

THE 1/16 DIN CONTROLLERS TEMPERATURE/PROCESS



MODELS T48 & P48 INSTRUCTION MANUAL

INTRODUCTION

The Temperature Controller (T48) and Process Controller (P48) are both multi-purpose series of industrial control products that are field-programmable for solving various applications. These series of products are built around the concept that the end user has the capability to program different personalities and functions into the controllers in order to adapt to different indication and control requirements.

The controller which you have purchased, has the same high quality workmanship and advanced technological capabilities that have made Red Lion Controls the leader in today's industrial market.

Red Lion Controls has a complete line of industrial indication and control equipment, and we look forward to servicing you now and in the future.



**UL Recognized Component,
File # E156876**



**CAUTION: Risk of Danger.
Read complete instructions prior to
installation and operation of the unit.**



CAUTION: Risk of electric shock.

Table of Contents

GENERAL DESCRIPTION	1
Safety Summary	1
INSTALLATION DESCRIPTION	2
Instructions	2
Multiple Unit Stacking	3
Unit Removal Procedure	3
Removing Bezel Assembly	3
Installing Bezel Assembly	3
CONNECTION DESCRIPTION	4
EMC Installation Guidelines	4
Wiring Connections	5
Signal Wiring	5
Thermocouple (T48)	5
RTD (T48)	5
Signal (P48)	6
Power Wiring	6
Control and Alarm Outputs	6
Relay Connections	6
Logic/SSR Connections (T48 only)	7
Triac Connections (T48 only)	7
Heater Current Monitor Wiring (T48 only)	7
Remote Setpoint Wiring	7
Main Linear DC Output Wiring	7
Second Linear DC Output Wiring	7
User Input Wiring	7
Rear Terminal Assignments	8
T48 Models Without RS-485 and Analog Output	8
T48 Models With RS-485 or Linear DC Analog Output	9
ALL P48 Models	10
Serial Connections to a Host Terminal	11
Linear DC Analog Output Jumper Selection	12
FRONT PANEL DESCRIPTION	13
Button Functions	13

INITIAL CONFIGURATION START-UP	14
Controller Power-up	14
Parameter Configuration Overview	14
Parameter Configuration Basic Start-up	14
Parameter Configuration for Serial Start-up	14
Control Start-up	14
Valid Control Mode Combinations	15
Front Panel Programming Chart For T48 & P48 Controllers	16
NORMAL DISPLAY MODE	17
FRONT PANEL PROGRAM DISABLE	17
UNPROTECTED PARAMETER MODE	18
PROTECTED PARAMETER MODE	19
HIDDEN FUNCTION MODE	20
CONFIGURATION PARAMETER MODE	20
REFERENCE TABLES: CONFIGURATION PARAMETER MODULES	21
Configure Module 1 - Input Parameters (1-IN) T48	21
Configure Module 1 - Input Parameters (1-IN) P48	22
Configure Module 2 - Output Parameters (2-OP)	23
Configure Module 3 - Lockout Parameters (3-LC)	24
Configure Module 4 - Alarm Parameters (4-AL)	25
Configure Module 5 - Cooling Parameters (5-O2)	26
Configure Module 6 - Serial Communications (6-SC)	27
Configure Module 7 - Remote Setpoint Parameters (7-rS or 7-n2)	28
Configure Module 7 - Heater Current Parameters (7-HC or 7-n2)	28
Configure Module 8 - Second Linear DC Analog Output (8-A2)	28
Configure Module 9 - Factory Service Operations (9-FS)	28
USER PARAMETER VALUE CHART	29
CONFIGURATION PARAMETER EXPLANATIONS	31
Input Parameter Module (1- IN) T48 Models	31
Input Type (tYPE)	31
Temperature Scale (SCAL)	31
Temperature Resolution (dCPt)	31
Digital Input Filtering and Display Update Rate (FLtr)	31

Input Sensor Correction Constant (SHFt)	31
Setpoint Limit Values (SPLO & SPHI)	31
Setpoint Ramp Rate (SPrP)	32
User Input (InPt)	32
Input Parameter Module (1- In) P48 models	33
Input Type (tYPE)	33
Decimal Point Position (dCPt)	33
Rounding Increment (rnd)	33
Digital Input Filtering and Display Update Rate (FLtr)	33
Scaling Points	33
Display Values (dSP1 & dSP2)	34
Signal Input Values (INP1 & INP2)	34
Setpoint Limit Values (SPLO & SPHI)	34
Setpoint Ramp Rate (SPrP)	34
User Input (InPt)	35
Output Parameter Module (2-OP)	36
Time Proportioning Cycle Time (CYCt)	36
Output Control Action (OPAC)	36
Output Power Limits (OPLO & OPHI)	36
Sensor Fail Power Level (OPFL) T48 only	36
Output Power Dampening Filtering Time (OPdP)	36
ON/OFF Control Hysteresis (CHYS)	37
Auto-Tune Code (tcod)	37
Main Linear DC Output Range (ANtP) (Optional)	37
Main Linear DC Output Source (ANAS) (Optional)	37
Main Linear DC Update Time (ANUt) (Optional)	37
Main Linear DC Output Scaling Points (ANLO, ANHI) (Optional)	37
Lockouts Parameter Module (3-LC)	38
Lower Display Lockouts (SP, OP, dEv, Hcur, UdSP and bdSP)	38
Protected Mode Lockouts (CodE, PId, and AL)	38
Hidden Mode Lockouts (ALrS, SPsL, trnF, and tUNE)	38
Alarm Parameter Module (4-AL) (Optional)	39
Alarm Action (Act1, Act2)	39
Heater Break Alarm	39

Alarm Action Figures	40
Alarm Reset (rSt1, rSt2)	42
Alarm Standby Delay (Stb1, Stb2)	42
Alarm Value (AL-1, AL-2)	42
Alarm Hysteresis (AHYS)	42
Cooling Parameters Module (5-02) (Optional)	43
Cooling Output Cycle Time (CYC2)	43
Cooling Relative Gain (GAn2)	43
Heat and Cool Overlap/Deadband (db-2)	43
Serial Communications Module (6-SC) (Optional)	44
Baud Rate (bAUd)	44
Character Frame Format (ConF)	44
Controller Address Number (Addr)	44
Abbreviated or Full Transmission (Abrv)	44
Print Options (PoPt)	44
Remote Setpoint Parameters Module (7-n2 or 7-rS) (Optional)	45
Remote Setpoint Display Values (dSP1 and dSP2)	45
Remote Setpoint Signal Input Values (INP1 and INP2)	45
Remote Setpoint Filtering (Fitr and bANd)	45
Remote/Local Setpoint Transfer Options (trnF)	45
Heater Current Monitor Module (7-N2 or 7-HC) (Optional)	46
Second Linear DC Analog Output Module (8-A2) (Optional)	46
Second Linear DC Output Range (A2tP)	46
Second Linear DC Output Scaling Points (A2LO, A2HI)	46
Factory Service Operations Module (9-FS)	46
MANUAL CONTROL	47
ON/OFF CONTROL	48
AUTO-TUNE FOR PID CONTROL	51
Initiate Auto-Tune	52
Auto-Tune Of Heat/Cool Systems	52
Auto-Tune Of Cascade Control	52
PID CONTROL EXPLANATIONS	53
Proportional Band	53
Integral Time	53

Derivative Time	54
Output Power Offset (Manual Reset)	54
PID Adjustments	54
MANUAL TUNING FOR PID CONTROL	56
REMOTE SETPOINT OPTION	57
CASCADE CONTROL	57
SERIAL COMMUNICATIONS INTERFACE	58
RS-485 Serial Communications	58
Configuration Software	58
Controller Configuration	58
Sending Commands And Data	58
Sending Numeric Data	58
Controller (Node) Address	58
Commands Table	58
Register Identification Table	59
Terminator Table	59
Examples of Command Strings:	59
Command Code Explanations	59
Controller (Node) Address: N	59
Read Register Command Code: T	60
Write Register Command Code: V	60
Reset Alarm Command Code: R	60
Control Action Command Code: C	60
Block Read Register Command Code: P	60
Terminator : * or \$	60
Block Read Command Byte Table	61
Unique Register Explanations	62
Setpoint Ramp Using Automatic Setpoint Ramping Register: K	62
Setpoint Ramp Using Periodic Setpoint Write Register: B	62
Periodic Setpoint Write Commands (E ² PROM precautions)	62
Heater Current Response: HC (T48 only)	62
Output Status: W	62
Communication Format	62
Command Response Time	63

Full Field Controller Transmission Byte Format	64
Abbreviated Controller Transmission Byte Format	65
Troubleshooting Serial Communications	65
APPLICATION EXAMPLES	66
T48 OEM Paint Sprayer Application	66
T48 Plastics Extruder Application	67
P48 Water Processing Application	68
CHECKS AND CALIBRATION	69
Main Input Check	69
mV Reading Check (T48)	69
Thermocouple Cold Junction Temperature Check (T48)	69
RTD Ohms Reading Check (T48)	69
Voltage Check (P48)	69
Current Check (P48)	69
Remote Setpoint Input Check (T48 and P48)	69
Heater Current Input Check (T48 only)	69
Error Flag E-CL	70
Calibration For T48	70
Factory Service Operations - Calibration (9-FS)	70
Millivolt Calibration (CAL)	70
Thermocouple Cold Junction Calibration (CJC)	71
RTD Ohms Calibration (rtd)	71
Main or Second Linear DC Analog Output Calibration	71
Remote Setpoint Calibration	71
Heater Current Input Calibration	71
Calibration For P48	72
Factory Service Operations (9-FS)	72
Input Calibration	72
Main or Second Linear DC Analog Output Calibration	72
Remote Setpoint Calibration	72
TROUBLESHOOTING	73
REPLACEABLE OUTPUT BOARD DESCRIPTION	75
SPECIFICATIONS AND DIMENSIONS	76
ORDERING INFORMATION	81

GENERAL DESCRIPTION

The T48 Controller accepts signals from a variety of temperature sensors (thermocouple or RTD elements), while the P48 Controller accepts either a 0 to 10 VDC or 0/4 to 20 mA DC input signal. Both controllers precisely display the process, and provide an accurate output control signal (time proportional or linear DC) to maintain a process at the desired control point. The controllers' comprehensive programming allows them to meet a wide variety of application requirements.

The controller can operate in the PID control mode for both heating and cooling, with on-demand Auto-Tune, which will establish the tuning constants. The PID tuning constants may be fine-tuned by the operator at any time and then locked out from further modification. The controller employs a unique overshoot suppression feature, which allows the quickest response without excessive overshoot. Operation of the controller can be transferred to manual mode, providing the operator with direct control of the output. The controller may also be programmed to operate in the ON/OFF control mode with adjustable hysteresis.

Dual 4-digit displays allow viewing of the process/temperature and setpoint simultaneously. Front panel indicators inform the operator of the controller and output status. The control output and the alarm outputs are field replaceable on select models.

Optional alarm (s) can be configured to activate according to a variety of actions (Absolute HI or LO, Deviation HI or LO, Band IN or OUT, and Heater Current Break) with adjustable hysteresis. A standby feature suppresses the alarm during power-up until the process stabilizes outside the alarm region.

Optional Main Linear DC output (10 V and 20 mA) can be used for control or retransmission purposes. Programmable output update time reduces valve or actuator activity. The output range can be scaled independent of the input range.

Optional Second Linear DC output (10 V or 20 mA) provides an independent process retransmission, while the main Linear DC output is being used for control. The output range can be scaled independent of the input range.

The T48 optional Heater Current Monitor provides a direct readout of process heater current. An alarm can be programmed to signal when the heater has failed. This provides early warning of system failure before product quality is affected.

A Remote Setpoint input (0/4 to 20 mA) allows for cascade control loops, where tighter control quality is required; and allows for remotely driven setpoint signal from computers or other similar equipment. Straightforward end point scaling with independent filtering and local/remote transfer option expands the controller's flexibility.

The optional RS485 serial communication interface provides two-way communication between a controller and other compatible equipment such as a printer, PLC, HMI, or a host computer. In multipoint applications (up to thirty-two), the address number of each controller on the line can be programmed from 0 to 99. Data from the controller can be interrogated or changed, and alarm output(s) may be reset by sending the proper command code via serial communications. PC software, SFCRM, allows for easy configuration of controller parameters. These settings can be saved to disk for later use or used for multi-controller down loading. On-line help is provided within the software.

The unit is constructed of a lightweight, high impact plastic case with a tinted front panel. The front panel meets NEMA 4X/IP65 specifications when properly installed. Multiple units can be stacked horizontally or vertically. Modern surface-mount technology, extensive testing, plus high immunity to noise interference makes the controller extremely reliable in industrial environments.

SAFETY SUMMARY

All safety related regulations, local codes and instructions that appear in the manual or on equipment must be observed to ensure personal safety and to prevent damage to either the instrument or equipment connected to it. If equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Do not use the controller to directly command motors, valves, or other actuators not equipped with safeguards. To do so, can be potentially harmful to persons or equipment in the event of a fault to the unit. An independent and redundant temperature limit indicator with alarm outputs is strongly recommended.

INSTALLATION DESCRIPTION

The controller meets NEMA 4X/IP65 requirements for indoor use to provide a watertight seal in steel panels with a minimum thickness of 0.09 inch, or aluminum panels with a minimum thickness of 0.12 inch. The units are intended to be mounted into an enclosed panel. It is designed so that the units can be stacked horizontally or vertically (see Figure 1). The bezel assembly **MUST** be in place during installation of the unit.

INSTRUCTIONS:

1. Prepare the panel cutout to the dimensions shown in Figure 1, Panel Installation.
2. Remove the panel latch from the unit. Discard the cardboard sleeve.
3. Carefully remove the center section of the panel gasket and discard. Slide the panel gasket over the unit from the rear, seating it against the lip at the front of the case.
4. Insert the unit into the panel cutout. While holding the unit in place, push the panel latch over the rear of the unit, engaging the tabs of the panel latch in the farthest forward slot possible.
5. To achieve a proper seal, tighten the panel latch screws evenly until the unit is snug in the panel, torquing the screws to approximately 7 in-lbs (79 N-cm). Over tightening can result in distortion of the panel, and reduce the effectiveness of the seal.

Note: The installation location of the controller is important. Be sure to keep it away from heat sources (ovens, furnaces, etc.), and away from direct contact with caustic vapors, oils, steam, or any other process byproducts in which exposure may affect proper operation.

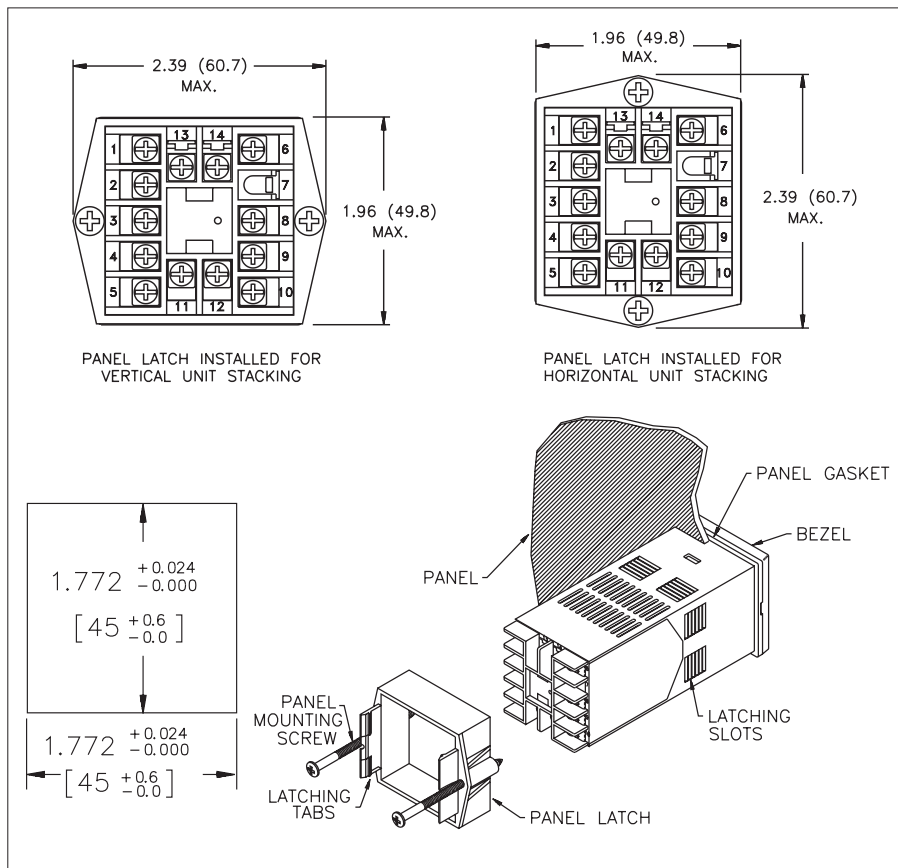


Figure 1, Panel Installation

MULTIPLE UNIT STACKING

The controller is designed for close spacing of multiple units. Units can be stacked either horizontally or vertically. For vertical stacking, install the panel latch with the screws to the sides of the unit. For horizontal stacking, the panel latch screws should be at the top and bottom of the unit. The minimum spacing from center line to center line of units is 1.96" (49.8 mm). This spacing is the same for vertical or horizontal stacking.

Note: When stacking units, provide adequate panel ventilation to ensure that the maximum operating temperature is not exceeded.

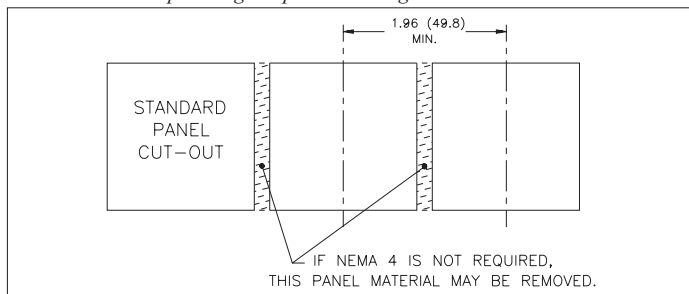


Figure 3, Multiple Unit Stacking Horizontal Arrangement



Caution: Disconnect power to the unit and to the output control circuits to eliminate the potential shock hazard when removing the bezel assembly.

UNIT REMOVAL PROCEDURE

To remove a unit from the panel, first loosen the panel latch screws. Insert flat blade screwdrivers between the latch and the case on either side of the unit, so that the latches disengage from the grooves in the case. Push the unit through the panel from the rear.

REMOVING BEZEL ASSEMBLY

The bezel assembly, shown in Figure 2, must be removed from the case to replace the output board. To remove the bezel assembly, insert a flat blade screwdriver into the pry slot on either side of the unit. Twist the screwdriver handle until the unit is ejected enough to allow removal.

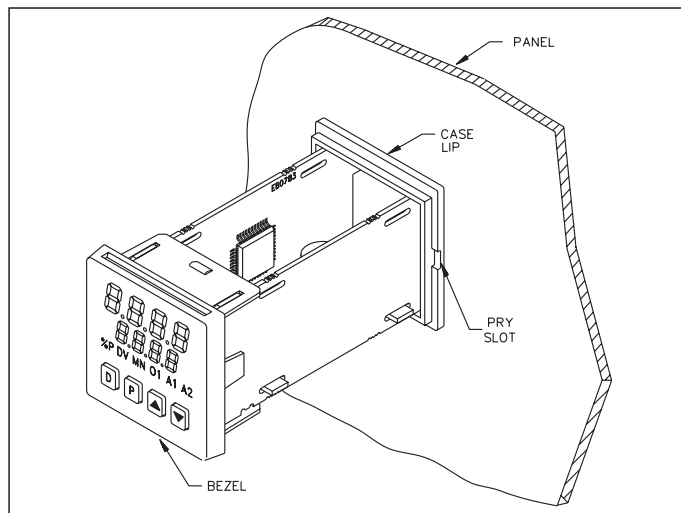


Figure 2, Bezel Assembly

Caution: The bezel assembly contains electronic circuits that can be damaged by static electricity. Before removing the assembly, discharge static charge on your body by touching an earth ground point. It is also important that the bezel assembly be handled only by the bezel itself. Additionally, if it is necessary to handle a circuit board, be certain that hands are free from dirt, oil, etc., to avoid circuit contamination that may lead to malfunction. If it becomes necessary to ship the unit for repairs, place the unit in its case before shipping.

INSTALLING BEZEL ASSEMBLY

To install the bezel assembly, insert the assembly into the case until the bezel is fully seated against the lip of the case. Properly installing the bezel assembly is necessary for watertight sealing.

CONNECTION DESCRIPTION

EMC INSTALLATION GUIDELINES

Although this unit is designed with a high degree of immunity to Electro Magnetic Interference (EMI), proper installation and wiring methods must be followed to ensure compatibility in each application. The type of the electrical noise, source or coupling method into the unit may be different for various installations. Listed below are some EMC guidelines for successful installation in an industrial environment.

1. The unit should be mounted in a metal enclosure, which is properly connected to protective earth.
2. Use shielded (screened) cables for all Signal and Control inputs. The shield (screen) pigtail connection should be made as short as possible. The connection point for the shield depends somewhat upon the application. Listed below are the recommended methods of connecting the shield, in order of their effectiveness.
 - a. Connect the shield only at the panel where the unit is mounted to earth ground (protective earth).
 - b. Connect the shield to earth ground at both ends of the cable, usually when the noise source frequency is above 1 MHz.
 - c. Connect the shield to common of the unit and leave the other end of the shield unconnected and insulated from earth ground.
3. Never run Signal or Control cables in the same conduit or raceway with AC power lines, conductors feeding motors, solenoids, SCR controls, and heaters, etc. The cables should be run in metal conduit that is properly grounded. This is especially useful in applications where cable runs are long and portable two-way radios are used in close proximity or if the installation is near a commercial radio transmitter.
4. Signal or Control cables within an enclosure should be routed as far away as possible from contactors, control relays, transformers, and other noisy components.

5. In very electrically noisy environments, the use of external EMI suppression devices, such as ferrite suppression cores, is effective. Install them on Signal and Control cables as close to the unit as possible. Loop the cable through the core several times or use multiple cores on each cable for additional protection. Install line filters on the power input cable to the unit to suppress power line interference. Install them near the power entry point of the enclosure.

The following EMI suppression devices (or equivalent) are recommended:
Ferrite Suppression Cores for signal and control cables:

Fair-Rite # 0443167251 (RLC #FCOR0000)

TDK # ZCAT3035-1330A

Steward #28B2029-0A0

Line Filters for input power cables:

Schaffner # FN610-1/07 (RLC #LFIL0000)

Schaffner # FN670-1.8/07

Corcom #1VR3

Note: Reference manufacturer's instructions when installing a line filter.

6. Long cable runs are more susceptible to EMI pickup than short cable runs. Therefore, keep cable runs as short as possible.
7. Switching of inductive loads produces high EMI. Use of snubbers across inductive loads suppresses EMI.
Snubbers:
RLC #SNUB0000

WIRING CONNECTIONS

After the unit has been mechanically mounted, it is ready to be wired. All wiring connections are made to the rear screw terminals. When wiring the unit, use the numbers on the label and those embossed on the back of the case, to identify the position number with the proper function.

All conductors should meet voltage and current ratings for each terminal. Also cabling should conform to appropriate standards of good installation, local codes and regulations. It is recommended that power supplied to the unit (AC or DC) be protected by a fuse or circuit breaker. Strip the wire, leaving approximately 1/4" (6 mm) bare wire exposed (stranded wires should be tinned with solder). Insert the wire under the clamping washer and tighten the screw until the wire is clamped tightly.

Caution: Unused terminals are NOT to be used as tie points. Damage to the controller may result if these terminals are used.

SIGNAL WIRING

Thermocouple (T48)

When connecting the thermocouple, be certain that the connections are clean and tight, refer to Figure 4 for terminal connections. If the thermocouple probe cannot be connected directly to the controller, thermocouple wire or thermocouple extension-grade wire must be used to extend the connection points (copper wire does not work). Always refer to the thermocouple manufacturer's recommendations for mounting, temperature range, shielding, etc. For multi-probe temperature averaging applications, two or more thermocouple probes may be connected to the controller (always use the same type). Paralleling a single thermocouple to more than one controller is not recommended. Generally, the red wire from the thermocouple is negative and connected to the controller's common.

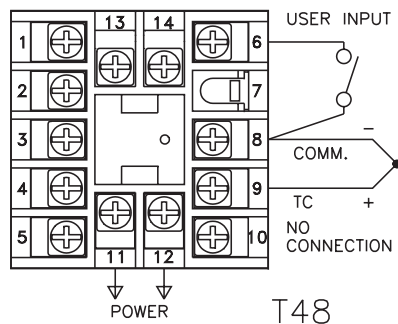


Figure 4, Thermocouple Connection

RTD (T48)

When connecting the RTD, be certain that the connections are clean and tight, refer to Figure 5 for terminal connections. RTD sensors have a higher degree of accuracy and stability than thermocouple sensors. Most RTD sensors available are the three wire type. The third wire is a sense lead for canceling the effects of lead resistance of the probe. Four wire RTD elements may be used by leaving one of the sense leads disconnected. Two wire RTD sensors may be used in either of two ways:

- Attach the RTD to terminals #8 and #10. Install a copper sense wire of the same wire gage as the RTD leads. Attach one end of the wire at the probe and the other end to terminal #9. Complete lead wire compensation is obtained. This is the preferred method.
- Attach the RTD to terminals #8 and #10. Install a shorting wire between terminals #9 and #10, as shown in Figure 5, RTD Connection. A temperature offset error of 2.5°C/ohm of lead resistance exists. The error may be compensated by programming a temperature offset.

Note: With extended cable runs, be sure the lead resistance is less than 15 ohms/lead. For thermocouple or RTD runs longer than 100 feet, convert the signal to a current near the temperature probe. Current or 20 mA loop signals are less susceptible to noise and signal loss than long thermocouple or RTD runs. The RLC ITMA and IRMA DIN rail modules are designed for these applications. By converting the temperature signal, the P48 can be used in place of a T48.

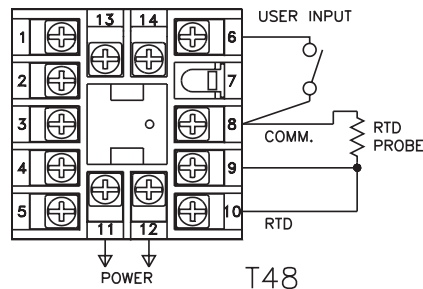


Figure 5, RTD Connection

Signal (P48)

When connecting signal leads, be certain that the connections are clean and tight. For voltage signals, use terminal #8 for common and terminal #9 for signal. For current signals, use terminal #8 for common and terminal #10 for signal. These connections are shown in Figure 6. Multicontroller applications using the same signal source are possible, by connecting current signals in series, and voltage signals in parallel.

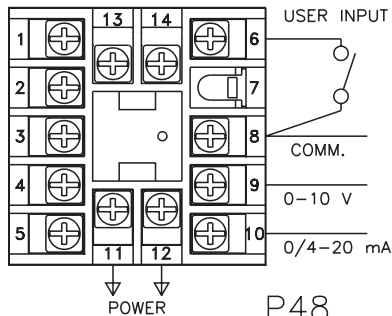


Figure 6, P48 Signal Connection

POWER WIRING AC Power

Primary AC power is connected to terminals #11 and #12, labeled AC. To reduce the chance of noise spikes entering the AC line and affecting the controller, an AC feed separate from that of the load should be used to power the controller. Be certain that the AC power to the controller is relatively “clean” and within the variation limit. Connecting power from heavily loaded circuits or circuits that also power loads that cycle on and off, (contacts, relays, motors, etc.) should be avoided.

DC Power

DC power (18 to 36 VDC) is connected to terminals #11 and #12 labeled DC+ and DC- respectively.



CAUTION: Observe proper polarity when connecting DC voltages. Damage to the unit may occur if polarity is reversed.

CONTROL AND ALARM OUTPUTS

For T48 heating, cooling, and alarms, there are up to three types of ON/OFF outputs. These outputs can be relay, logic, or Triac for control or alarm purposes. Relay outputs can switch user applied AC or DC voltages. Logic/SSR drive outputs supply power to external SSR power units. One Logic/SSR Drive output can control up to four SSR power units at one time. The Triac output supplies one Amp of AC current for control of an external AC relay or Triac device. The P48 is only available with relay outputs. Terminal numbers for the outputs and output types vary from model to model. Refer to the Rear Terminal Assignment Tables or the label on the controller for the terminal numbers corresponding to the model being wired.

Relay Connections

To prolong contact life and suppress electrical noise interference due to the switching of inductive loads, it is good installation practice to install a snubber across the contactor. Follow the manufacturer’s instructions for installation.
Note: Snubber leakage current can cause some electromechanical devices to be held ON.

Relay Outputs:

Type: Form-A

Rating: 3 Amps @ 250 VAC or 30 VDC (resistive load), 1/10 HP @ 120 VAC (inductive load).

Life Expectancy: 100,000 cycles at maximum load rating. (Decreasing load and/or increasing cycle time, increases life expectancy).

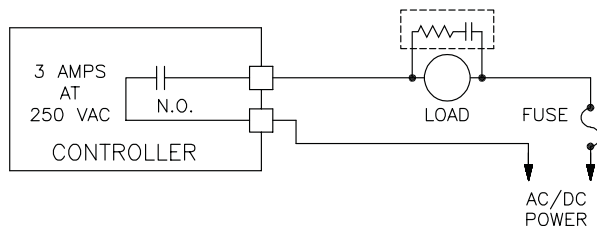


Figure 7, Relay Output

Logic/SSR Connections (T48 only)

Logic/SSR Drive Output:

Rating: 45 mA @ 4 V min., 7 V nominal (current limited)

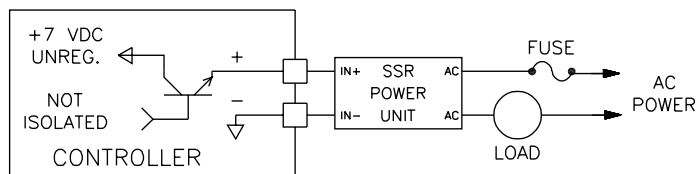


Figure 8, Logic/SSR Output

Triac Connections (T48 only)

Triac Outputs:

Type: Isolated, Zero Crossing Detection

Rating:

Voltage: 120/240 VAC

Max. Load Current: 1 Amp @ 35°C

0.75 Amp @ 50°C

Min Load Current: 10 mA

Offstate Leakage Current: 7 mA max. @ 60 Hz

Operating Frequency: 20 to 500 Hz

Protection: Internal transient snubber

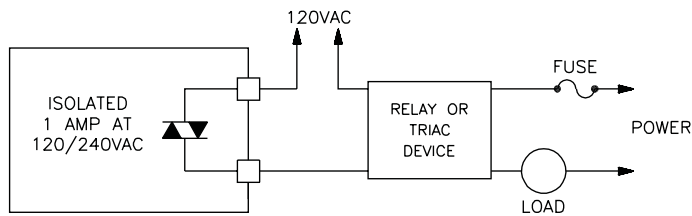


Figure 9, Triac Output

HEATER CURRENT MONITOR WIRING (T48 ONLY)

Models with the Heater Current Monitor option have two input terminals to receive the output directly from a 100 mA current transformer.

