USER MANUAL

TEC-2500

Self-Tune PID
Process Temperature Controller

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Warning Symbol ⚠

This symbol calls attention to an operating procedure, practice, or the like which, if not correctly performed or adhered to, could result in personal injury or damage to or destruction of part or all of the product and system. Do not proceed beyond a warning symbol until the indicated conditions are fully understood and met.

NOTE:

It is strongly recommended that a process should incorporate a LIMIT CONTROL like TEC-910 which will shut down the equipment at a preset process condition in order to preclude possible damage to products or system.

Information in this user's manual is subject to change without notice.

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Chapter 1 Overview
1–1 Features

Unique Features

** High accuracy 18-bit input A–D
** High accuracy 15-bit output D–A
** Fast input sample rate (5 times/second)
** Two function complexity levels
** User menu configurable
** Pump control

Features

* Fuzzy plus PID microprocessor-based control
* Automatic programming
* Differential control
* Auto-tune function
* Self-tune function
* Sleep mode function
* "Soft-start" ramp and dwell timer
* Programmable inputs(thermocouple, RTD, mA, VDC)
* Analog input for remote set point and CT
* Event input for changing function and set point
* Programmable digital filter
* Hardware lockout and remote lockout protection
* Loop break alarm
* Heater break alarm
* Sensor break alarm and bumpless transfer
* RS-485, RS-232 communication
* Analog retransmission
* Signal conditioner DC power supply
* A wide variety of output modules available
* Safety UL/IEC1010–1
* EMC/CE EN61326
* Front panel sealed to NEMA 4X and IP65

TEC-2500 Fuzzy Logic plus PID microprocessor-based controller incorporates a bright, easy to read, 4-digit LED display which indicates the process value. Fuzzy Logic technology enables a process to reach a predetermined set point in the shortest time, with the minimum of overshoot during power-up or external load disturbance. The units are housed in a 1/32 DIN case, measuring 24mm x 48mm with 98mm behind-panel depth. The units feature three touch keys to select the various control and input parameters. Using a unique function, you can put up to five parameters at the front of the user menu by using SEL1 to SEL5 found in the setup menu. This is particularly useful to OEM's as it is easy to configure the menu to suit the specific application.

TEC-2500 is powered by 11–26 or 90–264VDC/AC supply, incorporating a 2 amp control relay output, 5V logic alarm output and a 2 amp alarm relay output as standard with a second alarm that can be configured in the second output for cooling purposes or as a dwell timer. Alternative output options include SSR drive, triac, 4–20mA and 0–10 volts. TEC-2500 is fully programmable for PT100, thermocouple types J, K, T, E, B, R, S, N, L, 0–20mA, 4–20mA, and voltage signal input, with no need to modify the unit. The input signals are digitized by using an 18-bit A to D converter. Its fast sampling rate allows the TEC-2500 to control fast processes such as pressure and flow. Self-tuning is incorporated. Self-tuning can be used to optimize the control parameters as soon as undesired control results are observed. Unlike auto-tuning, self-tuning will produce less disturbance to the process during tuning, and can be used at any time.

Digital communications formats RS-485, RS-232 or 4–20mA retransmission are available as an additional option. These options allow the TEC-2500 to be integrated with supervisory control systems and software, or alternatively to drive remote displays, chart recorders, or data loggers.

Two different methods can be used to program the TEC-2500.
1. Use the keys on the front panel to program the unit manually or
2. use a PC with setup software to program the unit via the RS-485 or RS-232 COMM port.

For nearly a hundred years, PID control has been used and has proven to be an efficient controlling method by many industries, yet PID has difficulty dealing with some sophisticated systems such as second and higher order systems, long time-lag systems, during set point changes and/or load disturbances, etc. The PID principle is based on a mathematical model which is obtained by tuning the process. Unfortunately, many systems are too complex to describe precisely in numerical terms. In addition, these systems may vary from time to time. In order to overcome the imperfections of PID control, Fuzzy Logic was introduced.

What is Fuzzy Control? It works like a good driver. Under different speeds and circumstances, he can control a car well based on previous experience, and does not require knowledge of the kinetic theory of motion. Fuzzy Logic is a linguistic control which is different from numerical PID control. It controls the system by experience and does not need to simulate the system precisely as a PID controller would.

PID + FUZZY CONTROL

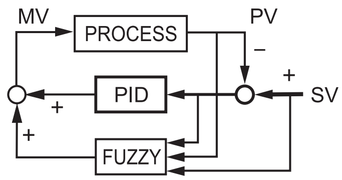
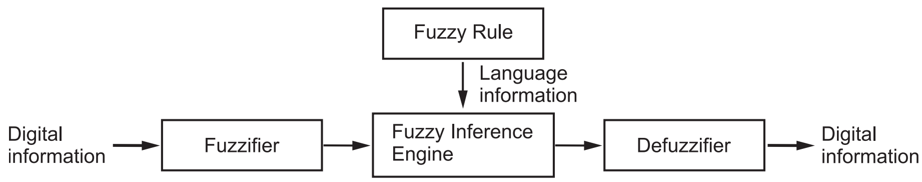


Figure 1.1
Fuzzy PID System Block



The function of Fuzzy Logic is to adjust PID parameters internally in order to make manipulation of output value MV more flexible and adaptive to various processes.

The Fuzzy Rule may work like this:
If the temperature difference is large, and the temperature rate is large, then ≠MV is large.
If the temperature difference is large, and the temperature rate is small, then ≠MV is small.

PID+Fuzzy Control has been proven to be an efficient method to improve the control stability as shown by the comparison curves below:

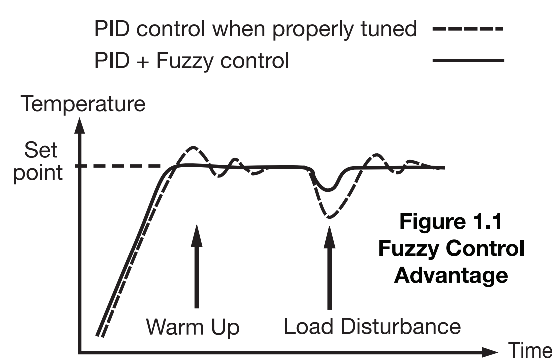


Figure 1.1
Fuzzy Control
Advantage

1–2 Hardware Code

TEC-2500 - □ □ □ □ □ □ □

1 2 3 4 5 6 7

1 — Power Input

4: 90 - 264 VAC, 50/60 HZ
5: 11 - 26 VAC or VDC

2 — Signal Input

1: Standard Input
Input 1 - Universal Input
Thermocouple: J, K, T, E, B, R, S, N, L
RTD: PT100 DIN, PT100 JIS
Current: 4 - 20mA, 0 - 20 mA.
Voltage: 0 - 1V, 0 - 5V, 1 - 5V, 0 - 10V
Input 2 - **
CT: 0 - 50 Amp. AC Current Transformer ***
Voltage Input: 0 - 1V, 0 - 5V, 1 - 5V, 0 - 10V.
Event Input (EI)

9: Special Order

3 — Output 1

0: None
1: Relay rated 2A/240VAC
2: Pulsed voltage to drive SSR, 5V/30mA
3: Isolated 4 - 20mA / 0 - 20mA *
4: Isolated 1 - 5V / 0 - 5V *
5: Isolated 0 - 10V
6: Triac Output 1A / 240VAC,SSR
9: Special order

4 — Output 2 / Alarm 2

0: None
1: Form A Relay 2A/240VAC
2: Pulsed voltage to drive SSR, 5V / 30mA
3: Isolated 4 - 20mA / 0 - 20mA *
4: Isolated 1 - 5V / 0 - 5V *
5: Isolated 0 - 10V
6: Triac Output, 1A / 240VAC, SSR
7: Isolated 20V / 25mA DC Output Power Supply
8: Isolated 12V / 40 mA DC Output Power Supply
9: Isolated 5V / 80mA DC Output Power Supply
A: Special order

5 — Alarm 1

1: 5V Logic Output
9: Special order

6 — Communications

0: None
1: RS-485
2: RS-232 **
3: Retransmit 4-20mA/0-20mA *
4: Retransmit 1 - 5V / 0 - 5V *
5: Retransmit 0 - 10V
9: Special order

7 — Units-°F or °C

1: °F on faceplate
2: °C on faceplate

*** Range set by front keyboard**
**** Alternative between RS-232 and Input 2**
***** Need to order accessory TEC99999 if Heater Break detection is required.**

Example

TEC-2500-411111

- 90 – 264 operating voltage
- Input: Standard Input
- Output 1: Relay
- Output 2: Relay
- Alarm 1: 5V Logic Output
- RS- 485 Communication Interface

Accessories

TEC99014 — RS-232 interface cable (2M)
TEC99999 — 0–50amp AC current transformer

Related Products

TEC99001 — Smart network adapter for third party software; converts 255 channels of RS-485 or RS-422 to RS-232 network
TEC99002 — Smart network adapter for DAQ (TEC99923) software; converts 255 channels of RS-485 or RS-422 to RS-232 network
TEC99927 — RS-232/485 ->USB Adapter

1–3 Programming Port and DIP Switch

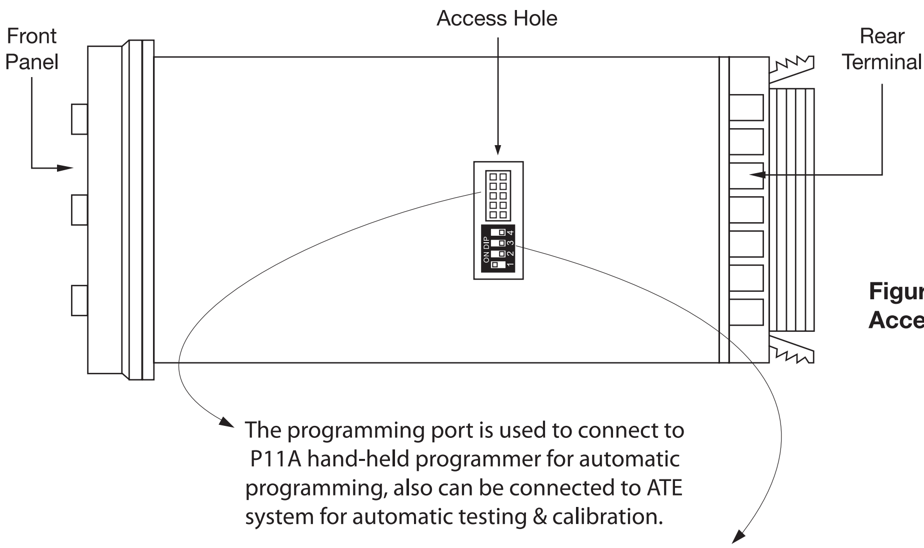


Figure 1.3
Access Hole Overview

		DIP Switch ■ :ON □ :OFF 1	2	3	4
Input 1 Select	TC, RTD, mV	■	□		
	0-1V, 0-5V, 1-5V, 0-10V	□	■		
	0-20 mA, 4-20 mA	■	■		
Lockout	All parameters are Unlocked			□	□
	Only SP1, SEL1 – SEL5* are unlocked			■	□
	Only SP1 is unlocked			□	■
	All Parameters are locked			■	■

Factory Default Setting	■	□	□	□

Table 1.1
DIP Switch Configuration

The programming port is used for off-line automatic setup and testing procedures only. Do not attempt to make any connection to these pins when the unit is being used for normal control purposes.

When the unit leaves the factory, the DIP switch is set so that TC and RTD are selected for input 1 and all parameters are unlocked.

Lockout function is used to disable the adjustment of parameters as well as operation of calibration mode. However, the menu can still be viewed even under lockout condition.

*SEL1-SEL5 represent those parameters which are selected by using SEL1, SEL2,...SEL5 parameters contained in the setup menu. The parameters that have been selected are then allocated at the beginning of the user menu.

1–4 Keys and Displays

The unit is programmed by using the three keys on the front panel.
The available key functions are listed in the following table.

Table 1.2 Keypad Operation

TOUCHKEYS	FUNCTION	DESCRIPTION
	Up Key	Press and release quickly to increase the value of parameter. Press and hold to accelerate increment speed.
	Down Key	Press and release quickly to decrease the value of parameter. Press and hold to accelerate decrement speed.
	Scroll Key	Scrolls through the parameters in order.
Press for at least 3 seconds	Enter Key	Allows access to more parameters on user menu, also used to enter manual mode, auto-tune mode, default setting mode, and to save calibration data during calibration procedure.
Press for at least 6 seconds	Start Record Key	Resets historical values of PVHI and PVLO. Used to record historical high and low process values.
Press	Reverse Scroll Key	Scrolls through the parameters in reverse order during menu scrolling.
Press	Mode Key	Selects the operation mode in sequence.
Press	Reset Key	Resets the front panel display to normal display mode, also used to leave the specific mode execution, to end auto-tune and manual control execution, and to quit sleep mode.
Press for at least 3 seconds	Sleep Key	The controller enters sleep mode if the sleep function (SLEP) is enabled (select YES).

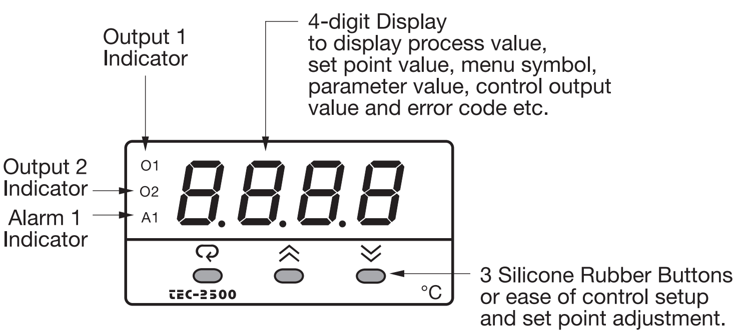


Figure 1.4 Front Panel Description

Table 1.3 Display Form of Characters

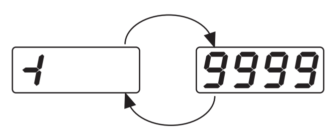
A		E		I		N		S		X	
B		F		J		O		T		Y	
C		G		K		P		U		Z	
c		H		L		Q		V		?	
D		h		M		R		W		=	

◤Indicates Abstract Characters

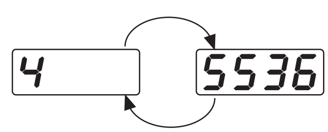
How to display a 5-digit number:
For a number with a decimal point, the display will be shifted one digit to the right:
-199.99 will be displayed as -199.9
4553.6 will be displayed as 4553

For a number without a decimal point, the display will be divided into two alternating phases:

-19999 will be displayed by:



45536 will be displayed by:



-9999 will be displayed by:

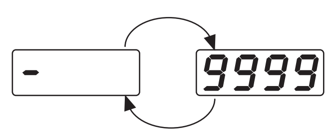
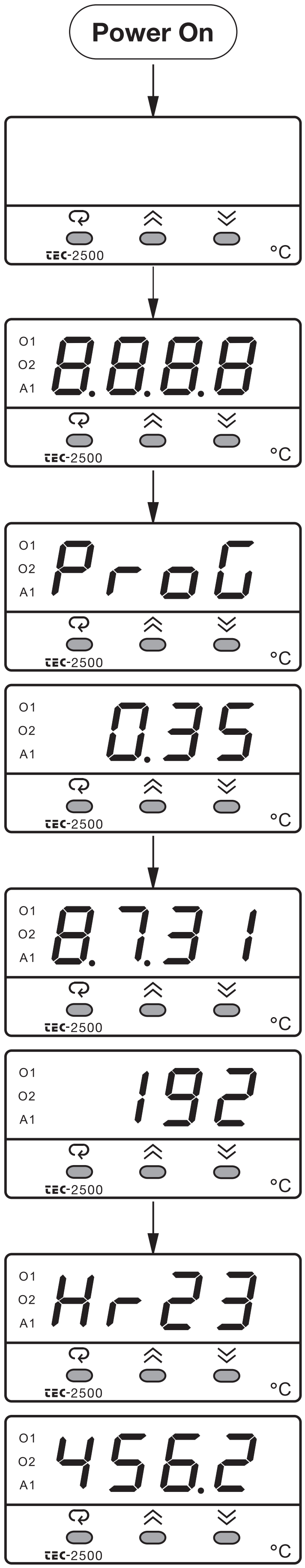


Figure 1.5 Display Sequence of Initial Message



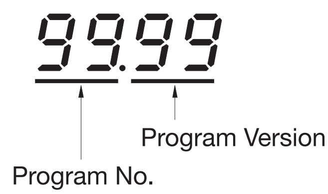
All segments of display and indicators are left off for 0.5 second.

All segments of display and indicators are lit for 2 seconds.

Display program code of the product for 2.5 seconds.
Each display stays for 1.25 seconds

The left diagram shows program no. 0 (for TEC-2500) with version 35.

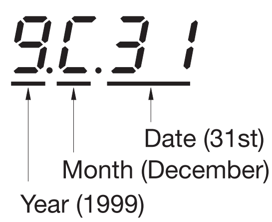
Program Code



Display Date Code and Serial number for 2.5 seconds.
Each display stays for 1.25 seconds

The left diagram shows Year 1998, Month July (7), Date 31st and Serial Number 192. This means that the product is the 192nd unit produced on July 31st, 1998.
Note that the month code **A** stands for **October**, **B** stands for **November** and **C** stands for **December**.

Date Code

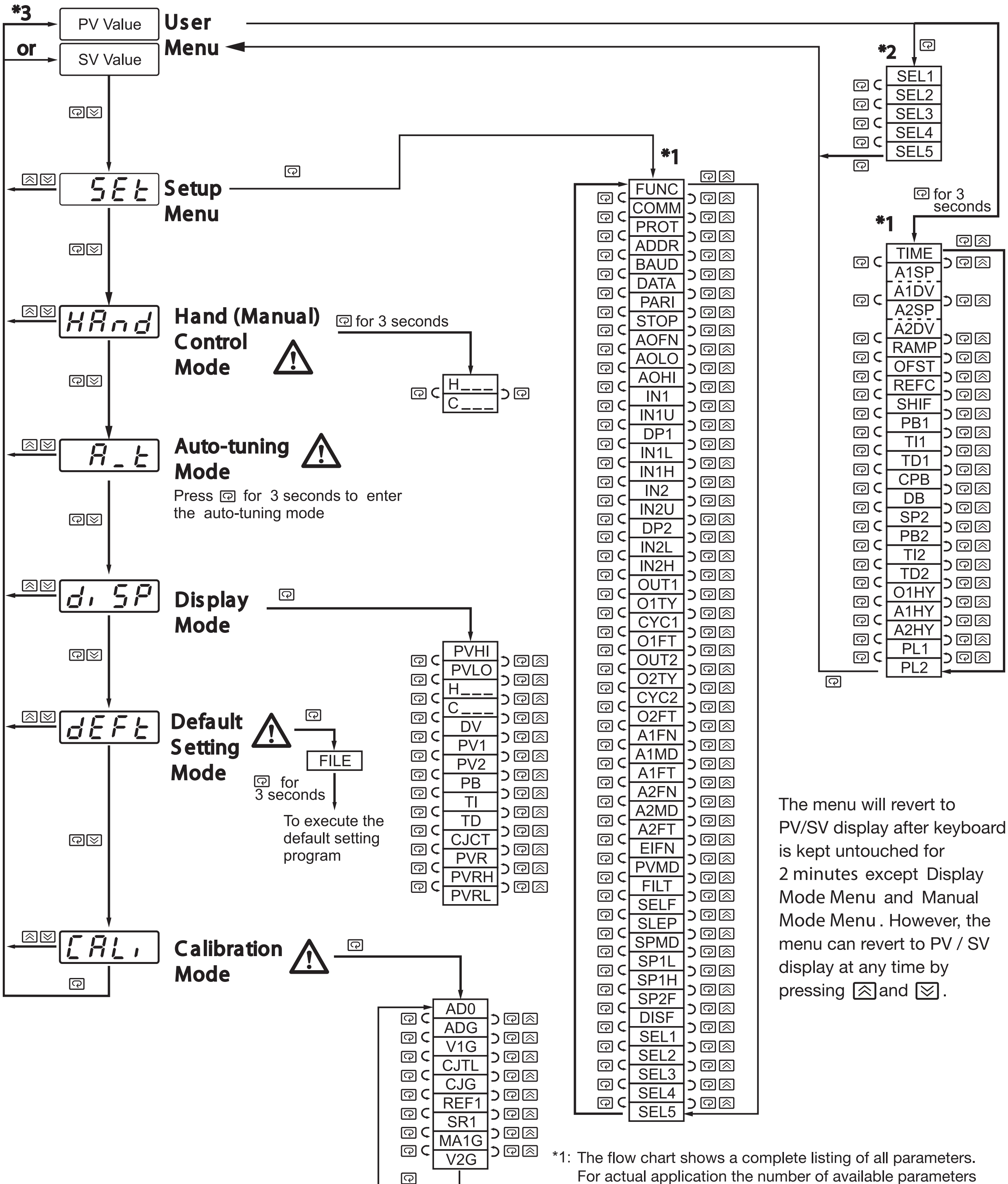


Display the used hours for 2.5 seconds.

