDGE OPERATION
- CONTROL TEMPERATURE OF –20° TO 100°C. WITH TS67 SERIES SENSOR
- PROPORTIONAL (P), INTEGRAL (I), AND DERIVATIVE (D) CONTROL THAT CAN BE SELECTED AS: P, PI, PD, OR PID; OR 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 ISOLATED RS-485 COMMUNICATIONS INTERFACE
- CONTROLS UP TO 680 WATTS
- SET TEMPERATURE SELECTABLE
  - PC SET WITH CONTROLLER STAND ALONE OPERATION
  - REMOTE USER SET TEMPERATURE POTENTIOMETER
  - 4 TO 20 MA CURRENT LOOP
  - 1V TO 5V ADJUSTABLE RANGE
  - 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 INTER-FACE 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 5C7-361 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 RS485 communication port for direct interface with a compatible PC or via an RS485 to RS232 converter. The RS485 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 up to 32 addressable interfaces, over a maximum of 4,000 feet of communications cable.

Once the desired set parameters are established, the PC may be disconnected and Model 5C7-361 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 5C7-361 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. is standard when using an Oven Industries' TS67 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.

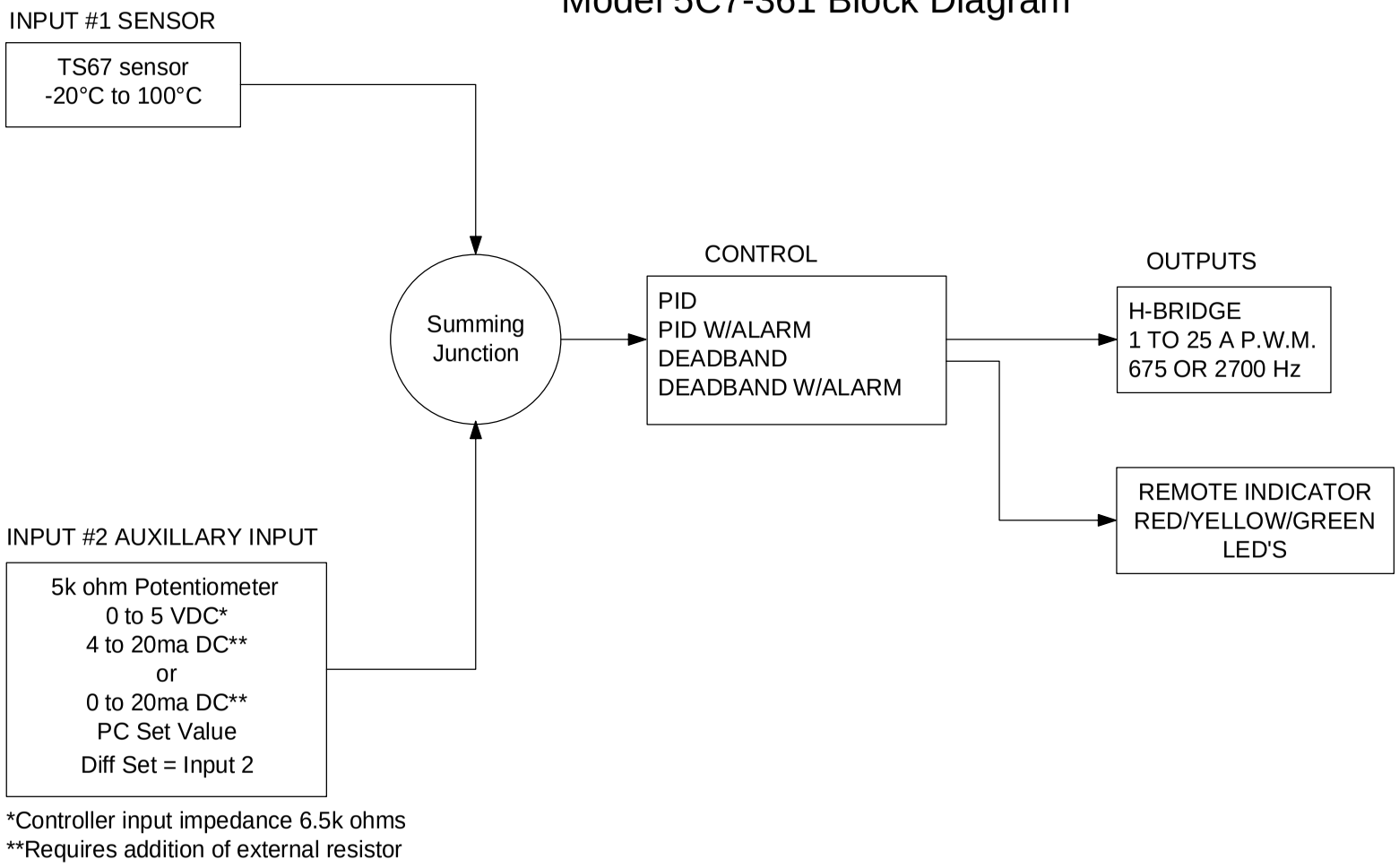
Differential control is accomplished by selecting the primary set temperature with the second thermistor input and establishing the offset with the computer set temperature. The unit will control the differential between Input 2 (reference temperature) and Input 1 (actual system temperature).