Caution: Never connect a current transformer with a rating other than 100 mA.

These terminals are labeled #13 and #14 "2nd Input Option". There is no polarity observation for these inputs. This input is only for single phase heaters.

REMOTE SETPOINT WIRING

Models with the Remote Setpoint option have two input terminals to receive a 0 to 20 mA signal. Connect the Remote Setpoint signal to terminals labeled #13 (+) and #14 (-, "2nd Input Option"). The common of this input is isolated from input common, but is not isolated from the Linear DC output commons. For proper operation, keep this common isolated from all other controller commons.

MAIN LINEAR DC OUTPUT WIRING

Models with the Linear DC output option provide either a linear 10 V or a linear 20 mA signal. The output range is selected by jumpers on the output board. (See Linear DC Analog Output Jumper Selection, page 12). The terminals are #1 (-) and #2 (+). The common of this output is isolated from input common, but is not isolated from other commons. For proper operation, keep this common isolated from all other controller commons.

SECOND LINEAR DC OUTPUT WIRING

Models with the Second Linear DC output option provide a conditioned and scaled retransmitted signal output. The terminals are #13 (+) and #14 (-). The common of this output is isolated from the input common, but not from the other commons. For proper operation, keep this common isolated from all other controller commons.

USER INPUT WIRING

The use of shielded cable is recommended. Follow the EMC installation guidelines for shield connection.

Terminal #6 is the User Input, which is programmable for a variety of functions. Any form of mechanical switch may be connected to terminal #6 (USER INPUT) and terminal #8 (COMM.). Sinking open collector logic with less than 0.7 V saturation and off-state leakage current of less than 1 μ A may also be used.

REAR TERMINAL ASSIGNMENTS
T48 Models Without RS-485 and Analog Output

TC		RTD		AC/DC Power		A2 or 02	Dedicated A1	Dedicated O1	User Input		2nd Input Option *		AC Model #	DC Model #
(+)	(-)	Short	(C)	AC/(+)	AC/(-)	(C)	(C)	(C)	(C)		(+)	(-)		
9	8	9 10	8	11	12			4 5	6 8				T4810000	T4810010
9	8	9 10	8	11	12			4 5	6 8		13	14	T4810003	T4810013
9	8	9 10	8	11	12			4 5	6 8		13	14	T4810004	T4810014
9	8	9 10	8	11	12		3 2	4 5	6 8				T4811000	T4811010
9	8	9 10	8	11	12	1 2	3 2	4 5	6 8				T4811100	T4811110
9	8	9 10	8	11	12	1 2	3 2	4 5	6 8		13	14	T4811103	T4811113
9	8	9 10	8	11	12	1 2	3 2	4 5	6 8		13	14	T4811104	T4811114
9	8	9 10	8	11	12			4 5	6 8				T4820000	T4820010
9	8	9 10	8	11	12			4 5	6 8		13	14	T4820003	T4820013
9	8	9 10	8	11	12			4 5	6 8		13	14	T4820004	T4820014
9	8	9 10	8	11	12	3 4		5 4	6 8				T4820200	T4820210
9	8	9 10	8	11	12	3 4		5 4	6 8		13	14	T4820203	T4820213
9	8	9 10	8	11	12	3 4		5 4	6 8		13	14	T4820204	T4820214
9	8	9 10	8	11	12		3 2	4 5	6 8				T4821000	T4821010
9	8	9 10	8	11	12	1 2	3 2	4 5	6 8				T4821100	T4821110
9	8	9 10	8	11	12	1 2	3 2	4 5	6 8		13	14	T4821103	T4821113
9	8	9 10	8	11	12	1 2	3 2	4 5	6 8		13	14	T4821104	T4821114
9	8	9 10	8	11	12	1 2	3 2	4 5	6 8				T4832200	T4832210

(C) is the Common Terminal.

Terminals 9 & 10 need to be shorted together.

* Remote Setpoint or Heater Current Input.

REAR TERMINAL ASSIGNMENTS

T48 Models With RS-485 or Linear DC Analog Output

TC	RTD	AC/DC Power	Analog Main Out	A2 or O2	Dedicated A1	O1 or A1	Dedicated O1	User Input	RS485 Output	2nd Input Option *	Analog 2nd Out	AC Model #	DC Model #
(+) (-)	Short (C)	AC/(+) AC/(-)	(+) (-)	(C)	(C)	(C)	(C)	(C)	A(+) B(-)	(+) (-)	(+) (-)		
9 8	9 10 8	11 12					4 5	6 8	13 14			T4810002	T4810012
9 8	9 10 8	11 12	2 1	3 4		5 4		6 8			13 14	T481010A	T481011A
9 8	9 10 8	11 12	2 1	3 4		5 4		6 8				T4810101	T4810111
9 8	9 10 8	11 12	2 1	3 4		5 4		6 8		13 14		T4810105	T4810115
9 8	9 10 8	11 12	2 1	3 4		5 4		6 8		13 14		T4810106	T481 0116
9 8	9 10 8	11 12	2 1	3 4		5 4		6 8	13 14			T4810107	T4810117
9 8	9 10 8	11 12		3 4			5 4	6 8	2 1	13 14		T4810108	T4810118
9 8	9 10 8	11 12		3 4			5 4	6 8	2 1	13 14		T4810109	T4810119
9 8	9 10 8	11 12			3 2		4 5	6 8	13 14			T4811002	T4811012
9 8	9 10 8	11 12		1 2	3 2		4 5	6 8	13 14			T4811102	T4811112
9 8	9 10 8	11 12	2 1	3 4		5 4		6 8				T4820201	T4820211
9 8	9 10 8	11 12	2 1	3 4		5 4		6 8		13 14		T4820205	T4820215
9 8	9 10 8	11 12	2 1	3 4		5 4		6 8		13 14		T4820206	T4820216
9 8	9 10 8	11 12		3 4			5 4	6 8	2 1	13 14		T4820208	T4820218
9 8	9 10 8	11 12		3 4			5 4	6 8	2 1	13 14		T4820209	T4820219
9 8	9 10 8	11 12		1 2	3 2		4 5	6 8	13 14			T4821102	T4821112

(C) is the Common Terminal.

Terminals 9 & 10 need to be shorted together.

* Remote Setpoint or Heater Current Input.

REAR TERMINAL ASSIGNMENTS

ALL P48 Models

0 - 10V Input		0 - 20 mA Input		AC/DC Power		Analog Main Out		A2 or O2	Dedicated A1	O1 or A1	Dedicated O1	User Input	RS485 Output	2nd Input Option *	Analog 2nd Out	AC Model #	DC Model #
(+) (-)	(+) (-)	(+) (-)	(+) (-)	AC/(+) AC/(-)	(+) (-)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	A(+) B(-)	(+) (-)	(+) (-)		
9 8	10 8	11 12	2 1									6 8				P4800001	P4800011
9 8	10 8	11 12									4 5	6 8				P4810000	P4810010
9 8	10 8	11 12									4 5	6 8	13 14			P4810002	P4810012
9 8	10 8	11 12	2 1	3 4				5 4				6 8				P4810101	P4810111
9 8	10 8	11 12	2 1	3 4				5 4				6 8		13 14		P4810105	P4810115
9 8	10 8	11 12	2 1	3 4				5 4				6 8	13 14			P4810107	P4810117
9 8	10 8	11 12	2 1	3 4				5 4				6 8			13 14	P481010A	P481011A
9 8	10 8	11 12			1 2	3 2			4 5			6 8				P4811100	P4811110
9 8	10 8	11 12			1 2	3 2			4 5			6 8	13 14			P4811102	P4811112

(C) is the Common Terminal.

* Remote Setpoint Input.

SERIAL CONNECTIONS TO A HOST TERMINAL

Six controllers are used to monitor and control parts packaging machines in a plant. The controllers are located at each machine in the production area of the building. A communication line is run to an industrial computer located in the production office.

Each controller is programmed for a different address and all are programmed for the same baud rate and parity as the computer (ex. 9600 baud, parity even). An application program is written by the user to send and receive data from the units using the proper commands.

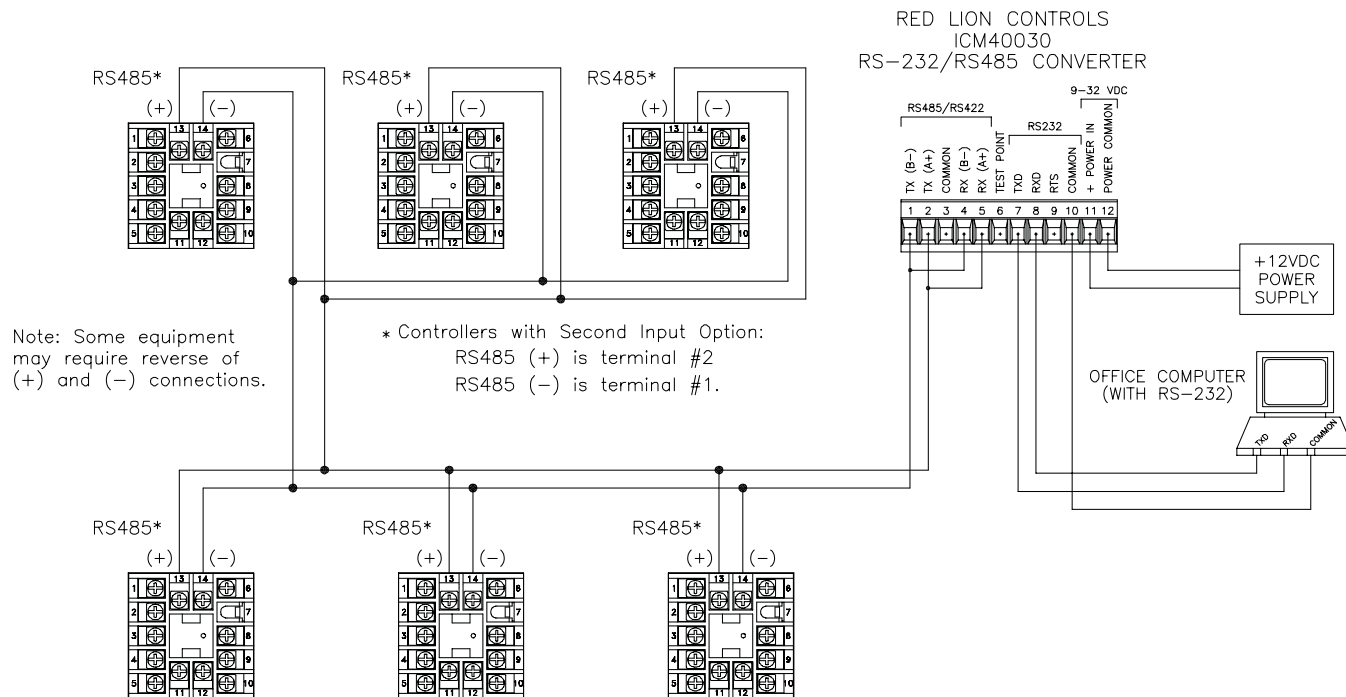


Figure 10, Connecting to a Host Terminal

LINEAR DC ANALOG OUTPUT JUMPER SELECTION (Main & Second)

The Linear Analog DC Output ranges are selectable for either voltage (0-10 V) or current (0/4-20 mA). The main set of jumpers must correspond with the configuration in Linear Output Range (ANAS) in the Output Parameter Module (2-OP). The optional secondary set of jumpers must correspond with the configuration in Second Linear DC Output Range (A2tP) in the Second Linear DC Analog Output Module (8-A2). The jumpers are accessible from the rear after removing the controller from the case. Dashed lines show factory setting of 20 mA.

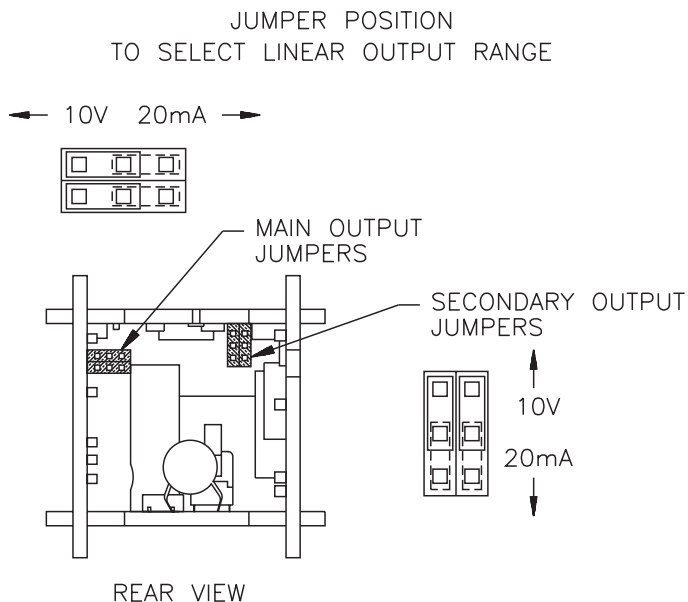


Figure 11, Linear Output Range Jumpers

FRONT PANEL DESCRIPTION

The front panel bezel material is flame and scratch resistant, tinted plastic that meets NEMA 4X/IP65 requirements, when properly installed. Continuous exposure to direct sunlight may accelerate the aging process of the bezel. The bezel should be cleaned only with a soft cloth and neutral soap product. Do NOT use solvents. There are two 4-digit LED displays, a red upper Main Display and a lower green Secondary Display.

There are up to six annunciators, with red backlighting, that illuminate to inform the operator of the controller and output status. See Figure 12, Front Panel, for a description of the annunciators.

Four front panel buttons are used to access different modes and parameters. The following is a description of each button.

Do NOT use tools of any kind (screwdrivers, pens, pencils, etc.) to operate the keypad of this unit.

BUTTON FUNCTIONS

D - In the Normal Display Mode, the Display (D) button is used to select one of the operational parameters in the secondary display. In other modes, pressing the D button causes the controller to exit (escape) directly to the Normal Display Mode.

P - The Parameter (P) button is used to access programming, enter the change, and scroll through the available parameters in any mode.

UP, DN - In the Normal Display Mode, the Up/Down (▲/▼) buttons can be used to directly modify the setpoint value or % output power (manual control only), when viewed in the secondary display.

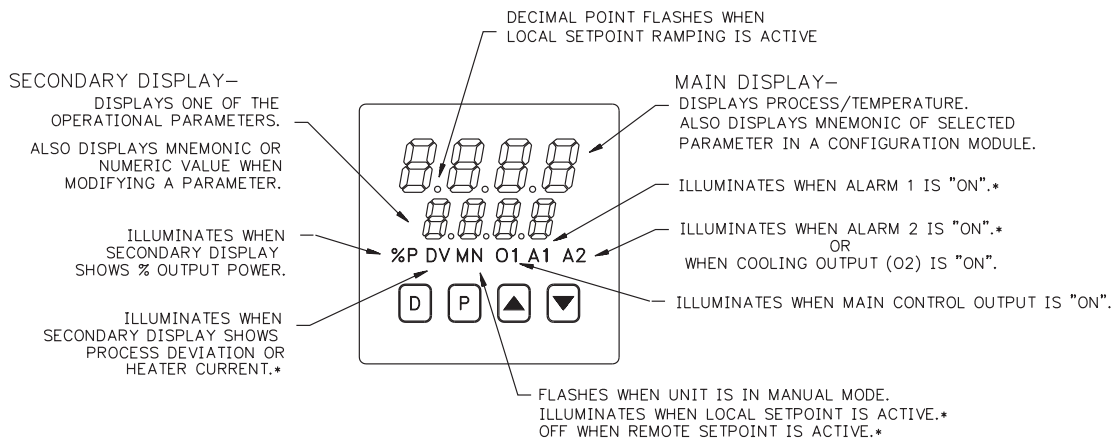


Figure 12, Front Panel

INITIAL CONFIGURATION START-UP

CONTROLLER POWER-UP

Upon applying power, the controller delays input indication and control action for five seconds to perform several self-diagnostic tests and to display basic controller information. Initially, the controller illuminates both displays and all annunciators to verify that all display elements are functioning. The controller then displays the programmed input sensor type in the main (top) display and the revision number of the controller's operating system software in the secondary (bottom) display. The controller checks for correct internal operation and displays an error message (E-xx) if an internal fault is detected. (See Troubleshooting, page 73, for further information).

Upon completion of this sequence, the controller begins displaying the input value and updating the outputs based upon the control calculation.

PARAMETER CONFIGURATION OVERVIEW

The controller is programmed with certain parameter settings from the factory. Factory settings are listed in parentheses in the various Configuration of Parameters tables. In many cases, these settings must be changed to the particulars of the application before proper operation can be started.

The controller is typically in the Normal Display Mode. When changes to parameter configurations are needed, the P button is pressed. From the factory, the controller will enter directly into the Unprotected Parameter Mode. Continue to press the P button until CnFP appears in the bottom display. At this time, press the Up arrow button and 1-In will appear in the bottom display. This will be the Configuration Parameter Mode. This programming flow is shown in the Front Panel Programming Chart. (If at any time during front panel programming the D button is pressed, the controller will return to the Normal Display Mode and the programming can be started over.)

In the Configuration Parameter Mode, the Up or Down arrow buttons can be pressed to move to the desired Parameter Module. The P button is then pressed to enter into that module. The main (top) display will be the parameter and the secondary (bottom) display will be the parameter value. The Up or Down arrow buttons are used to change the desired parameter value and the P button enters the new value and moves to the next parameter.

The Setpoint value (lower display) is changed with the Up or Down arrow buttons when it is selected in the Normal Display Mode.

PARAMETER CONFIGURATION BASIC START-UP

For basic start-up, it is important to verify or change Input Parameter Module (1-IN) parameters tYPE and SCAL, and Output Parameter Module (2-OP) parameter OPAC. For alarm and heat/cool set-up, it is important to verify or change Alarms Parameter Module (4-AL) parameters ACT1, AL-1, ACT2 and AL-2.

If the above Input Parameters or the input wiring connections are not correct, then the main (top) display may display an error message or incorrect value. Verify the input programming and wiring. (If incorrect display continues refer to Troubleshooting, page 73.) All other parameter configurations are important but will not prevent the controller from showing a correct display.

PARAMETER CONFIGURATION FOR SERIAL START-UP

The parameter settings can be changed by the front panel buttons or by serial communications using PC Windows based SFCRM software. The controller must have optional RS485 communications. An RS485 to RS232 converter is available from Red Lion Controls for RS232 interfaces. For serial communications set-up, it is important to check serial wiring and verify or change Serial Parameter Module (6-SC) parameters bAUd, ConF,s and Addr. (See Serial Communications Interface, page 58, for more details.)

CONTROL START-UP

After verifying proper programming and system start-up, a controlling method needs to be configured. For Manual Control or open loop, where the control does not work from the setpoint or process feedback, see Manual Control, page 47. For On / Off Control, set Proportional Band Prop to 0.0% and see On / Off Control, page 48. The controller comes with factory setting for PID Control. However, for optimum PID Control, several options exist for configuring Proportional Band, Integral Time, and Derivative Time parameters for specific applications.

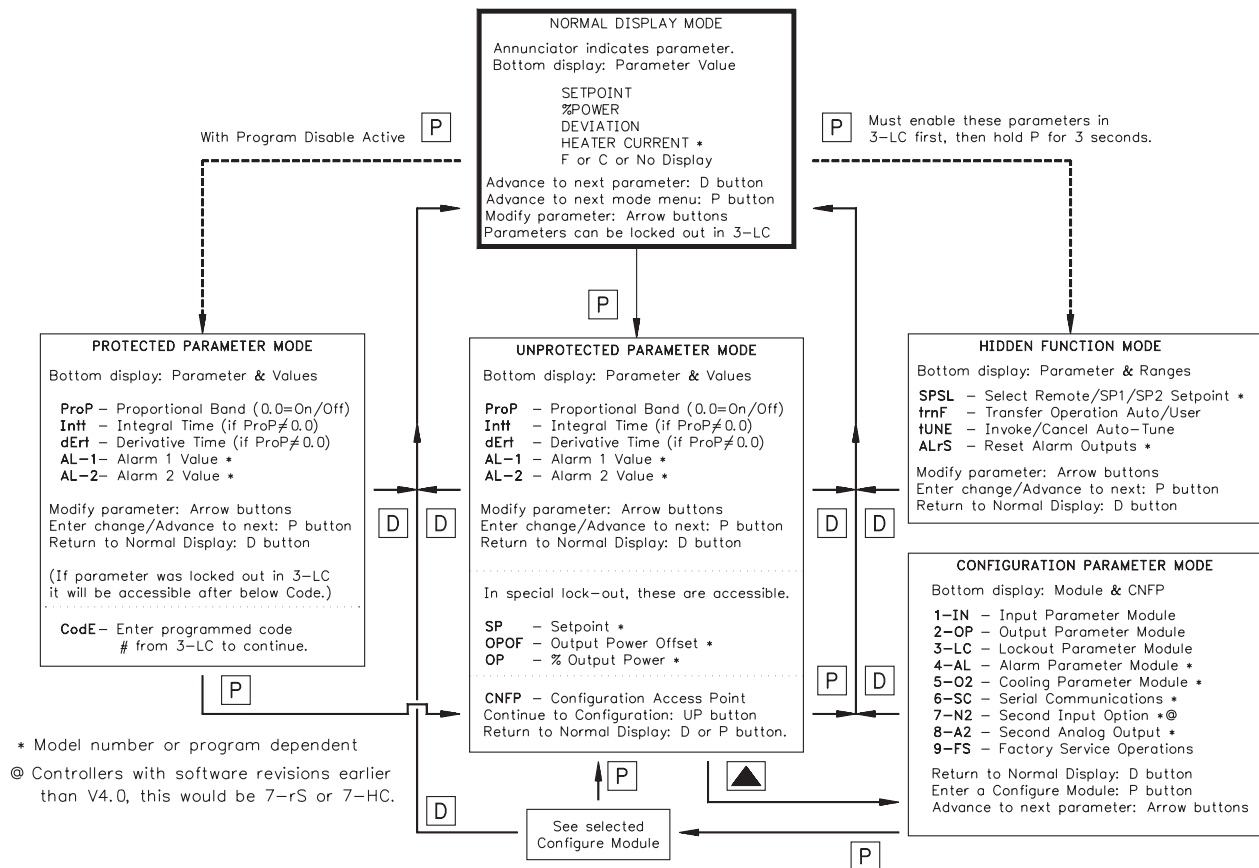
- a. Use controller's built-in Auto-Tune feature (See Auto-Tune For PID Control, page 51).
- b. Use a manual tuning technique (See Manual Tuning For PID Control, page 56).
- c. Use a third party tuning software package.
- d. Use values based on control loop experience, calculated values or values from a similar process or previous controller.

VALID CONTROL MODE COMBINATIONS

ON/OFF, PID, and Manual Control can be used for O1 (heat) and O2 (cool) outputs according to the combinations below.

O1 & O2 VALID CONTROL MODES				
O1 MODE	O2 MODE	MANUAL CONTROL OUTPUT POWER RANGE	O1 STATE	O2 STATE
PID	—	0% to +100%	O1-TP	—
ON/OFF (ProP = 0.0)	—	100%	O1-ON	—
		Any other setting	O1-OFF	—
PID	PID	-100% to +100%	O1-TP	O2-TP
PID	ON/OFF (GAN2=0.0)	0% to +100%	O1-TP	O2-OFF
		-100% to 0%	O1-TP	O2-ON
ON/OFF (ProP=0.0)	ON/OFF (GAN2=0.0)	+100%	O1-ON	O2-OFF
		-100%	O1-OFF	O2-ON
		Any other setting	O1-OFF	O2-OFF
TP - Time Proportioning				

FRONT PANEL PROGRAMMING CHART FOR T48 & P48 CONTROLLERS



NORMAL DISPLAY MODE

In the Normal Display Mode, the temperature or scaled process value is displayed in the main (top) display. By successively pressing the D button, the parameters listed below can be viewed in the secondary (bottom) display. Each of these parameters can be independently locked out from appearing or from being modified through the Lockout Parameter 3-LC. If all four displays are locked out, the display blanks after pressing the D button. To gain access to the next modes, press the P button from any parameter.

To modify values in % Output Power (for Manual Control) or Setpoint, use the Up or Down arrows while the parameter is displayed and not locked. If locked, these parameters can be changed in the Protected Parameter Mode. The controller responds to the new values immediately, however, the change is not committed to permanent memory until 10 seconds after the last key press.

Normal Display Mode Reference Table

Illuminate	Parameter	Range and Units (Factory Setting)	Description/Comments
---	Local Setpoint SP1 or SP2	-999 to 9999 (0) for T48 (0.0) for P48	Range limited by SPLO & SPHI in 1-In.
%P	% Output Power	-99.9% to 100.0% Read only Unless in Manual Control	Not limited by OPLO & OPHI in 2-OP.
DV	Setpoint Deviation	-999 to 9999 Read only	Shows difference between Temp/Process (top display) and Setpoint.
DV	Heater Current	-999 to 9999 Read only	Heater Current models show heater current value and not process deviation.
---	Units Symbol	°F or °C Read only	T48 models only
---	Blank	Blank display	P48 models only

FRONT PANEL PROGRAM DISABLE

There are several ways to limit the programming of parameters from the front panel buttons. The settings of the parameters in the Lockout Module 3-LC, the code number entered, and the state and/or function programmed for the User Input (Terminal #6) will all affect front panel access.

The following chart describes the possible program disable settings.

User Input State	Code Number	Description
Inactive or User Input not programmed for PLOC	0	Full access to all modes and parameter modules.
Active with User Input programmed for PLOC	0	Access to protected parameter mode only. Code number does not appear.
Active with User Input programmed for PLOC OR User Input not programmed for PLOC	Any # between 1 & 250	Access to protected parameter mode. Correct programmed code number allows access to unprotected parameter mode and configuration modules.

Note: A universal code number 222 can be entered to gain access to the unprotected mode and configuration modules, independent of the programmed code number.

UNPROTECTED PARAMETER MODE

The Unprotected Parameter Mode is accessed by pressing the P button from the Normal Display Mode with Program Disable inactive. While in this mode, the operator has access to the most commonly modified controller parameters by pressing the P button. The temperature or scaled process value is displayed in the main (top) display. The parameter display will appear with the corresponding range and units in the secondary (bottom) display.

To modify values, use the Up or Down arrows while the parameter is displayed. The controller responds to the new values immediately, however, the change is not committed to non-volatile memory until the controller is returned to the Normal Display Mode. If power loss occurred before returning to the Normal Display Mode, the new values must be entered again.

To gain access to the Configuration Parameter Modules, continue to CnFP and press the Up arrow. These modules allow access to the fundamental set-up parameters of the controller. When the program list has been scrolled through, or the D button is pressed, the controller displays "End" and returns to the normal display mode. The unit automatically returns to the Normal Display Mode if no action is taken.

Unprotected Parameter Mode Reference Table

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
SP	Local ** Setpoint SP1 or SP2 *	-999 to 9999 (0) T48 (0.0) P48	Range limited by SPLO & SPHI. User Input or Hidden Function Mode selects SP1 or SP2
OPOF	%Output ** Power Offset	-99.9% to 100.0% (0.0)	Appears only if Intt = 0 and unit is in Automatic Control.
OP	% Output ** Power	-99.9% to 100.0% (0.0)	Appears only if unit is in Manual Control. This parameter is not limited to output power limits (OPLO & OPHI).
ProP	Proportional Band	0.0 to 999.9% of selected input range (4.0) T48 (100.0) P48	0.0% is ON/OFF control. If using ON/OFF, set control hysteresis appropriately.
Intt	Integral Time	0 to 9999 sec. (120) T48 (40) P48	0 is off. This parameter does not appear if ProP = 0.0%.
dErt	Derivative Time	0 to 9999 sec. (30) T48 (4) P48	0 is off. This parameter does not appear if ProP = 0.0%.
AL-1	Alarm 1 Value *	-999 to 9999, (0) T48 (0.0) P48	This parameter does not appear if configured for "heat".
AL-2	Alarm 2 Value *	-999 to 9999, (0) T48 (0.0) P48	This parameter does not appear if configured for "cool".
CNFP	Configuration Access Point	NO Up Arrow	Return to Normal Display Mode. Enter Configuration modules.
End	Returns to Normal Display Mode	—	Brief display message while the unit returns to Normal Display Mode.

* Model Number Dependent.

** Only appears if locked out from Normal Display Mode.

PROTECTED PARAMETER MODE

The Protected Parameter Mode is accessed by pressing the P button from the Normal Display Mode with Program Disable active. While in this mode, the parameters can be accessed by pressing the P button. The temperature or scaled process value (after initial setup) will be displayed in the main (top) display. The parameter display will appear with the corresponding range and units in the secondary (bottom) display. Each of these parameters can be independently locked out from appearing or from being modified through the Lockout Parameter 3-LC.

To modify values, use the Up or Down arrows while the parameter is displayed. If locked, the parameter will not show in the Normal Display Mode, but can be changed in the Protected Parameter Mode. The controller responds to the new values immediately, however, the change is not committed to non-volatile memory until the controller is returned to the Normal Display Mode. If power loss occurred before returning to the Normal Display Mode, the new values must be entered again.

To gain access to the Unprotected Parameter Mode (with User Input inactive or not programmed for PLOC), continue to CodE and press the arrow buttons until the value equals the Code as entered in parameter lockouts. When an incorrect code value is entered, or when the D button is pressed, "End" will momentarily appear and the controller will return to the Normal Display Mode.