The 6-digit number of hour is indicated by two successive displays and each one stays for 1.25 seconds.

The left diagram shows that the unit has been used for 23456.2 hours since production.

1–5 Menu Overview



The menu will revert to PV/SV display after keyboard is kept untouched for 2 minutes except Display Mode Menu and Manual Mode Menu. However, the menu can revert to PV / SV display at any time by pressing ⌃ and ⌄.

*1: The flow chart shows a complete listing of all parameters. For actual application the number of available parameters depends on setup conditions, and should be less than that shown in the flow chart. See **Appendix A-1** for the existence conditions of each parameter.

*2: You can select at most 5 parameters put in front of the user menu by using SEL1 to SEL5 contained at the bottom of setup menu.

*3: Set DISF (display format) value in the setup menu to determine whether PV or SV is displayed.

⚠ Apply these modes will break the control loop and change some of the previous setting data. Make sure that if the system is allowable to use these modes.

1–6 System Modes

The controller performs closed loop control in its normal control mode condition. The controller will maintain its normal control mode when you are operating the user menu, setup menu, or display mode, reloading default values, or applying event input signals. Under certain conditions, the normal control mode will transfer to an exception mode. The exception modes include: sleep mode, manual mode, failure mode, calibration mode, and auto-tuning mode. All of these modes perform in an open loop control except auto-tuning mode which performs ON-OFF plus PID closed loop control. The mode transfer is governed by the priority conditions. A lower priority mode can not alter a higher priority mode, as shown in figure 1.6.

System Modes
Sleep mode:
See section 4-11.
Manual mode:
See section 3-23.
Failure mode:
See section 3-17.
Calibration mode:
See chapter 6.
Auto-tuning mode:
See section 3-20.
Normal control mode:
See section 3-24, 3-26, 4-1

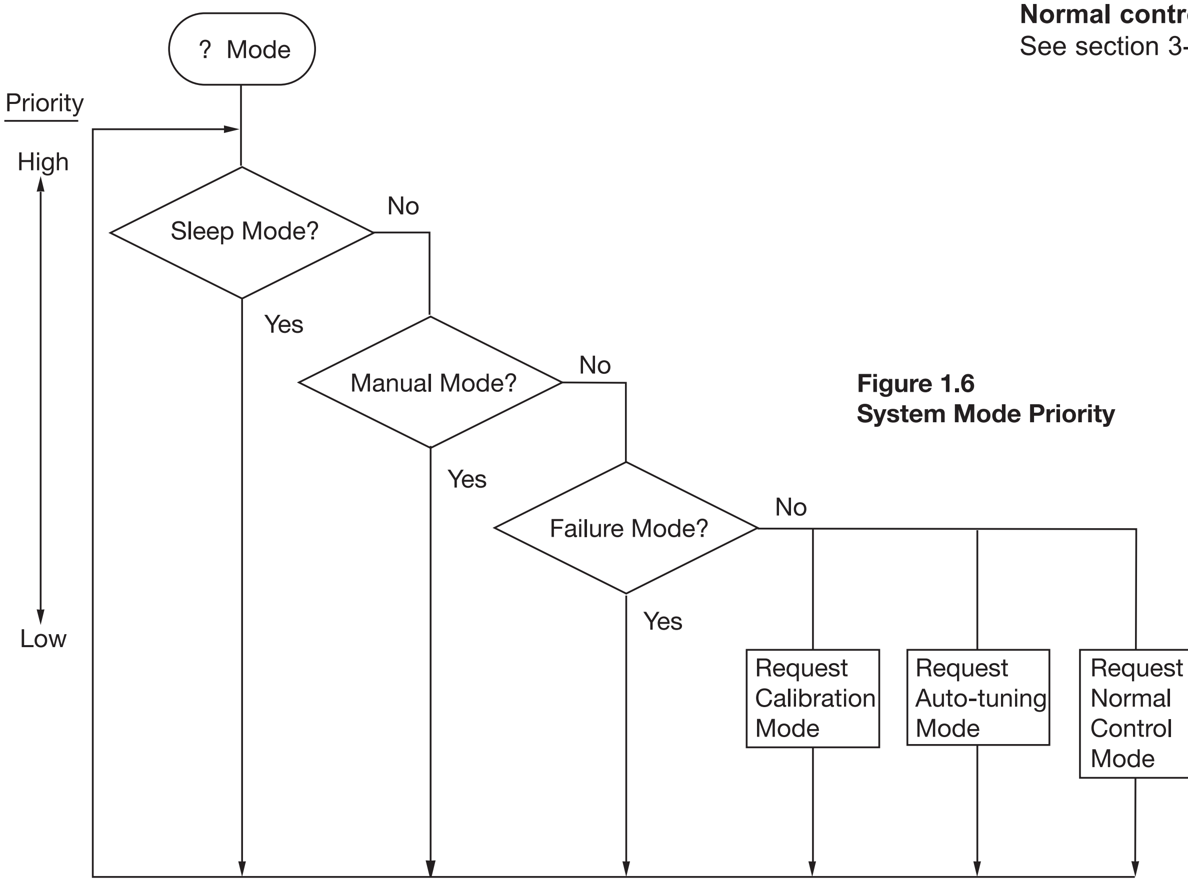


Figure 1.6
System Mode Priority

Calibration mode, auto-tuning mode, and normal control mode are in the same priority level. Sleep mode is in the highest priority level.

1–7 Parameter Description

Parameter values can easily be recorded in Chart A-5 on page 93

Table 1.4 Parameter Description (page 1 of 7)

Contained In	Basic Function	Parameter Notation	Display Format	Parameter Description	Range	Default Value
User Menu	✓	SP1		Set point 1	Low: SP1L High: SP1H	212.0°F (100.0°C)
	✓	TIME	timE	Dwell Time	Low: 0 High: 6553.5 minutes	0.0
	✓	A1SP	A1SP	Alarm 1 Set point	See Table 1.5, 1.6	212.0°F (100.0°C)
	✓	A1DV	A1dV	Alarm 1 Deviation Value	Low: -360.0°F (-200.0°C) High: 360.0°F (200.0°C)	18.0°F (10.0°C)
	✓	A2SP	A2SP	Alarm 2 Set point	See Table 1.5, 1.7	212.0°F (100.0°C)
	✓	A2DV	A2dV	Alarm 2 Deviation Value	Low: -360.0°F (-200.0°C) High: 360.0°F (200.0°C)	18.0°F (10.0°C)
		RAMP	rAmP	Ramp Rate	Low: 0 High: 900.0°F (500.0°C)	0.0
	✓	OFST	oFSt	Offset Value for P control	Low: 0 High: 100.0 %	25.0
		REFC	rEFC	Reference Constant for Specific Function	Low: 0 High: 60	2
	✓	SHIF	SHiF	PV1 Shift (offset) Value	Low: -360.0°F (-200.0°C) High: 360.0°F (200.0°C)	0.0
	✓	PB1	Pb1	Proportional Band 1 Value	Low: 0 High: 900.0°F (500.0°C)	18.0°F (10.0°C)
	✓	TI1	ti1	Integral Time 1 Value	Low: 0 High: 1000 sec	100
	✓	TD1	td1	Derivative Time 1 Value	Low: 0 High: 360.0 sec	25.0
	✓	CPB	C.Pb	Cooling Proportional Band Value	Low: 1 High: 255%	100
	✓	DB	db	Heating-Cooling Dead Band Negative Value= Overlap	Low: -36.0 High: 36.0%	0
		SP2	SP2	Set point 2	See Table 1.5, 1.8	100.0°F (37.8°C)
		PB2	Pb2	Proportional Band 2 Value	Low: 0 High: 900.0°F (500.0°C)	18.0°F (10.0°C)
		TI2	ti2	Integral Time 2 Value	Low: 0 High: 1000 sec	100
		TD2	td2	Derivative Time 2 Value	Low: 0 High: 360.0 sec	25.0
	✓	O1HY	o1HY	Output 1 ON-OFF Control Hysteresis	Low: 0.1 High: 100.0°F (55.6°C)	0.1
	✓	A1HY	A1HY	Hysteresis Control of Alarm 1	Low: 0.1 High: 18.0°F (10.0°C)	0.1
	✓	A2HY	A2HY	Hysteresis Control of Alarm 2	Low: 0.1 High: 18.0°F (10.0°C)	0.1
		PL1	PL1	Output 1 Power Limit (page 63)	Low: 0 High: 100%	100
		PL2	PL2	Output 2 Power Limit (page 63)	Low: 0 High: 100%	100
Setup Menu	✓	FUNC	FunC	Function Complexity Level (page 31)	0 bASC : Basic Function Mode 1 FuLL : Full Function Mode	1
		COMM	Comm	Communication Interface Type (page 64 & 65)	0 nonE : No communication function 1 485 : RS-485 interface (page 28 & 80) 2 232 : RS-232 interface (page 29 & 81) 3 4-20 : 4 - 20 mA analog retransmission output 4 0-20 : 0 - 20 mA analog retransmission output 5 0-1V : 0 - 1V analog retransmission output 6 0-5V : 0 - 5V analog retransmission output 7 1-5V : 1 - 5V analog retransmission output 8 0-10 : 0 - 10V analog retransmission output	1
		PROT	Prot	COMM Protocol Selection	0 rtu : Modbus protocol RTU mode	0

Continued…

Table 1.4 Parameter Description (page 2 of 7)

Contained In	Basic Function	Parameter Notation	Display Format	Parameter Description	Range	Default Value
Setup Menu		ADDR	Addr	Address Assignment of Digital COMM	Low: 1 High: 255	—
		BAUD	bAud	Baud Rate of Digital COMM	0 0.3 : 0.3 Kbits/s baud rate 1 0.6 : 0.6 Kbits/s baud rate 2 1.2 : 1.2 Kbits/s baud rate 3 2.4 : 2.4 Kbits/s baud rate 4 4.8 : 4.8 Kbits/s baud rate 5 9.6 : 9.6 Kbits/s baud rate 6 14.4 : 14.4 Kbits/s baud rate 7 19.2 : 19.2 Kbits/s baud rate 8 28.8 : 28.8 Kbits/s baud rate 9 38.4 : 38.4 Kbits/s baud rate	5
		DATA	dAtA	Data Bit count of Digital COMM	0 7bit : 7 data bits 1 8bit : 8 data bits	1
		PARI	PAri	Parity Bit of Digital COMM	0 EvEn : Even parity 1 odd : Odd parity 2 nonE : No parity bit	0
		STOP	StoP	Stop Bit Count of Digital COMM	0 1bit : One stop bit 1 2bit : Two stop bits	0
		AOFN	Ao.Fn	Analog Output Function	0 PV1 : Retransmit IN1 process value 1 PV2 : Retransmit IN2 process value 2 P1-2 : Retransmit IN1 −IN2 difference process value 3 P2-1 : Retransmit IN2 −IN1 difference process value 4 SV : Retransmit set point value 5 MV1 : Retransmit output 1 manipulation value 6 MV2 : Retransmit output 2 manipulation value 7 dV : Retransmit deviation(PV-SV) Value	0
		AOLO	Ao.Lo	Analog Output Low Scale Value	Low: -19999 High: 45536	32.0°F (0°C)
		AOHI	Ao.Hi	Analog Output High Scale Value	Low: -19999 High: 45536	212.0°F (100.0°C)
	✓	IN1	in1	IN1 Sensor Type Selection (page 31 & 32)	0 J_tC : J type thermocouple 1 K_tC : K type thermocouple 2 t_tC : T type thermocouple 3 E_tC : E type thermocouple 4 b_tC : B type thermocouple 5 r_tC : R type thermocouple 6 S-tC : S type thermocouple	1 (0)

NOTE: Parameter IN1 continued on next page

Table 1.4 Parameter Description (page 3 of 7)

Contained In	Basic Function	Parameter Notation	Display Format	Parameter Description	Range	Default Value	
Setup Menu	✓	IN1	in1	IN1 Sensor Type Selection (page 31 & 32)	7 n_tC: N type thermocouple 8 L-tC: L type thermocouple 9 Pt.dn: PT 100 ohms DIN curve 10 Pt.JS: PT 100 ohms JIS curve 11 4-20: 4 - 20 mA linear current input 12 0-20: 0 - 20 mA linear current input 13 0-1v: 0 - 1V linear Voltage input 14 0-5v: 0 - 5V linear Voltage input 15 1-5v: 1 - 5V linear Voltage input 16 0-10: 0 - 10V linear Voltage input 17 SPEC: Special defined sensor curve	1 (0)	
	✓	IN1U	in1u	IN1 Unit Selection	0 oC: Degree C unit 1 oF: Degree F unit 2 Pu: Process unit	0 (1)	
	✓	DP1	dP1	IN1 Decimal Point Selection	0 nodP: No decimal point 1 1-dP: 1 decimal digit 2 2-dP: 2 decimal digits 3 3-dP: 3 decimal digits	1	
	✓	IN1L	in1L	IN1 Low Scale Value	Low: -19999 High: 45536	0	*
	✓	IN1H	in1H	IN1 High Scale Value	Low: -19999 High: 45536	1000	*
		IN2	in2	IN2 Signal Type Selection	0 nonE: IN2 no function 1 Ct: Current transformer input 4 0-1v: 0 - 1V linear voltage input 5 0-5v: 0 - 5V linear voltage input 6 1-5v: 1 - 5V linear voltage input 7 0-10: 0 - 10V linear voltage input 20 Ei.Fn: Perform Event input function	1	
		IN2U	in2u	IN2 Unit Selection	Same as IN1U	2	
		DP2	dP2	IN2 Decimal Point Selection	Same as DP1	1	
		IN2L	in2L	IN2 Low Scale Value	Low: -19999 High: 45536	0	
		IN2H	in2H	IN2 High Scale Value	Low: -19999 High: 45536	1000	
	✓	OUT1	out1	Output 1 Function	0 rEvr: Reverse (heating) control action 1 dirt: Direct (cooling) control action	0	
	✓	O1TY	o1tY	Output 1 Signal Type (page 32)	0 rELY: Relay output 1 SSrd: Solid state relay drive output 2 SSr: Solid state relay output 3 4-20: 4 - 20 mA current module	0	

NOTE: Parameter O1TY continued on next page

**** Not Present for Thermocouple or RTD Input***

Continued…

Table 1.4 Parameter Description (page 4 of 7)

Contained In	Basic Function	Parameter Notation	Display Format	Parameter Description	Range	Default Value
	✓	O1TY	o1tY	Output 1 Signal Type (page 32)	4 0-20 : 0 - 20 mA current module 5 0-1v : 0 - 1V voltage module 6 0-5v : 0 - 5V voltage module 7 1-5v : 1 - 5V voltage module 8 0-10 : 0 - 10V voltage module	0
	✓	CYC1	CYC1	Output 1 Cycle Time	Low: 0.1 High: 100.0 sec	18.0
	✓	O1FT	o1Ft	Output 1 Failure Transfer Mode	Select BPLS (bumpless transfer) or 0.0 ~ 100.0 % to continue output 1 control function as the unit fails, power starts or manual mode starts.	0.0
	✓	OUT2	out2	Output 2 Function	0 nonE : Output 2 no function 1 CooL : PID cooling control 2 =AL2 : Perform alarm 2 function 3 dCPS : DC power supply module installed	0
	✓	O2TY	o2tY	Output 2 Signal Type	Same as O1TY	0
	✓	CYC2	CYC2	Output 2 Cycle Time	Low: 0.1 High: 100.0 sec	18.0
	✓	O2FT	o2Ft	Output 2 Failure Transfer Mode	Select BPLS (bumpless transfer) or 0.0 ~ 100.0 % to continue output 2 control function as the unit fails, power starts or manual mode starts.	BPLS
Setup Menu	✓	A1FN	A1Fn	Alarm 1 Function (page 38)	0 nonE : No alarm function 1 tImr : Dwell timer action (page 37, 60, 74) 2 dE.HI : Deviation high alarm 3 dE.Lo : Deviation low alarm 4 db.HI : Deviation band out of band alarm 5 db.Lo : Deviation band in band alarm 6 Pv1.H : IN1 process value high alarm 7 Pv1.L : IN1 process value low alarm 8 Pv2.H : IN2 process value high alarm 9 Pv2.L : IN2 process value low alarm 10 P1.2.H : IN1 or IN2 process value high alarm 11 P1.2.L : IN1 or IN2 process value low alarm 12 d1.2.H : IN1 – IN2 difference process value high alarm 13 d1.2.L : IN1 – IN2 difference process value low alarm 14 Lb : Loop break alarm 15 SEn.b : Sensor break or A-D fails	2
	✓	A1MD	A1md	Alarm 1 Operation Mode (page 38)	0 norm : Normal alarm action 1 LtcH : Latching alarm action 2 HoLd : Hold alarm action 3 Lt.Ho : Latching & Hold action	0

Table 1.4 Parameter Description (page 5 of 7)

Contained In	Basic Function	Parameter Notation	Display Format	Parameter Description	Range	Default Value
Setup Menu	✓	A1FT	A1.Ft	Alarm 1 Failure Transfer Mode	0 oFF : Alarm output OFF as unit fails 1 on : Alarm output ON as unit fails	1
	✓	A2FN	A2.Fn	Alarm 2 Function	Same as A1FN	2
	✓	A2MD	A2.Md	Alarm 2 Operation Mode	Same as A1MD	0
	✓	A2FT	A2.Ft	Alarm 2 Failure Transfer Mode	Same as A1FT	1
		EIFN	Ei.Fn	Event Input Function	0 nonE : Event input no function 1 SP2 : SP2 activated to replace SP1 2 Pid2 : PB2, TI2, TD2 activated to replace PB1, TI1, TD1 3 SP.P2 : SP2, PB2, TI2, TD2 activated to replace SP1, PB1, TI1, TD1 4 rS.A1 : Reset alarm 1 output 5 rS.A2 : Reset alarm 2 output 6 r.A1.2 : Reset alarm 1 & alarm 2 7 d.o1 : Disable Output 1 8 d.o2 : Disable Output 2 9 d.o1.2 : Disable Output 1 & Output 2 10 LocK : Lock All Parameters	1
		PVMD	PV.Md	PV Mode Selection	0 PV1 : Use PV1 as process value 1 PV2 : Use PV2 as process value 2 P1-2 : Use PV1 − PV2 (difference) as process value 3 P2-1 : Use PV2 − PV1 (difference) as process value	0
		FILT	FiLt	Filter Damping Time Constant of PV (page 66)	0 0 : 0 second time constant 1 0.2 : 0.2 second time constant 2 0.5 : 0.5 second time constant 3 1 : 1 second time constant 4 2 : 2 seconds time constant 5 5 : 5 seconds time constant 6 10 : 10 seconds time constant 7 20 : 20 seconds time constant 8 30 : 30 seconds time constant 9 60 : 60 seconds time constant	2
	✓	SELF	SELF	Self Tuning Function Selection	0 nonE : Self tune function disabled 1 YES : Self tune function enabled	0
		SLEP	SLEP	Sleep mode Function Selection	0 nonE : Sleep mode function disabled 1 YES : Sleep mode function enabled	0

Continued…

Table 1.4 Parameter Description (page 6 of 7)