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.

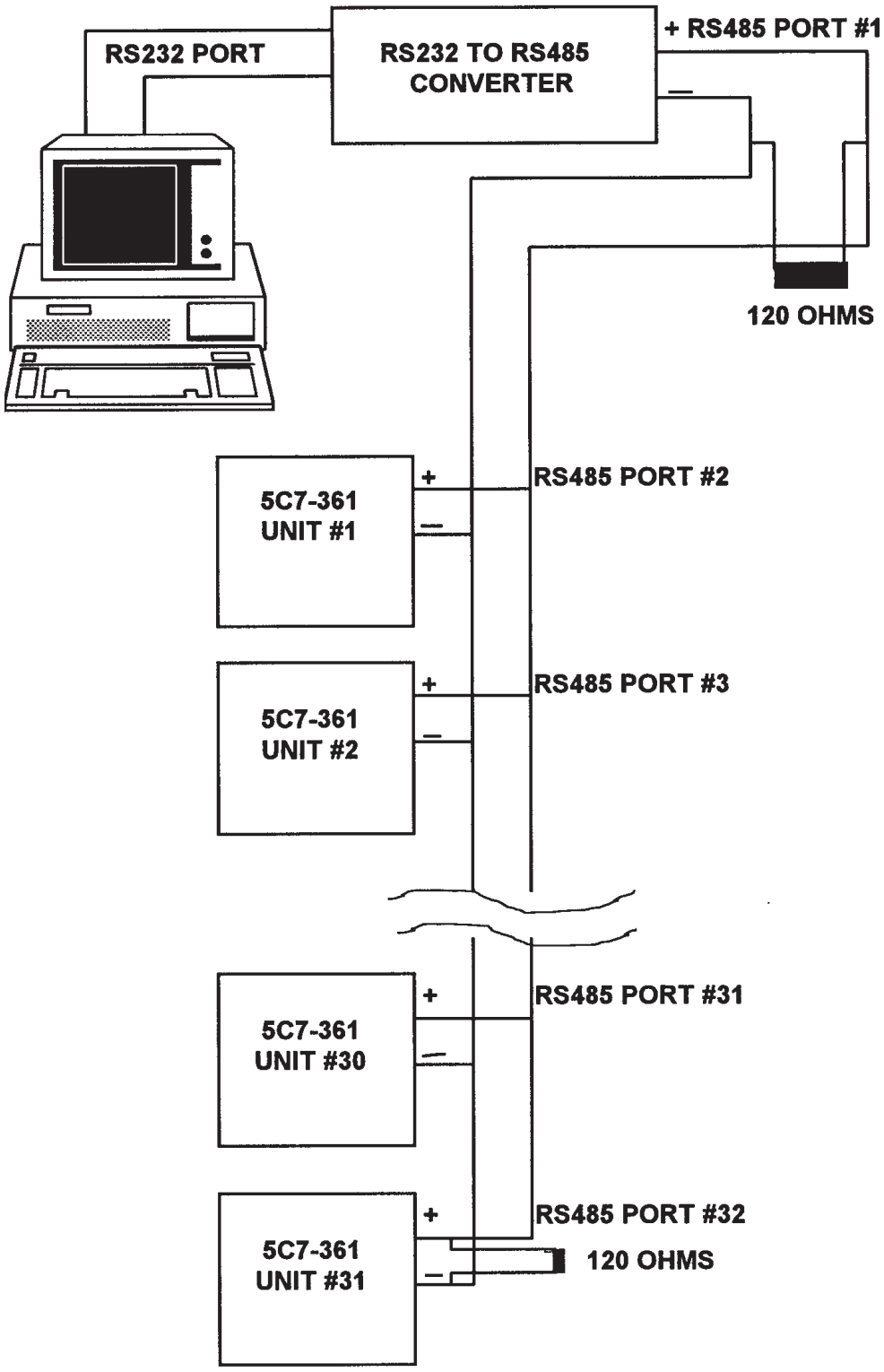
Several alarm types may be selected which provide a 5 VDC output, rated for 25 ma of current. They consist of no alarm function, tracking alarm, and fixed value alarm. Alarm set temperature values are entered in the setup menu. The computer-controlled selection is available for additional embedded controller 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 5C7-361 Block Diagram