Protected Parameter Mode Reference Table

Display	Parameter	Range and Units (Factory Setting)	Description/Comments
ProP	Proportional Band	0.0 to 999.9% of selected input range (4.0) T48 (100.0) P48	0.0% is ON/OFF Control. Adjusted by Auto-Tune.
Intt	Integral Time	0 to 9999 sec. (120) T48 (40) P48	0 is off. This parameter does not appear if ProP = 0.0%. Adjusted by Auto-Tune.
dErT	Derivative Time	0 to 9999 sec. (30) T48 (4) P48	0 is off. This parameter does not appear if ProP = 0.0%. Adjusted by Auto-Tune.
AL-1	Alarm 1 value *	-999 to 9999 (0) T48 (0.0) P48	This parameter does not appear if configured for "heat".
AL-2	Alarm 2 value *	-999 to 9999 (0) T48 (0.0) P48	This parameter does not appear if configured for "cool".
CodE	Access code to Unprotected Parameter Mode	0 to 250 (0)	To gain access to Unprotected Parameter Mode, enter the same value for Code as used in parameter lockouts. Does not appear if zero is entered in code parameter lockout.
End	Returns to Normal Display Mode.	—	Brief display message while the unit returns to Normal Display Mode.

* Model Number Dependent.

HIDDEN FUNCTION MODE

The Hidden Function Mode is only accessible from the Normal Display Mode by pressing and holding the P button for three seconds. These functions must first be unlocked in Configuration Module 3-LC. Factory settings for these parameters is lock. In this mode, these controller functions can be performed.

- Remote/SP1/SP2 Setpoint Selection
- Automatic/Manual Transfer
- Initiate/Cancel Auto-tune
- Reset Alarm Outputs

The P button is used to scroll to the desired function and the Up and Down buttons are used to select the operation. Pressing the P button while the function is displayed executes the function, and returns the unit to the Normal Display Mode. Pressing the D button exits this mode with no action taken. The unit automatically returns to the Normal Display Mode if no action is taken within a few seconds.

Hidden Function Mode Reference Table

Display	Parameter	Range and Units (Factory Setting Value)	Description/ Comments
SPSL	Setpoint Select	SP1 - Setpoint 1 SP2 - Setpoint 2 rSP - Remote Setpoint	Exits to Normal Display Mode after being executed.
trnF	Transfer mode of operation	Auto - Automatic control User - Manual control (Auto)	Exits to Normal Display Mode after being executed.
tUNE	Auto-tune Invocation	Yes: starts the auto-tune sequence. No: terminates the auto-tune sequence. (NO)	Exits to Normal Display Mode after being executed.
ALrS	Alarm Reset *	UP button resets Alarm 1 DOWN button resets Alarm 2	Does not exit to Normal Display Mode after being executed.

* Model Number Dependent

CONFIGURATION PARAMETER MODE

The Configuration Parameter Mode is accessed by pressing the Up button from CnFP in the Unprotected Parameter Mode. While in this mode, the various Configuration Modules can be displayed by pressing the Up or Down buttons. The process value (after initial setup) will be displayed in the main (top) display. The Configuration Module will appear alternating with CnFP in the secondary (bottom) display.

To access a Configuration Module, press the P button when the desired Configuration Module is displayed. The parameters of that Configuration Module can be accessed by pressing the P button. (The module's parameters are listed in the appropriate Configuration Module table in this section with configuration parameter explanations beginning on page 31.) To modify ranges and units, use the Up or Down arrows while the parameter is displayed. The controller responds to the new values after the P button is pressed, however, the change is not committed to permanent memory until the controller is returned to the Normal Display Mode. If power loss occurred before returning to the Normal Display Mode, the new values must be entered again. Whenever the D button is pressed, End will momentarily appear and the controller will return to the Normal Display Mode. At the end of each module, the controller will go to CnFP no. Pressing the Up or Down arrows will continue in Configuration Parameter Mode and pressing the P will return to the Normal Display Mode.

Unless specified, the parameters, ranges, units and factory settings are the same for T48 and P48 controllers. Parameters that are model number or program dependent will only be displayed when the appropriate options are installed or programmed. Some parameters are accessible but may not be applicable for the chosen output control mode type.

REFERENCE TABLES: CONFIGURATION PARAMETER MODULES

Configure Module 1 - Input Parameters (1-IN) T48

These tables are only used for programming the T48 models. Use the tables on page 22 if you are programming a P48.

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
tYPE	Input Type	tc-t - Type T TC tc-E - Type E TC tc-J - Type J TC tc-k - Type K TC tc-r - Type R TC tc-S - Type S TC tc-b - Type B TC tc-N - Type N TC LIN - Linear mV display	Thermocouple select
		r385 - 385 curve RTD r392 - 392 curve RTD rLIN - Linear ohms display (tc-J)	RTD select
SCAL	Temperature Scale	°F/°C (°F)	If scale is changed, be sure to check all parameters.
dCPt	Temperature Resolution	0 or 0.0 (0)	If resolution changed, be sure to check all parameters.
FLtr	Digital Input Filtering And Display Update	0 to 4 (1)	Increase number for more filtering effect. 4 = 500 msec display update rate. Adjusted by Auto-Tune.

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
SHFt	Input Signal Shift (correction offset)	-999 to 9999 1 or 0.1 degree (0)	Normally set to 0.
SPLO	Setpoint Lower Limit	-999 to 9999 0 or 0.1 degree (0)	Set low limit below high limit.
SPHI	Setpoint Upper Limit	-999 to 9999 1 or 0.1 degree (9999)	Set high limit above low limit.
SPrP	Setpoint Ramp Rate	0.0 to 999.9 degrees/minute (0.0)	0.0 is off (no ramping)
InPt	User Input *	PLOC - Program disable ILOC - Integral action on/off trnF - Auto/manual select SPrP - Setpoint ramp on/off ALrS - Reset alarm output(s) SP2 - Select SP1/SP2 rSP - Select Local/Remote PrNt - Serial block print (PLOC)	Low = lock Low = off Low = manual Low = end ramp Low = reset Low = SP2 Low = remote Low = block print

* Model Number Dependent

Configure Module 1 - Input Parameters (1-IN) P48

These tables are only used for programming the P48 models. Use the tables on page 21 if you are programming a T48.

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
tYPE	Input Type	VOLT - Voltage Curr - Current (Curr)	
dCpt	Decimal Point	0, 0.0, 0.00, or 0.000 (0.0)	If 0.000 is selected, scaling points must be a positive value.
rnd	Rounding Increment	1, 2, 5, 10, 20, 50, or 100 (0.1)	Used in conjunction with filtering to stabilize the display reading.
FLtr	Digital Input Filtering And Display Update	0 to 4 (1)	Increase number for more filtering effect. 4 = 500 msec display update rate. Adjusted by Auto-Tune.
dSP1	Scaling Point #1 Display Value	-999 to 9999 (0.0)	Key-in display low value.
InP1	Scaling Point #1 Input Signal 0/4-20 mA DC 0-10 VDC	0.00 to 20.00 mA 0.00 to 10.00 V (4.00)	Press D button to select Signal Input method.
	Value Key-in Method		Key-in input low value.
	Signal Input Method		Apply input low value.
dSP2	Scaling Point #2 Display Value	-999 to 9999 (100.0)	Key-in display high value.

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
InP2	Scaling Point #2 Input Signal 0/4-20 mA DC 0-10 VDC	0.00 to 20.00 mA 0.00 to 10.00 V (20.00)	Press D button to select Signal Input method.
	Value Key-in Method		Key-in input low value.
	Signal Input Method		Apply input low value.
SPLO	Setpoint Lower Limit	-999 to 9999 (0.0)	Set low limit below high limit.
SPHI	Setpoint Upper Limit	-999 to 9999 (999.9)	Set high limit above low limit.
SPrP	Setpoint Ramp Rate	0 to 9999 units/minute (0.0)	0.0 is off (no ramping).
InPt	User Input *	PLOC - Program disable ILOC - Integral action on/off trnF - auto/manual select SPrP - Setpoint ramp on/off ALrS - Reset alarm output(s) SP2 - Select SP1/SP2 rSP - Select Local/Remote PrNt - Serial block print (PLOC)	Low = lock Low = off Low = manual Low = end ramp Low = reset Low = SP2 Low = remote Low = block print

* Model Number Dependent

Configure Module 2 - Output Parameters (2-OP)

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
CYct	Time Proportioning Cycle Time	0 to 250 seconds (2)	0 turns O1 off. Set to zero for Linear DC output control. Not used for ON/OFF Control.
OPAC	Output Control Action	drct - cooling rEv - heating (rEv)	For both PID & ON/OFF control.
OPLO	Output Power Lower Limit (Not used in Manual Control)	0% to 100%, O1 (0)	Set OPLO < OPHI
		-100% to 100%, O1 & O2 (-100)	Negative % is only valid for O2 cooling control.
OPHI	Output Power Upper Limit (Not used in Manual Control)	0% to 100%, O1 (100)	Set OPHI > OPLO
		-100% to 100% O1 & O2 (100)	Negative % is only valid for O2 cooling control.
OPFL	Sensor Fail Power Level (Not used in Manual Control)	0% to 100%, O1 (0)	Select a level to safely control the process in the event of input sensor failure. T48 only.
		-100% to 100% O1 & O2 (0)	
OPdP	Output Power Dampening (filtering) Time	0 to 250 seconds (3) T48 (1) P48	0 = off (no dampening) Set in range of 1/50 to 1/10 of integral time. Adjusted by Auto-Tune.

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
CHYS	ON/OFF Control Hysteresis	1 to 250 (2) T48 (0.2) P48	For O1 ON/OFF Control. Change to Factory Setting prior to Auto-Tune.
tcOd	Auto-tune Dampening Code	0 to 2 (0)	0 = fastest response 2 = slowest response
ANIP	Main Linear DC Output Range *	0 to 10 V 0 to 20 mA 4 to 20 mA (4 to 20 mA)	Set linear output range jumper to match.
ANAS	Main Linear DC Output Source *	OP InP SP (OP)	SP = Active Setpoint
ANUt	Main Linear DC Output Update *	0 to 250 secs (0)	0 = Update rate of 0.1 sec.
ANLO	Main Linear DC Output Low Scaling Value *	-999 to 9999 (0.0)	Value depends on ANAS assignment.
ANHI	Main Linear DC Output High Scaling Value *	-999 to 9999 (100.0)	Value depends on ANAS assignment.

* Model Number Dependent

Configure Module 3 - Lockout Parameters (3-LC)

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
SP	Setpoint access	LOC - lockout rEd - read only Ent - enter (Ent)	Determines access to temperature setpoint.
OP	Output power access	LOC - lockout rEd - read only Ent - enter (Ent)	Determines direct access to output power. %P indicator illuminates when parameter is selected in display.
dEv	Deviation display access	LOC - lockout rEd - read only (rEd)	Determines display of deviation. DV indicator illuminates when parameter is selected in display. (Does not appear if heater current option is installed).
Hcur	Heater current display access * T48 only	LOC - Lockout rEd - read only (rEd)	Determines heater current readout. DV indicator illuminates when selected.
UdSP	Units display access For T48	LOC - lockout rEd - read only (rEd)	Determines display of F or C.
bdSP	Blank display access For P48	LOC - lockout rEd - read only (rEd)	Determines blank secondary display.
CodE	Access code	0 to 250 (0)	Refer to front panel disable section for access levels.

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
PId	PID values access	LOC - lockout rEd - read only Ent - enter (LOC)	Protected Mode lockout.
AL	Alarm values enable *	LOC - lockout rEd - read only Ent - enter (LOC)	Protected Mode lockout.
ALrS	Reset alarms enable *	LOC - lockout ENBL - enable (LOC)	Hidden Mode lockout.
SPSL	SP1/SP2/Remote setpoint enable *	LOC - lockout ENBL - enable (LOC)	Hidden Mode lockout.
trnF	Automatic/Manual (user) mode select enable	LOC - lockout ENBL - enable (LOC)	Hidden Mode lockout.
tUNE	Auto-tune enable	LOC - lockout ENBL - enable (LOC)	Hidden Mode lockout.

* Model Number Dependent

Configure Module 4 - Alarm Parameters (4-AL)

Controller returns to configuration access point (CnFP NO) if alarm(s) are not installed.

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
ACT1	Alarm 1 action mode	A-HI - absolute high A-LO - absolute low d-HI - deviation high d-LO - deviation low b-IN - band inside b-ot - band outside Hcur - heater current alarm * Heat - control output * (A-HI)(HEAT) *	If changed, check alarm values. If heat is selected, the remaining alarm parameters do not appear. For P48, heat is main control output.
rSt1	Alarm 1 reset mode	Auto - automatic LATc - manual reset (Auto)	Manual reset via Hidden Mode or user input.
Stb1	Alarm 1 standby function (delay)	yes/no (no)	Power-up standby delay.
AL-1	Alarm 1 value	-999 to 9999 (0) T48 (0.0) P48	If band alarm action, then only a positive value can be entered.
ACT2	Alarm 2 action mode *	A-HI - absolute high A-LO - absolute low d-HI - deviation high d-LO - deviation low b-IN - band inside b-ot - band outside Cool- cooling output Hcur - heater current alarm * (A-HI)	If changed, check alarm values. If cooling is selected, the remaining Alarm 2 parameters do not appear. For P48, cool is second PID control output.

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
rSt2	Alarm 2 reset mode *	Auto - automatic LATc - manual reset (Auto)	Manual reset via hidden Mode or user input.
Stb2	Alarm 2 standby function (delay) *	yes/no (no)	Power-up standby delay.
AL-2	Alarm 2 value *	-999 to 9999 (0) T48 (0.0) P48	If band alarm action, then only a positive value can be entered.
AHYS	Alarm Hysteresis value	1 to 250 (1) T48 (0.1) P48	Applies to both alarms. Set to eliminate chatter.

* Model Number or Mode Setting Dependent

Configure Module 5 - Cooling Parameters (5-02)

Controller returns to configuration access point (CnFP NO) if Alarm 2 is not configured as cooling output in Alarm Module (4-AL). Cooling output for the P48 is referred to as the second control output.

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
CYC2	Cooling output cycle time	0 to 250 sec (2)	0 turns O2 off.
GAN2	Relative cooling gain	0.0 to 10.0 (1.0)	0.0 places cooling output into ON/OFF Control and db-2 becomes hysteresis value.
db-2	Heating or cooling overlap/deadband	-999 to 9999 (0)	Positive value is deadband. Negative value is overlap. If GAN2 = 0, this parameter is cooling ON/OFF Control hysteresis. Change to Factory Setting prior to Auto-Tune.

Configure Module 6 - Serial Communications (6-SC)

Controller returns to configuration access point (CnFP NO) if RS485 serial option is not installed.

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
bAud	Baud rate	300 to 9600 (9600)	Baud rate of unit must match connected equipment.
ConF	Character Frame format	7O1 7E1 7n2 8n1 (7O1)	7 data, odd parity, 1 stop (was odd) 7 data, even parity, 1 stop (was even) 7 data, no parity, 2 stop (was none) 8 data, no parity, 1 stop
Addr	Controller address	0 to 99 (0)	For multiple unit applications, each unit must have a unique node address.
Abrv	Abbreviated or full transmission	yes/no (no)	Selecting yes, the controller does not transmit mnemonics.
PoPt	Print options	yes/no (no)	Selecting yes allows print options shown below, to be programmed.
INP	Input	yes/no (yes)	
SEt	Setpoint	yes/no (yes)	
OPr	% Output Power	yes/no (yes)	
Pbd	% Proportional Band	yes/no (no)	
INt	Integral Time	yes/no (no)	

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
dEr	Derivative Time	yes/no (no)	
AL1	Alarm 1 *	yes/no (no)	
AL2	Alarm 2 *	yes/no (no)	
dEv	Deviation From Setpoint *	yes/no (no)	
OFP	% Output Power Offset	yes/no (no)	
r-P	Setpoint Ramp Rate	yes/no (no)	
Crg	Relative Gain	yes/no (no)	
Cdb	Deadband	yes/no (no)	
OSt	Output Status	yes/no (no)	
rSP	Remote Setpoint *	yes/no (no)	
HCr	Heater Current *	yes/no (no)	

* Model Number Dependent

Configure Module 7 - Remote Setpoint Parameters (7-rS or 7-n2)

Controller returns to configuration access point (CnFP NO) if remote setpoint option is not installed.

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
dSP1	Remote setpoint display scaling point #1	-999 to 9999 (0) T48 (0.0) P48	Remote setpoint display low value.
INP1	Remote setpoint input scaling point #1.	0.00 to 20.00 mA (4.00)	Key in input low value or Press D to select Signal Input method.
dSP2	Remote setpoint display scaling point #2	-999 to 9999 (1000) T48 (100.0) P48	Remote setpoint display high value.
INP2	Remote setpoint input scaling point #2	0.00 to 20.00 mA (20.00)	Key in input low value or Press D to select Signal Input method.
FLtr	Remote setpoint filter time constant	0 to 25 seconds (2)	0 = off
bAnd	Remote setpoint filter band	0 to 250 (5)	0 = filter always engaged.
trnF	Remote/Local setpoint transfer options	nor - normal Auto - Automatic trAC - Tracking (nor)	Auto = Bumpless, other modes may bump.

Configure Module 7 - Heater Current Parameters (7-HC or 7-n2)

Controller returns to configuration access point (CnFP NO) if heater current option is not installed.

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
Hcur	Heater current transformer scaling	0.0 to 999.9 Amps (40.0)	Set scaling equal to primary rating of CT.

Configure Module 8 - Second Linear DC Analog Output (8-A2)

Controller returns to Configuration Access Point (CnFP-NO) if second linear DC analog option is not installed.

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
A2tP	Second linear DC output range	0 to 10 V 0 to 20 mA 4 to 20 mA (4-20)	Set Secondary Output jumper to match.
A2LO	Second linear DC output low scaling value	-999 to 9999 (0) T48 (0.0) P48	Corresponding temp or process value for low output.
A2HI	Second linear DC output high scaling value	-999 to 9999 (1000) T48 (100.0) P48	Corresponding temp / process value for high output.

Configure Module 9 - Factory Service Operations (9-FS)

Display	Parameter	Range and Units (Factory Setting)	Description/ Comments
CodE	Factory service function code.	48 - Calibrate instrument	Refer to Calibration Section for details.
		66 - Reset parameters to factory settings	
		77- (twice in succession) Reset controller calibration to nominal values (Caution: This operation results in up to $\pm 10\%$ reading error.)	

USER PARAMETER VALUE CHART

CONTROLLER NUMBER _____

MNEMONIC	PARAMETER	USER SETTING
SP	Setpoint	_____
OPOF	% Output Power Offset	_____
OP	% Output Power	_____
ProP	Proportional Band	_____
Intt	Integral Time	_____
dErt	Derivative Time	_____
AL-1	Alarm 1 Value	_____
AL-2	Alarm 2 Value	_____

T48 CONFIGURE INPUT 1-INP

MNEMONIC	PARAMETER	USER SETTING
tYPE	Input Sensor Type	_____
SCAL	Temperature Scale Units	_____
dCPt	Temperature Resolution	_____
FLtr	Digital Filtering	_____
SHFt	Input Offset	_____
SPLO	Setpoint Lower Limit	_____
SPHI	Setpoint Upper Limit	_____
SPrP	Setpoint Ramp Rate	_____
InPt	User Input	_____

P48 CONFIGURE INPUT 1-INP

MNEMONIC	PARAMETER	USER SETTING
tYPE	Input Type	_____
dCPt	Decimal Point	_____
rnd	Rounding Increment	_____
FLtr	Digital Filtering	_____
dSP1	Display Value #1	_____
InP1	Signal Input Value #1	_____
dSP2	Display Value #2	_____
InP2	Signal Input Value #2	_____
SPLO	Setpoint Lower Limit	_____
SPHI	Setpoint Upper Limit	_____
SPrP	Setpoint Ramp Rate	_____
InPt	User Input	_____

CONFIGURE OUTPUT 2-OP

MNEMONIC	PARAMETER	USER SETTING
CYCt	Cycle Time	_____
OPAC	Output Control Action	_____
OPLO	Output Power Lower Limit	_____
OPHI	Output Power Upper Limit	_____
OPFL	Sensor Fail Power Preset	_____
OPdP	Output Power Dampening	_____
CHYS	ON/OFF Control Hysteresis	_____
tcod	Auto-Tune Dampening Code	_____
ANtP	Linear Output Range	_____
ANAS	Linear Output Source	_____
ANUt	Linear Output Update time	_____
ANLO	Linear Output Scale Point Low	_____
ANHI	Linear Output Scale Point High	_____

CONFIGURE LOCKOUTS 3-LC

MNEMONIC	PARAMETER	USER SETTING
SP	Access Setpoint	_____
OP	Access Output Power	_____
dEv	Access Deviation Display	_____
Hcur	Access Heater Current	_____
UdSP	Access Display Units	_____
Code	Access Code Number	_____
PId	Access PID Values	_____
AL	Access Alarm(s) Values	_____
ALrS	Enable Reset Alarm(s)	_____
SPSL	Enable Remote/Local Transfer	_____
trnF	Enable Auto/Man Transfer	_____
tUNE	Enable Auto-tune	_____

CONFIGURE ALARMS 4-AL

MNEMONIC	PARAMETER	USER SETTING
Act1	Alarm 1 Action Mode	_____
rSt1	Alarm 1 Reset Mode	_____
Stb1	Alarm 1 Standby Enabled	_____
AL-1	Alarm 1 Value	_____
Act2	Alarm 2 Action Mode	_____
rSt2	Alarm 2 Reset Mode	_____
Stb2	Alarm 2 Standby Enabled	_____
AL-2	Alarm 2 Value	_____
AHYS	Alarm Hysteresis Value	_____

CONFIGURE COOLING 5-O2

MNEMONIC	PARAMETER	USER SETTING
CYC2	O2 Output Cycle Time	_____
GAN2	Relative Cooling Gain	_____
db-2	Heat-Cool Overlap/Deadband	_____

CONFIGURE SERIAL COMMUNICATIONS 6-SC

MNEMONIC	PARAMETER	USER SETTING
bAUd	Baud Rate	_____
ConF	Character Frame Format	_____
Addr	Controller Address	_____
Abrr	Abbrev. or Full Transmission	_____
PoPt	Print Options	_____
INP	_____	dEv _____
SEt	_____	OFf _____
OPr	_____	r_P _____
Pbd	_____	Crg _____
Int	_____	Cdb _____
dEr	_____	OSt _____
AL1	_____	RSP _____
AL2	_____	HCr _____

CONFIGURE REMOTE SETPOINT 7-rS / 7-n2

MNEMONIC	PARAMETER	USER SETTING
dSP1	Remote Setpoint Display Value #1	_____
INP1	Remote Setpoint Input Value #1	_____
dSP2	Remote Setpoint Display Value #2	_____
INP2	Remote Setpoint Input Value #2	_____
FLtr	Remote Setpoint Filter Time Constant	_____
bAnd	Remote Setpoint Filter Band	_____
trnF	Local/Remote Transfer Options	_____

CONFIGURE HEATER CURRENT INPUT 7-HC / 7-n2

MNEMONIC	PARAMETER	USER SETTING
Hcur	Heater Current Readout Scaling	_____

CONFIGURE SECOND LINEAR OUTPUT 8-A2

MNEMONIC	PARAMETER	USER SETTING
A2tP	Second Linear Output Range	_____
A2LO	Second Linear Output Low Value	_____
A2HI	Second Linear Output High Value	_____

CONFIGURATION PARAMETER EXPLANATIONS

Input Parameter Module (1- IN) T48 Models

The controller has several input set-up parameters that must be programmed prior to setting any other controller parameters.

Input Type (tYPE)

Select from the list of various thermocouple and RTD sensors.

The following is a list of the possible sensors:

tc-t	Type T TC
tc-E	Type E TC
tc-J	Type J TC
tc-k	Type K TC
tc-r	Type R TC
tc-S	Type S TC
tc-b	Type B TC
tc-N	Type N TC
LIN	Linear mV display
r385	385 curve RTD
r392	392 curve RTD
rLIN	Linear ohms display

Temperature Scale (SCAL)

Select either degrees Fahrenheit (F) or degrees Celsius (C).

If changed, be sure to check all parameters.

Temperature Resolution (dCPT)

Select either 1 or 0.1 degree resolution.

If changed, be sure to check all parameters.

Digital Input Filtering and Display Update Rate (FLtr)

Select the relative degree of input signal filtering and display update rate. The filter is an adaptive digital filter that discriminates between measurement noise and actual process changes. Therefore, the influence on

step response time is minimal. If the signal is varying too greatly due to measurement noise, increase the filter value. Additionally, with large derivative times, control action may be too unstable for accurate control. Increase the filter value. Conversely, if the fastest controller response is desired, decrease the filter value.

The Auto-tune procedure sets the filter value appropriate to the process characteristics. Also see Output Power Dampening parameter (OPdP), page 36, for filtering the output.

FLtr- 0 to 4

0 = least input filtering

3 = most input filtering

4 = most input filtering and slower (500 msec) display update rate
(outputs update at 100 msec rate)

Input Sensor Correction Constant (SHFt)

If the controller temperature disagrees with a reference temperature instrument or if the temperature sensor has a known calibration, the controller temperature can be compensated by a correction offset (SHFt).

SHFt - -999 to 9999

The following equation expresses the relationship:

Desired Display Temp = (Controller Temp) + SHFt

Example 1: The controller reads 293°F while a reference instrument indicates 300°F. A SHFt value of +7°F corrects the controller indication to match the reference.

Setpoint Limit Values (SPLO & SPHI)

The controller has programmable high and low setpoint limit values to restrict the setting range of the setpoint. Set the limit values so that the temperature setpoint value cannot be set outside the safe operating area of the process.

SPLO - -999 to 9999

SPHI - -999 to 9999

Setpoint Ramp Rate (SPrP)

The setpoint can be programmed to ramp independent of the controller's display resolution. The setpoint ramp feature can reduce thermal shock to the process, reduce temperature overshoot on start-up or setpoint changes, or ramp the process at a controlled rate.

SPrP - 0.0 to 999.9 degrees/minute

A ramp value of zero disables setpoint ramping, allowing the controller to stabilize as fast as possible to the new setpoint. If the user input is programmed for setpoint ramp, it affects the enabling and disabling of setpoint ramping. Setpoint ramping is initiated on power-up or when the setpoint value is changed. Active setpoint ramping is indicated by the left most decimal point flashing in the main display.

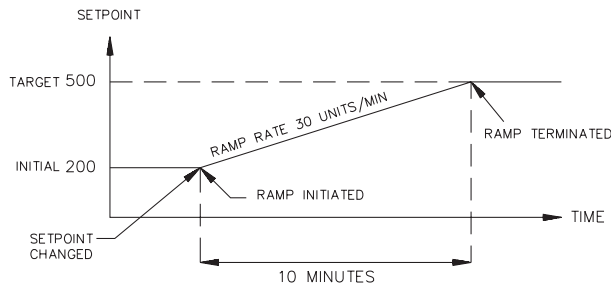


Figure 13, Setpoint Ramp Rate

Once the ramping setpoint reaches the target setpoint, the setpoint ramp rate disengages until the setpoint is changed again. If the ramp value is changed during ramping, the new ramp rate takes effect. If the setpoint is ramping prior to invoking Auto-Tune, the ramping is suspended during Auto-Tune and then resumed afterward using the current temperature as a starting value. Deviation and band alarms are relative to the target setpoint, not the ramping setpoint.

The Remote Setpoint input is also controlled by the setpoint ramp feature. In situations where the remote setpoint must be rate controlled, this parameter can be used to slowly increment (or decrement) the signal to its final value. The target value, not the instantaneous ramp value, is displayed. Setpoint ramp indication is disabled during remote setpoint ramping.

Note: Depending on the thermal characteristics of the process, the process temperature may not track the programmed setpoint rate.

User Input (InPt)

The user input may be programmed to perform a variety of controller functions. The input must be in its active state for 120 msec minimum to perform the function. A function is performed when the User Input, (Terminal 6) is pulled low to common (Terminal 8).

Note: Do not tie the commons of multiple units to a single switch. Use either a multiple pole switch for ganged operation or a single switch for each unit.

Note: "Low Level" is switch closed.

"High Level" is switch open.

PLOC - Program Lock. A low level enables the program disable function which places the unit in the Protected Parameter Mode.

ILOC - Integral Action Lock. A low level disables the integral action of the PID computation. A high level resumes the integral action.

trnF - Auto/Manual Transfer. A negative transition places the unit in the manual (user) mode and a positive transition places the unit in the automatic operating mode. The output is "bumpless" when transferring to either operating mode.

SPrP - Setpoint Ramp. A low level terminates setpoint ramping and the controller operates at the target setpoint. Terminating setpoint ramping is the same as setting the ramp rate to zero (SPrP = 0.0). A high level enables the programmed setpoint ramp rate.

ALrS - Alarm Reset. On models with alarms, a low level resets any active alarm(s) to their inactive state as long as the user input is low.

SP2 - Setpoint 1/ Setpoint 2 Select. On models with Second Setpoint, a low level selects setpoint 2. A high level selects setpoint 1.

SPSL or **RSP** - Local/Remote Select. On models with Secondary Analog Input, a negative transition engages Remote Setpoint operation and a positive transition engages Local Setpoint operation. The response of the controller to the setpoint transfer is set by the setpoint transfer parameter "trnF", under "7-rS" or "7-n2" module.

Prnt - Print Request. On models with Serial Communications, a low level transmits the print option selected in the Serial Communications Module (6-SC). If the user input is held low, after the printing is complete, another request is issued.

Input Parameter Module (1- In) P48 models

The controller has several input set-up parameters that must be programmed prior to setting any other controller parameters.

Input Type (tYPE)

Select the signal input type: Voltage (VOLt), or Current (Curr). The signal input terminal for voltage is #9 and for current is #10. Common is #8.

Decimal Point Position (dCPt)

Select the desired decimal point position for the scaled display. The selected decimal point position appears in the following parameters; rnd, dSP1, dSP2, SPLO, SPHI, SP, AL1, AL2, db-2, AHYS, and CHYS.

0
0.0
0.00
0.000

Rounding Increment (rnd)

Rounding values other than "1" causes the scaled number to 'round' to the nearest rounding increment selected (i.e., rounding of '5' causes '122' to round to '120' and '123' to round to '125'). If the process is inherently jittery, the display value may be rounded to a higher value than "1". If the range of the process exceeds the required resolution, (ex. 0-1000 PSI, but only 10 PSI resolution required), a rounding increment of 10 will effectively make the display more stable.