Contained In	Basic Function	Parameter Notation	Display Format	Parameter Description	Range	Default Value
Setup Menu		SPMD	SP.nd	Set point Mode Selection	0 SP 1.2 : Use SP1 or SP2 (depends on EIFN) as set point 1 nin.r : Use minute ramp rate as set point 2 Hr.r : Use hour ramp rate as set point 3 PV 1 : Use IN1 process value as set point 4 PV2 : Use IN2 process value as set point 5 PunP : Selected for pump control	0
	✓	SP1L	SP 1.L	SP1 Low Value	Low: -19999 High: 45536	32.0°F (0°C)
	✓	SP1H	SP 1.H	SP1 High Value	Low: -19999 High: 45536	1832.0°F (1000.0°C)
		SP2F	SP2F	Format of set point 2 Value	0 ACtu : set point 2 (SP2) is an actual value 1 dEVi : set point 2 (SP2) is a deviation value	0
	✓	DISF	di SF	Display Format	0 PV : Display PV value 1 SV : Display SV value	0
	✓	SEL1	SEL 1	Select 1st Parameter (page 33)	0 nonE : No parameter put ahead 1 tinE : Parameter TIME put ahead 2 A1SP : Parameter A1SP put ahead 3 A1dV : Parameter A1DV put ahead 4 A2SP : Parameter A2SP put ahead 5 A2dV : Parameter A2DV put ahead 6 rAnP : Parameter RAMP put ahead 7 oFSt : Parameter OFST put ahead 8 rEFC : Parameter REFC put ahead 9 SHiF : Parameter SHIF put ahead 10 Pb 1 : Parameter PB1 put ahead 11 ti 1 : Parameter TI1 put ahead 12 td 1 : Parameter TD1 put ahead 13 C.Pb : Parameter CPB put ahead 14 db : Parameter DB put ahead 15 SP2 : Parameter SP2 put ahead 16 Pb2 : Parameter PB2 put ahead 17 ti 2 : Parameter TI2 put ahead 18 td2 : Parameter TD2 put ahead	0
	✓	SEL2	SEL 2	Select 2nd Parameter	Same as SEL1	0
	✓	SEL3	SEL 3	Select 3rd Parameter	Same as SEL1	0
	✓	SEL4	SEL 4	Select 4th Parameter	Same as SEL1	0
	✓	SEL5	SEL 5	Select 5th Parameter	Same as SEL1	0
Calibration Mode Menu	✓	AD0	Ad0	A to D Zero Calibration Coefficient	Low: -360 High: 360	—
	✓	ADG	AdG	A to D Gain Calibration Coefficient	Low: -199.9 High: 199.9	—
	✓	V1G	V 1.G	Voltage Input 1 Gain Calibration Coefficient	Low: -199.9 High: 199.9	—
	✓	CJTL	CJt.L	Cold Junction Low Temperature Calibration Coefficient	Low: -5.00°C High: 40.00°C	—

Table 1.4 Parameter Description (page 7 of 7)

Contained In	Basic Function	Parameter Notation	Display Format	Parameter Description	Range	Default Value
Calibration Mode Menu	✓	CJG	CJ.G	Cold Junction Gain Calibration Coefficient	Low: -199.9 High: 199.9	—
	✓	REF1	rEF. 1	Reference Voltage 1 Calibration Coefficient for RTD 1	Low: -199.9 High: 199.9	—
	✓	SR1	Sr. 1	Serial Resistance 1 Calibration Coefficient for RTD 1	Low: -199.9 High: 199.9	—
	✓	MA1G	nA 1.G	mA Input 1 Gain Calibration Coefficient	Low: -199.9 High: 199.9	—
	✓	V2G	u2.G	Voltage Input 2 Gain Calibration Coefficient	Low: -199.9 High: 199.9	—
Display Mode Menu	✓	PVHI	Pu.Hi	Historical Maximum Value of PV	Low: -19999 High: 45536	—
	✓	PVLO	Pu.Lo	Historical Minimum Value of PV	Low: -19999 High: 45536	—
	✓	MV1	H_ _ _	Current Output 1 Value	Low: 0 High: 100.00%	—
	✓	MV2	C_ _ _	Current Output 2 Value	Low: 0 High: 100.00%	—
	✓	DV	du	Current Deviation (PV-SV) Value	Low: -12600 High: 12600	—
	✓	PV1	Pu 1	IN1 Process Value	Low: -19999 High: 45536	—
	✓	PV2	Pu2	IN2 Process Value	Low: -19999 High: 45536	—
	✓	PB	Pb	Current Proportional Band Value	Low: 0 High: 900.0°F (500.0°C)	—
	✓	TI	ti	Current Integral Time Value	Low: 0 High: 4000 sec	—
	✓	TD	td	Current Derivative Time Value	Low: 0 High: 1440 sec	—
	✓	CJCT	CJCt	Cold Junction Compensation Temperature	Low: -40.00°C High: 90.00°C	—
	✓	PVR	Pur	Current Process Rate Value	Low: -16383 High: 16383	—
	✓	PVRH	Pur.H	Maximum Process Rate Value	Low: -16383 High: 16383	—
	✓	PVRL	Pur.L	Minimum Process Rate Value	Low: -16383 High: 16383	—

Table 1.5 Input (IN1 or IN2) Range

Input Type	J_TC	K_TC	T_TC	E_TC	B_TC	R_TC	S_TC
Range Low	-120°C (-184°F)	-200°C (-328°F)	-250°C (-418°F)	-100°C (-148°F)	0°C (32°F)	0°C (32°F)	0°C (32°F)
Range High	1000°C (1832°F)	1370°C (2498°F)	400°C (752°F)	900°C (1652°F)	1820°C (3308°F)	1767.8°C (3214°F)	1767.8°C (3214°F)

Input Type	N_TC	L_TC	PT.DN	PT.JS	CT	Linear (V, mA) or SPEC
Range Low	-250°C (-418°F)	-200°C (-328°F)	-210°C (-346°F)	-200°C (-328°F)	0 Amp	-19999
Range High	1300°C (2372°F)	900°C (1652°F)	700°C (1292°F)	600°C (1112°F)	90 Amp	45536

Table 1.6 Range Determination for A1SP

If A1FN =	PV1.H, PV1.L	PV2.H,PV2.L	P1.2.H, P1.2.L D1.2.H, D1.2.L
Range of A1SP same as range of	IN1	IN2	IN1, IN2

Table 1.7 Range Determination for A2SP

If A2FN =	PV1.H, PV1.L	PV2.H,PV2.L	P1.2.H, P1.2.L D1.2.H, D1.2.L
Range of A2SP same as range of	IN1	IN2	IN1, IN2

Table 1.8 Range Determination for SP2

If PVMD =	PV1	PV2	P1−2, P2−1
Range of SP2 same as range of	IN1	IN2	IN1, IN2

Exception: If any of A1SP, A2SP or SP2 is configured with respect to CT input, its adjustment range is unlimited.

Chapter 2 Installation

Dangerous voltage capable of causing death can be present in this instrument. Before installation or beginning any troubleshooting procedures, the power to all equipment must be switched off and isolated. Units suspected of being faulty must be disconnected and removed to a properly equipped workshop for testing and repair. Component replacement and internal adjustments must be made by a qualified maintenance person only.

To minimize the possibility of fire or shock hazards, do not expose this instrument to rain or excessive moisture.

Do not use this instrument in areas under hazardous conditions such as excessive shock, vibration, dirt, moisture, corrosive gases, or oil. The ambient temperature of the areas should not exceed the maximum rating specified in chapter 8.

2–1 Unpacking

Upon receipt of the shipment, remove the unit from the carton and inspect the unit for shipping damage.
If there is any damage due to transit, report the damage and file a claim with the carrier.
Write down the model number and serial number for future reference when corresponding with our service center. The serial number (S/N) is located on the box and the housing of the controller.

2–2 Mounting

Make the panel cutout to fit the dimensions shown in figure 2.1.

Insert the controller into the panel cutout. Reinstall the mounting clamps. Slide the mounting collar over the control and push until tight.

An alternate installation method (shown below) is to gently tighten the screws in the clamp until the controller front panel fits snugly in the cutout.

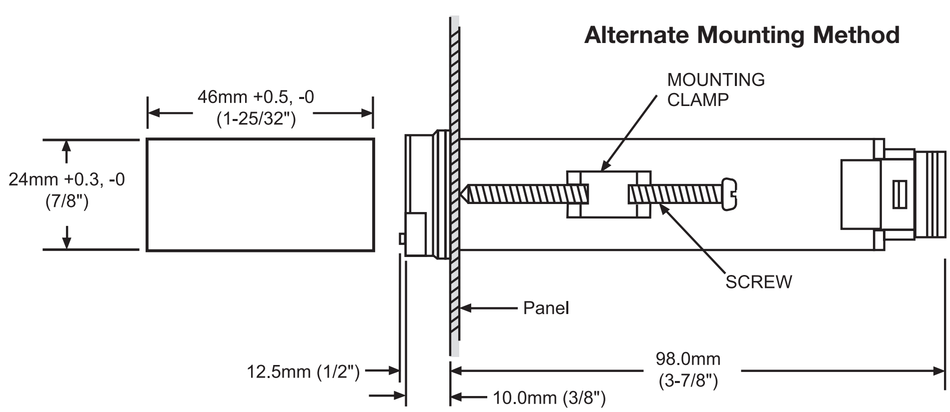


Figure 2.1 Mounting Dimensions

2–3 Wiring Precautions

- Before wiring, verify the correct model number and options on the label. Switch off the power while checking.
- Care must be taken to ensure that the maximum voltage rating specified on the label is not exceeded.
- It is recommended that the power for these units be protected by fuses or circuit breakers rated at the minimum value possible.
- All units should be installed in a suitable enclosure to prevent live parts from being accessible to human hands and metal tools. Metal enclosures and/or subpanels should be grounded in accordance with national and local codes.
- All wiring must conform to appropriate standards of good practice and local codes and regulations. Wiring must be suitable for the voltage, current, and temperature rating of the system.
- Beware not to over-tighten the terminal screws. The torque should not exceed 1 N-m (8.9 lb-in or 10 KgF-cm).
- Unused control terminals should not be used as jumper points as they may be internally connected, causing damage to the unit.
- Verify that the ratings of the output devices and the inputs as specified are not exceeded.
- Except for thermocouple wiring, all wiring should use stranded copper conductor with a maximum gage of 14 AWG.
- Electrical power in industrial environments contains a certain amount of noise in the form of transient voltage and spikes. This electrical noise can adversely affect the operation of microprocessor-based controls. For this reason the use of shielded thermocouple extension wire which connects the sensor to the controller is strongly recommended. This wire is a twisted-pair construction with foil wrap and drain wire. The drain wire is to be attached to ground in the control panel only.

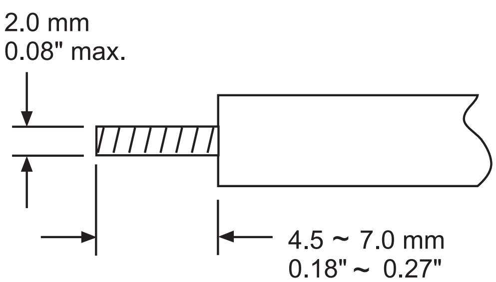


Figure 2.2 Lead Termination

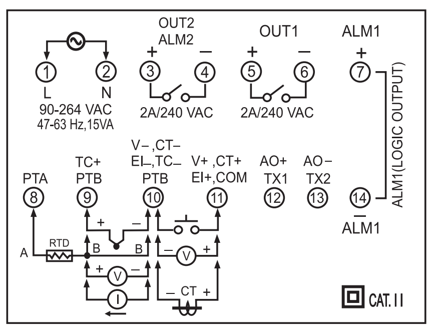


Figure 2.3 Rear Terminal Connection Diagram

2–4 Power Wiring

The controller is supplied to operate at 11–26VAC/VDC or 90–264VAC. Check that the installation voltage corresponds to the power rating indicated on the product label before connecting power to the controller.

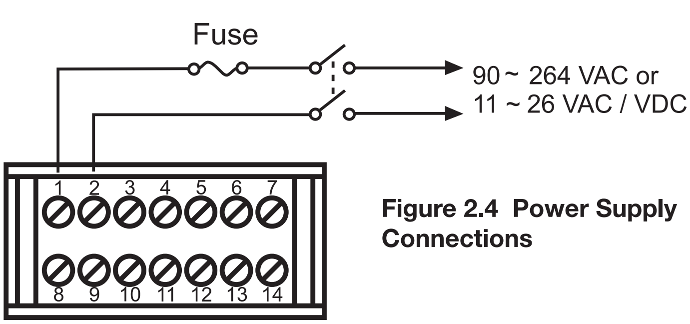


Figure 2.4 Power Supply Connections

⚠ This equipment is designed for installation in an enclosure which provides adequate protection against electrical shock. The enclosure must be connected to earth ground.

Local requirements regarding electrical installation should be rigidly observed. Consideration should be given to prevent unauthorized personnel from gaining access to the power terminals.

2–5 Sensor Installation Guidelines

Proper sensor installation can eliminate many problems in a control system. The probe should be placed so that it can detect any temperature change with minimal thermal lag. In a process that requires fairly constant heat output, the probe should be placed close to the heater. In a process where the heat demand is variable, the probe should be close to the work area. Some experiments with probe location are often required to find the optimum position.

In a liquid process, the addition of a stirrer will help eliminate thermal lag. Since a thermocouple is basically a point measuring device, placing more than one thermocouple in parallel can provide an average temperature readout and produce better results in most air-heated processes.

The proper sensor type is also a very important factor in obtaining precise measurements. The sensor must have the correct temperature range to meet the process requirements. In special processes, the sensor might have additional requirements such as leak-proof, anti-vibration, antiseptic, etc.

Standard sensor limits of error are ±4°F (±2°C) or 0.75% of sensed temperature (half that for special) plus drift caused by improper protection or an over-temperature occurrence. This error is far greater than controller error and cannot be corrected on the sensor except by proper selection and replacement.

2–6 Thermocouple Input Wiring

The thermocouple input connections are shown in figure 2.5. The correct type of thermocouple extension lead-wire or compensating cable must be used for the entire distance between the controller and the thermocouple, ensuring that the correct polarity is maintained throughout. Joints in the cable should be avoided, if possible.

If the length of the thermocouple plus the extension wire is too long, it may affect the temperature measurement. A 400 ohms K type or a 500 ohms J type thermocouple lead resistance will produce approximately 1°C temperature error.

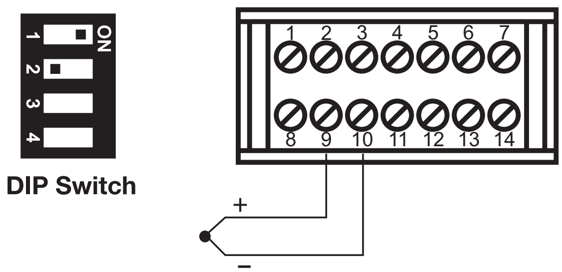


Figure 2.5 Thermocouple Input Wiring

The color codes used on the thermocouple extension leads are shown in Table 2.1.

Table 2.1 Thermocouple Cable Color Codes

Thermocouple Type	Cable Material	British BS	American ASTM	German DIN	French NFE
T	Copper (Cu) Constantan (Cu-Ni)	+ white – blue * blue	+ blue – red * blue	+ red – brown * brown	+ yellow – blue * blue
J	Iron (Fe) Constantan (Cu-Ni)	+ yellow – blue * black	+ white – red * black	+ red – blue * blue	+ yellow – black * black
K	Nickel-Chromium (Ni-Cr) Nickel-Aluminum (Ni-Al)	+ brown – blue * red	+ yellow – red * yellow	+ red – green * green	+ yellow – purple * yellow
R S	Pt-13%Rh, Pt Pt-10%Rh, Pt	+ white – blue * green	+ black – red * green	+ red – white * white	+ yellow – green * green
B	Pt-30%Rh Pt-6%Rh	Use Copper Wire	+ grey – red * grey	+ red – grey * grey	Use Copper Wire

* Color of overall sheath

2–7 RTD Input Wiring

The RTD connections are shown in figure 2.6, with the compensating lead connected to terminal 9. For two-wire RTD inputs, terminals 9 and 10 should be linked. A three-wire RTD offers the capability of lead resistance compensation, provided that the three leads are the same gauge and equal in length.

For the purpose of accuracy, two-wire RTD should be avoided if possible. A 0.4ohm lead resistance in a two-wire RTD will produce 1°C temperature error.

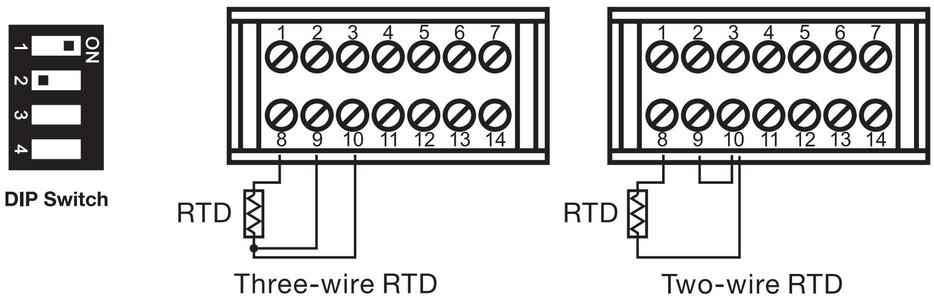


Figure 2.6
RTD Input Wiring

2–8 Linear DC Input Wiring

DC linear voltage and linear current connections for input 1 are shown in figure 2.7 and figure 2.8.

DC linear voltage and linear current connections for input 2 are shown in figure 2.9 and figure 2.10.

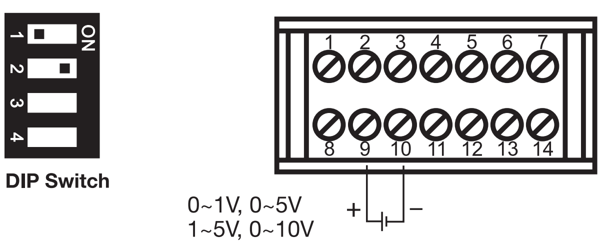


Figure 2.7 Input 1 Linear Voltage Wiring

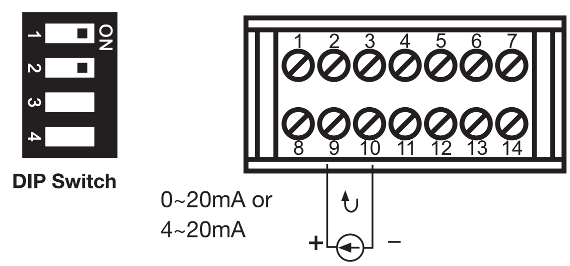


Figure 2.8 Input 1 Linear Current Wiring

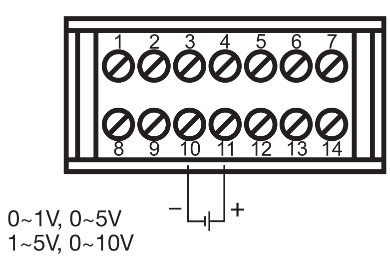
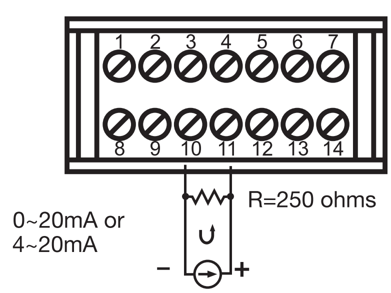