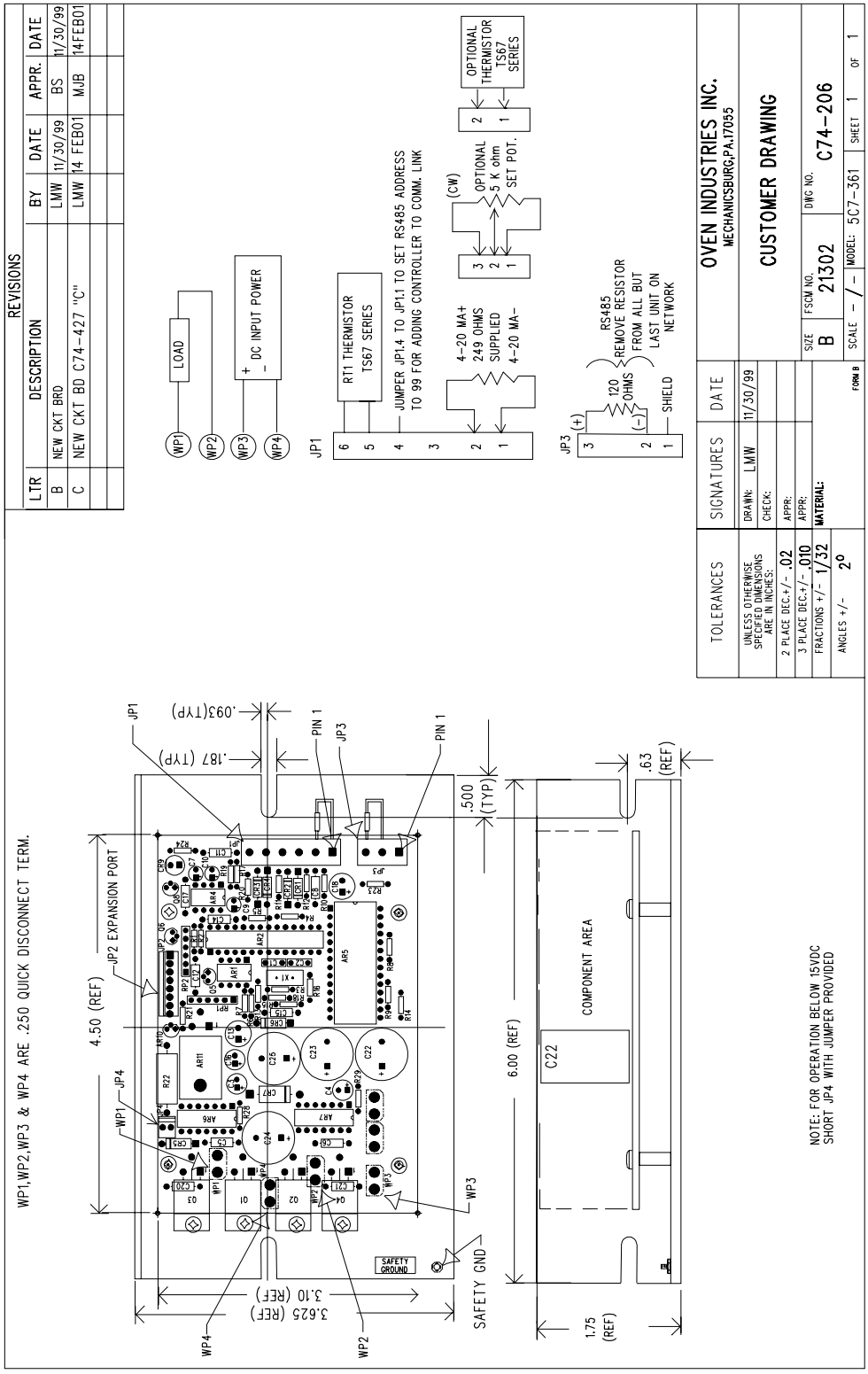


*Controller input impedance 6.5k ohms
**Requires addition of external resistor

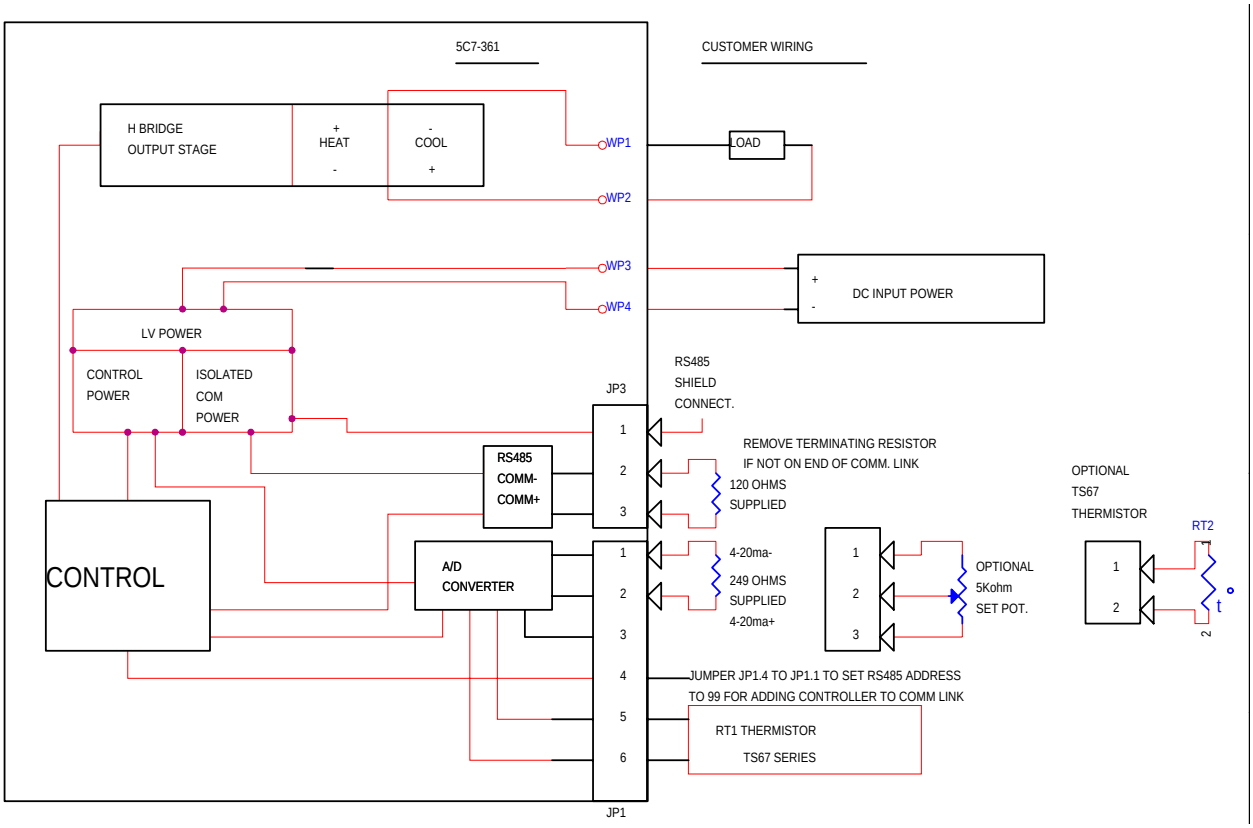


MULTIPLE MODEL 5C7-361 CONTROLLER WIRING DIAGRAM FOR PC'S WITH AN RS232 COMMUNICATIONS PORT

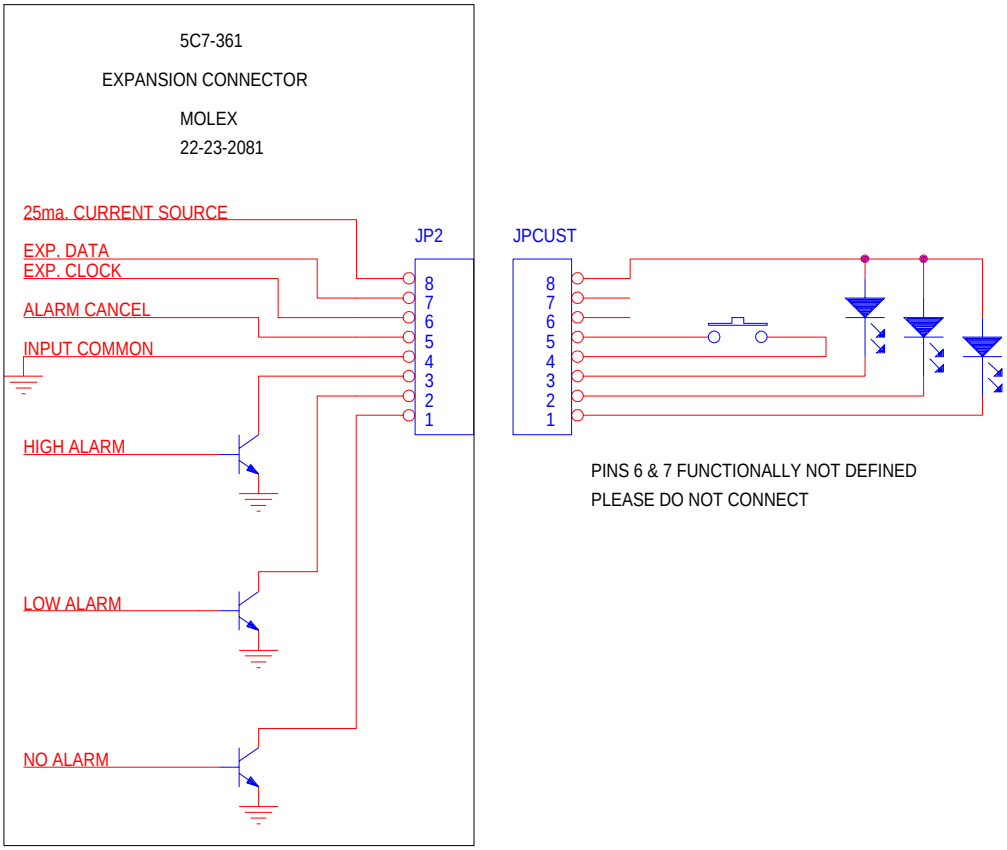
MECHANICAL PACKAGE DRAWING



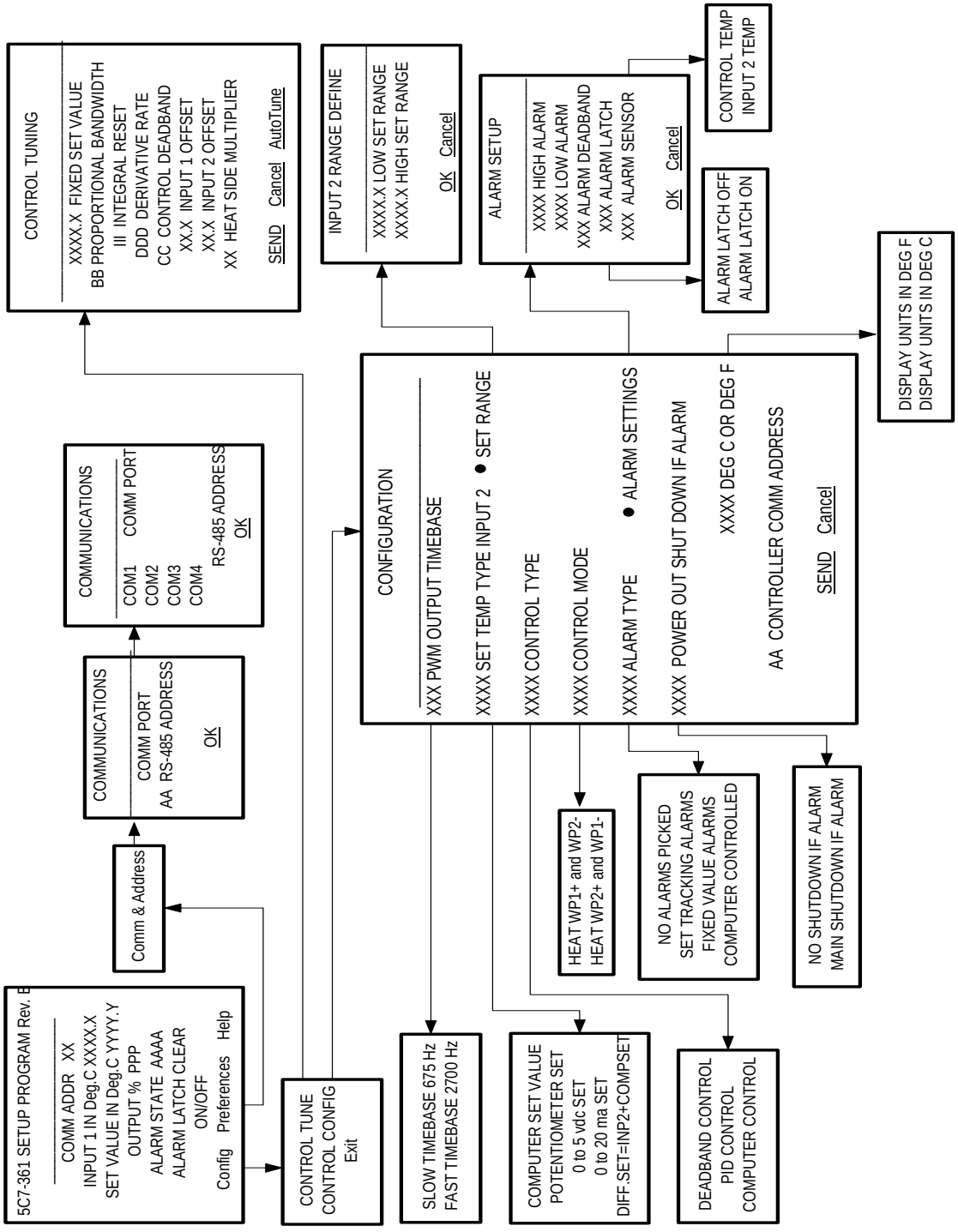
CUSTOMER HOOKUP DRAWING



EXPANSION CONNECTOR



MODEL 5C7-361 Menu Tree



SET-UP INSTRUCTIONS FOR MODEL 5C7-361, 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.

2. Connect the RS-485 Communications Port from the controller to the RS-485 input on the PC or to an RS-485 to RS-232 converter. If a converter is used, connect the RS-232 port to an available RS-232 port on the PC. See Appendix D for RS-485 Cable Termination Requirements before removing any of the resistors on the JP1 terminal strip.

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 5C7-361 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:\Oi361.exe and OK. This will load the PC interface into your computer's RAM.