This programming step is usually used in conjunction with programmable digital filtering to help stabilize display readings. (If display stability appears to be a problem and the sacrifice in display resolution is unacceptable, program higher levels of digital filtering or increase the level of process dampening.) Rounding increments of 10, 20, 50, and 100 may also be used to add "dummy zeroes" to the scaled readings, as desired.

1
2
5
10
20
50
100

The rounding increment is for the controller's display only and does not affect (improve or degrade) the control accuracy of the unit.

Digital Input Filtering and Display Update Rate (FLtr)

Select the relative degree of input signal filtering and display update rate. The filter is an adaptive digital filter that discriminates between measurement noise and actual process changes. Therefore, the influence on step response time is minimal. If the signal is varying too greatly due to measurement noise, increase the filter value. Additionally, with large derivative times, control action may be too unstable for accurate control. Increase the filter value. Conversely, if the fastest controller response is desired, decrease the filter value.

The Auto-tune procedure sets the filter value appropriate to the process characteristics. See Output Power Dampening parameter (OPdP), page 36, for filtering the output.

FLtr- 0 to 4

- 0 = least input filtering
- 3 = most input filtering
- 4 = most input filtering and slower (2/sec) display update rate (outputs update at 10/sec rate)

Scaling Points

Prior to installing and operating the controller, it may be necessary to change the scaling to suit the display units particular to the application. Although the unit has been programmed at the factory, the scaling will generally have to be changed.

The controller is unique in that two different scaling methods are available. The two scaling procedures are similar in that the operator keys in the display values and either keys in or applies a signal value that corresponds to those scaling points. The location of the scaling points should be near the process end limits, for the best possible accuracy.

Once these values are programmed (coordinates on a graph), the indicator calculates the slope and intercept of the signal/display graph automatically. No span/zero interaction occurs, making scaling a one-pass exercise.

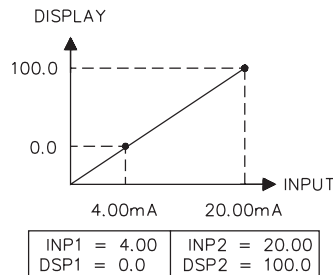


Figure 14, Scaling Points

Before programming the indicator, it is advised to organize all the data for the programming steps to avoid possible confusion.

To scale the indicator, two signal values and two display values that correspond to the signal values must be known. These four values are used to complete the scaling operation. An example is listed below:

Scaling Point #1		Scaling Point #2
0.0% @ 4.00 mA	&	100.0% @ 20.00 mA

Reverse acting indication can be accomplished by either reversing the two signal points or the display value points, but not both. If both are reversed, then forward (normal) acting indication will occur. In either case, do not reverse the input wires to correct the action.

Display Values (dSP1 & dSP2)

Key-in the display value for scaling point one and scaling point two.

dSP1	-999 to 9999	(Ex. 0.0%)
dSP2	-999 to 9999	(Ex. 100.0%)

Signal Input Values (INP1 & INP2)

The signal input value can either be keyed in via the front panel buttons or an input signal can be applied to the appropriate signal input terminals. When entering the signal input parameter, the unit is in the key-in mode.

Key-in Method

Key-in the signal value for scaling point one and scaling point two.

INP1	-999 to 9999	(Ex. 0.00 VDC or 4.00 mA DC)
INP2	-999 to 9999	(Ex. 10.00 VDC or 20.00 mA DC)

Signal Input Method

To change to the apply signal method press the D button. Front panel annunciators %P and DV will flash, and the display indicates the signal value applied to the input terminals. The unit can be toggled to the key-in method by pressing the D button again.

Signal Range	Display Range
4.00 to 20.0 mA DC	0.00 to 20.00
0.00 to 10.00 VDC	0.00 to 10.00

When the desired value is indicated on the display, press the P button to store the value and advance to the next parameter.

Setpoint Limit Values (SPLO & SPHI)

The controller has programmable high and low setpoint limit values to restrict the setting range of the setpoint. Set the limit values so that the setpoint value cannot be set outside the safe operating area of the process. On models equipped with Second Analog Input, configured as a Remote Setpoint, the Remote Setpoint reading is also restricted to these limits.

SPLO - -999 to 9999

SPHI - -999 to 9999

Setpoint Ramp Rate (SPrP)

The setpoint can be programmed to ramp independent of the controller's decimal point position and rounding increment. The setpoint ramp rate can reduce sudden shock to the process, reduce overshoot on start-up or setpoint changes, or ramp the process at a controlled rate.

SPrP - 1 to 9999 units/minute

Note: Defined here, a unit is the LSD of the display, regardless of decimal point position.

A ramp value of zero disables setpoint ramping. If the optional user input is programmed for setpoint ramp, it affects the enabling and disabling of setpoint ramping. Setpoint ramping is initiated on power-up or when the setpoint value is changed. Active Setpoint Ramping is indicated by the left most decimal point flashing in the main display.

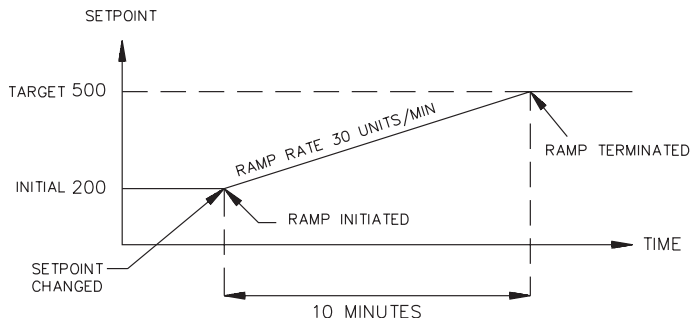


Figure 15, Setpoint Ramp Rate

Once the ramping setpoint reaches the target setpoint, the setpoint ramp rate disengages until the setpoint is changed again. If the ramp value is changed during ramping, the new ramp rate takes effect. If the setpoint is ramping prior to invoking Auto-Tune, the ramping is suspended during Auto-Tune and then resumed afterward using the current display as a starting value. Deviation and band alarms are relative to the target setpoint, not the ramping setpoint.

The Remote Setpoint input is also controlled by the setpoint ramp feature. In situations where the remote setpoint must be rate controlled, this parameter can be used to slowly increment (or decrement) the signal to its final value. The target value, not the instantaneous ramp value, is displayed. Setpoint ramp indication is disabled during remote setpoint ramping.

Note: Depending on the ramp rate relative to the process dynamics, the actual scaled process value may not track the ramping setpoint value.

User Input (InPt)

The user input may be programmed to perform a variety of controller functions. The input must be in its active state for 120 msec minimum to perform the function. A function is performed when the User Input, (Terminal 6) is pulled low to common (Terminal 8).

Note: Do not tie the commons of multiple units to a single switch. Use either a multiple pole switch for ganged operation or a single switch for each unit.

*Note: "Low Level" is switch closed.
"High Level" is switch open.*

PLOC - Program Lock. A low level enables the program disable function which places the unit in the Protected Parameter Mode.

ILOC - Integral Action Lock. A low level disables the integral action of the PID computation. A high level resumes the integral action.

trnF - Auto/Manual Transfer. A negative transition places the unit in the manual (user) mode and a positive transition places the unit in the automatic operating mode. The output is "bumpless" when transferring to either operating mode.

SPrP - Setpoint Ramp. A low level terminates setpoint ramping and the controller operates at the target setpoint. Terminating setpoint ramping is the same as setting the ramp rate to zero (SPrP = 0.0). A high level enables the programmed setpoint ramp rate.

ALrS - Alarm Reset. On models with alarms, a low level resets any active alarm(s) to their inactive state as long as the user input is low.

SP2 - Setpoint 1/ Setpoint 2 Select. On models with Second Setpoint, a low level selects setpoint 2. A high level selects setpoint 1.

SPSL or RSP - Local/Remote Select. On models with Secondary Analog Input, a negative transition engages Remote Setpoint operation and a positive transition engages Local Setpoint operation. The response of the controller to the setpoint transfer is set by the setpoint transfer parameter "trnF", under "7-n2" module.

PrNt - Print Request. On models with Serial Communications, a low level transmits the print option selected in the Serial Communications Module (6-SC). If the user input is held low, after the printing is complete, another request is issued.

Output Parameter Module (2-OP)

The controller has parameters that affect how the main control output (O1) and Main Linear DC output control signal responds to temperature changes and sensor failures.

Time Proportioning Cycle Time (CYCt)

The selection of cycle time depends on the time constant of the process and the type of output used.

CYCt - 0 to 250 seconds

For best control, a cycle time equal to 1/10 of the process time constant, or less is recommended; longer cycle times could degrade temperature control, and shorter cycle times provide little benefit at the expense of shortened relay life. When using a Logic/SSR drive output with the SSR Power Unit, a relatively short cycle time may be selected.

A setting of zero keeps the main control output and front panel indicator off. This is useful if using the linear DC output signal for control. On some models, output (O1) can be configured as an alarm output ACt1 under Module "4-AL".

Output Control Action (OPAC)

For heat and cool applications, the main output (O1) is normally used for heating (reverse acting) and the optional cooling output (O2) is normally used for cooling (direct acting).

OPAC - rEv (Reverse acting)
drct (Direct acting)

If O2 (cooling) is not used, then the action can be reverse or direct acting. When used for control output, the Main Linear DC output operation is affected by this parameter.

Output Power Limits (OPLO & OPHI)

Enter the safe output power limits for the process. These parameters may also be used to limit the minimum and maximum controller power due to process disturbances or setpoint changes, to reduce overshoots by limiting the process approach level.

OPLO & OPHI - 0 to 100%

If the cooling output is selected, the limits range from:

OPLO & OPHI - -100 to 100%

With Alarm 2 selected for cooling, the Lower Limit can be set to less than 0% to limit maximum cooling or set to greater than 0% to limit minimum heating. Set the High Limit to less than 0% to limit minimum cooling or greater than 0% to limit maximum heating. When controlling power in the manual control mode, the output power limits do not take effect.

Sensor Fail Power Level (OPFL) T48 only

If a failed sensor is detected, the control output(s) default to a preset power output.

OPFL - 0% (O1 output full "off") to 100% (O1 output full "on")

If Alarm 2 is selected for cooling, the range is extended from:

OPFL - -100% to +100%

At 0% both outputs are off, at 100% O1 is on and O2 is off, and at -100% O2 is on and O1 is off. The alarm outputs are up-scale drive (+9999) with an open sensor, and down-scale drive (-9999) with a shorted sensor (RTD only), independent of this setting. Manual Control overrides OPFL.

Output Power Dampening Filtering Time (OPdP)

The output power calculated by the PID controller can be dampened (filtered) to reduce the controller output activity. Those processes with high gain and/or derivative times, or those processes with a relatively high noise content, can benefit from the dampening action.

OPdP - 0 to 250 seconds

The dampening parameter is expressed as a time constant in seconds. Increasing the value increases the dampening or filtering effect. A value of zero disables output power dampening. The amount of dampening to be used depends primarily on the response time of the process and the amount of final actuator activity desired. Generally, dampening times in the range of 1/20 to 1/50 of the controller's integral time (or process time constant) prove to be effective. Dampening times longer than these may cause controller instability due to the added lag effect of too much filtering.

In the case where a relatively high dampening time is desired, the controller's proportional band may be increased to restore an adequate stability margin. The Auto-tune procedure of the controller sets the dampening value appropriate to the characteristics of the process.

ON/OFF Control Hysteresis (CHYS)

The controller can be placed in the ON/OFF control mode by setting the proportional band to 0.0%. The control hysteresis value affects only the control outputs. Alarms have a separate hysteresis setting. See ON/OFF Control, page 48, for more details.

CHYS - 1 to 250

The hysteresis band should be set to a minimum value to eliminate output chatter at the setpoint. Generally, 2 to 5 is sufficient for this purpose. Set the hysteresis band to factory setting prior to invoking Auto-Tune. After Auto-Tune, the hysteresis band has no effect on PID Control.

Auto-Tune Code (tcod)

Prior to invoking Auto-Tune, the Auto-Tune code should be set to achieve the desired dampening level under PID Control. After Auto-Tune is complete, changes to "tcod" parameter have no effect until Auto-Tune is restarted. When set to 0, this yields the fastest process response with possible overshoot. A setting of 2 yields the slowest response with the least amount of overshoot. Dampening codes of 0 or 1 are recommended for most thermal processes.

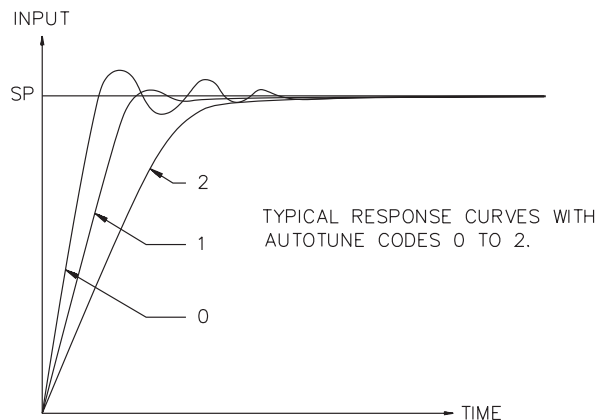


Figure 16, Auto-Tune Code

Main Linear DC Output Range (ANtP) (Optional)

Select the type of output range:

0-10 = 0 to 10 V

0-20 = 0 to 20 mA

4-20 = 4 to 20 mA

The linear DC output range jumper must be set to match the range selected. See Linear DC Output Jumper Selection, page 12. The linear DC output can be re-calibrated to provide up to 5% of over range operation. See Main or Second Linear DC Analog Output Calibration, page 71.

Main Linear DC Output Source (ANAS) (Optional)

The output can be programmed to transmit one of the below variables:

OP - Output Power % control

INP - Temperature retransmission

SP - Setpoint (local or remote) retransmission

For Linear DC Output control, the main output (O1) can be disabled by setting the Cycle Time (CYCt) to 0 in Output Parameter 2-OP or configuring it as an alarm in Alarm 1 Action (Act1) in Alarm Parameter 4-AL. For heat/cool with 4 to 20 mA control applications, the heat (0 to 100%) will be 12 to 20 mA and the cool (-100 to 0%) will be 4 to 12 mA. Notice that 0% (no heat or cool) is 12 mA.

Main Linear DC Update Time (ANUt) (Optional)

To reduce excess valve actuator, or pen recorder activity, the update time of the linear output can be set over the range of 0.1 to 250 seconds. A value of 0 seconds results in an update time of 0.1 second.

Main Linear DC Output Scaling Points (ANLO, ANHI) (Optional)

The output is scaled based on the Output Source (ANAS) display by use of low and high scaling parameters. Reverse acting output is possible by reversing the scaling points.

ANLO - Display value that corresponds to 0 V, 0 mA, or 4 mA as selected.

ANHI - Display value that corresponds to 10 V or 20 mA as selected.

Lockouts Parameter Module (3-LC)

The controller can be programmed to limit operator access to various parameters, control modes, and display contents. The configuration of the lockouts is grouped into three sections: Lower Display Lockouts, Protected Mode Lockouts and Hidden Mode Lockouts.

Lower Display Lockouts (SP, OP, dEv, Hcur, UdSP and bdSP)

The contents of the secondary display can be changed in the Normal Display Mode by successively pressing the D button. This action scrolls through the possible display parameters, when enabled. If all parameters are set to lock "LOC", press D to blank the display.

The parameters can be set for one of the following:

- LOC (Lockout) – Prevents the parameter from appearing in the secondary display.
- rEd (Read only) – Parameter appears, but cannot be modified.
- Ent (Entry) – Parameter appears and can be modified.

The lower display content possibilities are:

- SP – Setpoint Value
- OP – % Output Power
- dEv – Setpoint Deviation*
- UdSP – Temperature Units (T48)
- bdSP – Blank Display (P48)
- Hcur – Heater Current Readout*

** Models equipped with Heater Current Option replace "dEv" (Deviation) readout with "Hcur" (Heater current readout).*

Note: If a parameter is active in the lower display and is then subsequently locked out, press "D" once in the Normal Display Mode to remove it from the display.

Protected Mode Lockouts (CodE, PId, and AL)

The protected mode is active when program disable is active. The parameters in the protected mode can be set for one of the following modes:

- LOC (Lockout) – Prevents the parameter from appearing in the protected mode.
- rEd (Read only) – Parameter appears, but cannot be modified.

- Ent (Entry) – Parameter appears and can be modified.

The code number allows access to the unprotected mode. To enter the unprotected mode from the protected mode, the code number entered must match the code number entered here. See Front Panel Program Disable, page 17, for a description of the various program access levels.

- CodE – 0 to 250
- PId – Permits access to the main PID parameters.
- AL – Permits access to the alarm value(s).

Hidden Mode Lockouts (ALrS, SPsL, trnF, and tUNE)

The hidden mode is accessible from the Normal Display Mode by pressing and holding the P button for three seconds. The parameters can be set for:

- LOC (Lockout) – Prevents the parameter from appearing in the hidden mode.
- ENbL (Enable) – Allows operator to perform the selected hidden mode function.

The functions available in the hidden mode are accessible independent of the status of program disable.

- ALrS – Reset (override) the alarm output(s).
- SPsL – SP1/SP2/Remote setpoint selection.**
- trnF – Select Automatic or Manual operation.
- tUNE – Invoke or cancel Auto-Tune.

*** Model Number Dependent.*

Alarm Parameter Module (4-AL) (Optional)

The controller may be equipped with one or two optional alarms. On some models alarm output #1 is the same output as main control O1. In this case, the output is either programmed for the main output control function (O1) or as an alarm function (A1). This is set by alarm #1 action parameter (Act1).

If heat is selected, the remaining Alarm 1 parameters do not appear.

To enable the cooling output of the controller, select Cool for Alarm 2 action (Act2). The controller then utilizes the alarm 2 output as the cooling output (O2). Front panel annunciator A2 illuminates whenever the cooling output is on. See Cooling Output Module (5-O2), page 43, for configuration of the cooling output.

If cooling is selected, the remaining Alarm 2 parameters do not appear.

Alarm Action (Act1, Act2)

Note: When deviation low-acting with positive alarm value (d-LO), deviation high-acting with negative value (d-HI), or Band inside-acting (b-IN) is selected for the alarm action, the indicator is "OFF" when the alarm output is "ON".



Caution: In applications where equipment or material damage, or risk to personnel due to controller malfunction could occur, an independent and redundant temperature limit indicator with alarm outputs is strongly recommended. The indicators should have input sensors and AC power feeds independent from the other equipment.

The configuration options of the alarm output are model dependent.

(Act1) - Alarm #1		(Act2) Alarm #2	
A-HI	Absolute High Acting	A-HI	Absolute High Acting
A-LO	Absolute Low Acting	A-LO	Absolute Low Acting
d-HI	Deviation High Acting	d-HI	Deviation High Acting
d-LO	Deviation Low Acting	d-LO	Deviation Low Acting
b-In	Band Inside Acting	b-In	Band Inside Acting
b-Ot	Band Outside Acting	b-Ot	Band Outside Acting
Heat *	Assigns output O1/A1 as control output	Cool *	Assigns O2/A2 as cooling or second output
Hcur *	Assigns A1 as heater break alarm (T48)	Hcur *	Assigns A2 as heater break alarm (T48)

* Model Number Dependent.

Note: Deviation and band type alarms track both local and remote setpoint.

Heater Break Alarm

T48 models equipped with the Heater Current Monitor provide an alarm output in the event of a heater or a heater control circuit failure. The alarm is dual mode and activates under either of the following two conditions:

1. Main control output (O1) is on for a minimum of 600 msec and the feedback heater current is below the alarm value.
2. Main control output (O1) is off for a minimum of 600 msec and the feedback heater current is above 10% +0.5 amp of the alarm value.

For heater ground faults, the heater power circuit fuse opens. The heater break alarm activates per condition one above. This alarm is only useful for controller output cycle times (CYCt) of 10 seconds or more, due to the minimum on and off times of alarm detection.

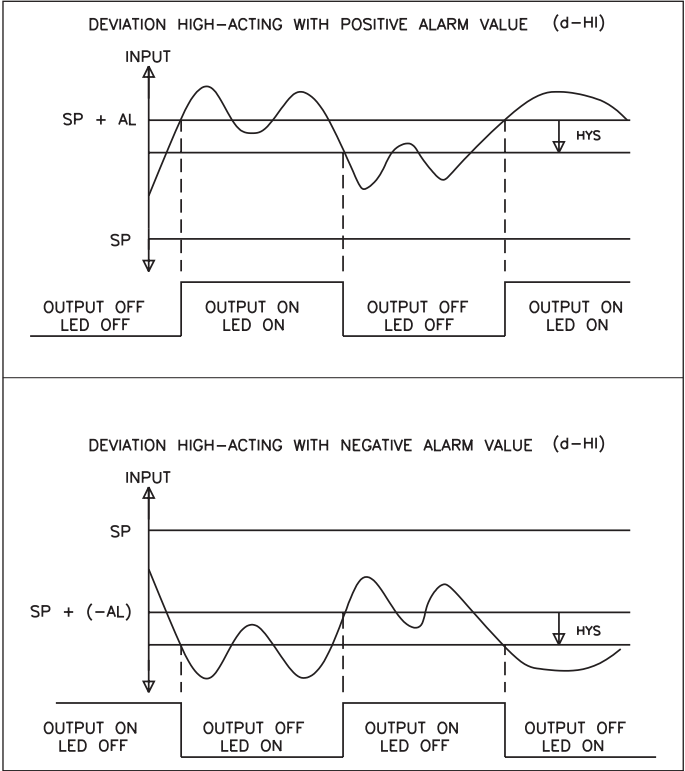
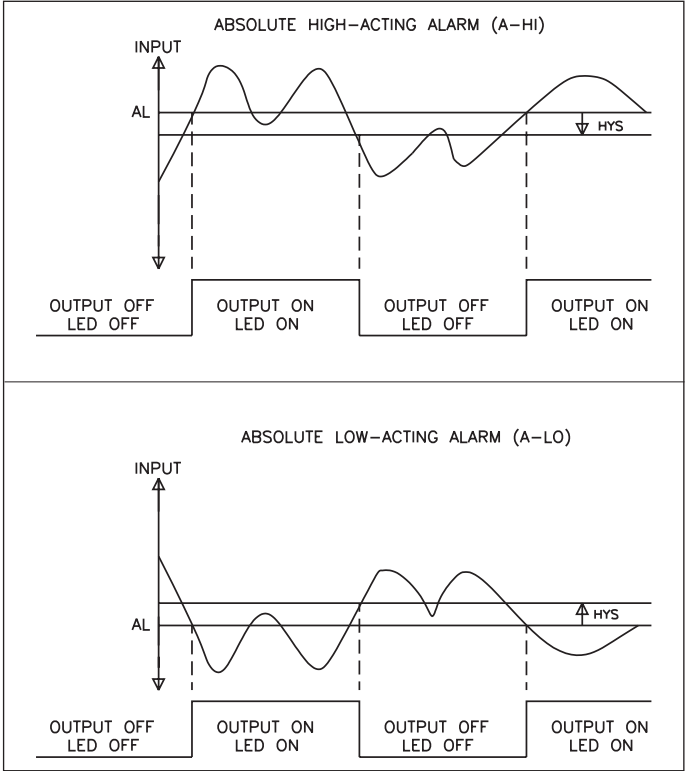
The heater break alarm value is usually set in the range of 50% to 80% of the nominal heater current. This usually provides sufficient margin against false alarms that may occur from line voltage drops and normal heater aging. Set the alarm value after observing the actual heater current readout.

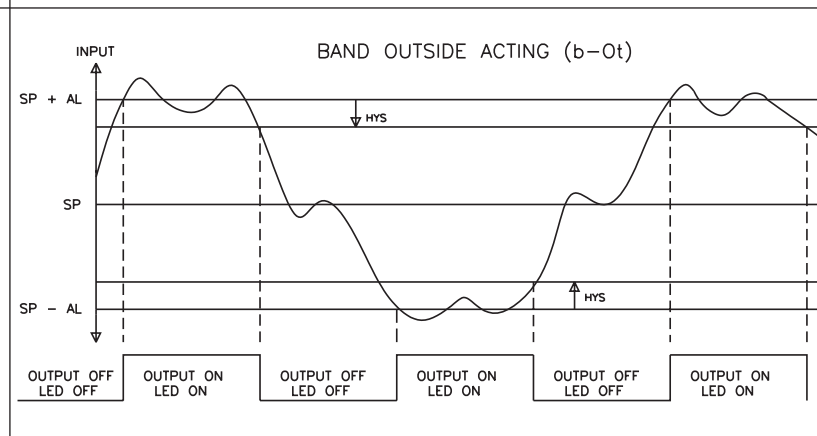
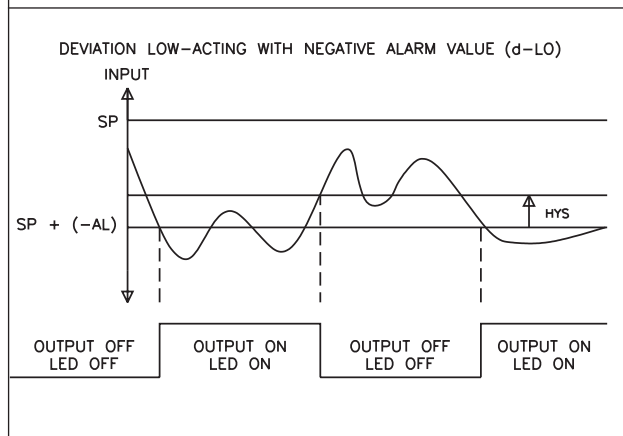
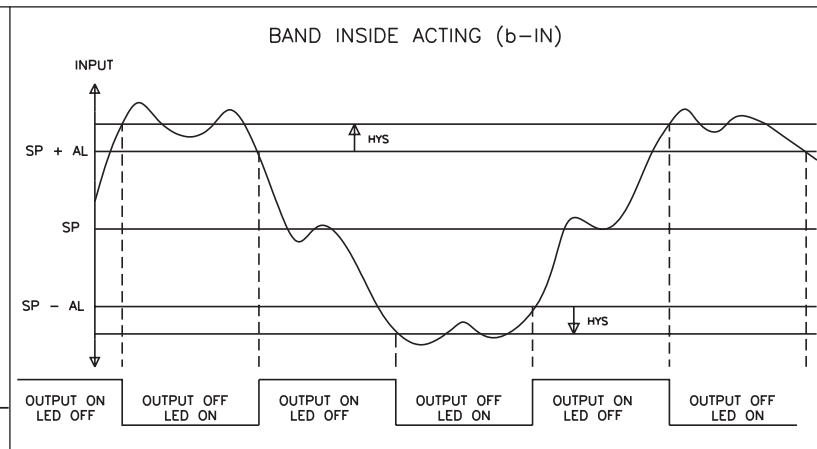
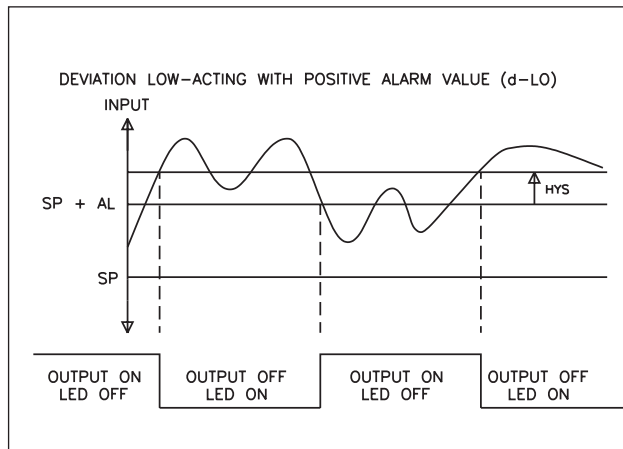
If the alarm is set for latching operation, the controller delays alarm action an additional 1 second (both on and off alarm detection). This suppresses false alarm outputs in the event of a brief power glitch in the heater circuit. A latched heater break alarm requires manual reset. If the alarm is set for auto reset (non-latching), once past the 600 msec minimum dwell time the alarm triggers and releases immediately after the condition that caused the alarm clears.

Alarm Action Figures

The alarm action figures describe the status of the alarm output and the front panel indicator for various over/under temperature conditions. The alarm output wave form is shown with the output in the automatic reset mode.

Note: Select the alarm action with care. In some configurations, the front panel indicator (LED) might be “OFF” while the output is “ON”.





Alarm Reset (rSt1, rSt2)

Each alarm reset action may be independently configured.

LAtC - Latched

Auto - Automatic

Latched alarms require operator action to reset the alarm condition. The front panel buttons can be used to reset an alarm when the controller is in the Hidden Function Mode (See page 20). An alarm condition may also be reset via the user input.

Automatic reset alarms are reset by the controller when the alarm condition clears. Figure 17, Alarm Reset Sequence, depicts the reset actions.

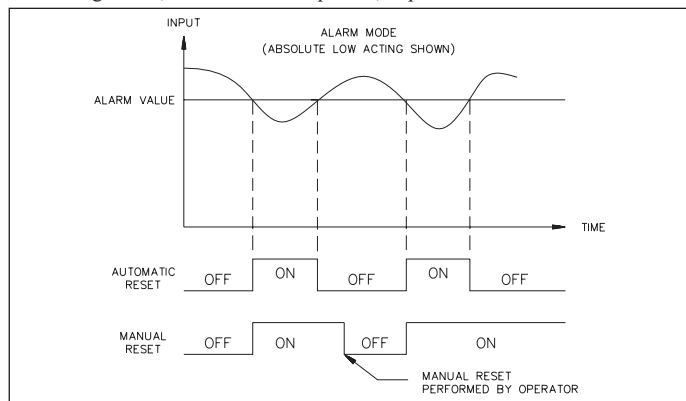


Figure 17, Alarm Reset Sequence

Alarm Standby Delay (Stb1, Stb2)

The alarm(s) may be independently configured to exhibit a power-on, standby delay which suppresses the alarm output from turning “ON” until the temperature first stabilizes outside the alarm region. After this condition is satisfied, the alarm standby delay is canceled and the alarm triggers normally, until the next controller power-on. This feature also works for deviation and band alarms when the setpoint is changed via keypad. This action suppresses “nuisance” alarms. Figure 18, Alarm Standby Delay Sequence, depicts a typical operation sequence.