Figure 2.9
Input 2 Linear Voltage Wiring



IN2=0-5V or 1-5V

Figure 2.10
Input 2 Linear Current Wiring

2–9 CT/Heater Current Input Wiring

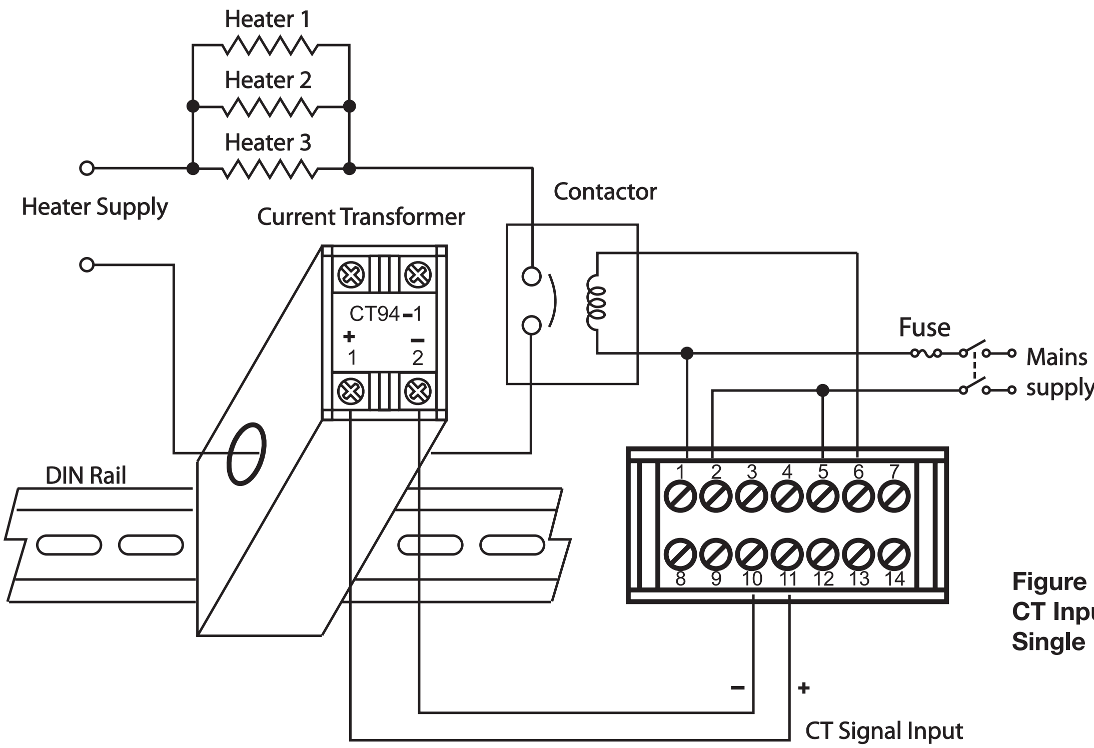


Figure 2.11
CT Input Wiring for Single Phase Heater

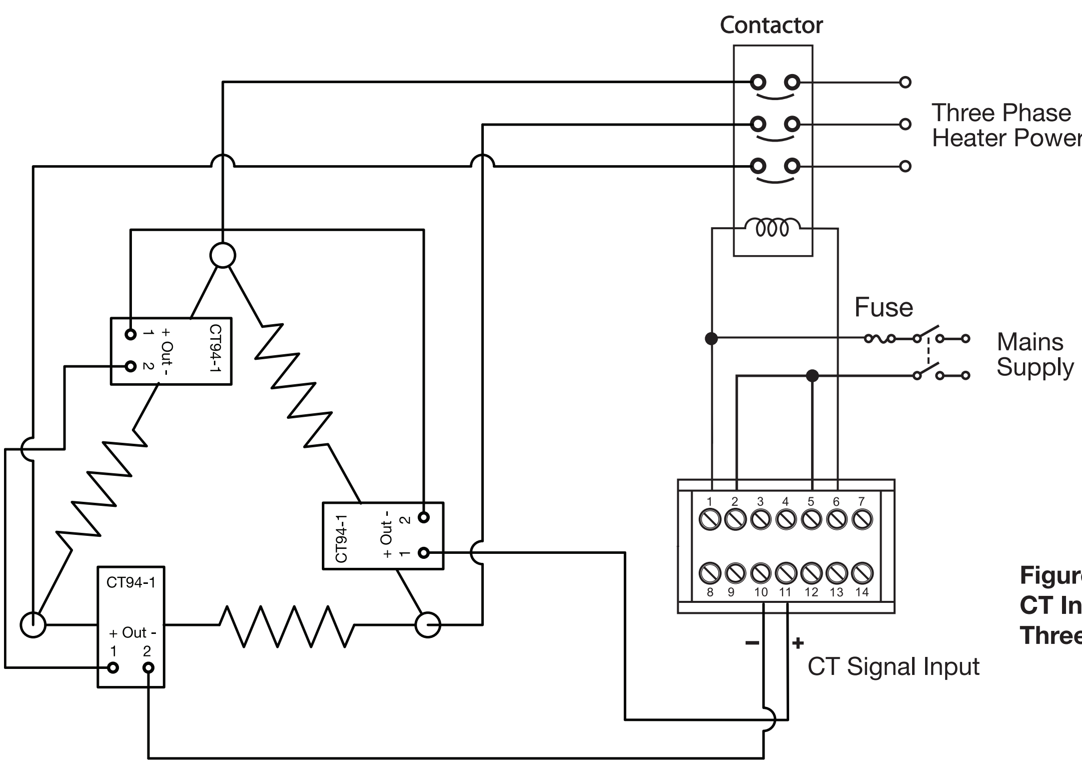
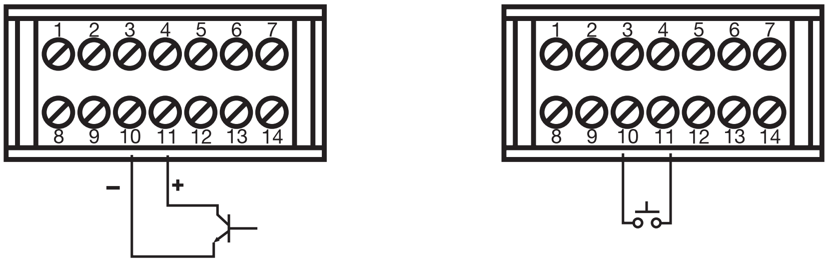


Figure 2.12
CT Input Wiring for Three Phase Heater

Make sure that the total 3-phase current does not exceed 100A rms.

2–10 Event Input wiring



Open Collector Input

Switch Input

Figure 2.13
Event Input Wiring

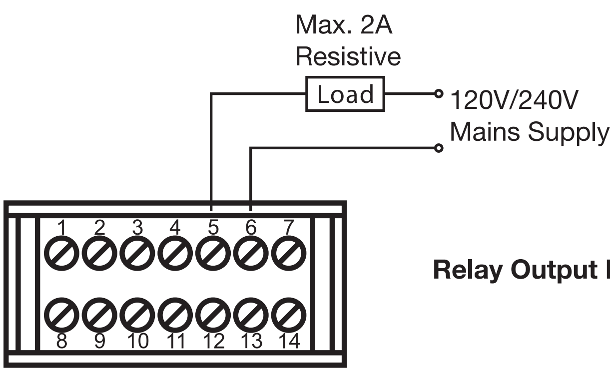
The event input can accept a switch signal as well as an open collector signal. The event input function (EIFN) is activated when the switch is closed or an open collector (or a logic signal) is pulled down.

Modification from RS-232 to event input:
Because of the limited number of pins, pin 11 is used for both event input and RS-232. If you want to change function of the TEC-2500 from RS-232 to event input, you must modify jumpers J51 and J52 on the CPU board by opening jumper J52 and shorting jumper J51. Refer to section 2-16 for the location of jumpers J51 and J52.

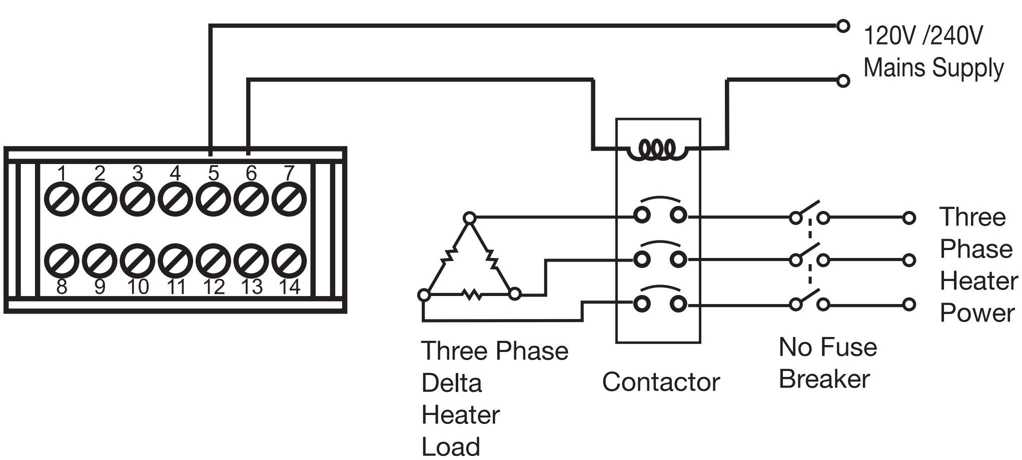
Also refer to section 4-1 for event input functions.

2–11 Output 1 Wiring

Figure 2.14 Output 1 Wiring



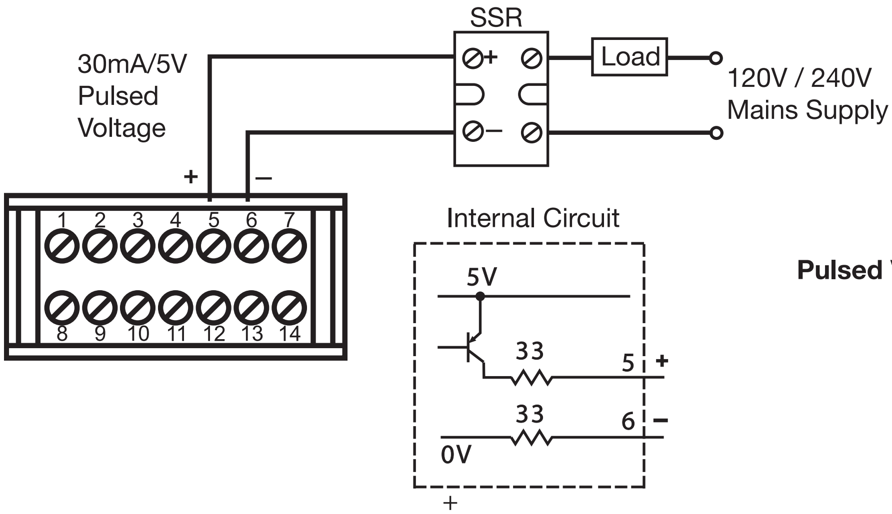
Relay Output Direct Drive



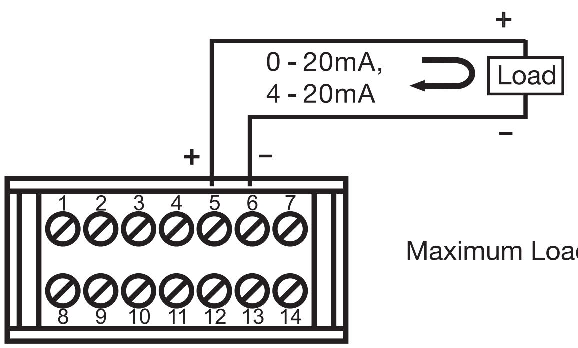
Relay or Triac (SSR) Output to Drive Contactor

Figure 2.14 continued on next page

2–11 Output 1 Wiring (Continued)

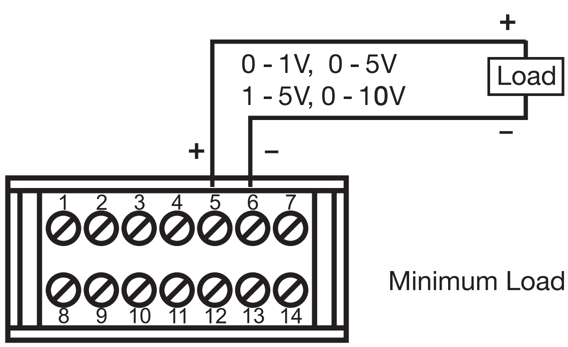


Pulsed Voltage to Drive SSR



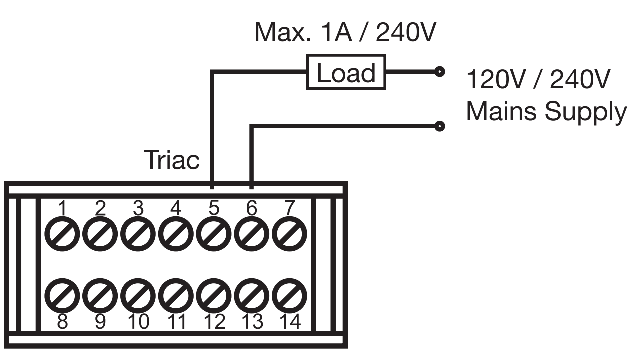
Linear Current

Maximum Load 500 ohms



Linear Voltage

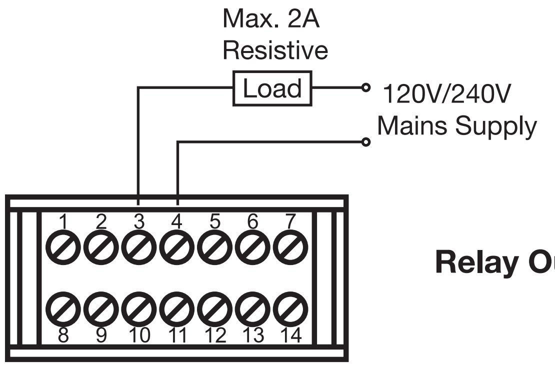
Minimum Load 10K ohms



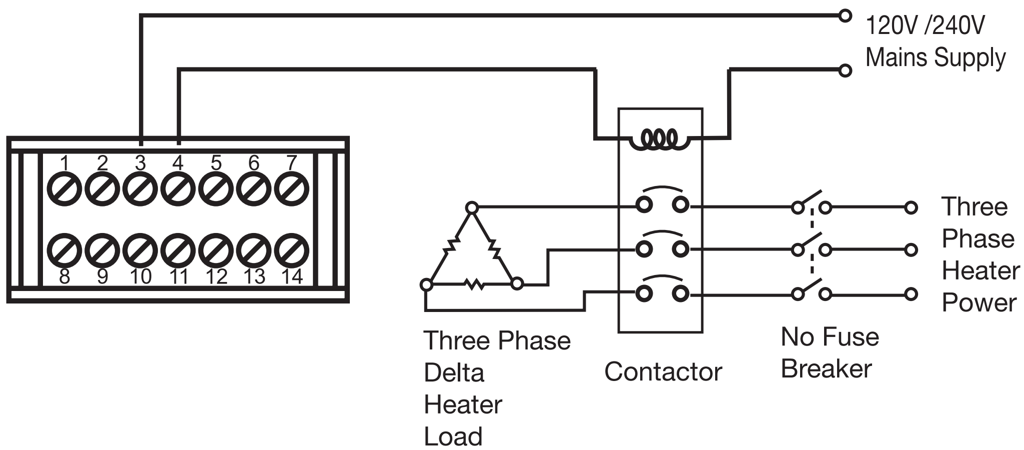
Triac (SSR) Output Direct Drive

2–12 Output 2 Wiring

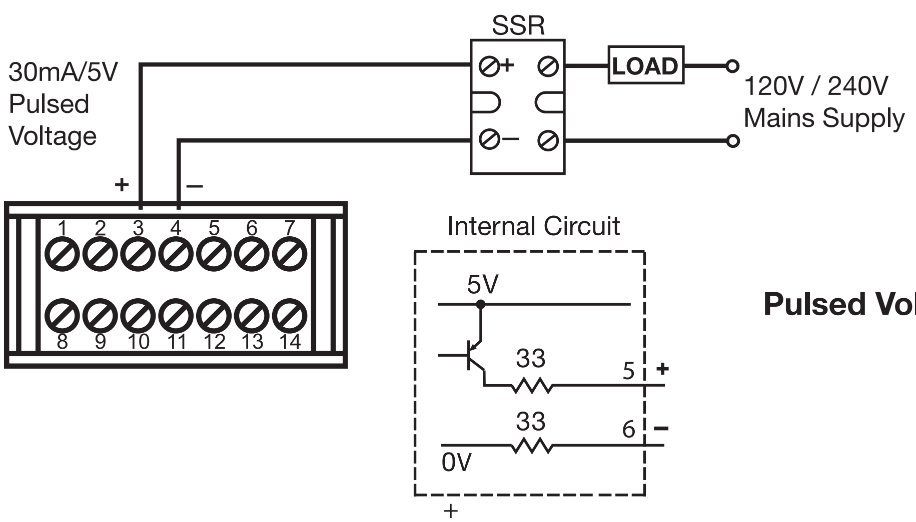
Figure 2.15 Output 2 Wiring



Relay Output Direct Drive



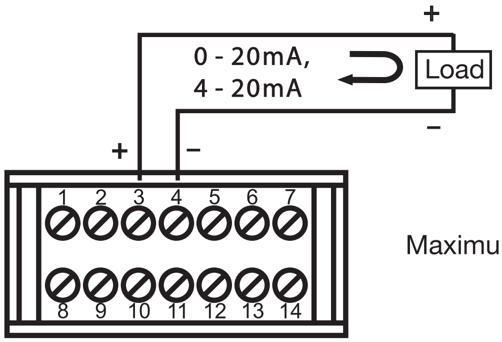
Relay or Triac (SSR) Output to Drive Contactor



Pulsed Voltage to Drive SSR

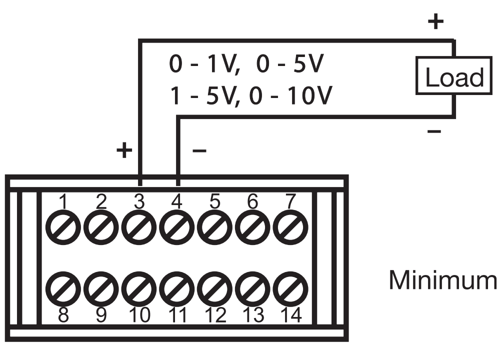
Figure 2.15 continued on next page

2–12 Output 2 Wiring (Continued)



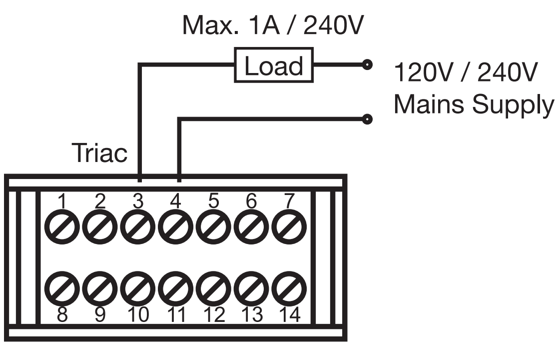
Linear Current

Maximum Load 500 ohms



Linear Voltage

Minimum Load 10K ohms



Triac (SSR) Output
Direct Drive

2–13 Alarm 1 Wiring

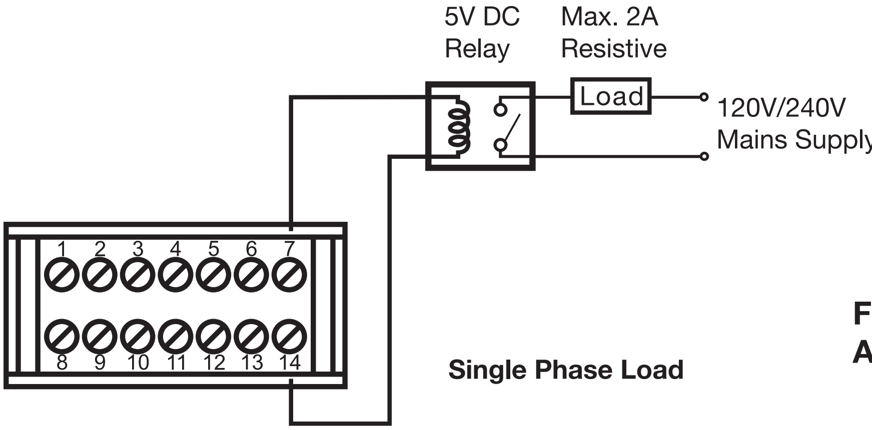
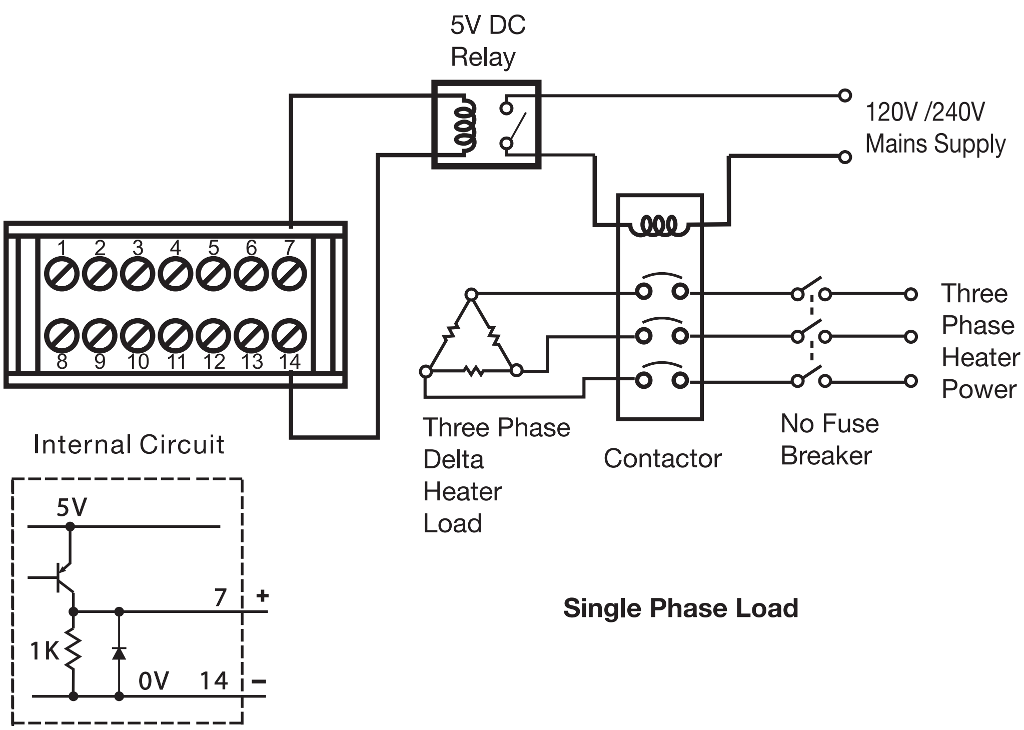
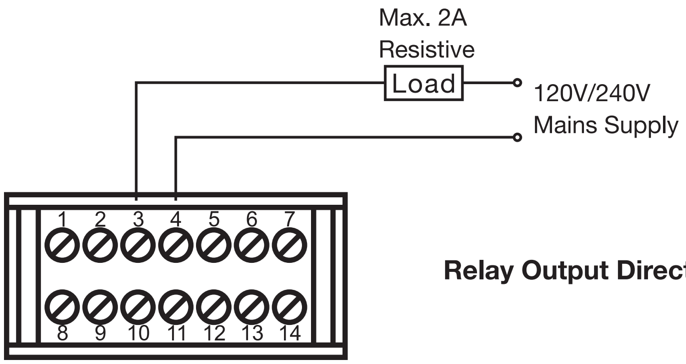