5. NOTE: Refer to the Model 5C7-361 Menu Tree

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

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

8. Select "Preferences" from this menu screen. The "Comm & Address" menu will be shown. Select this option and the "COMMUNICATIONS" menu appears. Select the "COMM PORT" (1 through 4) which will be your communications link to the controller. Assign an RS-485, two digit address code of "00" to the controller for the initial set-up. The "00" code is the universal address which will communicate with all the controllers in a multiple unit system. Refer to Appendix B for additional address code information. Select OK and you will receive a DOWNLOADING DATA!!! message and return to the Main Menu.

9. From the Main Menu select "Config" which will present the "CONTROL TUNE" and "CONTROL CONFIG" menu. Select "CONTROL CONFIG" from this menu to present the "CONFIGURATION" menu screen. The "CONFIGURATION" menu is used to establish the basic operation criteria for the controller.

10. First, select the "PWM OUTPUT TIMEBASE" (pulse width modulated), "SLOW TIMEBASE 675Hz" or "FAST TIMEBASE 2700Hz". Select the option that is appropriate for you application.

*** For operation below 15VDC move jumper on JP4 to short both PINS. This will allow operation down to 10VDC.**

11. Next, click on the "SET TEMP TYPE INPUT 2" selection and the "down" key to reveal the menu 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 settings 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 is the "SET RANGE" option. By clicking on the "SET RANGE", a drop down menu, "INPUT 2 RANGE DEFINE" is presented. This permits the selection of limitations on the temperature range of the external adjustments. Set the lower temperature limitation by entering that temperature in the "LOW SET RANGE" option and the high temperature limitation in the "HIGH SET RANGE" option. These set limits must be selected within the -20°C. and 100°C. range specified for the controller. Clicking OK will establish these limits and return you to the "CONFIGURATION" MENU.

13. Now, click "CONTROL TYPE" on the menu 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 "CONTROL MODE" will present a drop down menu that permits the selection of either "HEAT WP1+ and WP2-" or "HEAT WP2+ and WP1-". These selections establish 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. Associated with the "ALARM TYPE" configuration is the "ALARM SETUP" selection. By clicking on this option, a drop down menu will appear with the "ALARM SETTINGS" menu. This is where the desired temperature settings for the "HIGH ALARM" and "LOW ALARM" values are entered. The "ALARM DEADBAND" option is to set the hysteresis of the alarm values from 0.1°F. to 100°F. 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; "ALARM LATCH ON" will maintain that an alarm condition existed and must be manually cleared from the Main Menu. The "ALARM SENSOR" option allows for the selection of either the thermistor "CONTROL TEMP" sensor or the thermistor "INPUT 2 TEMP" sensor. Upon completion of the "ALARM SETUP", clicking on OK will complete the setup.