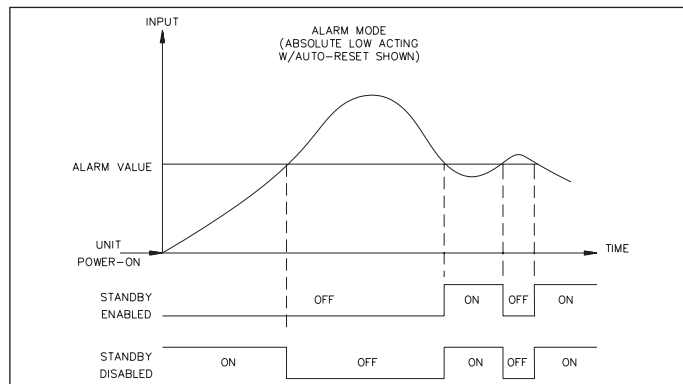


Figure 18, Alarm Standby Delay Sequence

Alarm Value (AL-1, AL-2)

The alarm values are either absolute (absolute alarms) or relative to the setpoint value (deviation and band alarms). An absolute alarm value is the value that is entered. A relative alarm value is offset from the temperature setpoint value by the amount entered and tracks the setpoint value as it is changed.

AL-1 and AL-2 - -999 to 9999

If the alarm action is set as a Band Alarm, then only a positive value can be entered.

Alarm Hysteresis (AHYS)

The alarm value(s) have a programmable hysteresis band to prevent alarm output chatter near the alarm trigger point. The hysteresis value should be set to eliminate this effect. A value of 2 to 5 is usually sufficient for most applications. A single alarm hysteresis value applies to both alarms. See the Alarm Action Figures, page 40, for the effect of hysteresis on the various alarm types.

AHYS - 1 to 250

Cooling Parameters Module (5-02) (Optional)

The cooling output (O2) is software selectable with dual alarm models (For the P48, this is referred to as the Second Control Output). This output operates as an independent cooling output for systems that use heating and cooling. To enter the Cooling Output Module, the cooling output of the controller must first be selected in Alarm Module (4-AL). When cooling is selected, alarm 2 is used for the cooling output.

The front panel indicator A2 illuminates when the cooling output (O2) is on. Cooling output power is defined as ranging from -100% (full cooling) to 0% (no cooling, unless a heat-cool band overlap is used). See Output Power Limits in Module 2 for maximum and minimum settings. The same PID values control both heat and cool.

Cooling Output Cycle Time (CYC2)

A value of 0 turns off the cooling output, independent of cooling power demand.

CYC2 - 0 to 250 seconds

Cooling Relative Gain (GAN2)

This parameter defines the gain of the cooling band relative to the heating band. A value of 0.0 places the cooling output into ON/OFF Control mode with the ON/OFF Control Hysteresis (CHYS) in Output Parameter Module (2-OP) becoming the cooling output hysteresis. This may be done independent of the main output control mode (PID or ON/OFF). Relative gain is generally set to balance the effects of cooling to that of heating for best control. Figures 19, 20, & 21, Heat/Cool Operation, illustrate the effect of different gains.

GAN2 - 0.0 to 10.0

Heat and Cool Overlap/Deadband (db-2)

This parameter defines the area in which both heating and cooling are active (negative value) or the deadband area between the bands (positive value). The parameter units are degrees or tenth's of degrees (depending on system resolution). If a heat/cool overlap is specified, the displayed percent output power is the sum of the heat power (O1) and the cool power (O2).

db-2 - -999 to 9999

When the Cooling Relative Gain is set to zero for ON/OFF Control mode, this parameter should only be set to a positive value or zero. The Heat/Cool Operation Figures illustrate the effects of different deadbands.

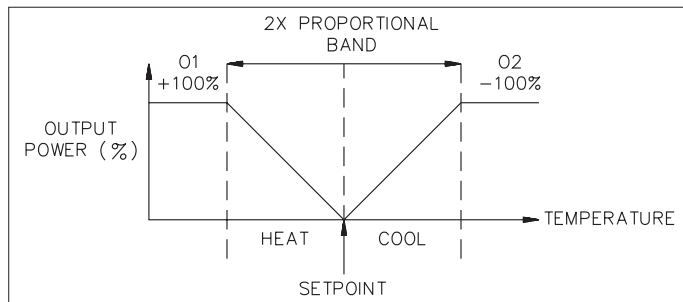


Figure 19, Heat/Cool Operation (db=0)

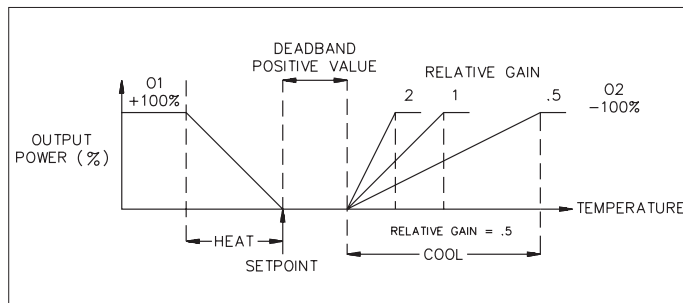


Figure 20, Heat/Cool Operation (db>0)

When using the cooling output, observe the controlled temperature characteristics. If the temperature remains above setpoint with a sluggish return, increase the cooling gain. Similarly, if the temperature drops too

sharply with an overall saw-tooth pattern, decrease the cooling gain. Alter the heat-cool overlap until a smooth response in the controlled temperature is observed during band transition.

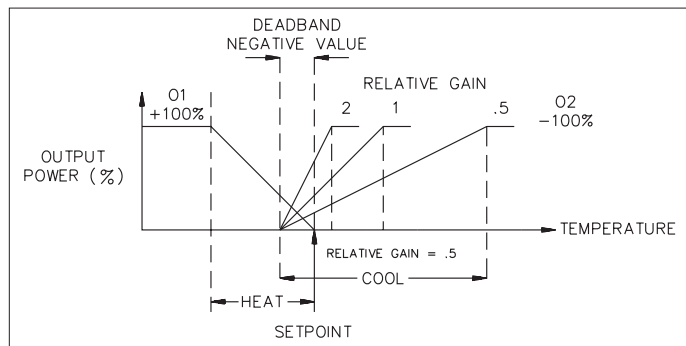


Figure 21, Heat/Cool Operation (db<0)

Serial Communications Module (6-SC) (Optional)

Unless controller serial configurations match those of the host communicating device, front panel serial parameter changing is needed for communication. Baud rate and character frame must be the same as the other communicating device. The controller address is the unique node address for multiple controllers applications. (See Serial Communications Interface, page 58, for further explanations.)

Baud Rate (bAud)

The available baud rates are:
300, 600, 1200, 2400, 4800, or 9600

Character Frame Format (ConF)

The character frame can be 7O1, 7E1, 7n2, or 8n1..

Controller Address Number (Addr)

Multiple controllers connected on the same RS485 interface line must each have a different address number. A value of 0 does not require the address specifier command, when communicating with the controller. The address numbers range from 0 to 99.

Abbreviated or Full Transmission (Abv)

When transmitting data, the controller can be programmed to suppress the address number, mnemonics, units, and some spaces by selecting YES. An example of abbreviated and full transmission are shown below:

NO - 6 SET 123.8F<CR> <LF> Full Transmission
YES - 123.8<CR> <LF> Abbreviated Transmission

Print Options (PoPt)

Selecting YES for the print options allows the operator to scroll through the available options using the P button. The up and down arrow keys toggle between “yes” and “no”. “yes” enables the option to be printed when a print function occurs.

- INP - Print Input Process Value
- SEt - Print Setpoint Value
- OPr - Print % Output Power Value
- Pbd - Print % Proportional Band Value
- INt - Print Integral Time Value
- dEr - Print Derivative Time Value
- AL1 - Print Alarm 1 Value
- AL2 - Print Alarm 2 Value
- dEv - Print Deviation From Setpoint Value
- OPF - Print % Output Power Offset Value
- r_P - Print Ramp Rate
- Crg - Print Relative Gain Value
- Cdb - Print Deadband Value
- OSt - Print Output Status
- rSP - Print Remote Setpoint Reading
- HCr - Print Heater Current Reading

Remote Setpoint Parameters Module (7-n2 or 7-rS) (Optional)

Configuration of the Remote Setpoint involves scaling the input to the desired setpoint range, selecting filter characteristics, and setting remote/local setpoint transfer response.

Remote Setpoint Display Values (dSP1 and dSP2)

Key-in the display value for Scaling Point 1 and Scaling Point 2.

dSP1 -999 to 9999 (Ex. 0)

dSP2 -999 to 9999 (Ex. 500)

Remote Setpoint Signal Input Values (INP1 and INP2)

The signal input value can either be keyed-in via the front panel buttons or an input signal can be applied to the appropriate signal input terminals. Initially, the unit is in the key-in method.

Key-in Method

Key-in the display value for Scaling Point 1 and Scaling Point 2.

INP1 0.00 to 20.00 (Ex. 4.00 mA DC)

INP2 0.00 to 20.00 (Ex. 20.00 mA DC)

Signal Input Method

To change to the apply signal input method, press the D button while INP1 or INP2 is displayed. Front panel annunciators %P and DV flash and the display indicates the signal value applied to the input terminals. The controller can be toggled to the key-in method by pressing the D button again. In this case, the previously accepted value is recalled.

When the desired value is indicated on the display, press the P button to store the value and advance to the next parameter.

Remote Setpoint Filtering (Filtr and bANd)

The remote setpoint signals can be filtered with a time constraint from 1 to 25 seconds; or the filter can be disabled. The filter is an adaptive, first-order, low pass type. As long as the difference between the current reading and the previous reading is less than the filter band value (band), the filter remains in effect. When the difference exceeds the filter band, the filter disengages until the difference is less than the filter band value. This action allows quick filter response to large setpoint changes, while retaining filtering action under normal process conditions.

Normally the filter band value is set slightly larger than the noise level of the remote input. The time constant of the filter is set consistent with the amount of filtering desired. Increased filter time constant values are effective for smoothing remote setpoint readings. This may be beneficial for cascade operation and other “live” signal applications.

Alternatively, the remote setpoint can be ramped at a controlled velocity to limit controller response to large setpoint changes.

Remote/Local Setpoint Transfer Options (trnF)

When switching between Local or Remote Setpoint, the response of the controller can be programmed in a variety of ways.

These responses apply to changes in setpoint mode from the controller’s front panel and User Input. The table summarizes the responses for Setpoint transfer operations:

<u>SPtr Parameter</u>	<u>Local to Remote</u>	<u>Remote to Local</u>
nor	– Output may bump.	Output may bump
Auto	– No output bump. Process error eliminated at rate of integral action	No output bump. Process error eliminated at rate of integral action
trAC	– Output may bump.	Local setpoint assumes value of Remote setpoint (tracks). No Output bump.

Note: In situations where an output bump may occur, the setpoint ramp function (SPrP) can be used to reduce or eliminate bumping when switching between setpoints.

Heater Current Monitor Module (7-N2 or 7-HC) (Optional)

Enter the full scale rating of the current transformers used with the T48 controllers. This scales the Heater Current Monitor of the controller to indicate directly in amperes of heater current.

Hcur - 0.0 to 999.9 amperes

Alternatively, the Heater Current Monitor may be scaled to indicate in percent of nominal heater current (0.0 to 100.0%). This may be useful in applications employing several controllers, each with nominal heater current readings that are different from each other. In this case, each controller can be scaled to indicate the same reading (100.0%), independent of each controller's actual heater current. For example, if using a 50 ampere current transformer and the actual maximum heater current is 38 amperes, the Heater Current Monitor scaling value is:

$$Hcur = \frac{50.0 \text{ Amperes}}{38.0 \text{ Amperes}} \times 100.0\% = 131.6$$

This scaling value results in a Heater Current Monitor indication of 100.0% at an actual heater current of 38 amperes.

See Alarm Action, page 39, to program a heater break alarm.

Second Linear DC Analog Output Module (8-A2) (Optional)

The Second Linear DC Analog Output provides retransmission of the conditioned and scaled input signal independent of the Main Linear DC Output.

Second Linear DC Output Range (A2tP)

Select the type of output range:

0-10 = 0 to 10 V

0-20 = 0 to 20 mA

0-40 = 4 to 20 mA

The linear DC output range jumper must be set to match the range selected. See Linear DC Output Jumper Selection, page 12. The linear DC output can be re-calibrated to provide up to 5% of over range operation. See Linear DC Output Calibration, page 71, for more details.

Second Linear DC Output Scaling Points (A2LO, A2HI)

The output can be scaled based on the controller's input display by use of low and high scaling parameters. Reverse acting output is possible by reversing the scaling points.

Factory Service Operations Module (9-FS)

The Factory Service Operations include: controller calibration, and reset programming to factory configuration setting. Access to each operation is protected by an access code number. Entering code 66 restores all parameters to factory settings, the unit indicates the operation after the P button is pressed, by displaying "rSEt" in the lower display momentarily.

Caution: Entering code 77, twice in succession, erases the controller calibration values and defaults the values to nominal settings. Reading errors of $\pm 10\%$ may result. Do not perform this operation unless the controller has lost calibration. Loss of calibration is signaled by an "E-CL" error flag at power-up. To clear this flag, perform calibration procedure as noted in Factory Service Operations - Calibration (9-FS), page 70. Alternatively, "stepping" through one of the calibration procedures clears the error flag, but does NOT validate the calibration accuracy in any manner.

MANUAL CONTROL

The controller can be transferred between Automatic Control (closed loop; On/Off or PID control) and Manual Control (open loop; where the control does not work from the setpoint or process feedback.)

Manual operation provides percentage of control of the main output (per the direct or reverse action configured in Output Parameter 2-OP OPAC) from 0 to +100% power. When A2 is configured for cooling (O2), Manual operation still provides 0 to 100% power to the main (O1) output and provides percentage of control to cooling (O2) output from -100% to 0% power. (Negative percent power is positive cooling (O2) percent power.)

To allow front panel switching between control modes, the Transfer Parameter (trnF) must be enabled (Enbl) in Lockout Module (3-LC). The user can then select Manual Control from the Hidden Function Mode using Transfer Parameter (trnF). The percent output power is then adjusted with the Up and Down arrow buttons in the Normal Display Mode with the %P and MN annunciators illuminated.

In Time Proportional output control (relay, logic, or triac) the percent output power is converted into output on time using Time Proportioning Cycle Time (CYCt) value in Output Parameter Module (2-OP). For example with 4 cycle time and 75% power, the output will be on (4 x .75) for 3 seconds and off for 1 second.

In Linear DC output control (0-10 VDC or 0/4-20 mA), the percent output power is converted into a linear value per the Linear output low scaling value (AnLO) and Linear output high scaling value (AnHI) in Output Parameter Module (2-OP). For example with 0 VDC (scaled 0.0%) to 10 VDC (scaled 100%) and 75% power, the linear DC output will be 7.5 VDC.

When transferring the controller mode from or to Automatic Control, the controlling outputs remain constant, exercising true “bumpless” transfer. When transferring from Manual to Automatic, the power initially remains steady but integral actions corrects (if necessary) the closed loop power demand at a rate proportional to the Integral Time. The low (OPLO) and high (OPHI) output power limits in Output Parameter (2-OP) are ignored when the controller is in Manual Control.

ON/OFF CONTROL

Single Output

The controller operates in ON/OFF Control when the Proportional Band is set to 0.0%. In this control, the process will constantly oscillate about the setpoint value. The amount of ON/OFF Control Hysteresis (CHYS) in Output Parameter Module (2-OP), together with the process characteristics determines the period and amplitude of the oscillations. Larger values of hysteresis increase both the amplitude and period of oscillations but also reduce the number of output switching cycles.

The Control Action (OPAC) in Output Parameter Module (2-OP) can be set to reverse (rEv) for heating (output on when below the setpoint) or direct (drct) for cooling (output on when above the setpoint) applications.

In controllers with operating system software revision earlier than V4.x, the ON/OFF Control Hysteresis value is not balanced around the setpoint value. In these controllers, the Hysteresis is totally added to the setpoint in reverse action and totally subtracted from the setpoint in direct action. The revision number of the controller's operating system software is shown in the secondary (bottom) display during controller power up.

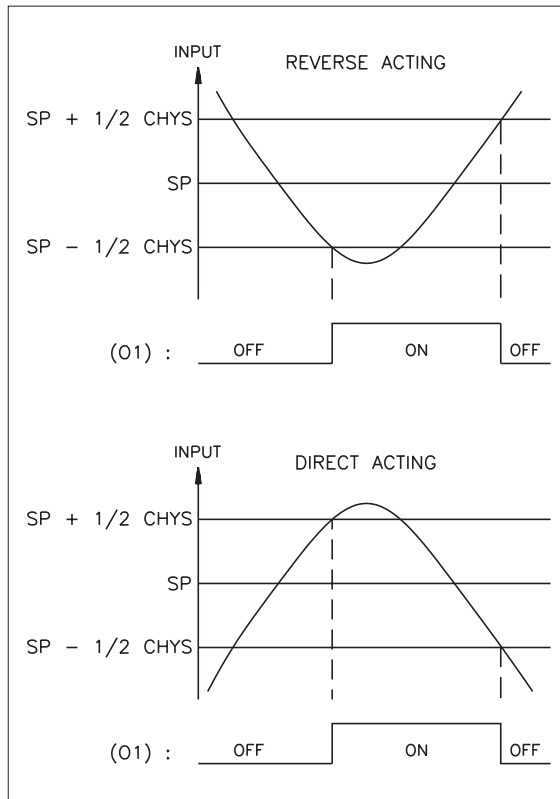


Figure 22, Output 1 (O1) ON/OFF Control
Software Revision V4.0 or Later

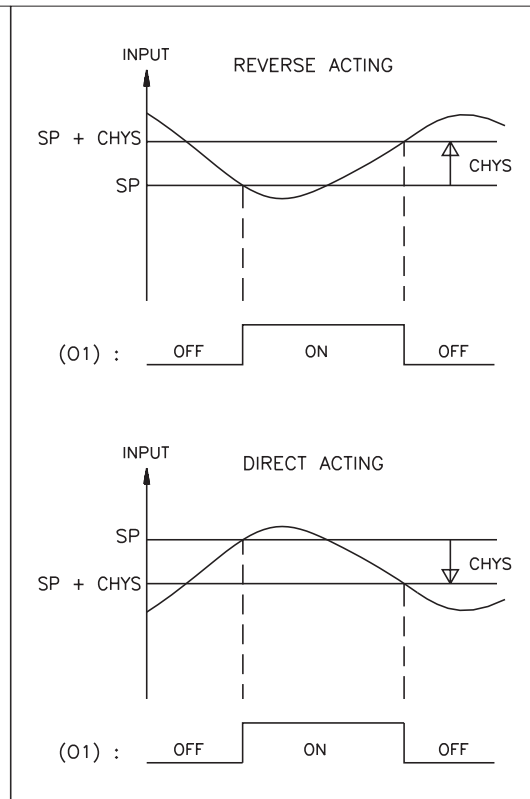


Figure 23, Output 1 (O1) ON/OFF Control
Software Revision V3.x or Earlier

Dual Output

For heat and cool systems, the heat (O1) and cool (O2) outputs can be used together in the ON/OFF control. For this operation, set the Cooling Relative Gain (GAN2) in Cooling Parameter Module (5-02) to 0.0. This places O2 into ON/OFF Control. In this mode, the ON/OFF Control Hysteresis (CHYS) in Output Parameter Module (2-OP) applies to both O1 and O2. The Heat/Cool Deadband (db-2) in Cooling Parameter Module (5-02) sets the amount of operational deadband or overlap between the outputs.

For these applications, the Control Action (OPAC) in Output Parameter Module (2-OP) is normally set to reverse (rEv). This sets O1 into reverse (heat) with O2 always in direct (cool). Cooling output for the P48 is referred to as the second control output.

In controllers with operating system software revision lower than 4.0, the ON/OFF Control Hysteresis value is not balanced. In these controllers, the Hysteresis is totally added or subtracted from the setpoint. The revision number of the controller's operating system software is shown in the secondary (bottom) display during controller power up.

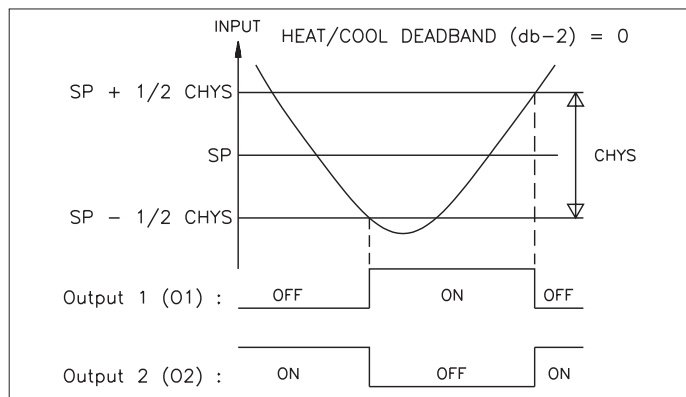


Figure 24, O1/O2 ON/OFF Control
Software Revision V4.0 or Later

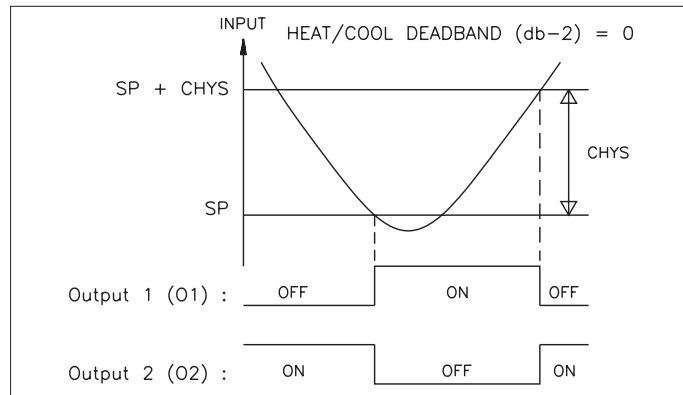


Figure 25, O1/O2 ON/OFF Control
Software Revisions V3.x or Earlier

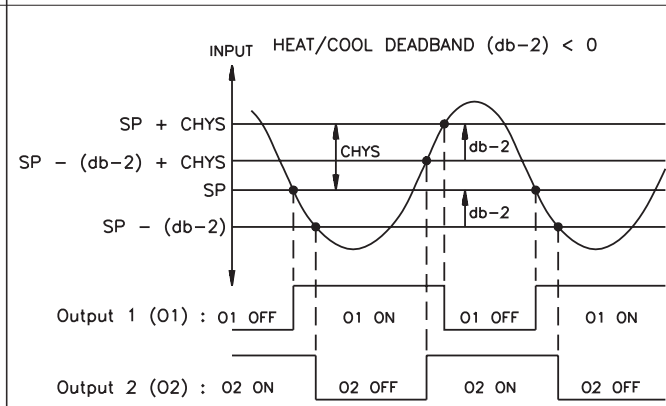
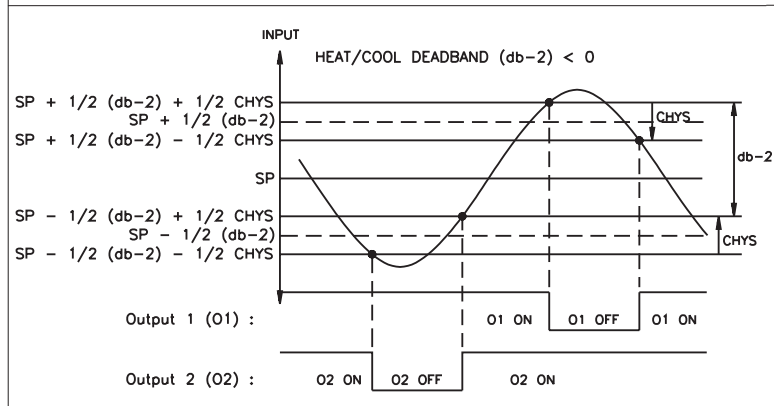
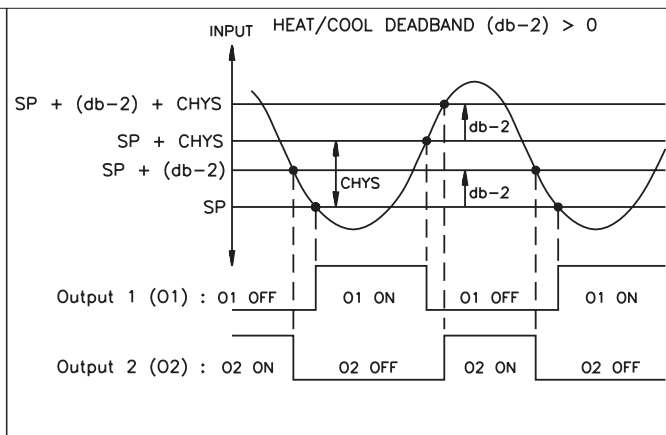
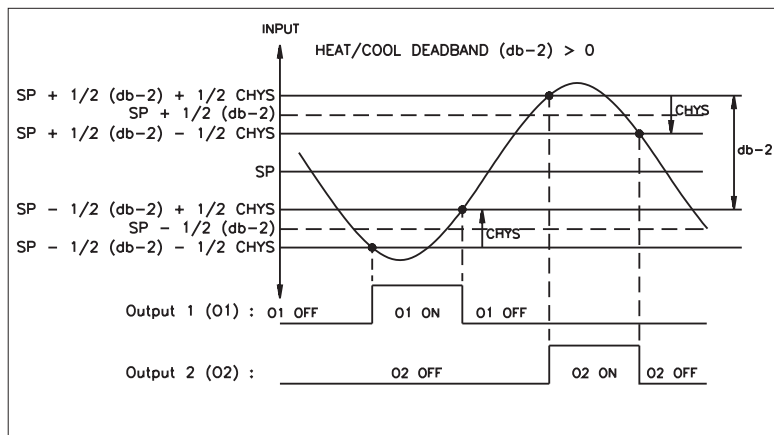


Figure 26, O1/O2 ON/OFF Control
Software Revision V4.0 or Later

Figure 27, O1/O2 ON/OFF Control
Software Revisions V3.x or Earlier

AUTO-TUNE FOR PID CONTROL

Auto-Tune is a user initiated function in which the controller automatically determines the PID settings based upon the process characteristics. During Auto-Tune, the controller temporarily causes the system to oscillate by cycling the output power from 0 to 100%. The nature of these oscillations determines the settings of the controller's parameters.

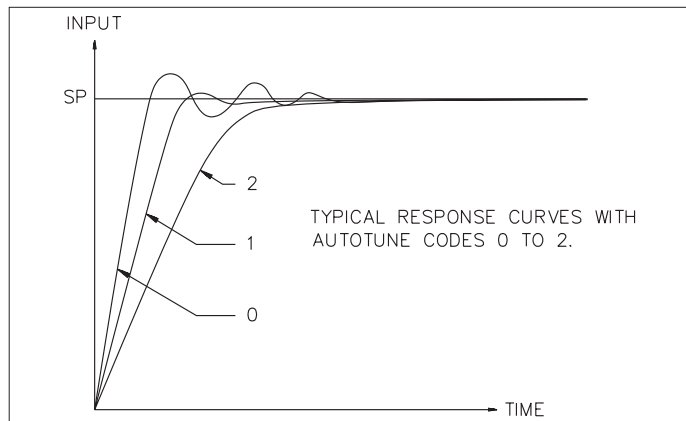


Figure 28, Auto-Tune Code

Note: If the induced oscillations caused by Auto-Tune can cause system problems or are otherwise unacceptable, the Manual Tuning Procedure can be used as a tuning alternative.

Prior to initiating Auto-Tune, it is essential that the controller be configured to the application. In particular, Control Hysteresis (CHYS) and Auto-Tune code (tcod) must be set in the Output Parameters section. Auto-Tune requires the hysteresis setting to be above the process noise floor; generally, 2 - 5 degrees or 1-2% of range is adequate. For most applications, the control hysteresis should be set at 2 (factory setting). The Auto-Tune code may be set to yield the response characteristics shown in Figure 28,

Auto-Tune Code. A code setting of zero gives the fastest response with possible overshoot, and a code of two gives the slowest response with minimum overshoot.

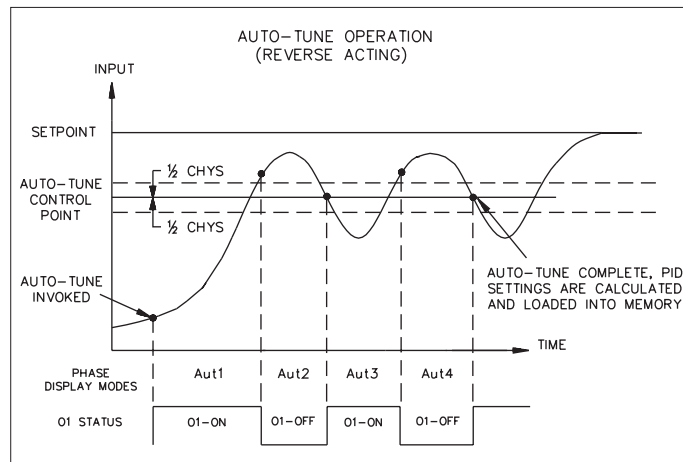


Figure 29, Auto-Tune Operation

The following controller parameters are automatically adjusted by Auto-Tune according to the characteristics of the process:

- Proportional Band (ProP)
- Integral Time (Intt)
- Derivative Time (dErt)
- Input Filter (Fltr)
- Output Power Dampening (OPdP)

As shown in Auto-Tune Operation, Figure 29, Auto-Tune Operation cycles the process at a control point 3/4 of the distance between the current process value (at the instant Auto-Tune is started) and the setpoint. The 3/4 control

point was selected to reduce the chance of overshoot at setpoint when Auto-Tuning at start-up. If Auto-Tuning from setpoint and overshoot is unacceptable, temporarily lower the setpoint by an amount of the oscillation and then Auto-Tune. Reset the setpoint to the original value when Auto-Tune is complete. After starting Auto-Tune, the secondary display indicates the current phase (Aut1, Aut2, Aut3, & Aut4). If the controller remains in an Auto-Tune phase unusually long, the process or connections may be faulty. Additionally, during Auto-Tune it is important that disturbances to the system be minimized, as these may have an effect on the parameter determination.

Initiate Auto-Tune

Auto-Tune may be initiated at start-up, from setpoint, or at any other process point.