Figure 2.16
Alarm 1 Wiring

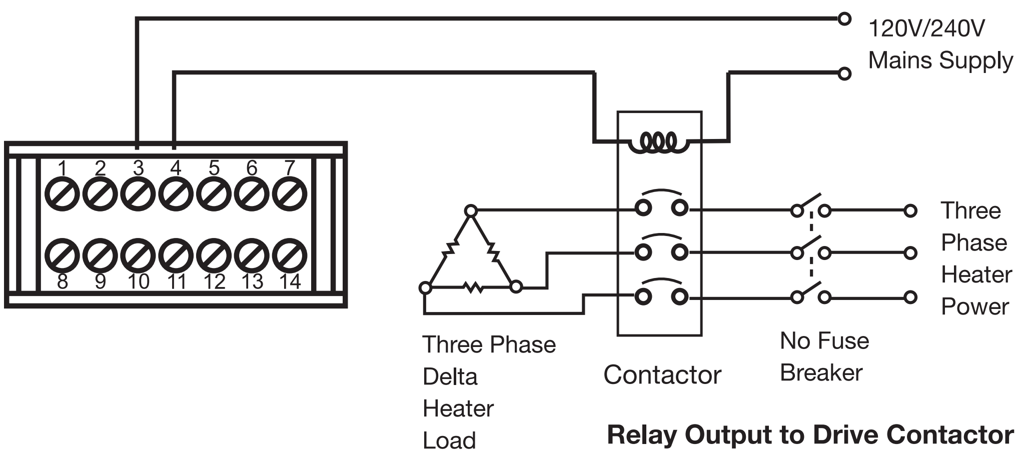


2–14 Alarm 2 Wiring

Figure 2.17
Alarm 2 Wiring



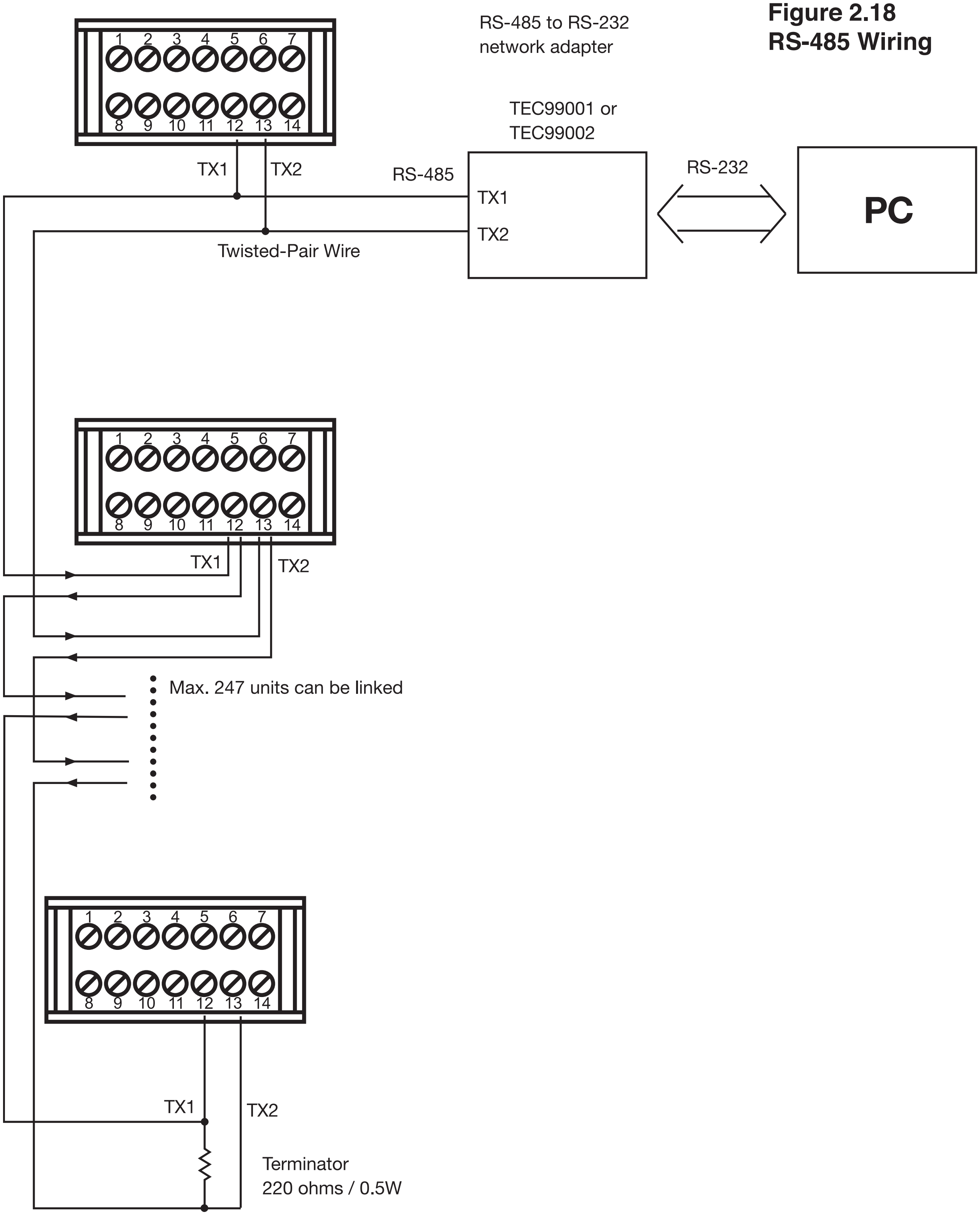
Relay Output Direct Drive



Relay Output to Drive Contactor

2–15 RS-485

Figure 2.18
RS-485 Wiring



2–16 RS-232

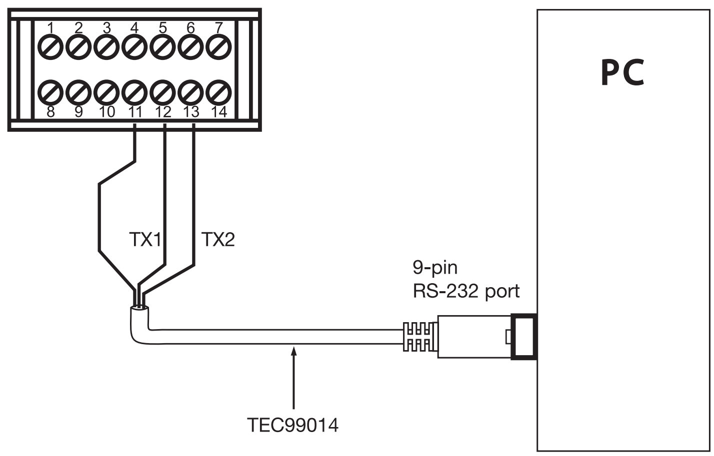


Figure 2.19
RS-232 Wiring

Note: If the TEC-2500 is configured for RS-232 communication, the input 2 and EI (Event Input) are disconnected internally. The unit can no longer perform event input functions (EIFN) or input 2 functions.

When you connect an RS-232 module (TEC-102-103) to the connectors on a CPU board (C250), jumpers J51 and J52 must be modified as following: J52 must be shorted and J51 must be cut and left open. The location of the jumpers are shown in the following diagram.

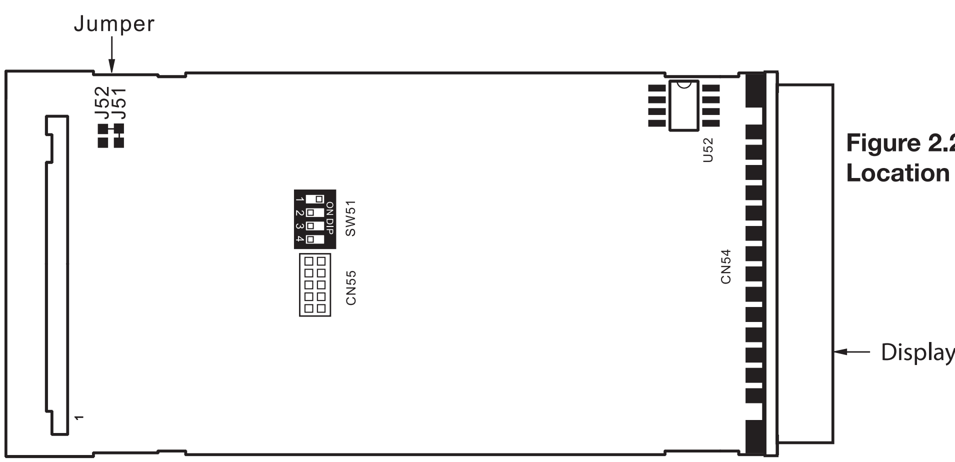


Figure 2.20
Location of Jumper J51/J52

If you use a conventional 9-pin RS-232 cable instead of TEC99014, the cable must be modified according to the following circuit diagram.

To DTE (PC) RS-232 Port

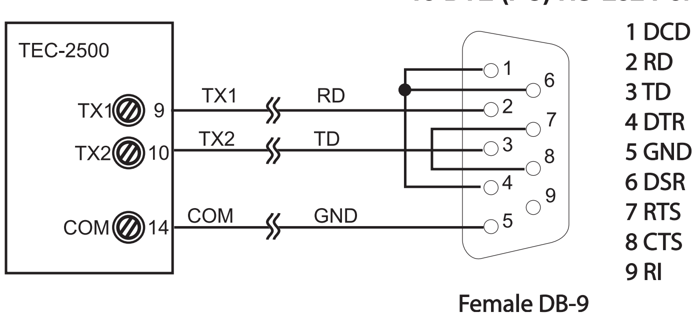
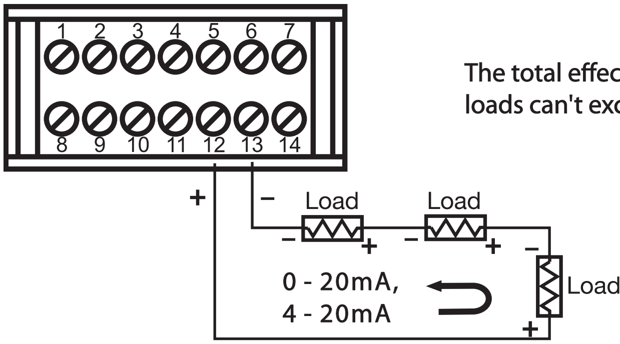


Figure 2.21
Configuration of RS-232 Cable

2–17 Analog Retransmission

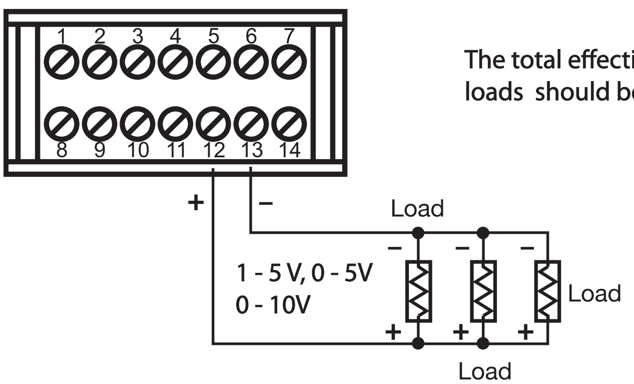


The total effective resistance of serial loads can't exceed 500 ohms.

Indicators
PLC's
Recorders
Data loggers
Inverters etc.

Retransmit Current

Figure 2.22 Analog Retransmission Wiring



The total effective resistance of parallel loads should be greater than 10K Ohms.

Indicators
PLC's
Recorders
Data loggers
Inverters etc.

Retransmit Voltage

Chapter 3 Programming Basic Functions

This unit provides a useful parameter "FUNC" which can be used to select the function complexity level before setup. If Basic Mode (FUNC=BASC) is selected for a simple application, then the following functions are ignored and deleted from the full function menu:
RAMP, SP2, PB2, TI2, TD2, PL1, PL2, COMM, PROT, ADDR, BAUD, DATA, PARI, STOP, AOFN, AOLO, AOHI, IN2, IN2U, DP2, IN2L, IN2H, EIFN, PVMD, FILT, SLEP, SPMD, and SP2F.

Basic Mode capabilities:
1. Input 1: thermocouple, RTD, volt, mA
2. Input 2: CT for heater break detection
3. Output 1: heating or cooling (relay, SSR, SSRD, volt, mA)
4. Output 2: cooling (relay, SSR, SSRD, volt, mA), DC power supply
5. Alarm 1: relay for deviation, deviation band, process, heater break, loop break, sensor break, latch, hold, or normal alarm.
6. Alarm 2: relay for deviation, deviation band, process, heater break, loop break, sensor break, latch, hold, or normal alarm.
7. Dwell timer
8. Heater break alarm
9. Loop break alarm
10. Sensor break alarm
11. Failure transfer
12. Bumpless transfer
13. PV1 shift
14. Programmable SP1 range
15. Heat-cool control
16. Hardware lockout
17. Self-tune
18. Auto-tune
19. ON-OFF, P, PD, PI, PID control
20. User-defined menu (SEL)
21. Manual control
22. Display mode
23. Reload default values
24. Isolated DC Power supply
25. PV or SV selection

If you don't need:
1. Second setpoint
2. Second PID
3. Event input
4. Soft start (RAMP)
5. Remote set point
6. Complex process value
7. Output power limit
8. Digital communication
9. Analog retransmission
10. Power shut off (sleep mode)
11. Digital filter
12. Pump control
13. Remote lockout

then you can use basic mode.

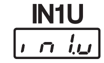
3–1 Input 1

Press to enter setup mode. Press to select the desired parameter. The upper display indicates the parameter symbol, and the lower display indicates the selection or the value of the parameter.

IN1: Selects the sensor type and signal type for Input 1.
Range: (Thermocouple) J_TC, K_TC, T_TC, E_TC, B_TC, R_ TC, S_TC, N_TC, L_TC
(RTD) PT.DN, PT.JS
(Linear) 4–20, 0–20, 0–1V, 0–5V, 1–5V, 0–10
Default: J_TC if °F is selected, K_TC if °C is selected.

IN1


IN1U: Selects the process unit for Input 1.
Range: °C, °F, PU (process unit). If the unit is neither °C nor °F, then PU is selected.
Default: °C or °F

IN1U


DP1: Selects the location of the decimal point for most (not all) process-related parameters. DP1

Range: (T/C and RTD) NO.DP, 1-DP
(Linear) NO.DP, 1-DP, 2-DP, 3-DP
Default: NO.DP

IN1L: Selects the low scale value for Linear type input 1. IN1L
Hidden if: T/C or RTD type is selected for IN1.

IN1H: Selects the high scale value for Linear type input 1. IN1H
Hidden if: T/C or RTD type is selected for IN1.

How to use IN1L and IN1H:
If 4–20mA is selected for IN1, SL specifies the input signal low (i.e., 4mA), SH specifies the input signal high (i.e., 20mA), S specifies the current input signal value, and the conversion curve of the process value is shown as follows:

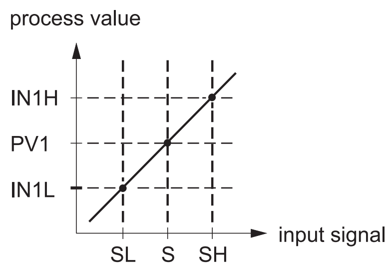


Figure 3.1
Conversion Curve for
Linear Type Process Value

Formula: $$PV1 = IN1L + (IN1H - IN1L) \frac{S - SL}{SH - SL}$$

Example: If a 4–20mA current loop pressure transducer with range 0–15 kg/cm≈ is connected to input 1, then perform the following setup:

IN1=4–20 IN1L=0.0
IN1U=PU IN1H=15.0
DP1=1-DP
Of course, you may select another value for DP1 to alter the resolution.

3–2 OUT1 and OUT2 Types

O1TY: Selects the signal type for Output 1. O1TY
The selection should be consistent with the output 1 module installed.
The available output 1 signal types are:
RELY: Mechanical relay
SSRD: Pulsed voltage output to drive SSR
SSR: Isolated zero-switching solid-state relay
4–20: 4–20mA linear current output
0–20: 0–20mA linear current output
0–1V: 0–1V linear voltage output
0–5V: 0–5V linear voltage output
1–5V: 1–5V linear voltage output
0–10V: 0–10V linear voltage output

O2TY: Selects the signal type for Output 2 O2TY
The selection should be consistent with the output 2 module installed.
The available output 2 signal types are the same as for O1TY.

The range for linear current or voltage may not be very accurate. For 0% output, the value for 4–20mA may be 3.8–4mA; while for 100% output, the value for 4–20mA may be 20–21mA. However, this deviation will not degrade the control performance at all.

3–3 Configuring User Menu

Most conventional controllers are designed with a fixed order in which the parameters scroll. The TEC-2500 has the flexibility to allow you to select those parameters which are most significant to you and put these parameters at the front of the display sequence.

SEL1: Selects the most significant parameter for view and change.
SEL2: Selects the 2nd most significant parameter for view and change.
SEL3: Selects the 3rd most significant parameter for view and change.
SEL4: Selects the 4th most significant parameter for view and change.
SEL5: Selects the 5th most significant parameter for view and change.

Range: NONE, TIME, A1.SP, A1.DV, A2.SP, A2.DV, RAMP, OFST, REFC, SHIF, PB1, TI1, TD1, C.PB, DB, SP2, PB2, TI2, TD2

When using the up and down keys to select the parameters, you may not see all of the above parameters. The number of visible parameters is dependent on the setup condition. The hidden parameters for the specific application are also deleted from the SEL selection.

SEL1 SEL 1

SEL2 SEL2

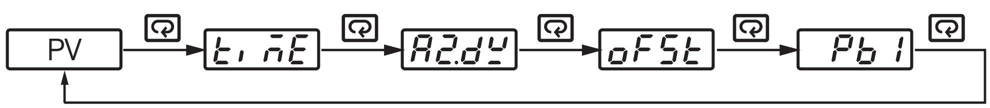
SEL3 SEL3

SEL4 SEL4

SEL5 SEL5

Example:

A1FN selects TIMR
A2FN selects DE.HI
PB1=10
TI1=0
SEL1 selects TIME
SEL2 selects A2.DV
SEL3 selects OFST
SEL4 selects PB1
SEL5 selects NONE
Now, the upper display scrolling becomes:



3–4 Display SV Instead of PV

In certain applications where set point value (SV) is more important than process value (PV), the parameter **DISF** (display format) can be used.

Press keys to enter setup menu SEt, then press several times until dISF appears on the display. If you need the process value to be displayed, then select PV by using or key while in DISF. If you need set point value instead of process value displayed, then select SV for DISF. Refer to the flow chart in section 1-5 to see the location of DISF.

DISF dISF
has two values:

PV Display process value

SV Display set point value

3–5 Heat Only Control

Heat Only ON-OFF Control: Select REVR for OUT1, set PB1 to 0, SP1 is used to adjust set point value, O1HY is used to adjust dead band for ON-OFF control, TIME is used to adjust the dwell timer (enabled by selecting TIMR for A1FN or A2FN). Output 1 hysteresis (O1HY) is enabled in the case of PB1=0. The heat only on-off control function is shown in the following diagram:

Setup ON-OFF:
OUT1= rEVr
PB1=0
Adjust:
SP1, O1HY, TIME(if enabled)

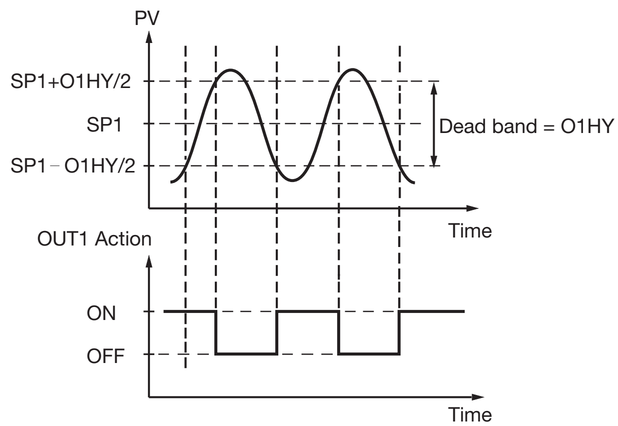


Figure 3.2 Heat Only ON-OFF Control

The ON-OFF control may introduce excessive process oscillation even if hysteresis is minimized to the smallest. If ON-OFF control is set (i.e., PB1=0), TI1, TD1, CYC1, OFST, CPB and PL1 will be hidden and have no function to the system. The manual mode, auto-tuning, self-tuning and bumpless transfer will be disabled too.