17. The "POWER OUT SHUT DOWN IF ALARM" provides a drop down menu that allows the two selections. "NO SHUT DOWN IF ALARM" which will let the power output stage of the controller to continue to function or "MAIN SHUTDOWN IF ALARM" which disables the power output stage under an alarm condition.

18. The "DEG C OR DEG F" portion of the "CONFIGURATION" menu allows for selection of "DISPLAY UNITS IN DEG F" or "DISPLAY UNITS IN DEG C".

19. Review all of your controller configuration selections. If all the configuration selections are correct for your application, select the SEND button to download these settings to the controller. This will also return you to the Main Menu.

20. In the Main Menu, click on "Config" to reveal the "CONTROL TUNE" and "CONTROL CONFIG" menu. Select the "CONTROL TUNE" option which will then display the "CONTROL TUNING" menu.

21. The “CONTROL TUNING” menu provides the method to enter the various constants required by the controller to optimize the system performance .

22. NOTE: Refer to Appendix C for the factory default settings for the following parameters.

23. The “FIXED SET VALUE” is the set temperature value entered in degrees. This temperature is one within the range of the selected 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.

24. “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°.

25. “INTEGRAL RESET” 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.

26. “DERIVATIVE RATE” 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.

27. “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.

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

29. “INPUT 2 OFFSET” is a manual method for compensating for the sensor 2 temperature and actual temperature.

30. “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.

31. “AUTOTUNE” is the ability of the controller to sample the operating system which selects the proportional, integral, and derivative constants for one set of conditions and downloads these values to the selected controller. If the system conditions change, the “AUTOTUNE” function must be repeated.

32. Review the tuning parameters for correctness and then select SEND to download these constants to the controller. This will also return you to the Main Menu.

33. Initial set-up of your Model 5C7-361 controller is complete.

APPENDIX A

Troubleshooting Communications Port and RS-485 Address:

For troubleshooting always set the RS-485 port to 00, unit correct communication is established.

Error Message:	Cause:	Solution:
Comm Port Timeout	No power to 5C7-361 unit.	Apply power to 5C7-361, review Customer Drawing for proper hookup.
Comm Port Timeout	RS-485 Address is wrong.	Set to 00 the universal address.
Comm Port Timeout	Wrong Comm Port Selected.	Check computer hardware setting and set to teh correct comm port.
Comm Port Timeout	Comm Port is not connected to converter or computer.	Check for correct connection of the converter to the computer, review Converter Specifications & Computer for proper hookup.
Comm Port Timeout	Incorrect wiring of Comm Port to the converter or computer.	Check for correct wiring of the converter to the computer, review Converter Specifications & Computer for proper hookup.
Comm Port Timeout	Converter is not connected to 5C7-361.	Check for correct connection of the converter to 5C7-361, review Converter Specifications & 5C7-361 Customer Drawing for proper hookup.
Comm Port Timeout	Incorrect wiring of the converter to 5C7-361.	Check for correct wiring fo the converter to 5C7-361, review Converter Specifications & 5C7-361 Customer Drawing for proper hookup.
Comm Port Open Error	No Comm Port available at this port setting.	Check Computer hardware setting and set to the correct Comm Port.