To Initiate Auto-Tune:

1. Make sure that Auto-Tuning is enabled in Lockouts Parameter Module (3-LC).
 2. Place the controller into the Normal Display Mode.
 3. Press P for 3 seconds from Normal Display Mode.
 4. Scroll to "tUNE" by use of P, if necessary.
 5. Select "YES" and press P.
- Auto-Tune is initiated.

To Cancel Auto-Tune: (Old PID settings remain in effect).

A) Make sure that Auto-Tuning is enabled in parameter lockouts module.

1. Place the controller into the normal display mode.
2. Press P for 3 seconds from normal display mode.
3. Scroll to "tUNE" by use of P, if necessary.
4. Select "NO" and press P.
5. Auto-Tune canceled.

B) Or reset the controller by disconnecting power.

Auto-Tune Of Heat/Cool Systems

During Auto-Tune of heat/cool systems, the controller switches the cooling output (O2) on and off in addition to the heat output (O1). The heat/cool overlap deadband parameter (db-2) determines the amount of overlap or deadband between the two outputs during Auto-Tune. For most applications, set this parameter to 0.0 prior to starting Auto-Tune. After the completion of Auto-Tune, this parameter may need to be reset.

It is important that external load disturbances be minimized, and if present, other zone controllers idled as these may have an effect on the PID constant determination. The controller additionally sets the Cooling Relative Gain parameter (GAN2) for heat/cool systems.

Some water cooled processes exhibit an extreme non-linear gain characteristic. That is, the process cooling gain starts very high and flattens out deeper into the cooling region. This effect may result in regular oscillations at setpoint as the controller applies heat to counteract the effect. These processes may benefit from a lower cooling fan setting and/or reduced water flow in the jacket or manifold. The process heat and cool gains should be balanced as much as possible, and the controller gains adjusted to the process.

Auto-Tune Of Cascade Control

The following procedure may be used to tune cascaded controllers:

1. Place the Secondary controller into Local Setpoint mode and Manual (USER) mode of operation
2. Adjust output power level of the secondary until primary variable is close to primary setpoint (5% of range).
3. Key-in secondary setpoint value equal to secondary process value.
4. Auto-Tune the secondary controller while in Local Setpoint mode.
5. Place the secondary controller into Remote Setpoint mode and Automatic (Auto) mode of operation.
6. Auto-Tune the primary controller while the primary is in Automatic mode of operation.
7. Initial tuning of system is complete.

After the process has stabilized, the primary and secondary may be re-tuned in Automatic mode of operation. Normally, the primary requires re-tuning whenever the secondary PID constants are changed.

Note: For Remote Setpoint controllers, the Auto-Tune control point is derived from the Remote Setpoint when in Remote Setpoint mode and from the Local Setpoint when in Local Setpoint mode.

PID CONTROL EXPLANATIONS

Proportional Band

Proportional band is defined as the “band” (range) the process changes to cause the percent output power to change from 0% to 100%. The band may or may not be centered about the setpoint value depending upon the steady state requirements of the process. The band is shifted by manual offset or integral action (automatic reset) to maintain zero error. Proportional band is expressed as percent of input sensor range.

For T48, the ranges are fixed for the thermocouple and RTD types.

For P48, the range is set by the difference between “dSP2 and dSP1”.

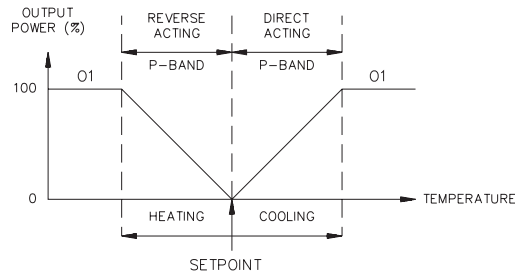


Figure 30, Proportional Band

Example: Thermocouple type T with a temperature range of 600°C is used and is indicated in degrees Celsius with a proportional band of 5%. This yields a band of $600^{\circ}\text{C} \times 5\% = 30^{\circ}\text{C}$.

The proportional band should be set to obtain the best response to a disturbance while minimizing overshoot. Low proportional band settings (high gain) result in quick controller response at expense of stability and increased overshoot. Settings that are excessively low produce continuous oscillations at setpoint. High proportional band settings (low gain) result in a sluggish response with long periods of process “droop”. A proportional band of 0.0% forces the controller into ON/OFF control mode with its characteristic cycling at setpoint (See ON/OFF Control, page 48, for more information).

Integral Time

Integral time is defined as the time, in seconds, in which the output due to integral action alone equals the output due to proportional action with a constant process error. As long as a constant error exists, integral action repeats the proportional action each integral time. Integral action shifts the center point position of the proportional band to eliminate error in the steady state. The units of integral time are seconds per repeat.

Integral action (also known as “automatic reset”) changes the output power to bring the process to setpoint. Integral times that are too fast (small times) do not allow the process to respond to the new output value. This causes over-compensation and leads to an unstable process with excessive overshoot. Integral times that are too slow (large times) cause a slow response to steady state errors. Integral action may be disabled by setting the time to zero. If time is set to zero, the previous integral output power value is maintained.

If integral action is disabled, manual reset is available by modifying the output power offset (“OPOF” initially set to zero) to eliminate steady state errors. This parameter appears in unprotected parameter mode when integral time is set to zero. The controller has the feature to prevent integral action when operating outside the proportional band. This prevents “reset wind-up”.

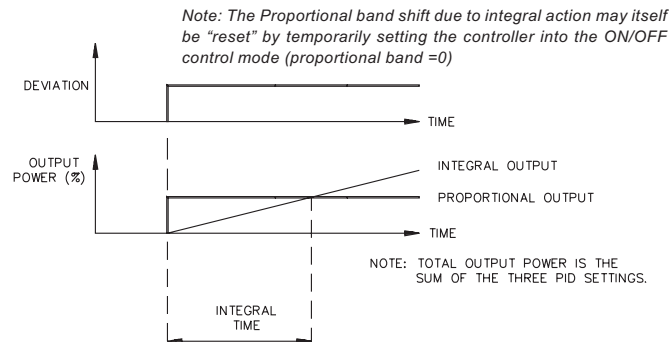


Figure 31, Integral Time

Derivative Time

Derivative time is defined as the time, in seconds, in which the output due to proportional action alone equals the output due to derivative action with a ramping process error. As long as a ramping error exists, the derivative action is “repeated” by proportional action every derivative time. The units of derivative time are seconds per repeat.

Derivative action is used to shorten the process response time and helps to stabilize the process by providing an output based on the rate of change of the process. In effect, derivative action anticipates where the process is headed and changes the output before it actually “arrives”. Increasing the derivative time helps to stabilize the response, but too much derivative time coupled with noisy signal processes, may cause the output to fluctuate too greatly, yielding poor control. None or too little derivative action usually results in decreased stability with higher overshoots. No derivative action usually requires a wider proportional and slower integral times to maintain the same degree of stability as with derivative action. Derivative action is disabled by setting the time to zero.

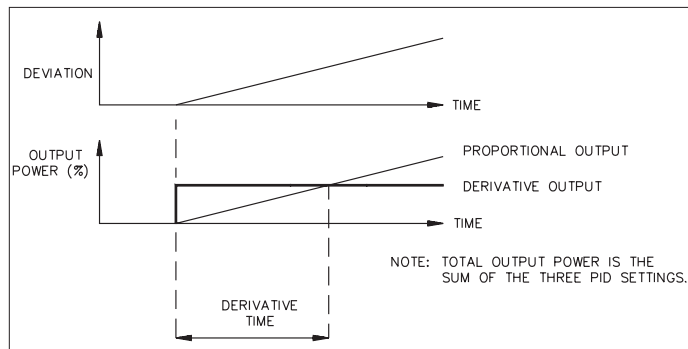


Figure 32, Derivative Time

Output Power Offset (Manual Reset)

If the integral time is set to zero (automatic reset is off), it may be necessary to modify the output power to eliminate errors in the steady state. The output power offset (OPOF) is used to shift the proportional band to compensate for errors in the steady state. The output power offset (OPOF) parameter appears in the unprotected mode, if the integral time equals zero. If integral action (automatic reset) is later invoked, the controller continues from the previous output power offset and updates accordingly.

PID Adjustments

To aid in the adjustment of the PID parameters for improved process control, a chart recorder is necessary to provide a visual means of analyzing the process. Compare the actual process response to the PID response figures with a step change to the process. Make changes to the PID parameters in no more than 20% increments from the starting value and allow the process sufficient time to stabilize before evaluating the effects of the new parameter settings.

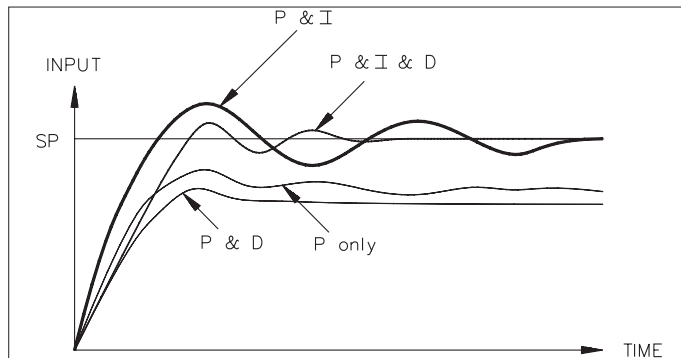


Figure 33, Typical Response Curve

PID Adjustments (Cont'd)

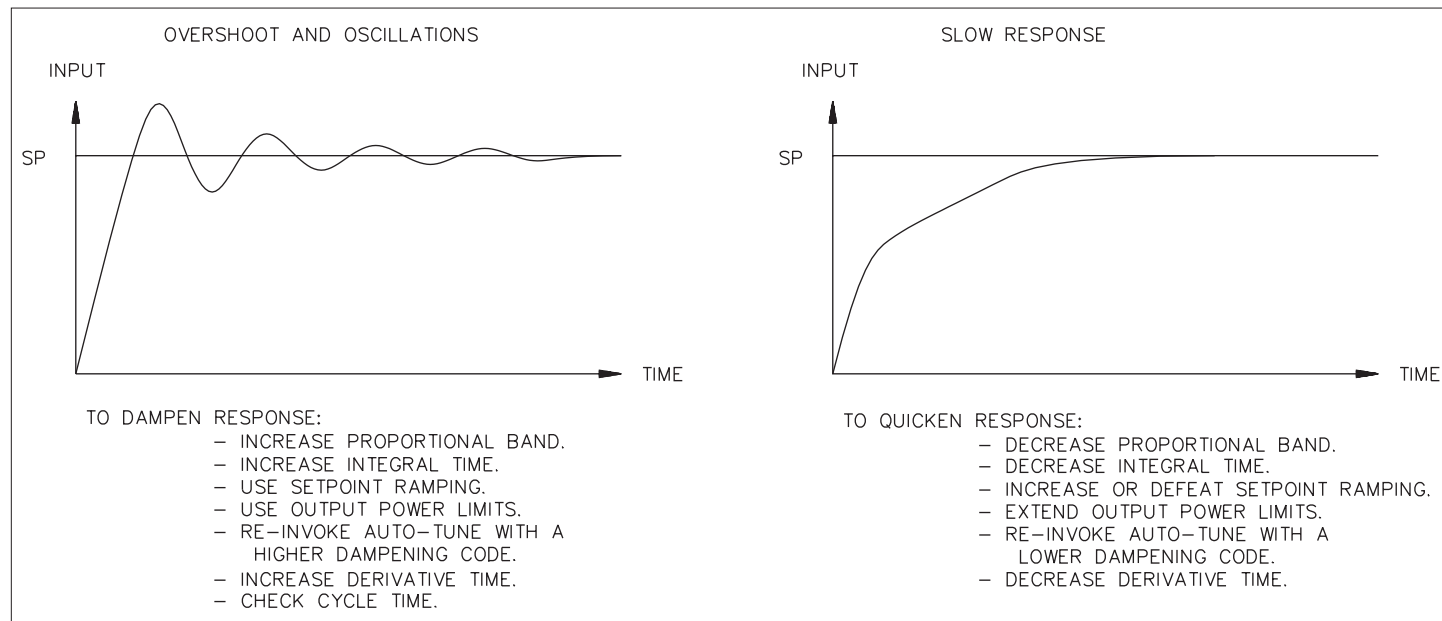


Figure 34, Process Response Extremes

MANUAL TUNING FOR PID CONTROL

In some unusual cases, the Auto-Tune function may not yield acceptable control results. In this case, the controller can be manually tuned to optimize the PID setting according to the process and the desired control requirements.

Manual Tuning Procedure

A chart recorder or data logging device is necessary to measure the time between process cycles.

1. Set the Proportional Band (ProP) from the Unprotected Parameter Mode to 10.0% for T48 models and 100.0% for P48 models.
2. Set the Integral Time (Intt) and Derivative Time (dErt) to 0 seconds.
3. Set Output Power Dampening Time (OPdP) in Output Parameter Module (2-OP) to 0 seconds.
4. Set Output Cycle Time (CYCt) in Output Parameter Module (2-OP) to no higher than 1/10 of the process time constant (when applicable).
5. Place controller in Manual Control and set % Power from the Normal Display Mode to drive the process value to the desired value. Make certain that the controller can drive the process to the setpoint. Allow the process to stabilize after setting the % Power.
6. Place controller into Automatic Control. If the process will not stabilize and starts to oscillate, set the Proportional Band 2x higher and go back to step 5.
7. If the process is stable, decrease Proportional Band setting by 2x and change the setpoint value a small amount to excite the process. Continue with this step until the process oscillates in a continuous nature.
8. Fix the Proportional Band to 3x the setting that just caused the oscillations.
9. Set the Integral Time to 2x the period of the oscillations.
10. Set the Derivative Time to 1/8 (0.125) the Integral Time.
11. Set Output Power Dampening Time to 1/40 (0.025) the period of the oscillation.

Note: This procedure is an alternate to the controller's Auto-tune function. It will not provide acceptable results if system problems exist.

REMOTE SETPOINT OPTION

A remote 0/4 to 20 mA analog input signal can be used to change the setpoint value. This input can be scaled over a process range independent of that of the system range. In operation, the front panel “MN” indicator illuminates for local setpoint operation and is off for remote setpoint operation. In either mode, the indicator flashes during Manual Mode. Filtering, ramp rate (velocity limiting), and local/remote transfer response options can be configured to suit the application. Local/Remote transfer operations are performed either externally (user input) or at the keypad.

If large changes in the remote setpoint signal result in undesirable controller performance, the remote setpoint can be velocity limited (ramped) by the setpoint ramp parameter (SPrP).

Similarly, if fluctuation in the remote setpoint signal also results in poor performance, the programmable filter can be used to provide a steady setpoint to the controller. A unique feature of the filter is the filter band. Fluctuations that occur that are less than the filter band value keep the filter engaged, while fluctuations outside the filter band disable the filter. This action allows the controller to respond rapidly to large changes of the remote setpoint signal.

CASCADE CONTROL

External cascade control involves the use of two controllers, one of which has a Remote Setpoint Input.

The outer loop controller (Primary controller) directs the setpoint of the inner loop controller (secondary controller) through the linear DC output. The secondary controller has a Remote Setpoint option in order to receive the directed setpoint. See Figure 35, Cascade Control, for more details.

Note: The Remote Setpoint of the secondary controller must be scaled prior to tuning the controllers. Normally, the Remote Setpoint is scaled to equal the actual process range of the secondary. Scaled in this way, the primary controller can direct the setpoint of the secondary controller over its operating range. Normally, the secondary controller is a faster control loop. It is able to respond quickly to disturbances before they affect the primary loop. Therefore, the control quality of the primary loop under cascade control is superior to that of a single loop controller.

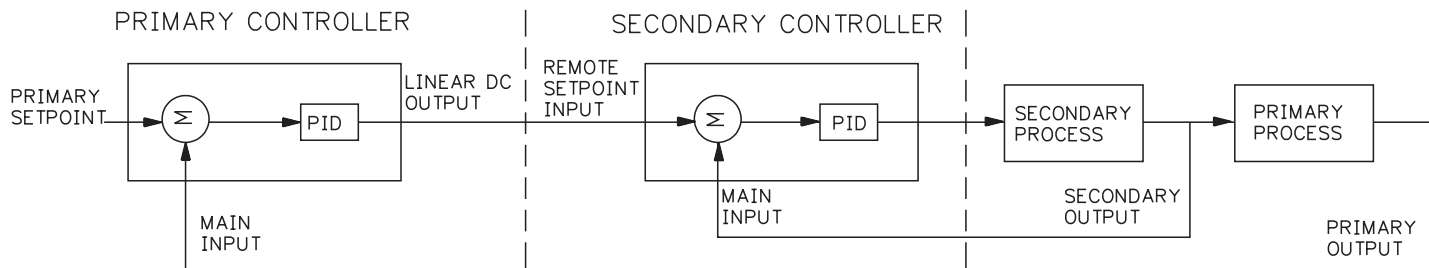


Figure 35, Cascade Control

SERIAL COMMUNICATIONS INTERFACE

RS-485 Serial Communications

The optional RS-485 serial communication interface provides two-way communication between the controller and other compatible equipment such as a printer, PLC, HMI, or a host computer. In multipoint applications, each controller can be configured with a unique node address ranging from 0-99. Through this serial interface, data from the controller can be interrogated or changed, alarm output(s) reset and Auto-tune invoked.

Since the same pair of wires are used for both transmit and receive, only one-way communication is possible at a time. The controller has a variable response time, to allow the host device adequate time to release the communication line after issuing a command to the controller.

Configuration Software

The Serial communications option is necessary to work with Red Lion Control's Windows based SFCRM software. This software allows for easy controller parameter configuration by computer. These settings can be saved to a disk file for later use or used for multi-controller down loading. On-line help is provided within the software.

Controller Configuration

The controller's serial communication format is configured in Serial Communication Program Module 6-SC using the front panel. Baud rate and character frame must be matched to the other communicating device. The node address parameter is a unique address number assigned to each slave unit on the bus.

Sending Commands And Data

When sending commands to the controller, a command string of ASCII characters must be constructed. The string varies in length depending on the nature of the command. At most, a command string consists of a Controller (Node) Address number (not required for address of 0), a Command Code character, a Register Identification character (for most commands), Numerical Data (if writing data to the controller) and ending with a string Terminator of "*" or "\$". The controller will not respond with an error message to invalid commands.

Sending Numeric Data

Data written to individual registers must be limited to the registers numerical data range (See Register Identification Table). If more digits are sent, the controller only accepts the last four digits of the numeric data. Negative numbers must have a minus sign. The controller ignores any decimal point and conforms the number to the register identification resolution. (Example: "25" is written to the proportional band register. The value recorded by the register is now 2.5. If a value of 25% is intended, write a value of 25.0 or 250.

Controller (Node) Address

Code	Description	Comments
N	Controller Node Address Specifier	Target a specific controller with the next Command. Must be followed by a one or two digit (0-99) controller node address number. Not required for a node address of 0.

Commands Table

Code	Description	Comments
T	Read Value (Transmit)	Read value register command. Must be followed by Register ID character A-M, BB, HC, or W.
V	Write Value (Change)	Write value register command. Must be followed by Register ID character B-H or J-M and appropriate Numeric Data.
R	Reset Alarm	Write alarm register command. Must be followed by Register ID character G or H.
C	Control Action	Write control register command. Must be followed by Register ID character S-U with Numeric Data of 1 or 2.
P	Print Block Request	Read block register command. Allows multiple reads with one command.

Register Identification Table

Register ID	Register (Parameter)	Applicable Command	Abbreviation (Mnemonic)	Numeric Data Range	Engineering Units
A	Input	T	T48: TMP P48: INP	-999 to 9999	T48: F or C P48: Blank
B	Setpoint	T, V	SET	-999 to 9999	T48: F or C P48: Blank
C	Output power	T, V (manual mode only)	PWR	-99.9 to 100.0	%
D	Proportional	T, V	PBD	0.0 to 999.9	%
E	Integral	T, V	INT	0 to 9999	S
F	Derivative	T, V	DER	0 to 9999	S
G	Alarm 1	T, V, R	AL1	-999 to 9999	T48: F or C P48: Blank
H	Alarm 2	T, V, R	AL2	-999 to 9999	T48: F or C P48: Blank
I	Deviation	T	DEV	-999 to 9999	T48: F or C P48: Blank
J	Power Offset	T, V (auto mode only)	OFP	-99.9 to 999.9	T48: F or C P48: Blank
K	Setpoint Ramp	T, V	RMP	0 to 9999	R
L	Cooling Gain	T, V	CRG	0.0 to 10.0	G
M	Cooling Offset	T, V	CDB	-999 to 9999	T48: F or C P48: Blank
BB	Remote Setpoint	T	RSP	-999 to 9999	T48: F or C P48: Blank
HC	Heater Current	T	HCF or HCN	0.0 to 999.9	A
S	Auto / Manual	C	—	1 (Auto), 2 (Manual)	Blank
T	Auto-tune	C	—	1 (Start), 2 (Stop)	Blank
U	Local / Remote	C	—	1 (Local), 2 (Remote)	Blank
W	Output Status	T	OST	0000 to 1111	Blank

Terminator Table

Character	Description	Comments
*	Command Terminator	Slow response (100 to 200 msec) setpoint saved to E ² PROM
\$	Command Terminator	Fast response (2 to 100 msec) setpoint not saved to E ² PROM

Examples of Command Strings:

Example: Write 10.0 to Setpoint register with a controller address of 2.

Command String: N2VB100*

Explanation: Address = 2, Command = V, Register ID = B, Numeric Data = 100, Terminator = * (with \$ setpoint will not be saved to E²PROM)

Example: Read input register of controller with an address of 3.

Command String: N3TA*

Explanation: Address = 3, Command = T, Register ID = A, Terminator = *

Example: Reset Alarm Output 1 of controller with an address of 0.

Command String: RG*

Explanation: Address = not used for address 0, Command = R, Register ID = G, Terminator = *

Example: Write to Auto-Tune control register (start Auto-Tune) on controller with an address of 5.

Command String: N05CT1\$

Explanation: Address = 5, Command = C, Register ID = T, Numeric Data = 1 (start), Terminator = \$

Command Code Explanations

Controller (Node) Address: N

When more than one controller is on the serial communication bus, a unique controller (node) address must be assigned to each unit. The address range extends from 0 to 99. This is defined in the controller configurations. To communicate with a specific controller, the address code N followed by the controller's address value must start a command string. A controller with an address of 0 does not require the node address command. Controllers with an address greater than 0 will respond to transmit commands by sending their address followed by the requested data.

Read Register Command Code: T

The Read Register command is used to read data from a register. This command must be followed by a Register ID character. In full response mode, the controller responds to this command by transmitting its Address (if greater than 0), corresponding register mnemonic and register data. In abbreviated response mode, the controller transmits data only. The response time to this command is controlled by the type of termination character. This is a single register response.

Write Register Command Code: V

The Write Register command is used to write data to a register. This command must be followed by a Register ID character and Numeric Data. A unique command line is required for each register write operation. No response occurs for invalid write operations. The Read Register command (T) can be used for readback verification.

Reset Alarm Command Code: R

The Reset Alarm command resets the alarm outputs. This command must be followed by a Register ID character (G for Alarm 1, and H for Alarm 2). This command does not alter the actual alarm mode or value setting.

Control Action Command Code: C

The Control Action command is used to affect certain controller operating modes. The registers used with this command are: Auto/Manual mode select, Auto-Tune mode select, and Remote Setpoint mode select. After the Register ID character, either a "1" or "2" is sent to set a specific controller mode.

Block Read Register Command Code: P

The Block Read Register command is used to read data from multiple registers with a single command. With this command, if no register ID characters follow, the controller responds with register data that is preset by the Print Options parameter (Module 6-SC). This mode is useful for print ticket applications. However, if Register ID characters follow this command, the controller responds with register data indicated by the ID character field. This character ID field does not follow the normal Register ID format, but instead is a field composed of ASCII encoded bit mapped bytes. (See Block Read Command Register ID Table.)

Four of these field bytes are used in this format:

P<Byte1><Byte2><Byte3><Byte4>

Each byte represents a code that selects a register(s) for transmission. The Block Read Command Byte Table relates specific registers for reads to the field bytes.

Examples:

Print: Alarm 1 and Alarm 2 values (both are in Byte2 table)

Explanation: Byte1 = 0, Byte2 = 3, Byte3 & Byte4 are not needed

ASCII String : P03* (Either the "*" or "\$" terminator could be used.)

For those programming in HEX: P=<50>, 0=<30>, *=<2A>, \$=<24>

HEX String : <50><30><33><2A>

Print: Input, Cooling Deadband and Output Status (Input is in Byte1 table and the other two are in Byte4 table)

Explanation: Byte1 = 8, Byte2 = 0, Byte3 = 0, Byte4 = C

ASCII String : P800C\$ (Either the "*" or "\$" terminator could be used.)

HEX String : <50><38><30><30><43><24>

Terminator : * or \$

After a Read Register command is sent, the response time of the controller is determined by the type of command terminator character. The "\$" terminator causes a response time of 2 msec to 100 msec and the "*" terminator causes a response time of 100 msec to 200 msec. (The 2 msec delay allows for a two character transmission time at 9600 baud.) The controller does not begin processing the command string until the "\$" or "*" is received. The Carriage Return <CR> and the Line Feed <LF> cause the controller to ignore the command string. When writing setpoint values, only values using the "*" terminator are saved to E²PROM memory.

Block Read Command Byte Table

Locate the desired register combination for each Byte.

X=register to be printed. Use ASCII 0 for blank trailing byte locations.

For those programming in HEX: P = <50>, 0 = <30>, * = <2A>, \$ = <24>

Byte1

Input	Setpoint	Output Power	P Band	ASCII	HEX
			X	1	<31>
		X		2	<32>
		X	X	3	<33>
	X			4	<34>
	X		X	5	<35>
	X	X		6	<36>
	X	X	X	7	<37>
X				8	<38>
X			X	9	<39>
X		X		A	<41>
X		X	X	B	<42>
X	X			C	<43>
X	X		X	D	<44>
X	X	X		E	<45>
X	X	X	X	F	<46>

Byte2

Integral Time	Derivative Time	Alarm 1	Alarm 2	ASCII	HEX
			X	1	<31>
		X		2	<32>
		X	X	3	<33>
	X			4	<34>
	X		X	5	<35>
	X	X		6	<36>
	X	X	X	7	<37>
X				8	<38>
X			X	9	<39>
X		X		A	<41>
X		X	X	B	<42>
X	X			C	<43>
X	X		X	D	<44>
X	X	X		E	<45>
X	X	X	X	F	<46>

Byte3

Deviation	Offset Power	Setpoint Ramp	Cooling Gain	ASCII	HEX
			X	1	<31>
		X		2	<32>
		X	X	3	<33>
	X			4	<34>
	X		X	5	<35>
	X	X		6	<36>
	X	X	X	7	<37>
X				8	<38>
X			X	9	<39>
X		X		A	<41>
X		X	X	B	<42>
X	X			C	<43>
X	X		X	D	<44>
X	X	X		E	<45>
X	X	X	X	F	<46>

Byte4

Cooling Deadband	Output Status	Remote Setpoint	Heater Current	ASCII	HEX
			X	1	<31>
		X		2	<32>
		X	X	3	<33>
	X			4	<34>
	X		X	5	<35>
	X	X		6	<36>
	X	X	X	7	<37>
X				8	<38>
X			X	9	<39>
X		X		A	<41>
X		X	X	B	<42>
X	X			C	<43>
X	X		X	D	<44>
X	X	X		E	<45>
X	X	X	X	F	<46>

Unique Register Explanations

Setpoint Ramp Using Automatic Setpoint Ramping Register: K

The controller's Setpoint Ramp parameter provides a controlled ramp when the setpoint value is changed. (The Setpoint Ramp value can be changed by using VK command.) When the setpoint value is changed, the controller begins to ramp from the existing value to the new target setpoint, at a rate set by this register. A value of zero in the Setpoint Ramp register disables ramping.

During the controlled ramp phase, the Integral Action is automatically disabled. This tends to reduce overshoot due to excessive integral build-up. The Integral Action automatically resumes at the end of the controlled ramp phase.

To terminate a ramp in progress, write 0 (zero) to the Setpoint Ramp register. This results in immediate control to the target setpoint.

Setpoint Ramp Using Periodic Setpoint Write Register: B

A host computer can command the setpoint value of the controller by writing new setpoint values based on clock ticks. In this manner, the host has explicit control over setpoint values, ramp and hold phases.

During ramp phases, the Integral Action may lead to overshoot problems. In this case, the integral action may be slowed or completely disabled by setting the integral time register.

Periodic Setpoint Write Commands (E²PROM precautions)

In the case of periodically writing setpoint values to the controller (host is running a temperature/process profile), terminate the write command with the "\$" terminator character. This instructs the controller to accept the setpoint value, but not to write the value to E²PROM memory. This eliminates cycling of the internal memory chip, which has a finite life-cycle rating (1 million typical). This rating should not be exceeded.

After power loss, the setpoint value written will be lost when using "\$". Termination of the setpoint write command with the "*" character instructs the controller to save the value to E²PROM memory. In this case, the setpoint value will be recalled after a power loss.

Heater Current Response: HC (T48 only)

The Heater Current register identifies whether the output is on or off at the time it is read. This is indicated by the three letter mnemonic HCN or HCF (N=on, F=off). For example, when a read occurs while the output is off, this response occurs: "HCF x.x". This indicates that the heater current reading is with the main output switched off. If the controller responds with "HCN x.x", the reading is with the main output switched on. The output status register is not synchronous in time with heater current register.

Output Status: W

The Output Status register indicates the present status of the controller's discrete alarm outputs (coils). This is a read only register. The controller responds with OST followed by a field consisting of 4 bytes. The bytes represent the status of the outputs in the following order: main output O1, cooling/ secondary output (O2), alarm 2 output (A2), alarm 1 output (A1). When the output is on, the corresponding byte is "1." When the output is off, the corresponding byte is "0".

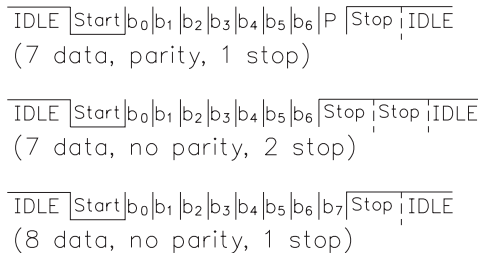
Communication Format

Data is transferred from the controller over a serial communication channel. In serial communications, the voltage is switched between a high and low level at a predetermined rate (baud rate) using ASCII encoding. The receiving device reads the voltage levels at the same intervals and then converts the number back to a character.