Heat only P (or PD) control: Select REVR for OUT1, set TI1 to 0, SP1 is used to adjust set point value, TIME is used to adjust the dwell timer (enabled by selecting TIMR for A1FN or A2FN). OFST been enabled in case of TI1=0 and is used to adjust the control offset (manual reset). Adjust CYC1 according to the output 1 type (O1TY). Generally, CYC1=0.5~2 seconds for SSRD and SSR, CYC1=10~20 seconds for relay output. CYC1 is ignored if linear output is selected for O1TY. **O1HY is hidden** if PB1 is not equal to 0.

Setup P:
OUT1= rEVr
TI1=0
CYC1 (if RELAY, SSRD or SSR is selected for O1TY)

Adjust:
SP1, OFST, TIME (if enabled), PB1(≠0), TD1

OFST Function: OFST is measured by % with range 0–100.0%. In the steady state (i.e., process has been stabilized), if the process value is lower than the set point a definite value, say 5°C, while 20°C is used for PB1, that is lower than the process value by 25%, then increase OFST 25%, and vice versa. After adjusting OFST value, the process value will be varied and eventually coincide with set point. Using the P control (TI1 set to 0), the auto-tuning and self-tuning are disabled. Refer to section 3-21 "manual tuning" for the adjustment of PB1 and TD1. Manual reset (adjust OFST) is not practical because the load may change from time to time and often need to adjust OFST repeatedly. The PID control can avoid this situation.

Heat only PID control: Selecting REVR for OUT1, SP1 is used to adjust set point value. TIME is used to adjust the dwell timer (enabled by selecting TIMR for A1FN or A2FN). PB1 and TI1 should not be zero. Adjust CYC1 according to the output 1 type (O1TY). Generally, CYC1=0.5~2 seconds for SSRD and SSR, CYC1=10~20 seconds for relay output. CYC1 is ignored if a linear output is selected for O1TY. In most cases, self-tuning can be used to substitute for auto-tuning. See section 3-19. If self-tuning is not used (select NONE for SELF), then use auto-tuning for the new process, or set PB1, TI1, and TD1 with historical values. See section 3-20 for auto-tuning operation. If the control result is still unsatisfactory, then use manual tuning to improve control. See section 3-21 for manual tuning. The TEC-2500 contains a very clever PID and Fuzzy algorithm to achieve a very small overshoot and very quick response to the process if it is properly tuned.

Setup PID:
OUT1= rEVr
O1TY
CYC1 if RELAY, SSRD or SSR is selected for O1TY)
SELF=NONE or YES
Adjust:
SP1, TIME (if enabled), PB1(≠0), TI1(≠0), Td1
Auto-tuning:
Used for new process during initial tuning
Self-tuning:
Used for a process any time.
Manual Tuning:
May be used if self-tuning and auto-tuning are inadequate.

3–6 Cool Only Control

ON-OFF control, P (PD) control, and PID control can be used for cool control. Set OUT1 to DIRT (direct action). The other functions for cool only ON-OFF control, cool only P (PD) control, and cool only PID control are the same as the descriptions in section 3-5 for heat only control except that the output variable (and action) for the cool control is inverse to the heat control, such as the following diagram shows:

Setup Cool Control:
OUT1= dirt

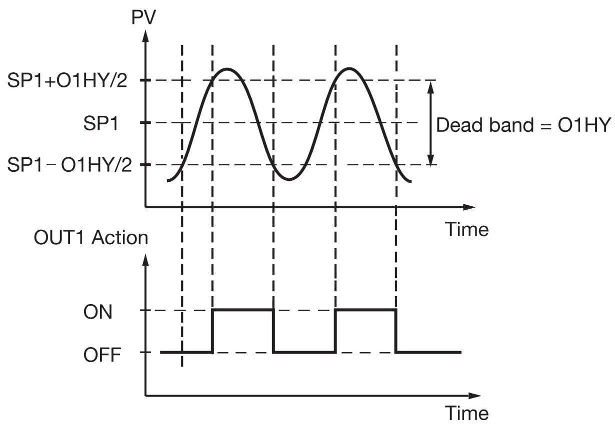


Figure 3.3 Cool Only ON-OFF Control

Refer to section 3-5, in which similar descriptions for heat only control can be applied to cool only control.

3–7 Heat-Cool Control

The heat-cool control can use one of six combinations of control modes. Setup of parameters for each control mode are shown in the following table.

Control Modes	Heat Uses	Cool Uses	Setup Values											
			OUT1	OUT2	O1HY	OFST	PB1	TI1	TD1	CPB	DB	A2FN	A2MD	A2HY
Heat : ON-OFF Cool : ON-OFF	OUT1	OUT2	REVR	=AL2	☆	×	=0	×	×	×	×	DE.HI or PV1.H	NORM	☆
Heat : ON-OFF Cool : P (PD)	OUT2	OUT1	DIRT	=AL2	×	☆	≠0	=0	☆	×	×	DE.LO or PV1.L	NORM	☆
Heat : ON-OFF Cool : PID	OUT2	OUT1	DIRT	=AL2	×	×	≠0	≠0	☆	×	×	DE.LO or PV1.L	NORM	☆
Heat : P (PD) Cool : ON-OFF	OUT1	OUT2	REVR	=AL2	×	☆	≠0	=0	☆	×	×	DE.HI or PV1.H	NORM	☆
Heat : PID Cool : ON-OFF	OUT1	OUT2	REVR	=AL2	×	×	≠0	≠0	☆	×	×	DE.HI or PV1.H	NORM	☆
Heat : PID Cool : PID	OUT1	OUT2	REVR	COOL	×	×	≠0	≠0	☆	☆	☆	×	×	×

× : Does not apply
☆ : Adjust to meet process requirements

Table 3.1 Heat – Cool Control Setup

NOTE: The ON-OFF control may result in excessive overshoot and undershoot problems in the process. The P (or PD) control will result in a deviation process value from the set point. It is recommended to use PID control for the heat-cool control to produce a stable and zero offset process value.

Other Setup Required : O1TY, CYC1, O2TY, CYC2, A2SP, A2DV
O1TY and O2TY are set in accordance with the types of OUT1 and OUT2 installed. CYC1 and CYC2 are set according to the output 1 type (O1TY) and output 2 type (O2TY). Generally, select 0.5~2 seconds for CYC1 if SSRD or SSR is used for O1TY. Select 10~20 seconds if relay is used for O1TY; CYC1 is ignored if linear output is used. Similar conditions are applied to CYC2 selection. If OUT2 is configured for ON-OFF control (by selecting AL2), OUT2 will act as alarm output, and the process alarm as well as deviation alarm (see sections 3-9 and 3-10) can be used. Adjust A2SP to change the set point if process alarm is used, and adjust SP1 (with preset A2DV) to change the set point if deviation alarm is used.

Examples:
Heat PID+Cool ON-OFF: Set OUT1=REVR, OUT2=AL2, A2FN=PV1.H, A2MD=NORM, A2HY=0.1, PB1≠0, TI1≠0, TD1≠0, and set appropriate values for O1TY and CYC1.

Heat PID+Cool PID: set OUT1=REVR, OUT2=COOL, CPB=100, DB=-4.0, PB1≠0, TI1≠0, TD1≠0, and set appropriate values for O1TY, CYC1, O2TY, CYC2.

If you have no idea about a new process, then use the self-tuning program to optimize the PID values by selecting YES for SELF to enable the self-tuning program. See section 3-19 for a description of the self-tuning program. You can use the auto-tuning program for the new process or directly set the appropriate values for PB1, TI1, and TD1 according to the historical records for the repeated systems. If the control behavior is still inadequate, then use manual tuning to improve the control. See section 3-21 for more information on manual tuning.

CPB Programming: The cooling proportional band is measured by % of PB with a range of 1~255. Initially set 100% for CPB and examine the cooling effect. If the cooling action should be enhanced then decrease CPB, if the cooling action is too strong then increase CPB. The value of CPB is related to PB and its value remains unchanged throughout the self-tuning and auto-tuning procedures.

Adjustment of CPB is related to the cooling media used. If air is used as the cooling medium, set CPB at 100(%). If oil is used as the cooling medium, set CPB at 125(%). If water is used as the cooling medium, set CPB at 250(%).

DB Programming: Adjustment of DB is dependent on the system requirements. If a higher positive value of DB (greater dead band) is used, unwanted cooling action can be avoided, but an excessive overshoot over the set point will occur. If a lower negative value of DB (greater overlap) is used, an excessive overshoot over the set point can be minimized, but an unwanted cooling action will occur. It is adjustable in the range -36.0% to 36.0% of PB1 (or PB2 if PB2 is selected). A negative DB value shows an overlap area over which both outputs are active. A positive DB value shows a dead band area over which neither output is active.

3–8 Dwell Timer

Alarm 1 or alarm 2 can be configured as dwell timer by selecting TIMR for A1FN or A2FN, but not both, otherwise **Er07** will appear. As the dwell timer is configured, the parameter TIME is used for dwell time adjustment. The dwell time is measured in minutes ranging from 0 to 6553.5 minutes. Once the process reaches the set point the dwell timer starts to count from zero until time out.The timer relay will remain unchanged until time out. The dwell timer operation is shown as following diagram.

Er07 Error Code

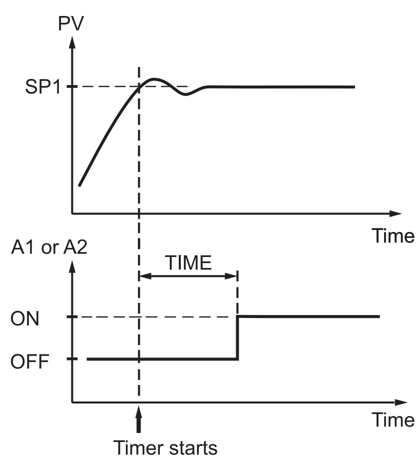


Figure 3.4 Dwell Timer Function

If alarm 1 is configured as dwell timer, A1SP, A1DV, A1HY and A1MD are hidden.
The case is the same for alarm 2.

Example:
Set A1FN=TIMR or A2FN=TIMR, but not both.
Adjust TIME in minutes
A1MD (if A1FN=TIMR) or A2MD (if A2FN=TIMR) is ignored in this case.
If alarm 1 is selected for dwell timer, an external 5V DC relay is required to drive AC load.

3–9 Process Alarms

There are at most two independent alarms available by adjusting OUT2. If AL2 is selected for OUT2, then OUT2 will perform alarm 2 function. Now NONE can't be selected for A2FN, otherwise **Er06** will be displayed. A process alarm sets an absolute trigger level (or temperature). When the process (could be PV1, PV 2, or PV1-PV2) exceeds that absolute trigger level, an alarm occurs. A process alarm is independent from the set point. Adjust A1FN (Alarm 1 function) in the setup menu. One of eight functions can be selected for process alarm. These are: PV1.H, PV1.L, PV2.H, PV2.L, P1.2.H, P1.2.L, D1.2.H and D1.2.L.

Er06 Error Code

When PV1.H or PV1.L is selected, the alarm examines the PV1 value. When PV2.H or PV2.L is selected, the alarm examines the PV2 value. When P1.2.H or P1.2.L is selected, the alarm occurs if the PV1 or PV2 value exceeds the trigger level. When D1.2.H or D1.2.L is selected, the alarm occurs if the PV1-PV2 (difference) value exceeds the trigger level. The trigger level is determined by A1SP (Alarm 1 set point) and A1HY (Alarm 1 hysteresis value) in User Menu for alarm 1. The hysteresis value is introduced to avoid interference action of alarm in a noisy environment. Normally A1HY can be set with a minimum (0.1) value. A1DV and/or A2DV are hidden if alarm 1 and/or alarm 2 are set for process alarm.

Normal Alarm: A1MD=NORM
When a normal alarm is selected, the alarm output is de-energized in the non-alarm condition and energized in an alarm condition.

Latching Alarm: A1MD=LTCH
If a latching alarm is selected, once the alarm output is energized, it will remain unchanged even if the alarm condition is cleared. The latching alarms are disabled when the power is shut off or if event input is applied with proper selection of EIFN.

Holding Alarm: A1MD=HOLD
A holding alarm prevents an alarm from powering up. The alarm is enabled only when the process reaches the set point value (may be SP1 or SP2, see section 4-1 event input). Afterwards, the alarm performs the same function as a normal alarm.

Latching/Holding Alarm: A1MD=LT.HO
A latching/holding alarm performs both holding and latching function.

8 Types of Process Alarms:
PV1.H, PV1.L, PV2.H, PV2.L, P1.2.H, P1.2.L, D1.2.H, D1.2.L

Process Alarm 1
Setup: A1FN, A1MD
Adjust: A1SP, A1HY
Trigger level=A1SP-A1HY

Process Alarm 2
Setup: OUT2, A2FN, A2MD
Adjust: A2SP, A2HY
Trigger level=A2SP-A2HY
Reset Latching alarm
1. Power off
2. Apply event input in accordance with proper selection of EIFN

Examples:

A1SP = 200　A1HY = 10.0
A1MD = NORM　A1FN = PV1.H

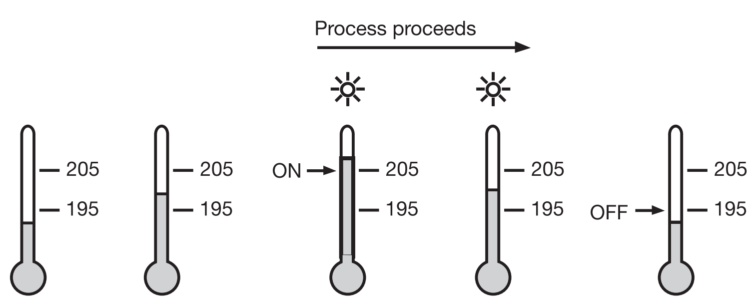


Figure 3.5
Normal Process Alarm

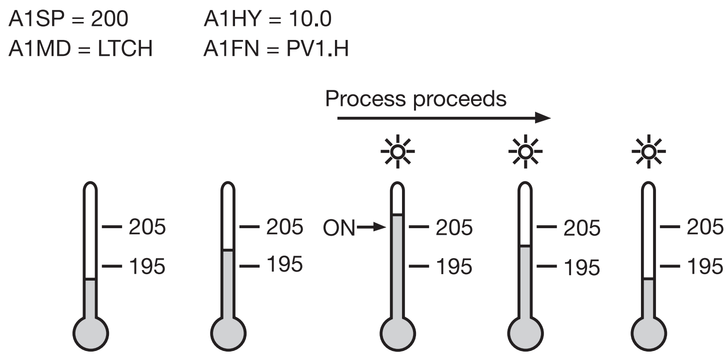


Figure 3.6
Latching Process Alarm

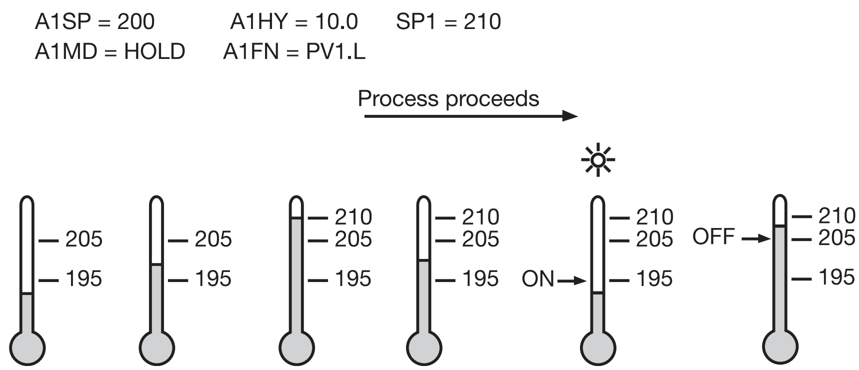


Figure 3.7
Holding Process Alarm

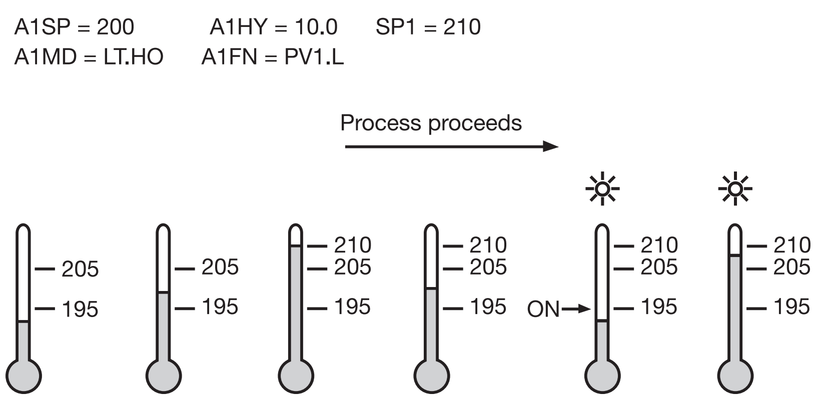


Figure 3.8
Latching/Holding
Process Alarm

Although the above descriptions are based on alarm 1, the same conditions can be applied to alarm 2.

3–10 Deviation Alarm

OUT2 can be configured as alarm 2 by selecting AL2. If AL2 is selected for OUT2, then output 2 will perform alarm 2 function. Now NONE can't be selected for A2FN, otherwise **Er06** will appear. A deviation alarm alerts the user when the process deviates too far from the set point. The user can enter a positive or negative deviation value (A1DV, A2DV) for alarm 1 and alarm 2. A hysteresis value (A1HY or A2HY) can be selected to avoid interference problems in a noisy environment. Normally, A1HY and A2HY can be set with a minimum (0.1) value. The trigger level of the alarm moves with the set point.

For alarm 1, trigger level=SP1+A1DV±A1HY.

For alarm 2, trigger level=SP1+A2DV±A2HY.

A1SP and/or A2SP are hidden if alarm 1 and/or alarm 2 are set for deviation alarm. One of four alarm modes can be selected for alarm 1 and alarm 2. These are: normal alarm, latching alarm, holding alarm and latching/holding alarm. See section 3-9 for descriptions of these alarm modes.

Er06 Error Code

2 Types of deviation alarms:
DE.HI, DE.LO

Deviation alarm 1:
Setup: A1FN, A1MD
Adjust: SP1, A1DV, A1HY
Trigger levels:
SP1+A1DV±A1HY

Deviation alarm 2:
Setup: OUT2, A2FN, A2MD
Adjust: SP1, A2DV, A2HY
Trigger levels:
SP1+A2DV±A2HY

Examples:

A1FN = DE.HI, A1MD = NORM, SP1 = 100, A1DV=10, A1HY=4

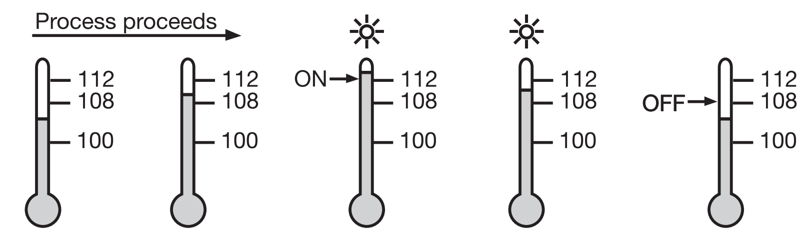


Figure 3.9
Normal Deviation Alarm

A1FN = DE.HI, A1MD = LTCH, SP1 = 100, A1DV=10, A1HY=4

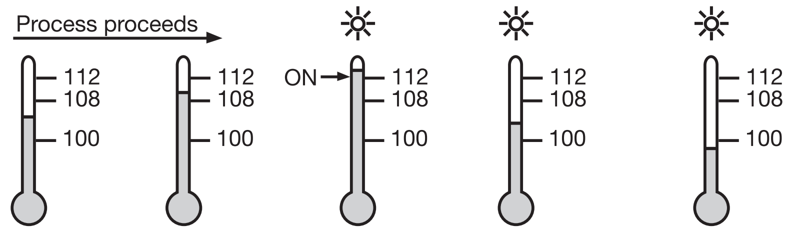


Figure 3.10
Latching Deviation Alarm

A1HY = DE.LO, A1MD = HOLD, SP1 = 100, A1DV= -10, A1HY=4

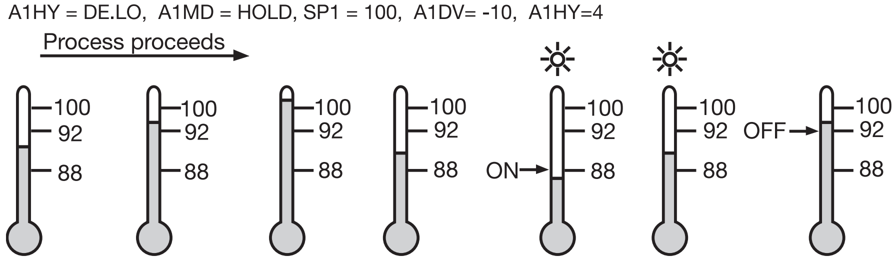


Figure 3.11
Holding Deviation Alarm

A1HY= DE.LO, A1MD = LT.HO, SP1 = 100, A1DV= -10, A1HY=4

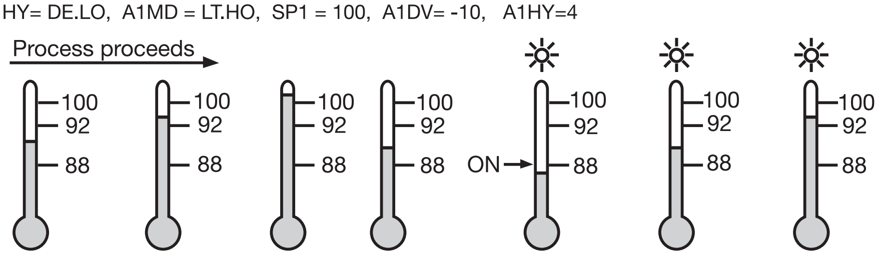


Figure 3.12
Latching/Holding
Deviation Alarm

3–11 Deviation Band Alarm

A deviation band alarm presets two reference levels relative to set point. Two types of deviation band alarm can be configured for alarm 1 and alarm 2. These are deviation band high alarm (A1FN or A2FN select DB.HI) and deviation band low alarm (A1FN or A2FN select DB.LO). If alarm 2 is required, then select AL2 for OUT2. Now NONE can't be selected for A2FN, otherwise **Er06** will appear. A1SP and A1HY are hidden if alarm 1 is selected as a deviation band alarm. Similarly, A2SP and A2HY are hidden if alarm 2 is selected as a deviation band alarm.