APPENDIX B

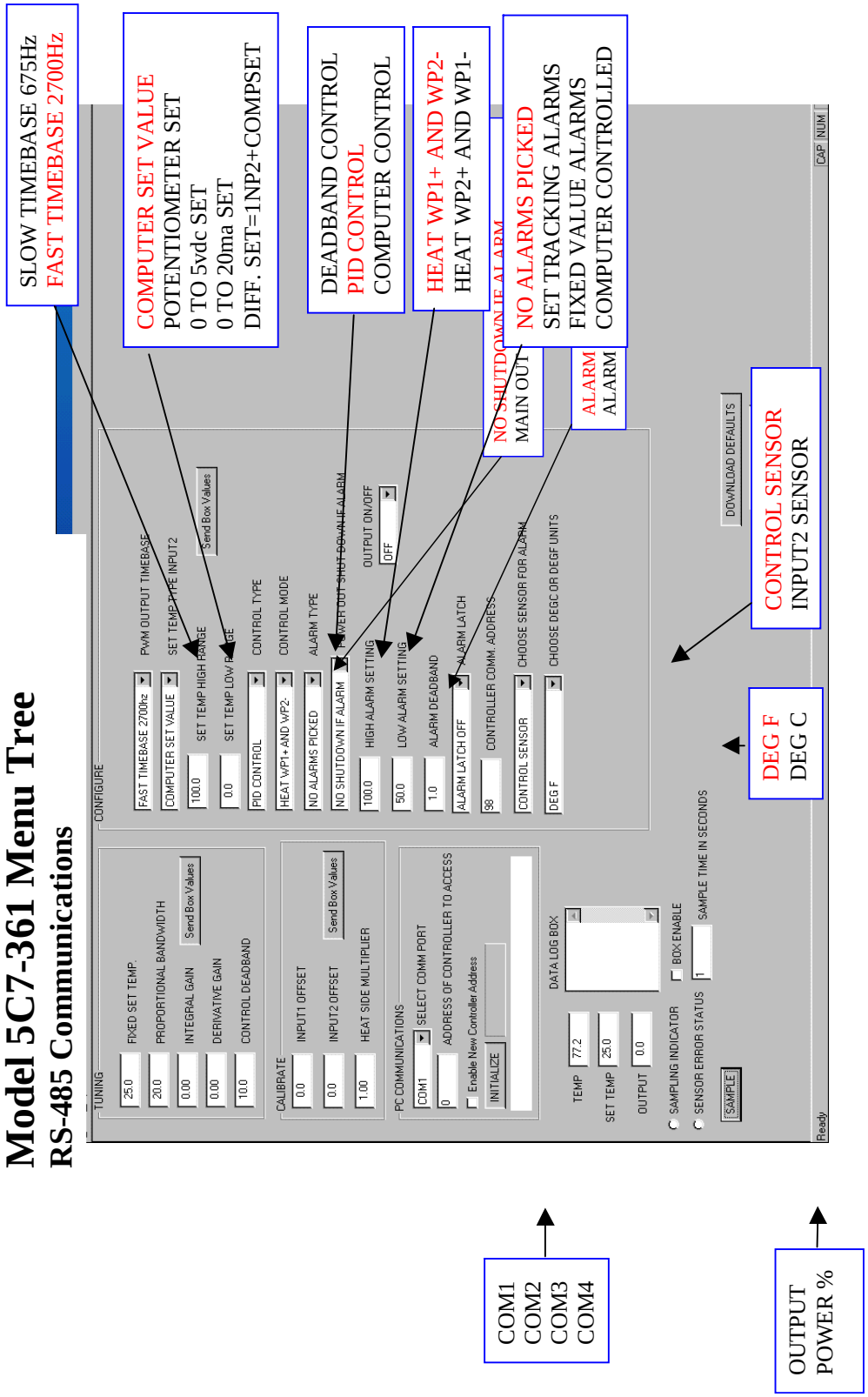
RS-485 Communications Port Addresses for Model 5C7-361

The “00” Communications Port Address code is the universal address to which all controllers will respond.

Placing a jumper between pins JP1-4 and JP1-1 on the host controller will initiate a “99” Communications Port Address code, when the controller is powered. This code is used to set-up a newly added controller to the serial link. This jumper should be removed upon completion of this set-up.

Additional Communications Port Address codes from “01” to “98” are used to identify individual controllers of the serial link. The total number of controllers that make up the serial link is 32 ports.

APPENDIX C



NOTE: THE FACTORY DEFAULT VALUES ARE SHOWN IN RED.

APPENDIX D

RS-485 CABLE TERMINATION REQUIREMENTS

A twisted pair of wires for an RS-485 application may connect up to 32 ports for half duplex data transmission. An optional shield around the twisted pair help reduce unwanted noise, and is connected to ground at one end.

Proper termination of the cable is very important. If the cable is not correctly terminated with its characteristic impedance, normally 120Ω, distorted waveforms will result. Unwanted reflection signals may occur which can distort or interrupt data transmission.

Cable terminating resistors are required at the physical ends of the cable run to prevent these unwanted reflections (Refer to Multiple Controller Wiring Diagram). The typical differential output is 2 volts with two 120Ω terminating resistors, causing 33mA of DC current in the cable when no data is being sent. The preferred terminating resistor type is a metal film rated at 1/4 watt.

This termination method permits connections up to 4,000 feet of RS-485 cable.

NOTE: *If an RS-485 to RS-232 converter is being used, please check the converter manual to determine if a 120 ohm terminating resistor is included.*

Application Note 352

5 Minutes to PID Tuning of the 5C7-361 Controller

Tuning the Model 5C7-361 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 5C7-361 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 5C7-361 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 5C7-361 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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