The table lists the required voltage levels at the receiver for RS485 interface.

Logic	RS485	Interface State
1	a-b <-200 mV	mark (idle)
0	a-b >+200 mV	space (active)

Data is transmitted one byte at a time. Each ASCII character is "framed" with a beginning start bit, an optional error detection parity bit and one or more ending stop bits.



Note: b₀ – b₇ is ASCII data.

Figure 36, Character Frame

To allow the host adequate time to release the bus after a transmission, the response time of the controller is programmable. The controller utilizes a receiver design that interprets a mark condition for open connections.

Start Bit and Data Bits

Data transmission always begins with the start bit. The start bit signals the receiving device to prepare for reception of data. One bit period later, the least significant bit of the ASCII encoded character is transmitted, followed by the remaining data bits. The receiving device then reads each bit position as it is transmitted. Since the sending and receiving devices operate at the same transmission speed (baud rate), the data is read without timing errors.

Parity Bit

After the data bits, the parity bit is sent. The transmitter sets the parity bit to a zero or a one, so that the total number of ones contained in the transmission (including the parity bit itself) is either even or odd. This bit is used by the receiver to detect one bit errors occurring in the transmission. Given this limitation, the parity bit is often ignored by the receiving device. The controller ignores the parity bit of incoming data and sets the parity bit to odd, even or none (mark parity) for outgoing data.

Stop Bit

The last character transmitted is the stop bit. The stop bit provides a single bit period pause to allow the receiver to prepare to re-synchronize to the start of new transmission (start bit of next byte). After the stop bit, the receiver continuously looks for the occurrence of the next start bit.

Command Response Time

The controller can only receive or transmit data at any one time (half-duplex operation). If bus activity, such as another command, occurs before the controller has ended its transmission, garbled data will result. When sending commands and data to the controller, timing restrictions are imposed when sending another command afterwards. This allows enough time for the controller to process the command and prepare for the next command. If the timing requirements are not obeyed, lost transmissions may result.

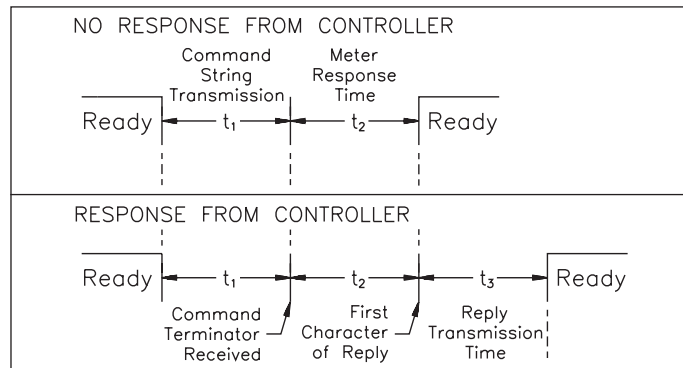


Figure 37, Timing Diagram

At the start of the time interval t_1 , the computer program prints or writes the string to the com port, thus initiating a transmission. During t_1 , the command characters are transmitting and at the end of this period, the command terminating character (*) is received by the controller. The time duration of t_1 is dependent on the number of characters and baud rate of the channel.

$$t_1 = (10 \times \text{\# of characters}) / \text{baud rate}$$

At the start of time interval t_2 , the controller starts the interpretation of the command and when complete, performs the command function. This time interval varies from 2 msec to 100 msec. If no response from the controller is expected, the controller is ready to accept another command at the end of t_2 . A minimum delay of 100 msec for period t_2 must be observed before sending another command to the same controller.

If the controller is to reply with data, the time interval t_2 is controlled by the use of the command terminating character. The standard command line terminating character is '*'. This terminating character results in a response time window of 100 msec minimum and 200 msec maximum. This allows sufficient time for the release of the bus by the transmitter. Terminating the command line with '\$' results in a response time window (t_2) of 2 msec minimum and 100 msec maximum. The faster response time of this terminating character requires that the transmitter release within 2 msec after the terminating character is received.

At the beginning of time interval t_3 , the controller responds with the first character of the reply. As with t_1 , the time duration of t_3 is dependent on the number of characters and baud rate of the channel.

$$t_3 = (10 \times \text{\# of characters}) / \text{baud rate}.$$

The number of response characters varies depending on the setting of the full / abbreviated transmissions parameter. At the end of t_3 , the controller is ready to receive the next command.

The maximum serial throughput of the controller is limited to the sum of:

t_1 , t_2 and t_3 .

Full Field Controller Transmission Byte Format

The first two characters transmitted are the node address, unless the node address assigned = 0, in which case spaces are substituted. A space follows the node address field. The next three characters are the register ID. The numeric data is transmitted next. The numeric field is 5-6 characters long. If the decimal point is present, the field is 6 characters. Negative values have a leading minus sign. The data field is right justified with leading spaces. Engineering Units byte is next. The end of the response string is terminated with a carriage return <CR> and line feed<LF>. When print block transmission is finished, an extra <SP><CR><LF> is used to provide separation between the blocks.

Byte	Description
1-2	2 byte Node Address field [00-99]
3	<SP> (Space)
4-6	3 byte Register ID field
7-12	6 byte data field, 4 bytes for number, one byte for sign, one byte for decimal point
13	1 byte Engineering Units
14	<CR>
15	<LF>
16	<SP>(Space). <i>This character only appears in the last line of a print block.</i>
17	<CR> <i>This character only appears in the last line of a print block.</i>
18	<LF> <i>This character only appears in the last line of a print block.</i>

Abbreviated Controller Transmission Byte Format

The abbreviated response suppresses the node address and register ID characters, leaving only the numeric part of the response. The numeric field is 5-6 characters long. If the decimal point is present, the field is 6 characters. Negative values have a leading minus sign. The data field is right justified with leading spaces. The end of the response string is terminated with a carriage return <CR> and line feed <LF>. When print block transmission is finished, an extra <SP><CR><LF> is used to provide separation between the blocks.

Byte	Description
1-6	6 byte data field, 4 bytes for number, one byte for sign, one byte for decimal point
7	<CR>
8	<LF>
9	<SP>(Space). <i>This character only appears in the last line of a print block.</i>
10	<CR> <i>This character only appears in the last line of a print block.</i>
11	<LF> <i>This character only appears in the last line of a print block.</i>

Example of Full Field Printout of Factory Settings

P48		T48	
INP	25.0	TMP	87F
SET	0.0	SET	0F
PWR	47.8%	PWR	0.0%
PBD	100.0%	PBD	4.0%
INT	40S	INT	120S
DER	4S	DER	30S
AL1	0.0	AL1	0F
AL2	0.0	AL2	0F
DEV	25.0	DEV	87F
OFP	0.0%	OFP	0.0%
RMP	0.0R	RMP	0.0R
CRG	1.0G	CRG	1.0G
CDB	0.0	CDB	0F
OST	0000	RSP	0F
		HCF	0.0A
		OST	0101

Troubleshooting Serial Communications

If problems are encountered when interfacing the controller(s) and host device or printer, the following check list can be used to help find a solution.

1. Check all wiring. Proper polarity of all devices on the serial loop must be observed. Refer to previous application examples.
2. Check the controller's communication format in module 6-SC. Make sure all devices on the serial loop are configured with the same communication format.
3. Check the requesting device constructed command string format.
4. When sending commands to the controller, an asterisk "*" or dollar sign "\$" must terminate the command. Make sure a carriage return or line feed does not follow the command terminator.
5. Check the controller's unit address in module 6-SC. It should be zero if the address command is not used in the command string for single controller configurations. In multiple controller configurations, make sure each controller has a unique unit address.
6. Initiate transmissions from the controller by programming the User Input for PrNt in module 1-IN for print and programming module 6-SC at PoPt set INP (input) to YES. As long as the user input is connected to common, controller data will be sent.
7. With two-way communications or multiple controller configurations, make sure only one device is communicating at a time.
8. If all of the above has been done, try reversing the polarity of the serial wires at host device or printer. Some devices have reversed polarity.

APPLICATION EXAMPLES

T48 OEM Paint Sprayer Application

An OEM manufacturing spray painting equipment utilizes the T48 to maintain optimum paint temperature. In addition to the low cost, the 1/16 DIN package size permits the OEM to design temperature control into various sized painting equipment, from small hand sprayers to large paint booths. The heating element used to heat the paint, is connected to the Main Control Output (OP1) programmed for On/Off control. Alarm 1 is programmed as Band Inside Acting, so that as long as the paint temperature is within manufacturer's specifications for temperature, the "GO" light is on. Alarm 2 is programmed as Band Outside acting so that the "NO GO" light is lit when the paint temperature is more than 12° outside the manufacturer's specifications of 140 to 150°F.

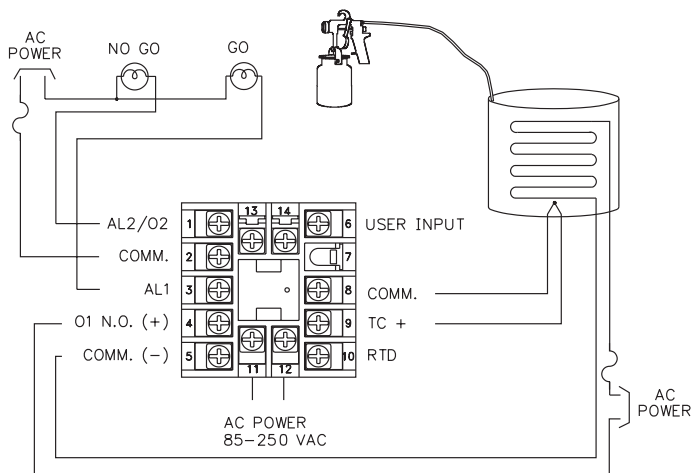


Figure 38, OEM Paint Sprayer Application

Process Requirements

Unprotected Parameters

PrOP	0	On/Off control
AL-1	12	GO light on within setpoint ± 12
AL-2	12	NO GO light on outside setpoint ± 12

1 - In Configure Input Parameters

tYPE	tc-J *	Thermocouple type "J"
SCAL	F *	Control and indicate in °F
dCPt	0 *	One degree display resolution
FLtr	1 *	Nominal input signal digital filtering
SHFt	0 *	No shift correction necessary
SPLO	140	Limit min. setpoint temperature to 140 °F
SPHI	150	Limit max. setpoint temperature to 150 °F
SPrP	0.0 *	No setpoint ramping
InPt	PLOC *	User Input program lock

2 - OP Configure Output Parameters

CYCt	2 *	Not used for On/Off control
OPAC	rEv *	Use reverse acting for heating
OPLO	0 *	For on/off, leave at 0%
OPHI	100 *	For on/off, leave at 100%
OPFL	0 *	Turn off if sensor fails
OPdP	3 *	Output power dampening = 3 seconds
CHYS	2 *	2 degree on/off band
tcod	0 *	Not used for On/Off control

4 - AL Configure Alarm Parameters

Act1	b-IN	Band Inside
rSt1	Auto *	Automatic light on/off
Stb1	no *	Power-up standby
AL-1	12	Go light on within setpoint ± 12
Act2	b-ot	Band outside
rSt2	Auto *	Automatic light on/off
Stb2	no *	Power-up standby
AL-2	12	No Go light on outside setpoint ± 12
AHYS	1 *	1° alarm activation hysteresis

* Factory Settings

T48 Plastics Extruder Application

Several T48 controllers are employed to control the temperature of a plastics extruder. Each T48 controls a heating element and a cooling water solenoid to maintain each extruder zone at the desired temperature. The Heater Current Monitor option is used for early detection of heater element failure.

The multi-function User Input can be programmed to allow selection of manual operation when connected to common. This allows the user to hold the control output of the controller during abnormal process conditions. Figure 39, Plastics Extruder Application, shows one such zone.

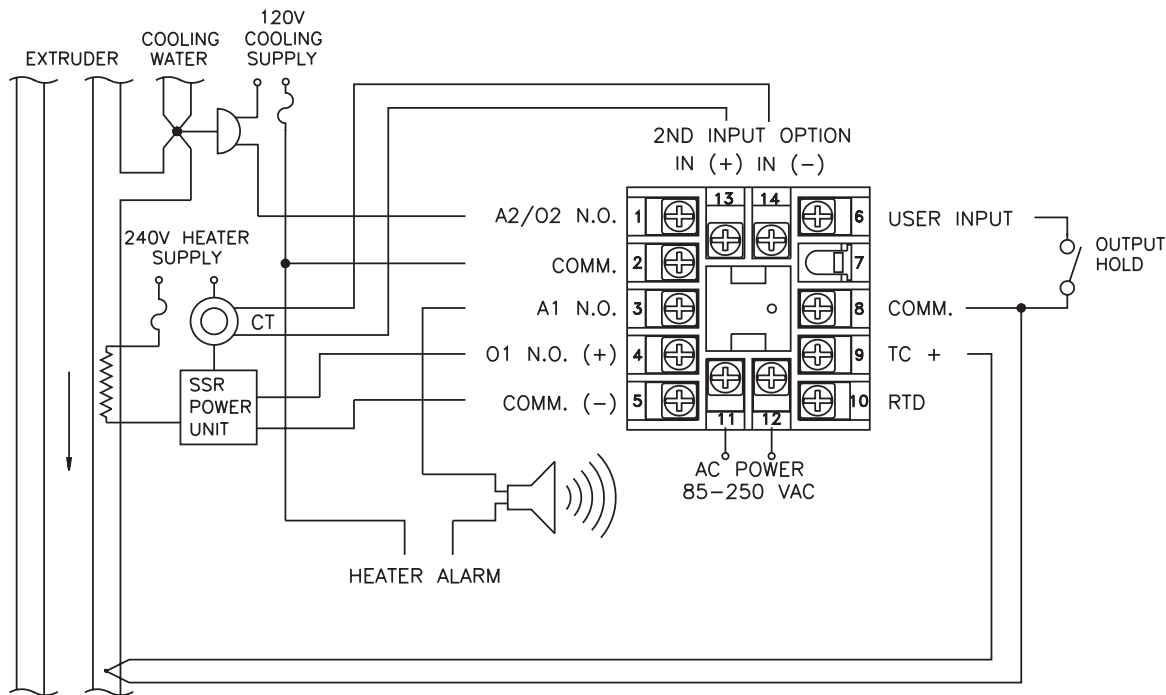


Figure 39, Plastics Extruder Application

P48 Water Processing Application

A city water company needs to maintain a steady flow of water for their customer needs. They have an existing 0 to 10 VDC flow transmitter to measure the water flow. They need to control the water flow, have a high and low alarm, and keep a recorded chart of the flow for later reference. The Main Linear DC output of the P48 is used to control the position of water value to maintain the desired flow setpoint value. The P48 relay outputs are programmed to give a high flow alarm and a low flow alarm. With the Second Linear DC output model, the flow measurement to the P48 can be retransmitted to a chart recorder.

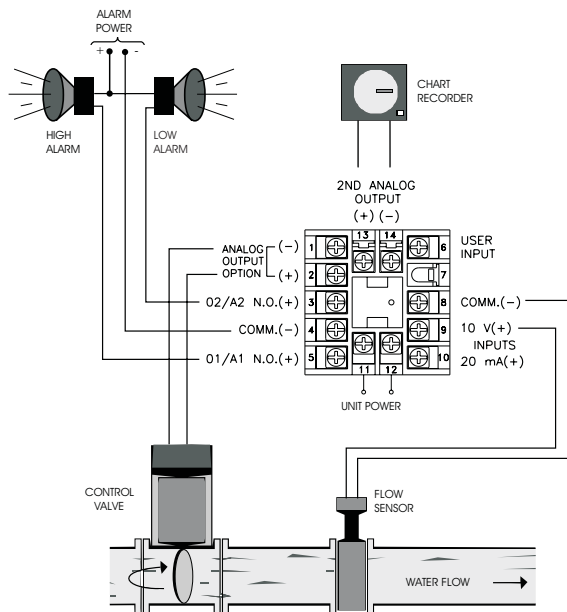


Figure 40, Water Processing Application

Process Requirements

Unprotected Parameters

ProP	XX	Calculated by Auto-Tune
Intt	XX	Calculated by Auto-Tune
dErt	XX	Calculated by Auto-Tune
AL-1	90.0	High alarm
AL-2	20.0	Low alarm

1-IN Configure Input Parameters

tYPE	VOLt	Voltage Input
dCPt	0.0 *	Resolution
FLtr	XX	Calculated by Auto-Tune
dSP1	0.0	Input low value
INP1	0.00	Low display value
dSP2	10.0	Input high value
INP2	150.00	High display value
SPLO	40.0	Setpoint low limit
SPHI	80.0	Setpoint high limit
SPrP	0.0 *	No ramping
INPt	PLOC *	User input program lock

2-OP Configure Output Parameters

CYct	0	Disable O1 output
------	---	-------------------

The remaining parameters in this module are set to factory settings.

4-AL Configure Alarm Parameters

Act1	A-HI	Set 01/A1 for control output
rSt1	LATc	Manual reset
Stb1	yes	Disable alarm during power-up
AL-1	90.0	Set 90.0 gal/min high alarm value
Act2	A-LO	Set alarm #2 for deviation band from setpoint
rSt2	LATc	Manual reset
Stb2	yes	Disable alarm during power-up
AL-2	20.0	Set 20.0 gal/min low alarm value
AHYS	5.0	Alarm activation hysteresis

8-A2 Configure Second Analog Parameter

A2tP	4-20	4-20 mA retransmitted
A2LO	0.0	Display low value
A2HI	150.0	Display high value

* Factory Settings

CHECKS AND CALIBRATION

The instrument has been fully calibrated at the factory for all input types. If the unit appears to be indicating or controlling incorrectly, see Troubleshooting, page 73, before attempting this procedure.

If the controller is suspected of reading incorrectly, the instrument may be checked for indication accuracy without disturbing the factory calibration. The following procedures may be used for this purpose.

Note: Allow 1/2 hour warm-up before checking these parameters.

MAIN INPUT CHECK

mV Reading Check (T48)

1. Connect a DC mV source with an accuracy of 0.03% or better to terminal #8 (-) & #9 (+).
2. Configure Input Parameters Module 1 for linear mV (lin) input, under tYPE.
3. Compare the controller read-out to the standard at various points over the range (-5.00 mV to 56.00 mV). The tolerance is $\pm(0.15\%$ of reading +1 LSD).
4. Calibrate the controller if the readings are out of tolerance.

Thermocouple Cold Junction Temperature Check (T48)

1. Connect a thermocouple probe of known accuracy (Types T, E, J, K, N only) to controller. Select the probe used in Configure Module 1.
2. Connect a reference temperature probe to measuring end of thermocouple to monitor temperature. Allow sufficient time for temperatures to equalize.
3. Compare controller display with reference temperature probe. The controller display should equal the calibrated probe temperature. (Tolerance is $\pm 1^{\circ}\text{C}$).
4. Calibrate the cold junction temperature if out of tolerance.

RTD Ohms Reading Check (T48)

1. Connect RTD simulator (with an accuracy of 0.1 ohm or better) capable of operating with less than 150 μA to terminals #8, #9, & #10.
2. Configure Input Parameters Module 1 for linear ohms (rLin) input, under tYPE.
3. Compare the controller read-out with the RTD simulator at various points over the range 1.0 to 300.0 ohms. The tolerance is $\pm(0.3\%$ of span $\pm 1\text{LSD}$).
4. Calibrate the controller RTD ohms if out of tolerance.

Voltage Check (P48)

1. Connect a DC voltage source with an accuracy of 0.1% or better. Apply a 0 to 10 V signal to terminals #8 (-) & #9 (+).
2. In Input Module 1, configure input signal InP1 and display value dSP1 to 0.00. Configure input signal InP2 and display value dSP2 to 10.00.
3. Compare the controller readout to the voltage source over the range (0-10 V). The tolerance is $\pm(0.3\%$ of reading +0.03 V).
4. Calibrate the controller if the readings are out of tolerance.

Current Check (P48)

1. Connect a DC current source with an accuracy of 0.1% or better. Apply a 0 to 20 mA signal to terminals #8 (-) & #10 (+).
2. In Input Module 1, configure input signal InP1 and display value dSP1 to 0.00. Configure input signal InP2 and display value dSP2 to 20.00.
3. Compare the controller readout to the current source over the range (0-20 mA). The tolerance is $\pm(0.3\%$ of reading +0.04 mA).
4. Calibrate the controller if the readings are out of tolerance.

Remote Setpoint Input Check (T48 and P48)

1. Connect a DC current source with an accuracy of 0.03% or better. Apply a 0 to 20 mA signal to terminals 13 (+) and 14 (-).
2. In Remote Setpoint Input Module 7, configure input signal InP1 and display value dSP1 to 0.00. Configure input signal InP2 and display value dSP2 to 20.00.
3. Compare the readout in the secondary main display to the current source over the range (0-20 mA). The tolerance is $\pm(0.2\%$ of full scale + $\frac{1}{2}$ LSD).
4. Calibrate Remote Setpoint Input if readings are out of tolerance.

Heater Current Input Check (T48 only)

1. Connect an AC current source with an accuracy of 0.1% or better. Apply a 100 mA signal to terminals 13 (+) and 14 (-).
2. In Heater Current Input Module 7-HC. Configure HCur for 100.0.
3. The readout in the secondary main display should be 100.0. The tolerance is $\pm(1.0\%$ of full scale + $\frac{1}{2}$ LSD).
4. Calibrate Heater Current Input if readings are out of tolerance.

Error Flag E-CL

If error flag “E-CL” appears at power-up, a loss of calibration parameters due to noise spikes has occurred. Entering code 77 twice in Factory Service Operations Module (9-FS) erases the controller calibration values and defaults the values to nominal settings. Reading errors of $\pm 10\%$ may result. It is recommended that the controller be fully re-calibrated. If using thermocouple only, the RTD calibration need not be performed.

Note: The “E-CL” flag may be cleared by “stepping” through cold junction or linear output calibration procedures without the need to change any calibration values. A $\pm 10\%$ reading error will still exist.

Calibration For T48

When re-calibration is required (generally every two years), this procedure should be performed by qualified technicians using appropriate equipment. Equipment source accuracy of 0.03% or better is required.

The procedure consists of: applying accurate mV signals, setting the thermocouple cold junction temperature, and applying precision resistance, among others. Allow a 30 minute warm-up period before starting this procedure. Do not use thermocouple wire for the Millivolt or RTD ohms Calibration.

This procedure may be aborted by disconnecting power to the controller before exiting the configuration mode. The existing calibration settings remain in affect.

Note: After completing any of the calibration sequences, the controller defaults the input sensor type to thermocouple type “J” (tc-j). Be sure to set input sensor for proper type.

Note: The controller must be restored to normal display mode before any data is stored.

Factory Service Operations - Calibration (9-FS)

Display	Parameter	Range	Description/Comments
CodE	Enter function code	48	Calibrate instrument
CAL	Millivolt Calibration	yes/no	Calibration required for both RTD and TC input. If this procedure is performed, the cold junction temp or RTD ohms calibration procedures in turn must be completed.
CJC	Thermocouple cold junction temperature calibration	yes/no	Not required if only using RTD input. This procedure can only be performed AFTER an accurate mV calibration.
rtd	RTD Resistance Calibration	yes/no	Not required if only using TC input. This procedure can only be performed AFTER an accurate mV calibration.
A1CL	Main Linear DC Output Calibration	yes/no	Model number dependent. Calibrate either 10 V or 20 mA Range
A2CL	Second Linear DC Output Calibration	yes/no	Model number dependent. Calibrate either 10 V or 20 mA Range
2CAL or N2CL	Remote Setpoint or Heater Current Input Calibration	yes/no	Model number dependent

Millivolt Calibration (CAL)

Connect precision millivolt source with an accuracy of 0.03% to terminals (-) #8 and (+) #9. Cold Junction or RTD Ohms calibration MUST be performed after millivolt calibration.

Display	Action	Description/Comments
StP1	Apply 0.0 mV	Wait 10 seconds, press P.
StP2	Apply 14.0 mV	Wait 10 seconds, press P.
StP3	Apply 28.0 mV	Wait 10 seconds, press P.
StP4	Apply 42.0 mV	Wait 10 seconds, press P.
StP5	Apply 56.0 mV	Wait 10 seconds, press P.

Thermocouple Cold Junction Calibration (CJC)

This procedure must be performed AFTER an accurate mV calibration.

1. Exit Factory Service Operations (press D) and return to Normal Display Mode.
2. Connect a thermocouple probe of known accuracy to the controller (Types T, E, J, K, and N only). Select the probe type used in Configure Module 1.
3. Connect a reference temperature probe to the measuring end of the T48 thermocouple probe. The two probes should be shielded from air movement and allowed sufficient time to equalize in temperature. (As an alternative, the T48 thermocouple probe may be placed in a calibration bath of known temperature.)
4. Compare controller display with reference temperature probe (or calibration bath). If the displayed controller temperature does not equal the reference probe temperature, calculate the CJ Error as follows:
CJ Error = reference probe temperature - displayed controller temperature
5. Enter Factory Service Operations Module (9-FS).

Display	Parameter	Description/Comments
CJC	Cold Junction Temperature	Observe the indicated cold junction temperature. Add the calculated CJ Error to the displayed value. Enter the sum as the new value for CJC. Exit 9-FS and repeat step 4. Note: If the initial value for CJC is not within the range 15.0°C to 40.0°C, enter 25.0°C for CJC and repeat the Cold Junction Calibration procedure.

RTD Ohms Calibration (rtd)

This procedure must be performed AFTER an accurate mV calibration. Connect one leg of precision resistance (accuracy of 0.1 ohm) to terminals #9 and #10 together, and the other leg to #8.

Display	Action	Description/Comments
Rtd1	Connect 0.0 ohm (jumper wire)	Wait 10 seconds, press P.
Rtd2	Connect 277.0 ohm	Wait 10 seconds, press P.

Main or Second Linear DC Analog Output Calibration

1. Set the Linear DC Output jumper for the range to be calibrated. (See Linear DC Analog Output Jumper Selection, page 12).
2. Connect a meter with an accuracy of 0.05% or better to the output.
3. For each step, use the controller arrow keys to adjust the external meter display to match the parameter being calibrated. Press P when the output is correct, or if the parameter is not being calibrated.

Display	Parameter	External Meter	Action
C 0V	0 V Calibration	0.00	Adjust if necessary, press P.
C 10V	10 V Calibration	10.00	Adjust if necessary, press P.
C 0c	0 mA Calibration	0.00	Adjust if necessary, press P.
C 20c	20 mA Calibration	20.00	Adjust if necessary, press P.

Remote Setpoint Calibration

Connect DC mA source with an accuracy of 0.03% or better.

Display	Action	Description/Comments
StP1	Apply 0 mA	Wait 10 seconds, press P.
StP2	Apply 5 mA	Wait 10 seconds, press P.
StP3	Apply 10 mA	Wait 10 seconds, press P.
StP4	Apply 15 mA	Wait 10 seconds, press P.
StP5	Apply 20 mA	Wait 10 seconds, press P.

Heater Current Input Calibration

Connect AC mA source with an accuracy of 0.1% or better.

Display	Action	Description/Comments
StP1	Apply 0 mA AC	Wait 10 seconds, press P.
StP2	Apply 5 mA AC	Wait 10 seconds, press P.
StP3	Apply 50 mA AC	Wait 10 seconds, press P.
StP4	Apply 75 mA AC	Wait 10 seconds, press P.
StP5	Apply 100 mA AC	Wait 10 seconds, press P.

Calibration For P48

When re-calibration is required (generally every two years), this procedure should be performed by qualified technicians using appropriate equipment. Equipment source accuracy of 0.03% or better is required.

The procedure consists of applying accurate voltage and current signals. Allow a 30 minute warm-up period before starting this procedure.

This procedure may be aborted by disconnecting power to the controller before exiting the configuration mode. The existing calibration settings remain in effect.

Factory Service Operations (9-FS)

Display	Parameter	Range	Description/Comments
CodE	Enter factory service function code	48	Calibrate Instrument
CAL	Input calibration	yes/no	Calibration for both voltage and current.
A1CL	Main Linear DC Output calibration	yes/no	Model number dependent. Calibrate either 10 V or 20 mA.
A2CL	Second Linear DC Output calibration	yes/no	Model number dependent. Calibrate either 10 V or 20 mA.
n2CL	Remote Setpoint Calibration	yes/no	Model number dependent

Input Calibration

Connect voltage calibration source with an accuracy of 0.1% or better.

Display	Action	Description/ Comments
StP1	Apply 0.0 V	Wait 10 seconds press P.
StP2	Apply 2.5 V	Wait 10 seconds press P.
StP3	Apply 5.0 V	Wait 10 seconds press P.
StP4	Apply 7.5 V	Wait 10 seconds press P.
StP5	Apply 10 V	Wait 10 seconds press P.
Connect current calibration source with an accuracy of 0.1% or better.		
StPA	Apply 0 mA	Wait 10 seconds press P.
StPB	Apply 20 mA	Wait 10 seconds press P.

Main or Second Linear DC Analog Output Calibration

1. Set the Linear DC Output jumper for the range to be calibrated. (See Linear DC Analog Output Jumper Selection, page 12).
2. Connect a meter with an accuracy of 0.05% or better to output.
3. For each step, use the controller arrow keys to adjust the external meter display to match the parameter being calibrated. Press P when the output is correct, or if the parameter is not being calibrated.

Display	Parameter	External Meter	Action
C 0V	0 V Calibration	0.00	Adjust if necessary, press P.
C 10V	10 V Calibration	10.00	Adjust if necessary, press P.
C 0c	0 mA Calibration	0.00	Adjust if necessary, press P.
C 20c	20 mA Calibration	20.00	Adjust if necessary, press P.

Remote Setpoint Calibration

Connect DC mA source with an accuracy of 0.03% or better.

Display	Action	Description/Comments
StP1	Apply 0 mA	Wait 10 seconds, press P.
StP2	Apply 5 mA	Wait 10 seconds, press P.
StP3	Apply 10 mA	Wait 10 seconds, press P.
StP4	Apply 15 mA	Wait 10 seconds, press P.
StP5	Apply 20 mA	Wait 10 seconds, press P.

TROUBLESHOOTING

The majority of problems can be traced to improper connections or incorrect set-up parameters. Be sure all connections are clean and tight, that the correct output board is fitted, and that the set-up parameters are correct. For further technical assistance, contact technical support at the appropriate company numbers listed.