The trigger level for deviation band alarm moves with the set point. For alarm 1, the trigger level=SP1±A1DV. For alarm 2, the trigger level=SP1±A2DV. One of four alarm modes can be selected for alarm 1 and alarm 2. These are: normal alarm, latching alarm, holding alarm and latching/holding alarm. See section 3-9 for descriptions of these alarm modes.

*DBHi will trigger an alarm if the process value is outside of the deviation value (out of band)

*DBLo will trigger an alarm if the process value is within the deviation value (in band)

2 types of deviation band alarms:
DB.HI, DB.LO
Deviation band alarm 1:
Setup: A1FN, A1MD
Adjust: SP1, A1DV
Trigger level=SP1±A1DV
Deviation band alarm 2:
Setup: OUT2, A2FN, A2MD
Adjust: SP1, A2DV
Trigger level=SP1±A2DV

Error Code

Examples:

A1FN = DB.HI, A1MD = NORM, SP1 = 100, A1DV = 5

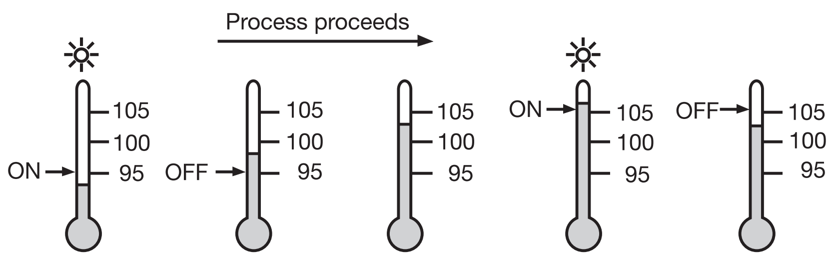


Figure 3.13
Normal Deviation Band Alarm

A1FN = DB.LO, A1MD = LTCH, SP1 = 100, A1DV = 5

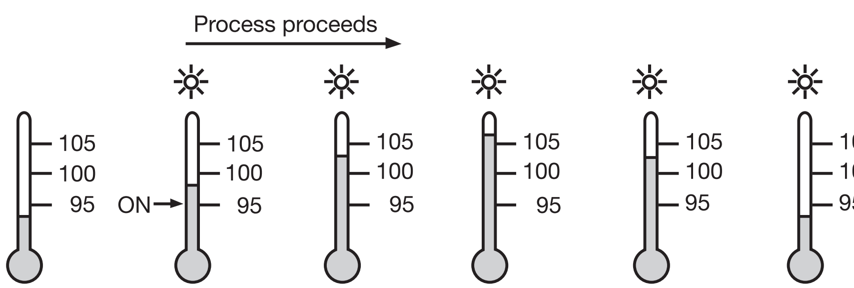


Figure 3.14
Latching Deviation Band Alarm

A1FN = DB.HI, A1MD = HOLD, SP1 = 100, A1DV = 5

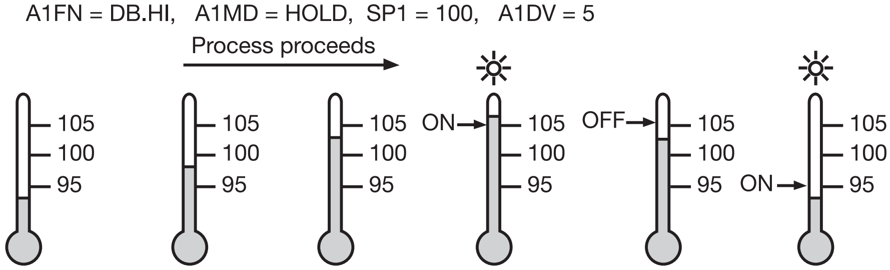


Figure 3.15
Holding Deviation Band Alarm

A1FN = DB.HI, A1MD = LT.HO, SP1 = 100, A1DV = 5

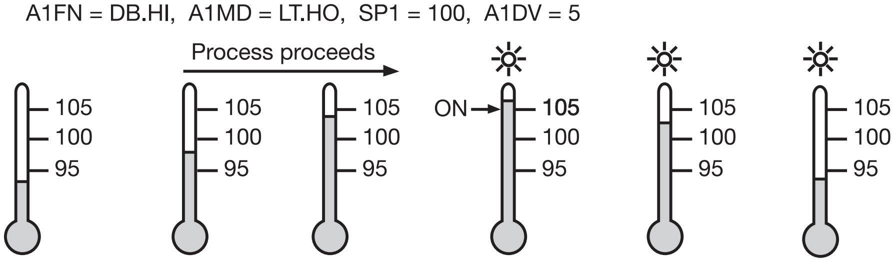


Figure 3.16
Latching/Holding Deviation Band Alarm

3–12 Heater Break Alarm

A current transformer (Part Number TEC99999) should be installed to detect the heater current if a heater break alarm is required. The CT signal is sent to input 2, and the PV2 will indicate the heater current in 0.1amp resolution. The range of the current transformer is 0 to 50.0amp. For more detailed descriptions about heater current monitoring, please see section 3-25.

Heater break alarm 1
Setup: IN2=CT
A1FN=PV2.L
A1MD=NORM
A1HY=0.1
Adjust: A1SP
Trigger level: A1SP±A1HY

Heater break alarm 2
Setup: IN2=CT
A2FN=PV2.L
A2MD=NORM
A2HY=0.1
Adjust: A2SP
Trigger level: A2SP±A2HY

Example:
A furnace uses two 2KW heaters connected in parallel to warm up the process. The line voltage is 220V and the rating current for each heater is 9.09A. If we want to detect any one heater break, set A1SP=13.0A, A1HY=0.1, A1FN=PV2.L, A1MD=NORM, then:

Limitations:
1. Linear output can't use heater break alarm.
2. CYC1 should use 1 second or longer to detect heater current reliably.

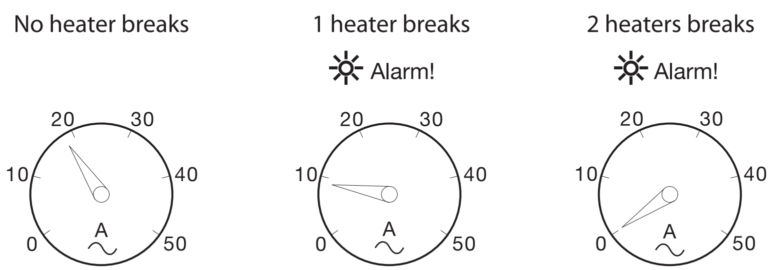


Figure 3.17
Heater Break Alarm

3–13 Loop Break Alarm

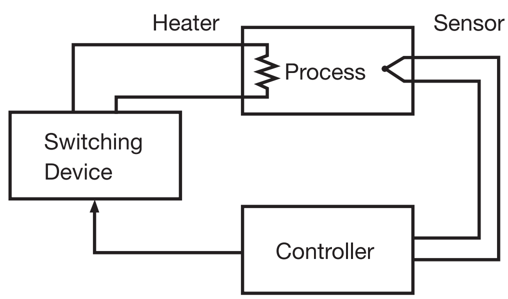
A1FN selects LB if alarm 1 is required to act as a loop break alarm. Similarly, if alarm 2 is required to act as a loop break alarm, then set OUT2 to AL2 and A1FN to LB. TIME, A1SP, A1DV, and A1HY are hidden if alarm 1 is configured as a loop break alarm. Similarly, TIME, A2SP, A2DV, and A2HY are hidden if alarm 2 is configured as a loop break alarm.

One of four kinds of alarm modes can be selected for alarm 1 and alarm 2. These are: normal alarm, latching alarm, holding alarm and latching/holding alarm. However, the holding mode and latching/holding mode are not recommended for loop break alarm since loop break alarm will not perform the holding function even if it is set for holding or latching/holding mode. See section 3-9 for descriptions of these alarm modes.

Loop break conditions are detected during a time interval of 2TI1 (double the integral time, but 120 seconds maximum). Hence the loop break alarm doesn't respond as quickly as it occurs. If the process value doesn't increase (or decrease) while the control variable MV1 has reached its maximum (or minimum) value within the detecting time interval, a loop break alarm (if configured) will be activated.

Loop break alarm 1
Setup: A1FN=LB
A1MD=NORM, LTCH

Loop break alarm 2
Setup: OUT2=AL2
A2FN=LB
A2MD=NORM, LTCH



Loop Break Sources: Sensor, Controller, Heater, Switching Device

Figure 3.18
Loop Break Sources

Loop break alarm (if configured) occurs when any following conditions happen:
1. Input sensor is disconnected (or broken).
2. Input sensor is shorted.
3. Input sensor is defective.
4. Input sensor is installed outside (isolated from) the process.
5. Controller fails (A-D converter damaged).
6. Heater (or chiller, valve, pump, motor etc.) breaks or fails or is uninstalled.
7. Switching device (used to drive heater) is open or shorted.

3–14 Sensor Break Alarm

Alarm 1 or alarm 2 can be configured as a sensor break alarm by selecting SENB [SEnb] for A1FN or A2FN. If alarm 2 is required as a sensor break alarm, then AL2 should be selected for OUT2. The sensor break alarm is activated as soon as failure mode occurs. Refer to section 3-17 for failure mode conditions. Note that A-D failure also creates a sensor break alarm. TIME, A1SP, A1DV, and A1HY are hidden if alarm 1 is configured as a sensor break alarm. Similarly, TIME, A2SP, A2DV and A2HY are hidden if alarm 2 is configured as a sensor break alarm.
One of four kinds of alarm modes can be selected for sensor break alarm. These are: normal alarm, latching alarm, holding alarm, and latching/holding alarm. However, the holding alarm and latching/holding alarm are not recommended for the sensor break alarm since the sensor break alarm will not perform the holding function even if it is set for holding or latching/holding mode. See section 3-9 for the descriptions of these alarm modes.

Sensor Break Alarm 1
Setup: A1FN=SENB
A1MD=NORM, LTCH
Hidden: TIME, A1SP, A1DV, A1HY

Sensor Break Alarm 2
Setup: OUT2=AL2
A2FN=SENB
A2MD=NORM, LTCH
Hidden: TIME , A2SP, A2DV, A2HY

3–15 SP1 Range

SP1L (SP1 low limit value) and SP1H (SP1 high limit value) in the setup menu are used to confine the adjustment range of SP1.

Setup : SP1L, SP1H

Example: A freezer is working in its normal temperature range -10°C to -15°C. In order to avoid an abnormal set point, SP1L and SP1H are set with the following values:

SP1L=-15°C   SP1H=-10°C

Now SP1 can only be adjusted within the range of -10°C to -15°C.

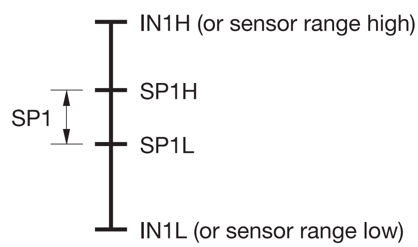


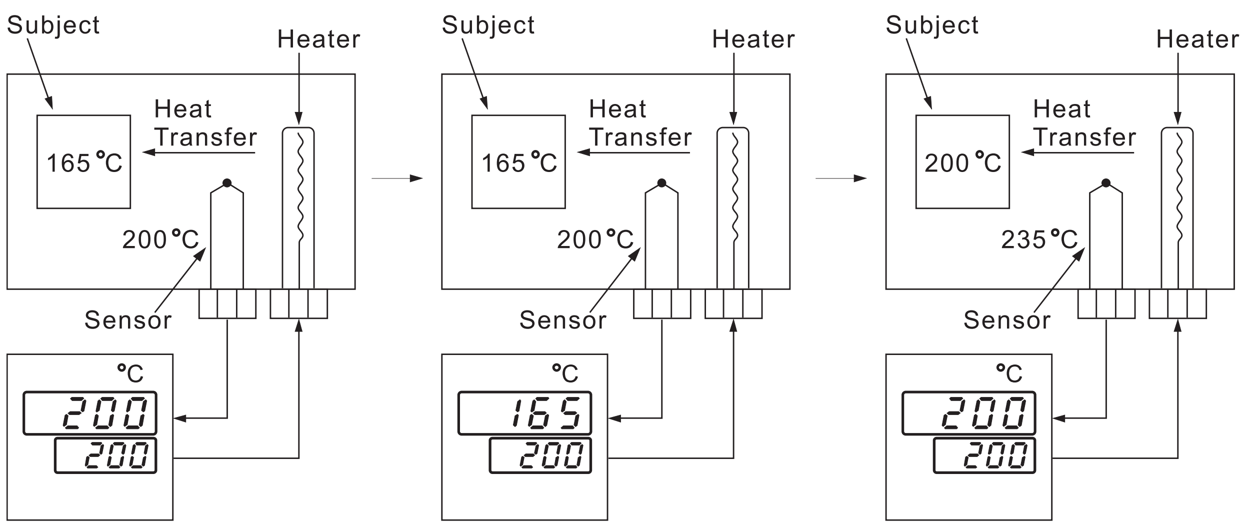
Figure 3.19 SP1 Range

3–16 PV1 Shift

In certain applications it is desirable to shift the controller display value from its actual value. This can easily be accomplished by using the PV1 shift function.

Enter the configuration menu and press the "scroll" key to bring up the parameter SHIF. The value you adjust here, either positive or negative, will be added to the actual value. The SHIF function will alter PV1 only.

Here is an example. A process is equipped with a heater, a sensor, and a subject to be warmed up. Due to the design and position of the components in the system, the sensor could not be placed any closer to the part. Thermal gradient (different temperature) is common and necessary to an extent in any thermal system for heat to be transferred from one point to another. If the difference between the sensor and the subject is 35°C, and the desired temperature at the subject to be heated is 200°C, the controlling value or the temperature at the sensor should be 235°C. You should input -35°C so as to subtract 35°C from the actual process display. This in turn will cause the controller to energize the load and bring the process display up to the set point value.



35°C temperature difference is observed
SHIF= 0

Adjust SHIF
SHIF = -35°C
Supply more heat

Display is stable
SHIF = -35°C
PV=SV

Figure 3.20
PV1 Shift Application

3–17 Failure Transfer

The controller will enter failure mode if one of the following conditions occurs:
1. **SB1E** occurs (due to input 1 sensor break or input 1 current below 1mA if 4–20mA is selected or input 1 voltage below 0.25V if 1–5V is selected) if PV1, P1-2, or P2-1 is selected for PVMD or PV1 is selected for SPMD.
2. **SB2E** occurs (due to input 2 sensor break or input 2 current below 1mA if 4–20mA is selected or input 2 voltage below 0.25V if 1–5V is selected) if PV2, P1-2, or P2-1 is selected for PVMD or PV2 is selected for SPMD.
3. **ADER** occurs if the A-D converter of the controller fails.

Output 1 and output 2 will perform the failure transfer function as one of the following conditions occurs:
1. During power starts (within 2.5 seconds).
2. The controller enters failure mode.
3. The controller enters manual mode.
4. The controller enters calibration mode.

Output 1 failure transfer, if activated, will perform:
1. If output 1 is configured as proportional control (PB1≠0), and BPLS is selected for O1FT, then output 1 will perform bumpless transfer. Thereafter, the previous averaging value of MV1 will be used for controlling output 1.
2. If output 1 is configured as proportional control (PB1≠0), and a value of 0 to 100.0% is set for O1FT, then output 1 will perform failure transfer. Thereafter, the value of O1FT will be used for controlling output 1.
3. If output 1 is configured as ON-OFF control (PB1≠0), then output 1 will be driven OFF if O1FN selects REVR and be driven ON if O1FN selects DIRT.

Output 2 failure transfer, if activated, will perform:
1. If COOL is selected for OUT2, and BPLS is selected for O1FT, then output 2 will perform bumpless transfer. Thereafter, the previous averaging value of MV2 will be used for controlling output 2.
2. If COOL is selected for OUT2, and a value of 0 to 100.0 % is set for O2FT, then output 2 will perform failure transfer. Thereafter, the value of O1FT will be used for controlling output 2.

Alarm 1 failure transfer is activated as the controller enters failure mode. Thereafter, alarm 1 will transfer to the ON or OFF state preset by A1FT.
Exception: If A1FN is configured for loop break (LB) alarm or sensor break (SENB) alarm, alarm 1 will be switched to ON state independent of the setting of A1FT. If A1FN is configured for dwell timer (TIMR), alarm 1 will not perform failure transfer.

Alarm 2 failure transfer is activated as the controller enters failure mode. Thereafter, alarm 2 will transfer to the ON or OFF state preset by A2FT.
Exception: If A2FN is configured for loop break (LB) alarm or sensor break (SENB) alarm, alarm 2 will be switched to ON state independent of the setting of A2FT. If A2FN is configured for dwell timer (TIMR), alarm 2 will not perform failure transfer.

Failure mode occurs as:
1. SB1E
2. SB2E
3. ADER

Failure Transfer of output 1 and output 2 occurs as:
1. Power start (within 2.5 seconds)
2. Failure mode is activated
3. Manual mode is activated
4. Calibration mode is activated

Failure Transfer of alarm 1 and alarm 2 occurs as: Failure mode is activated

Failure Transfer Setup:
1. O1FT
2. O2FT
3. A1FT
4. A2FT

3–18 Bumpless Transfer

The bumpless transfer function is available for output 1 and output 2 (provided that OUT2 is configured as COOL).

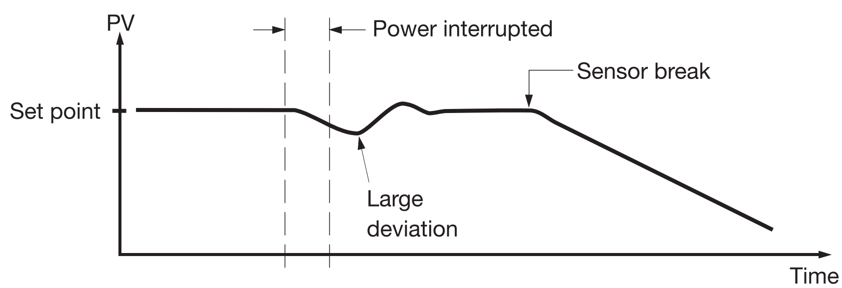
Bumpless transfer is enabled by selecting BPLS for O1FT and/or O2FT and activated as one of the following cases occurs:
1. Power starts (within 2.5 seconds).
2. The controller enters failure mode. See section 3-17 for failure mode descriptions.
3. The controller enters manual mode. See section 3-23 for manual mode descriptions.
4. The controller enters calibration mode. See chapter 6 for calibration mode descriptions.