PROBLEMS	POSSIBLE CAUSE	REMEDIES
NO DISPLAY	1. Power off 2. Brown out condition. 3. Loose connection or improperly wired. 4. Bezel assembly not fully seated into rear of unit.	1. Check power. 2. Verify power reading. 3. Check connections. 4. Check installation.
CONTROLLER NOT WORKING	1. Incorrect parameter set-up.	1. Check set-up parameters.
"E-FP" IN DISPLAY	1. Defective front panel button.	1. Press D to escape, then check all buttons for proper operation. 2. Replace unit.
"E-UP" IN DISPLAY	1. Internal problem with controller.	1. Replace unit.
"E-E2" IN DISPLAY	1. Loss of set-up parameters due to noise spike.	1. Press D to clear, then check all set-up parameters. a. Check sensor input and AC line for excessive noise. b. If fault persists, replace unit.
"E-CL" IN DISPLAY	1. Loss of calibration parameters due to noise spike.	1. Press D to clear, then check accuracy of controller. a. Recalibrate controller. b. Reset calibration parameters to nominal values (See Factory Service Operations Module).
"..." OR "-.." IN DISPLAY	1. Display value exceeds display range. 2. Defective or mis-calibrated cold junction circuit. 3. Loss of set-up parameters. 4. Internal malfunction.	1. Change resolution to display whole number. a. Verify reading. 2. Check cold junction calibration. 3. Check set-up parameters. 4. Check calibration.
"OPEN" IN DISPLAY (T48)	1. Probe disconnected. 2. Broken or burned out probe. 3. Corroded or broken terminations. 4. Excessive process temperature.	1. Connect probe. (Connection must remain intact for 3 sec. to clear "OPEN" condition.) 2. Replace probe. 3. Check connections. 4. Check process parameters.

TROUBLESHOOTING (Cont'd)

PROBLEMS	POSSIBLE CAUSE	REMEDIES
“SENS” IN DISPLAY (P48)	1. Input exceeds range of controller. 2. Incorrect input wiring. 3. Defective transmitter 4. Internal malfunction.	1. Check input signal level. 2. Check input wiring. 3. Check signal calibration. 4. Check calibration.
“LOL” IN UPPER DISPLAY	1. Input exceeds range of controller. 2. Temperature exceeds range of input probe. 3. Excessive positive probe temperature. 4. Loss of set-up parameters.	1. Check sensor or input signal level. 2. Change to input sensor with a higher temperature range. 3. Reduce temperature. 4. Check set-up parameters.
“ULUL” IN UPPER DISPLAY	1. Input is below range of controller. 2. Temperature below range of input probe. 3. Excessive negative probe temperature. 4. Loss of set-up parameters.	1. Check sensor or input signal level. 2. Change to input sensor with a lower bottom range. 3. Increase temperature. 4. Check set-up parameters.
“SHrt” IN DISPLAY (T48)	1. RTD probe shorted.	1. Check wiring. 2. Replace RTD probe.
CONTROL SLUGGISH OR NOT STABLE	1. Incorrect PID values. 2. Improper probe location.	1. See PID Control. 2. Evaluate probe location.
“LOL” OR “ULUL” IN LOWER DISPLAY	1. Signal input exceeds allowable range by 5%.	1. Check Remote Signal Source.

REPLACEABLE OUTPUT BOARD DESCRIPTION

Output Board

The controller is supplied with an output board (relay, logic/SSR or triac) installed. The output board is configured for the type of Main Control and Alarm Output based upon the model number ordered. The output board is field replaceable in many models. (For models where the output board is not replaceable, the controller must be returned to the factory for output board repair.) See Ordering Information, page 81, for available models.

Replacing Output Board

1. Remove the bezel assembly. (See Removing Bezel Assembly, page 3).
2. Lift up on the top bezel board latch while gently pulling out on the bezel/display board assembly. Do NOT remove the display board from the bezel.
3. Remove the output board by pulling it away from the other boards. Replace the output board by aligning the board to board connector. Be certain the connector is fully mated.
4. Connect the bezel/display board assembly by guiding the board ends into the bezel latches. Slide the assembly on evenly until the display board connector is completely engaged and bezel latches are fully seated onto the boards.

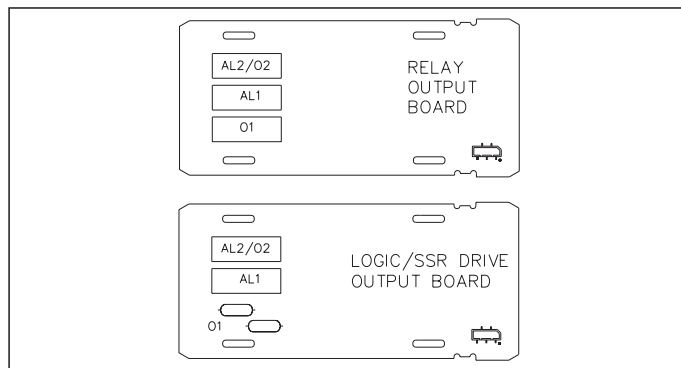


Figure 41, Output Boards

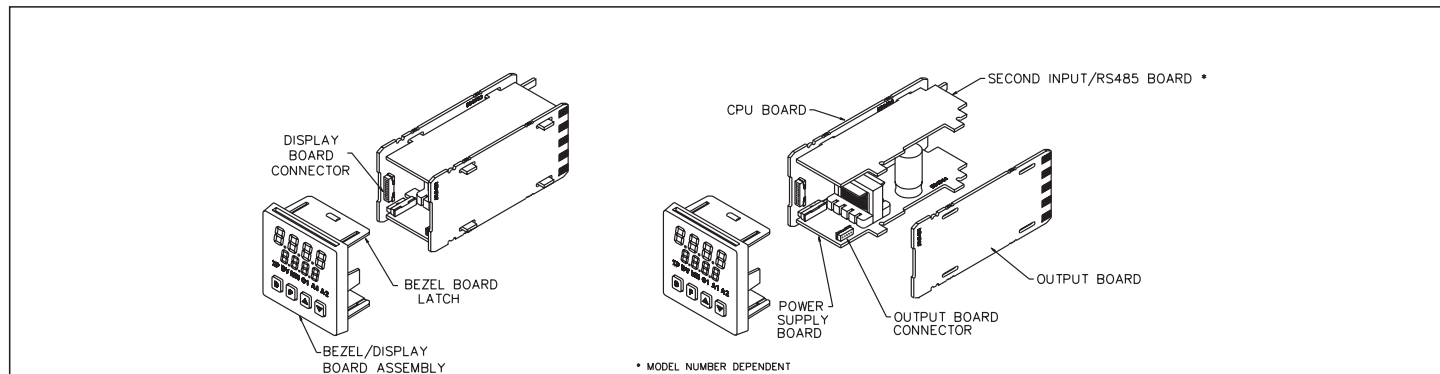


Figure 42, Output Board Replacement

SPECIFICATIONS AND DIMENSIONS

1. DISPLAY: Dual 4-digit

Upper Process Display: 0.4" (10.2 mm) high red LED

Lower Auxiliary Display: 0.3" (7.6 mm) high green LED

Display Messages:

"LOL"	—	Measurement exceeds + input range.
"ULUL"	—	Measurement exceeds - input range.
"OPEN"	—	Open sensor is detected. (T48 only)
"SHrt"	—	Shorted sensor is detected (RTD only)
"SENS"	—	Measurement exceeds controller limits. (P48 only)
"..."	—	Display values exceed + display range.
"-..."	—	Display values exceed - display range.

LED Status Annunciators:

%P	—	Lower auxiliary display shows power output in (%).
MN	—	Flashing: Controller is in manual mode. ON: Local Setpoint (Remote Setpoint option) OFF: Remote Setpoint
DV	—	Lower auxiliary display shows deviation (error) from process setpoint or shows heater current.
O1	—	Main control output is active.
A1	—	Alarm #1 is active. (for AL1 Option)
A2	—	Alarm #2 is active OR Cooling (Second) output (O2) is active.

2. POWER:

AC Versions: 85 VAC min. to 250 VAC max., 50 to 60 Hz, 8 VA max.

DC Versions:

DC Power: 18 to 36 VDC; 7 W

AC Power: 24 VAC $\pm 10\%$; 50 to 60 Hz, 9 VA

3. CONTROLS: Four front panel push buttons for modification and setup of controller functions and one external user input for parameter lockout or other functions.

4. MEMORY: Nonvolatile E²PROM retains all programmable parameters and values.

5. MAIN SIGNAL INPUT:

Sample Period: 100 msec

Response Time: Less than 300 msec typical, 400 msec max. (to within 99% of final value w/step input; typically, response is limited to response time of probe)

Failed Sensor Response (T48 only):

Main Control Output(s): Programmable preset output

Display: "OPEN"

Alarms: Upscale drive

Normal Mode Rejection: 40 dB @ 50/60 Hz
(improves with increased digital filtering).

DIMENSIONS In inches (mm)

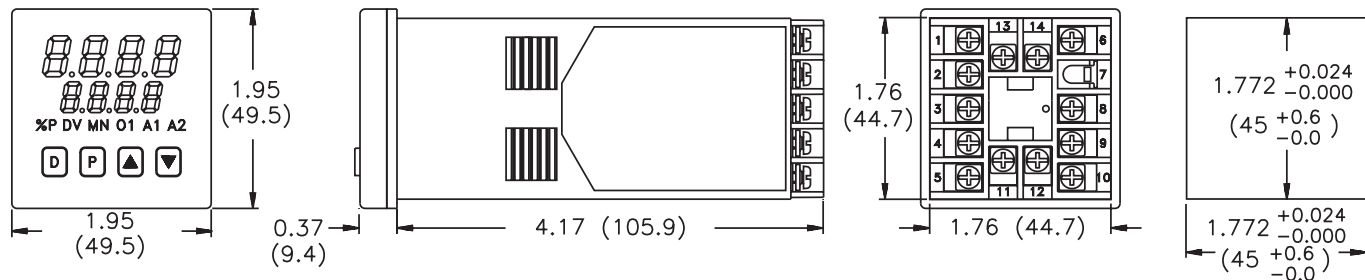


Figure 43, Dimensions

Common Mode Rejection: Greater than 120 dB, DC to 60 Hz

Protection: Input overload 120 VAC max. for 15 sec. max.

- 6. T48 INDICATION ACCURACY:** $\pm(0.3\%$ of Span $+1^{\circ}\text{C})$ Includes NIST conformity, cold junction effect and A/D conversion errors at 23°C after 20 min. warm-up.

7. THERMOCOUPLE INPUT (T48 only):

Types: T, E, J, K, R, S, B, N, Linear mV, Software selectable

Input Impedance: 20 M Ω , all types

Lead resistance effect: 0.25 $\mu\text{V}/\Omega$

Cold junction compensation: Less than $\pm 1^{\circ}\text{C}$ ($\pm 1.5^{\circ}\text{C}$ max.) error over 0 to 50°C max. ambient temperature range. Defeated for Linear mV indication mode.

Resolution: 1° for all types, or 0.1° for T, E, J, K and N only.

TC TYPE	RANGE	WIRE COLOR	
		ANSI	BS 1843
T	-200 to $+400^{\circ}\text{C}$ -328 to $+752^{\circ}\text{F}$	(+) blue (-) red	(+) white (-) blue
E	-200 to $+750^{\circ}\text{C}$ -328 to $+1382^{\circ}\text{F}$	(+) violet (-) red	(+) brown (-) blue
J	-200 to $+760^{\circ}\text{C}$ -328 to $+1400^{\circ}\text{F}$	(+) white (-) red	(+) yellow (-) blue
K	-200 to $+1250^{\circ}\text{C}$ -328 to $+2282^{\circ}\text{F}$	(+) yellow (-) red	(+) brown (-) blue
R	0 to $+1768^{\circ}\text{C}$ $+32$ to $+3214^{\circ}\text{F}$	(+) black (-) red	(+) white (-) blue
S	0 to $+1768^{\circ}\text{C}$ $+32$ to $+3214^{\circ}\text{F}$	(+) black (-) red	(+) white (-) blue
B	$+149$ to $+1820^{\circ}\text{C}$ $+300$ to $+3308^{\circ}\text{F}$	(+) grey (-) red	(+) none (-) blue
N	-200 to $+1300^{\circ}\text{C}$ -328 to $+2372^{\circ}\text{F}$	(+) orange (-) red	(+) orange (-) blue
mV	-5.00 to +56.00	no standard	no standard

- 8. RTD INPUT (T48 only):** 2 or 3 wire, 100 Ω platinum, $\alpha = 0.00385$ (DIN 43760), $\alpha = 0.0039162$

Excitation: 150 μA typical

Resolution: 1 or 0.1 degree

Lead Resistance: 15 Ω max. per input lead.

RTD TYPE	RANGE
385	-200 to $+600^{\circ}\text{C}$ -328 to $+1100^{\circ}\text{F}$
392	-200 to $+600^{\circ}\text{C}$ -328 to $+1100^{\circ}\text{F}$
OHMS	1.0 to 320.0

9. P48 RANGE AND ACCURACY:

Input Range	Accuracy* (18 to 28°C)	Accuracy* (0 to 50°C)	Impedance	Max. Continuous Overload	Resolution
10 VDC (-1 to 11)	0.10% of reading $+0.02\text{ V}$	0.30% of reading $+0.03\text{ V}$	1M ohm	300 V	10 mV
20 mA DC (-2 to 22)	0.10% of reading $+0.03\text{ mA}$	0.30% of reading $+0.04\text{ mA}$	10 ohm	100 mA	10 μA

* Accuracies are expressed as $\pm$ percentages after 20 minute warm-up. The controller's accuracy is specified in two ways: Accuracy over an 18 to 28°C range at 10 to 75% RH environment; and accuracy over a 0 to 50°C range at 0 to 85% RH (non-condensing) environment. Accuracy over the wide sensor range reflects the coefficient of the internal circuitry.

- 10. USER INPUT:** Internally pulled up to +5 VDC (1 M Ω). $V_{\text{IN MAX}} = 5.25\text{ VDC}$; $V_{\text{IL}} = 0.85\text{ V max}$; $V_{\text{IH}} = 3.65\text{ V min}$; $I_{\text{OFF}} = 1\text{ }\mu\text{A max}$.

Response time: 120 msec max

Functions: Program Lock

Integral Action Lock

Auto/Manual Mode Select

Setpoint Ramp Enable

Reset Alarms

Local/Remote Setpoint Select

Setpoint 1/Setpoint 2 Select

Serial Block Print

11. CONTROL AND ALARM OUTPUTS (Heating, Cooling or Alarm):

Relay outputs with Form A contacts

Contact Rating: 3 A @ 250 VAC or 30 VDC (resistive load) 1/10 HP @ 120 VAC (inductive load)

Life Expectancy: 100,000 cycles at max. load rating.

(Decreasing load and/or increasing cycle time, increases life expectancy.)

Logic/SSR Drive Outputs (T48 only):

Rating: 45 mA @ 4 V min., 7 V nominal

Triac Outputs (T48 only):

Type: Isolated, Zero Crossing Detection

Rating:

Voltage: 120/240 VAC

Max. Load Current: 1 Amp @ 35°C

0.75 Amp @ 50°C

Min Load Current: 10 mA

Offstate Leakage Current: 7 mA max. @ 60 Hz

Operating Frequency: 20 to 400 Hz

Protection: Internal transient snubber

12. MAIN CONTROL:

Control: PID or ON/OFF

Output: Time proportioning or linear DC

Cycle time: Programmable

Auto-tune: When selected, sets proportional band, integral time, and derivative time values.

Probe Break Action (T48 only): Programmable

13. ALARM: 1 or 2 alarms (model dependent)(optional)

Modes:

Absolute high acting

Absolute low acting

Deviation high acting

Deviation low acting

Inside band acting

Outside band acting

Heater break alarm

Reset Action: Programmable; automatic or latched

Standby Mode: Programmable; enable or disable

Hysteresis: Programmable

Probe Break Action (T48 only): Upscale

Annunciator: LED backlight for "A1", "A2"

14. COOLING/SECOND: Software selectable (overrides alarm 2).

Control: PID or ON/OFF

Output: Time proportioning

Cycle time: Programmable

Proportional Gain Adjust: Programmable

Heat/Cool Deadband Overlap: Programmable

15. MAIN AND SECOND LINEAR DC OUTPUT: (optional)

Main: Control or Re-transmission, programmable update rate from 0.1 sec to 250 sec

Second: Re-transmission only, fixed update rate of 0.1 sec

Output ** Range	Accuracy * (18 to 28°C)	Accuracy * (0 to 50°C)	Compliance	Resolution
0 to 10 V	0.10% of FS + 1/2 LSD	0.30% of FS + 1/2 LSD	10k ohm min.	1/3500
0 to 20 mA	0.10% of FS + 1/2 LSD	0.30% of FS + 1/2 LSD	500 ohm max.	1/3500
4 to 20 mA	0.10% of FS + 1/2 LSD	0.30% of FS + 1/2 LSD	500 ohm max.	1/2800

* Accuracies are expressed as $\pm$ percentages after 20 minute warm-up. Output accuracy is specified in two ways: Accuracy over an 18 to 28°C range at 10 to 75% RH environment; and accuracy over a 0 to 50°C range at 0 to 85% RH (non-condensing) environment. Accuracy over the wide signal range reflects the coefficient of the internal circuitry.

** Outputs are independently jumper selectable for either 10 V or 20 mA. The output range may be field calibrated to yield approximate 10% overrange and a small underrange (negative) signal.

16. REMOTE SETPOINT INPUT: (optional)

Input type: 0/4 to 20 mA

Input Resistance: 10 ohms.

Overrange: -5% to 105%

Overload: 100 mA (continuous)

Scale Range: -999 to 9999 degrees or -99.9 to 999.9 degrees

Resolution: 1 part in 10,000

Accuracy:

At 25°C: $\pm(0.1\% \text{ of full scale} + 1/2 \text{ LSD})$

Over 0 to 50°C range: $\pm(0.2\% \text{ of full scale} + 1/2 \text{ LSD})$

Reading Rate: 10/sec

Setpoint Filtering: Programmable Digital

Setpoint Ramping: Programmable, 0.1 to 999.9 degrees/minute.

17. HEATER CURRENT MONITOR INPUT (T48 only): (optional)

Type: Single phase, full wave monitoring of load currents controlled by main output (01)

Input: 100 mA AC output from current transformer (RLC #CT004001) or any CT with 100 mA AC output.

Display Scale Range: 1.0 to 999.9 Amps or 0.0 to 100.0%

Input Resistance: 5 Ω

Accuracy:

At 25°C range: $\pm(0.5\%$ of full scale + 1/2 LSD), (5 to 100% of range)

Over 0 to 50°C range: $\pm(1.0\%$ of full scale +1/2 LSD), (5 to 100% of range)

Frequency: 50 to 400 Hz

Alarm Mode: Dual acting: heater element fail detect and control device fail detect

Overrange: 105% Capacity

Overload: 200 mA (Continuous)

18. SERIAL COMMUNICATIONS: (optional)

Type: RS485 multipoint, balanced interface

Baud Rate: 300 to 9600

Data Format: 7O1, 7E1, 7N2, 8N1

Node Address: 0-99, max of 32 units per line

Transmit Delay: 2-100 msec or 100-200 msec

Data Encoding: ASCII

Isolation w.r.t Main Input Common: 500 Vrms for 1 min. (50 V working)

Not isolated w.r.t. Remote Setpoint or Heater Current inputs, or Analog Output common

Note: RS485 and the Analog Output commons are not internally isolated within the controller. The terminating equipment of these outputs must not share the same common (i.e., earth ground).

19. ISOLATION BREAKDOWN RATINGS:

AC line with respect to all Inputs and outputs: 250 V working (2300 V for 1 minute).

Main input with respect to Analog Outputs, Remote Setpoint Input, Heater Current Input: 50 V working (2300 V for 1 minute).

All other inputs and outputs with respect to relay contacts: 2000 VAC

Not isolated between Analog Outputs, Remote Setpoint and Heater Current commons.

20. CERTIFICATIONS AND COMPLIANCES:

SAFETY

UL Recognized Component, File #E156876, UL873, CSA 22.2 No. 24

Recognized to U.S. and Canadian requirements under the Component Recognition Program of Underwriters Laboratories, Inc.

Type 4X Enclosure rating (Face only), UL50

IECEE CB Scheme Test Certificate # UL1369-156876/USA,

CB Scheme Test Report # 96ME50224-040396 (T48 only)

Issued by Underwriters Laboratories, Inc.

IEC 61010-1, EN 61010-1: Safety requirements for electrical equipment for measurement, control, and laboratory use, Part 1.

IP65 Enclosure rating (Face only), IEC 529

ELECTROMAGNETIC COMPATIBILITY

Immunity to EN 50082-2

Electrostatic discharge	EN 61000-4-2	Level 2; 4 kV contact Level 3; 8 kV air
Electromagnetic RF fields	EN 61000-4-3	Level 3; 10 V/m ¹ 80 MHz - 1 GHz
Fast transients (burst)	EN 61000-4-4	Level 4; 2 kV I/O Level 3; 2 kV power
RF conducted interference	EN 61000-4-6	Level 3; 10 V/rms ² 150 KHz - 80 MHz
Power frequency magnetic fields	EN 61000-4-8	Level 4; 30 A/m
Simulation of cordless telephones	ENV 50204	Level 3; 10 V/m 900 MHz $\pm$ 5 MHz 200 Hz; 50% duty cycle

Emissions to EN 50081-2

RF interference	EN 55011	Enclosure class A Power mains class A
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Notes:

1. No loss of performance during EMI disturbance at 10 V/m.

Unit is panel mounted in a metal enclosure (Buckeye SM7013-0 or equivalent) that provides at least 20 dB shielding effectiveness. Metal panel is connected to earth ground.

Power Line and I/O cables routed in metal conduit connected to earth ground.

2. Self-recoverable loss of performance during EMI disturbance at 10 Vrms:

Analog output may deviate during EMI disturbance.

For operation without loss of performance:

Install power line filter, RLC#LFIL0000 or equivalent.

OR

Install 2 ferrite cores, RLC#FCOR0000 or equivalent, to AC lines at unit for frequencies above 5 MHz.

I/O cables routed in metal conduit connected to earth ground.

Refer to the EMC Installation Guidelines section of the manual for additional information.

21. ENVIRONMENTAL CONDITIONS:

Operating Range: 0 to 50°C

Storage Range: -40 to 80°C

T48 Span Drift (maximum): 130 ppm/°C, main input

T48 Zero Drift (maximum): 1 µV/°C, main input

Operating and Storage Humidity:

85% max. relative humidity (non-condensing) from 0°C to 50°C.

Vibration according to IEC 68-2-6: 5 to 150 Hz, in X, Y, Z direction for 1.5 hours, 2gs.

Shock according to IEC 68-2-27: Operational 20 g (10 g relay), 11 msec in 3 directions.

Altitude: Up to 2000 meters

22. CONNECTION: Wire clamping screw terminals

23. CONSTRUCTION: Black plastic alloy case and collar style panel latch.

Panel latch can be installed for vertical or horizontal instrument stacking.

One piece tinted plastic bezel. Bezel assembly with circuit boards can be removed from the case to change the output board without removing the case from the panel or disconnecting wiring. Unit meets NEMA 4X/IP65 requirements for indoor use when properly installed. Installation Category II, Pollution Degree 2.

24. WEIGHT: 0.38 lbs (0.17 kgs)

T48 TEMPERATURE CONTROLLER ORDERING INFORMATION

Options and Output Boards are factory configured per the part number specified. Part numbers without replacement output boards listed must be returned to the factory for output board replacement.

MODELS WITHOUT RS485 AND LINEAR DC ANALOG OUTPUT

DEDICATED MAIN CONTROL O1 OUTPUT	DEDICATED ALARM 1 A1 OUTPUT	A2 (ALARM 2) OR 02 (COOL) *	REMOTE SETPOINT INPUT@	HEATER CURRENT INPUT@	PART NUMBERS		REPLACEMENT OUTPUT BOARD
					18 to 36 VDC/24 VAC	85 to 250 VAC	
Relay					T4810010	T4810000	RBD48100
Relay	Relay				NA	T4811000	RBD48111
Relay	Relay	Relay			T4811110	T4811100	RBD48111
Relay	Relay	Relay	YES		T4811113	T4811103	RBD48111
Relay	Relay	Relay		YES	T4811114	T4811104	RBD48111
Logic/SSR					T4820010	T4820000	RBD48200
Logic/SSR	Relay				NA	T4821000	RBD48211
Logic/SSR	Relay	Relay			T4821110	T4821100	RBD48211
Logic/SSR	Relay	Relay	YES		T4821113	T4821103	RBD48211
Logic/SSR	Relay	Relay		YES	T4821114	T4821104	RBD48211
Triac	Logic/SSR	Logic/SSR			T4832210	T4832200	N/A

* - This output is programmable as either Control (PID) or as an Alarm.

@ - These part numbers are equipped with a second setpoint.

MODELS WITH RS485 OR LINEAR DC ANALOG OUTPUT

DEDICATED MAIN CONTROL O1 OUTPUT	MAIN CONTROL O1 OR A1 * (ALARM 1)	DEDICATED ALARM 1 A1 OUTPUT	(ALARM 2) A2 OR O2 (COOL) *	REMOTE SETPOINT INPUT@	HEATER CURRENT INPUT@	RS485 @	MAIN ANALOG OUTPUT** @	SECOND ANALOG OUTPUT**@	PART NUMBERS	
									18 to 36 VDC/ 24 VAC	85 to 250 VAC
Relay						YES ¹			NA	T4810002
	Relay		Relay				YES	YES	T481011A	T481010A
	Relay		Relay				YES		T4810111	T4810101
	Relay		Relay	YES			YES		T4810115	T4810105
	Relay		Relay		YES		YES		T4810116	T4810106
	Relay		Relay			YES	YES		T4810117	T4810107
Relay			Relay	YES		YES			T4810118	T4810108
Relay			Relay		YES	YES			T4810119	T4810109
Relay		Relay	Relay			YES ²			T4811112	T4811102
	Logic/SSR		Logic/SSR				YES		T4820211	T4820201
	Logic/SSR		Logic/SSR	YES			YES		T4820215	T4820205
	Logic/SSR		Logic/SSR		YES		YES		T4820216	T4820206
Logic/SSR			Logic/SSR	YES		YES			T4820218	T4820208
Logic/SSR			Logic/SSR		YES	YES			T4820219	T4820209
Logic/SSR		Relay	Relay			YES			T4821112	T4821102

* - This output is programmable as either Control (PID) or as an Alarm.

** - This output is jumper and program selectable for either a current or voltage Linear DC output.

@ - These part numbers are equipped with a second setpoint.

¹ - Replacement Output Board RBD48100 may be used.

² - Replacement Output Board RBD48111 may be used.

T48 ACCESSORIES

MODEL	DESCRIPTION	PART NUMBERS
RLY	External SSR Power Unit (for Logic/SSR output models)	RLY50000
	Single Phase 25 A DIN Rail Mount Solid State Relay	RLY60000
	Single Phase 40 A DIN Rail Mount Solid State Relay	RLY6A000
	Three Phase DIN Rail Mount SSR	RLY70000
CT	40 Ampere Current Transformer (for Heater Current Input models)	CT004001
	50 Ampere Current Transformer (for Heater Current Input models)	CT005001
SFCRM	PC Configuration Software for Windows 98, ME, 2000 and XP (for RS485 models)	SFCRM
ICM4	RS232/RS485 Serial Converter Module	ICM40030
ICM5	Three Way Isolated RS232/RS485 Serial Converter	ICM50000

P48 PROCESS CONTROLLER ORDERING INFORMATION

Options and Output Boards are factory configured per the part number specified. Part numbers without replacement output boards listed must be returned to the factory for output board replacement.

All part numbers are software version V4.0 or greater. Models with Remote Setpoint Input, RS485, Main Analog Output or Second Analog Output include a second setpoint.

DEDICATED MAIN CONTROL O1 OUTPUT	MAIN CONTROL O1 OR A1 (ALARM 1)*	DEDICATED ALARM 1 A1 OUTPUT	A2 (ALARM 2) A2 OR O2 (SECOND) *	REMOTE SETPOINT INPUT@	RS485 @	MAIN ANALOG OUTPUT**@	SECOND ANALOG OUTPUT** @	PART NUMBERS		REPLACEMENT OUTPUT BOARD
								18 to 36 VDC/ 24 VAC	85 to 250 VAC	
						YES		P4800011	P4800001	N/A
Relay								P4810010	P4810000	RBD48100
	Relay		Relay			YES		P4810111	P4810101	N/A
	Relay		Relay	YES		YES		P4810115	P4810105	N/A
	Relay		Relay		YES	YES		P4810117	P4810107	N/A
	Relay		Relay			YES	YES	P481011A	P481010A	N/A
Relay		Relay	Relay					P4811110	P4811100	RBD48111
Relay		Relay	Relay		YES			P4811112	P4811102	RBD48111

* - This output is programmable as either Control (PID) or as an Alarm.

** - These part numbers are jumper and program selectable for either a current or voltage Linear DC output.

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P48 ACCESSORIES

MODEL	DESCRIPTION	PART NUMBERS
SFCRM	PC Configuration Software for Windows 98, ME, 2000 and XP (for RS485 models)	SFCRM
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LIMITED WARRANTY

The Company warrants the products it manufactures against defects in materials and workmanship for a period limited to two years from the date of shipment, provided the products have been stored, handled, installed, and used under proper conditions. The Company's liability under this limited warranty shall extend only to the repair or replacement of a defective product, at The Company's option. The Company disclaims all liability for any affirmation, promise or representation with respect to the products.

The customer agrees to hold Red Lion Controls harmless from, defend, and indemnify RLC against damages, claims, and expenses arising out of subsequent sales of RLC products or products containing components manufactured by RLC and based upon personal injuries, deaths, property damage, lost profits, and other matters which Buyer, its employees, or sub-contractors are or may be to any extent liable, including without limitation penalties imposed by the Consumer Product Safety Act (P.L. 92-573) and liability imposed upon any person pursuant to the Magnuson-Moss Warranty Act (P.L. 93-637), as now in effect or as amended hereafter.

No warranties expressed or implied are created with respect to The Company's products except those expressly contained herein. The Customer acknowledges the disclaimers and limitations contained and relies on no other warranties or affirmations.

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