As bumpless transfer is activated, the controller will transfer to open-loop control and uses the previous averaging value of MV1 and MV2 to continue control.

Bumpless transfer setup:
1. O1FT=BPLS
2. O2FT=BPLS

Bumpless transfer occurs as:
1. Power starts (within 2.5 seconds)
2. Failure mode is activated
3. Manual mode is activated
4. Calibration mode is activated

Without Bumpless Transfer



Since the hardware and software need time to be initialized, the control is abnormal as the power is recovered and results in a large disturbance to the process. During the sensor breaks, the process loses power.

With Bumpless Transfer

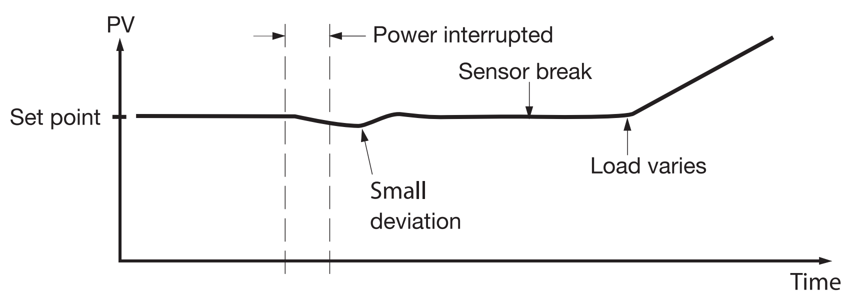


Figure 3.21 Benefits of Bumpless Transfer

When bumpless transfer is configured, the correct control variable is applied immediately as power is recovered, and the disturbance is small. During sensor breaks, the controller continues to control by using its previous value. If the load doesn't change, the process will remain stable. If the load changes, the process may run away. Therefore, you should not rely on bumpless transfer for extended periods of time. For fail safe reasons, an additional alarm should be used to announce to the operator when the system fails. For example, a sensor break alarm, if configured, will switch to failure state and tell the operator to use manual control or take proper security action when the system enters failure mode.

Warning: After the system fails, never depend on bumpless transfer for a long time, or it might cause the system to run away.

3–19 Self Tuning

Self-tuning, which was designed using an innovative algorithm, provides an alternate option for tuning the controller. It is activated when YES is selected for SELF. When self-tuning is working, the controller will change its working PID values and compare the process behavior to previous cycles. If the new PID values achieve better control, then it changes the next PID values in the same direction. Otherwise, it changes the next PID values in the reverse direction. When an optimal condition is obtained, the optimal PID values will be stored in PB1, TI1, and TD1, or PB2, TI2, and TD2, as determined by the event input conditions. See section 4-1. When self-tuning is completed, the value of SELF will change from YES to NONE to disable the self-tuning function.

Self-tune Menu

SELF

Selects

nonE Disable Self-tuning

or

YES Enable Self-tuning

Default

SELF=NONE

When self-tuning is enabled, the control variables are tuned slowly so that the disturbance to the process is less than auto-tuning. Usually, self-tuning will perform successfully with no need to apply additional auto-tuning.

Exceptions: Self-tuning will be disabled as soon as one of the following conditions occurs:
1. NONE is selected for SELF.
2. The controller is used for on-off control, that is PB=0.
3. The controller is used for manual reset, that is TI=0.
4. The controller is in a loop break condition.
5. The controller is in failure mode (e.g., sensor break).
6. The controller is in manual control mode.
7. The controller is in sleep mode.
8. The controller is being calibrated.

If self-tuning is enabled, auto-tuning can still be used any time. Self-tuning will use the auto-tuning results for its initial values.

Benefits of self-tuning:
1. Unlike auto-tuning, self-tuning will produce less disturbance to the process.
2. Unlike auto-tuning, self-tuning doesn't change the control mode during the tuning period. It always performs PID control.
3. Changing the set point during self-tuning is allowable. Therefore, self-tuning can be used for ramping set point control as well as remote set point control where the set point is changed from time to time.

Benefits of self-tuning:
1. Less disturbance to the process.
2. Perform PID control during tuning period.
3. Available for ramping set point control and remote set point control.

Operation:
The parameter SELF is contained in the setup menu. Refer to section 1-5 to find SELF for initiating self-tuning.

3–20 Auto tuning

The auto-tuning process is performed at the set point.
The process will oscillate around the set point during the tuning process.
Set the set point to a lower value if overshooting beyond the normal process value is likely to cause damage.

Auto-tuning is applied in cases of:
- Initial setup for a new process
- The set point is changed substantially from the previous auto-tuning value
- The control result is unsatisfactory

Operation:

1. The system has been installed normally.
2. Use the default values for PID before tuning.
   The default values are: PB1=PB2=18.0°
   TI1=TI2=100 seconds, TD1=TD2=25.0 seconds.
   Of course, you can use other reasonable values for PID before tuning according to your previous experiences. But don't use a zero value for PB1 and TI1 or PB2 and TI2, otherwise, the auto-tuning program will be disabled.
3. Set the set point to a normal operating value or a lower value if overshooting beyond the normal process value is likely to cause damage.
4. Press until A_t appears on the display.
5. Press for at least 3 seconds. The upper display will begin to flash and the auto-tuning procedure is beginning.

Applicable conditions:

PB1≠0, TI1≠0 if PB1,TI1,TD1 assigned

PB2≠0, TI2≠0, if PB2, TI2, TD2 assigned

NOTE:
Ramping function, remote set point, or pump function, if used, will be disabled once auto-tuning is proceeding.

Procedures:
Auto-tuning can be applied either as the process is warming up (cold start) or when the process has been in a steady state (warm start). See figure 3.22.

If auto-tuning begins apart from the set point (cold start), the unit enters warm-up cycle. As the process reaches the set point value, the unit enters a waiting cycle. The waiting cycle elapses for a double integral time (TI1 or TI2, dependent on the selection, see section 4.1), then it enters a learning cycle. The double integral time is introduced to allow the process to reach a stable state. Before the learning cycle, the unit performs a pre-tune function with PID control. While in the learning cycle, the unit performs a post-tune function with an ON-OFF control. The learning cycle is used to test the characteristics of the process. The data is measured and used to determine the optimal PID values. At the end of two successive ON-OFF cycles, the PID values are obtained and automatically stored in the nonvolatile memory.

Pre-tune function advantage:
Consistent tuning results can be obtained

Once the auto-tuning procedures are completed, the process display will cease to flash and the unit will revert to PID control using its new PID values.

During the pre-tune stage the PID values will be modified if any instability is caused by incorrect PID values is detected. Without the pre-tune stage, like other conventional controllers, the tuning result will be strongly related to the time when the auto-tuning is applied. Hence, different values will be obtained every time auto-tuning is completed without pre-tune.

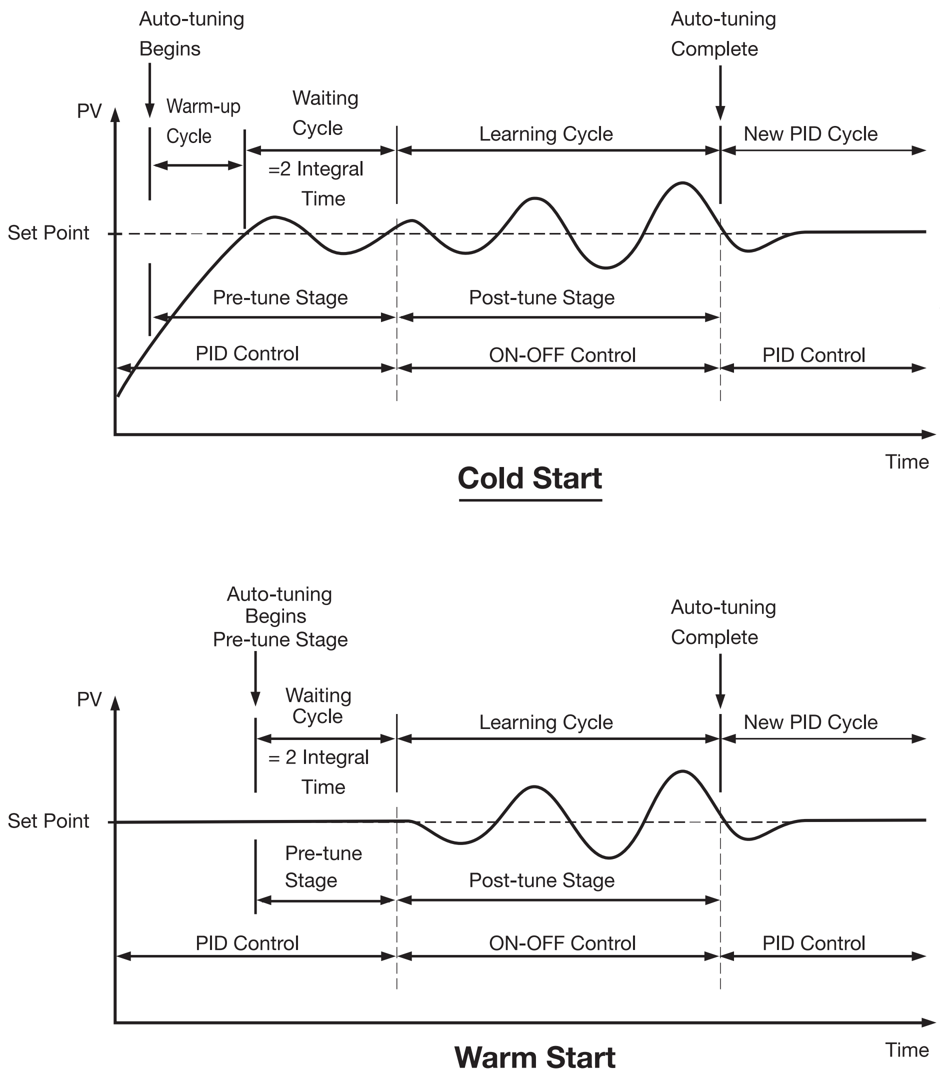


Figure 3.22
Auto-Tuning Procedure

If auto-tuning begins near the set point (warm start), the unit skips the warm-up cycle and enters the waiting cycle. Afterward, the procedures are the same as described for cold start.

AtEr Auto-Tuning Error

If auto-tuning fails, an ATER message will appear on the upper display in the following cases:

• If PB exceeds 9000 (9000 PU, 900.0°F or 500.0°C);
• if TI exceeds 1000 seconds;
• if the set point is changed during the auto-tuning procedure;
• or if the event input state is changed so that the set point value is changed.

AtEr Auto-tuning error

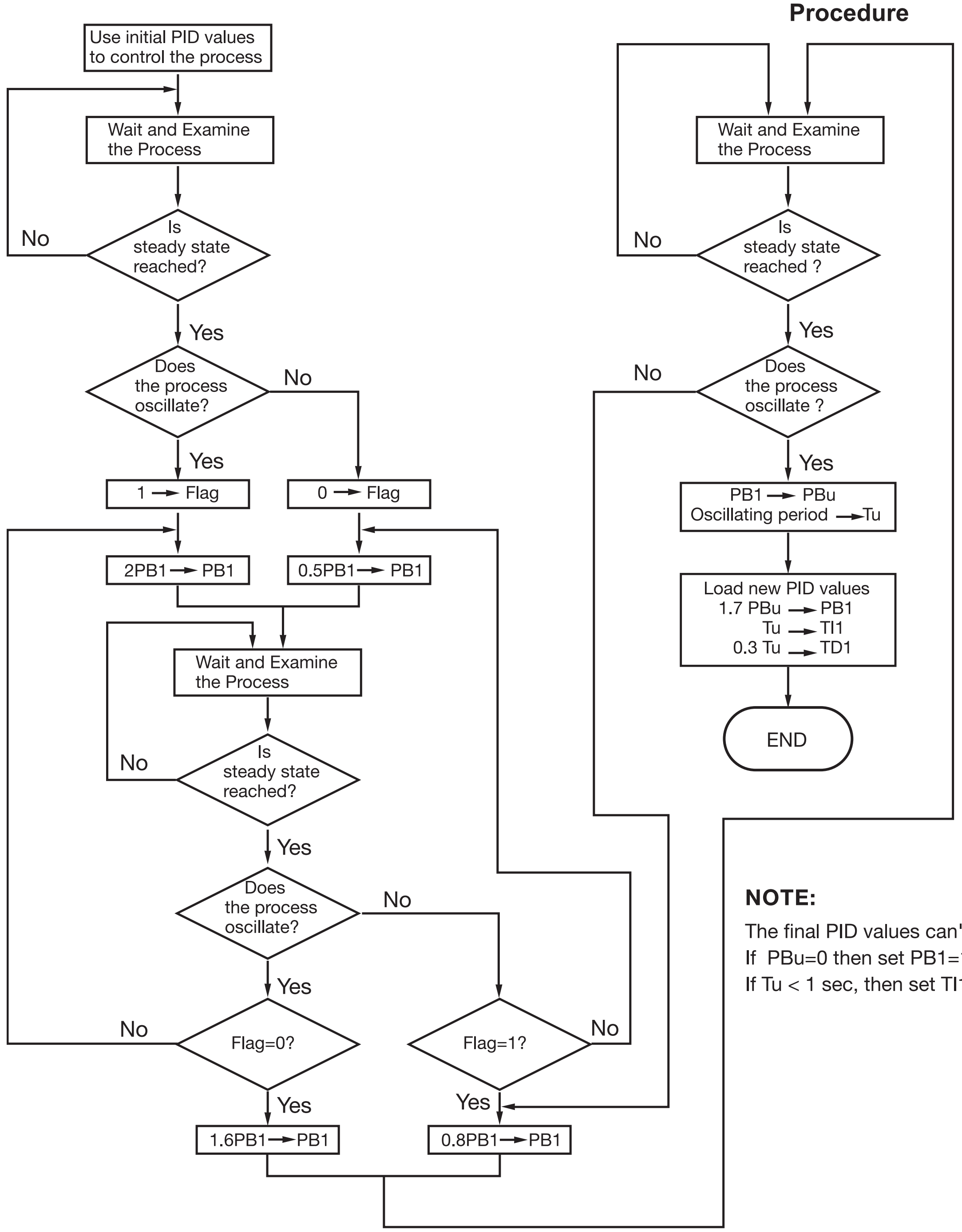
Solutions to AtEr

1. Try auto-tuning again.
2. Don't change the set point value during the auto-tuning procedure.
3. Don't change the event input state during the auto-tuning procedure.
4. Use manual tuning instead of auto-tuning. (See section 3-21)
5. Touch any key to reset AtEr message.

3–21 Manual Tuning

In certain applications (very few), when using both self-tuning and auto-tuning to tune a process proves inadequate for the control requirements, you can try manual tuning. Connect the controller to the process and perform the procedures according to the flow chart shown in the following diagram.

Figure 3.23
Manual Tuning
Procedure



NOTE:

The final PID values can't be zero.
If PBu=0 then set PB1=1.
If Tu < 1 sec, then set TI1=1 sec.

The above procedure may take a long time before reaching a new steady state since the P band was changed. This is particularly true for a slow process. As a result, the above manual tuning procedures will take from minutes to hours to obtain optimal PID values.

The PBu is called the ultimate P band, and the period of oscillation Tu is called the ultimate period in the flow chart in figure 3.23. When this occurs, the process is said to be in a critical steady state. figure 3.24 shows an example of a critical steady state.

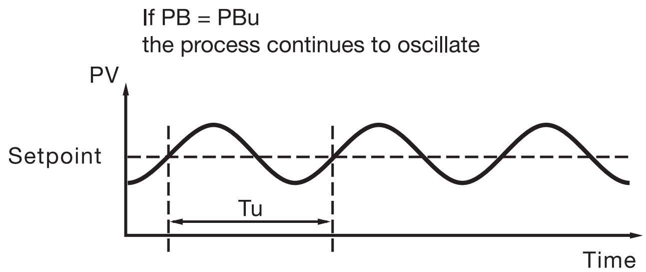


Figure 3.24
Critical Steady State

If the control performance using above tuning is still unsatisfactory, the following rules can be applied for further adjustment of PID values:

Table 3.2 PID Adjustment Guide

ADJUSTMENT SEQUENCE	SYMPTOM	SOLUTION
(1) Proportional Band (P) PB1 and/or PB2	Slow Response	Decrease PB1 or PB2
	High overshoot or Oscillations	Increase PB1 or PB2
(2) Integral Time (I) TI1 and/or TI2	Slow Response	Decrease TI1 or TI2
	Instability or Oscillations	Increase TI1 or TI2
(3) Derivative Time (D) TD1 and/or TD2	Slow Response or Oscillations	Decrease TD1 or TD2
	High Overshoot	Increase TD1 or TD2

Figure 3.25 shows the effects of PID adjustment on process response.

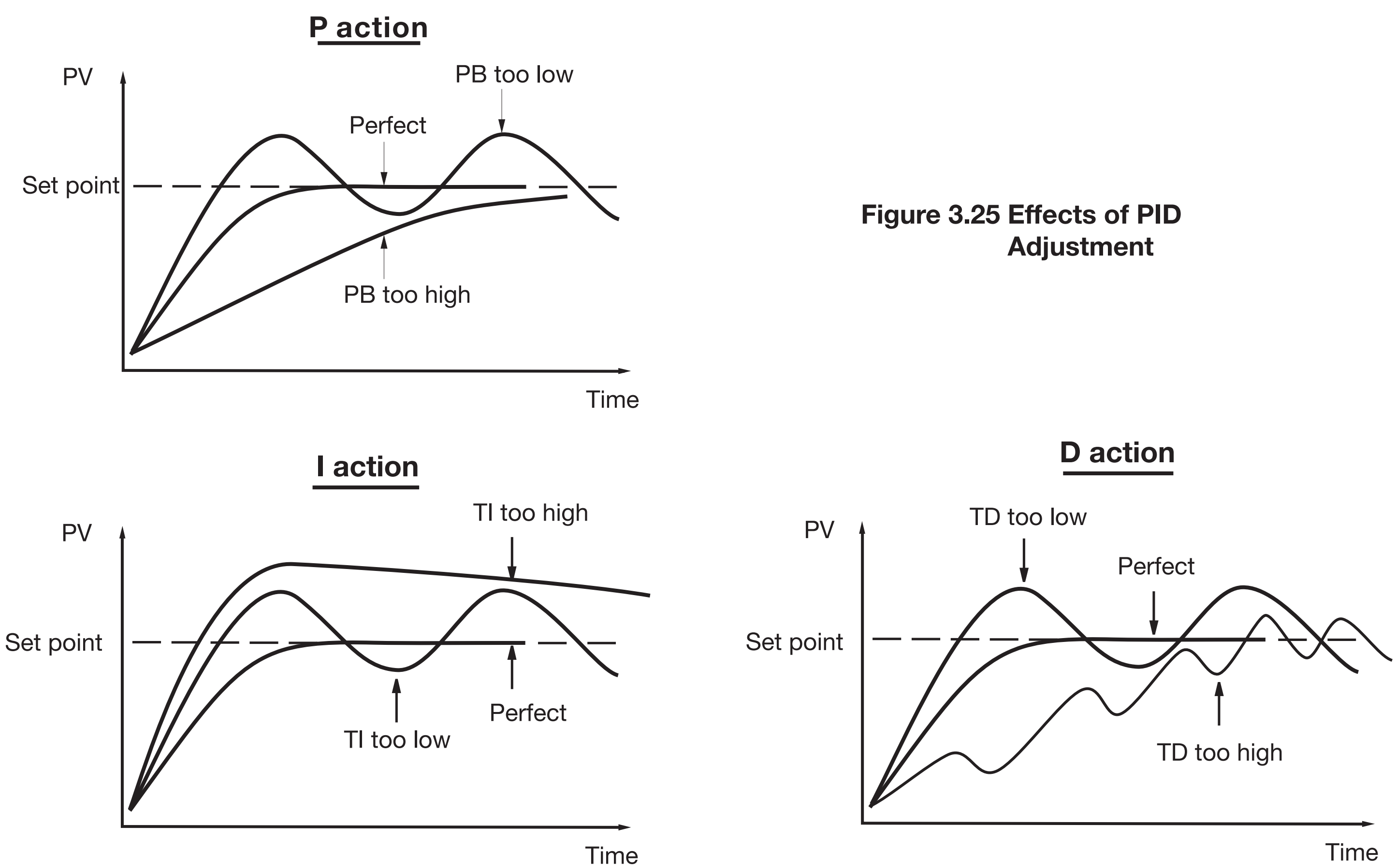


Figure 3.25 Effects of PID Adjustment

3–22 Signal Conditioner DC Power Supply

Three types of isolated DC power supplies are available to supply an external transmitter or sensor. These are 20V rated at 25mA, 12V rated at 40mA and 5V rated at 80mA. The DC voltage is delivered to the output 2 terminals.

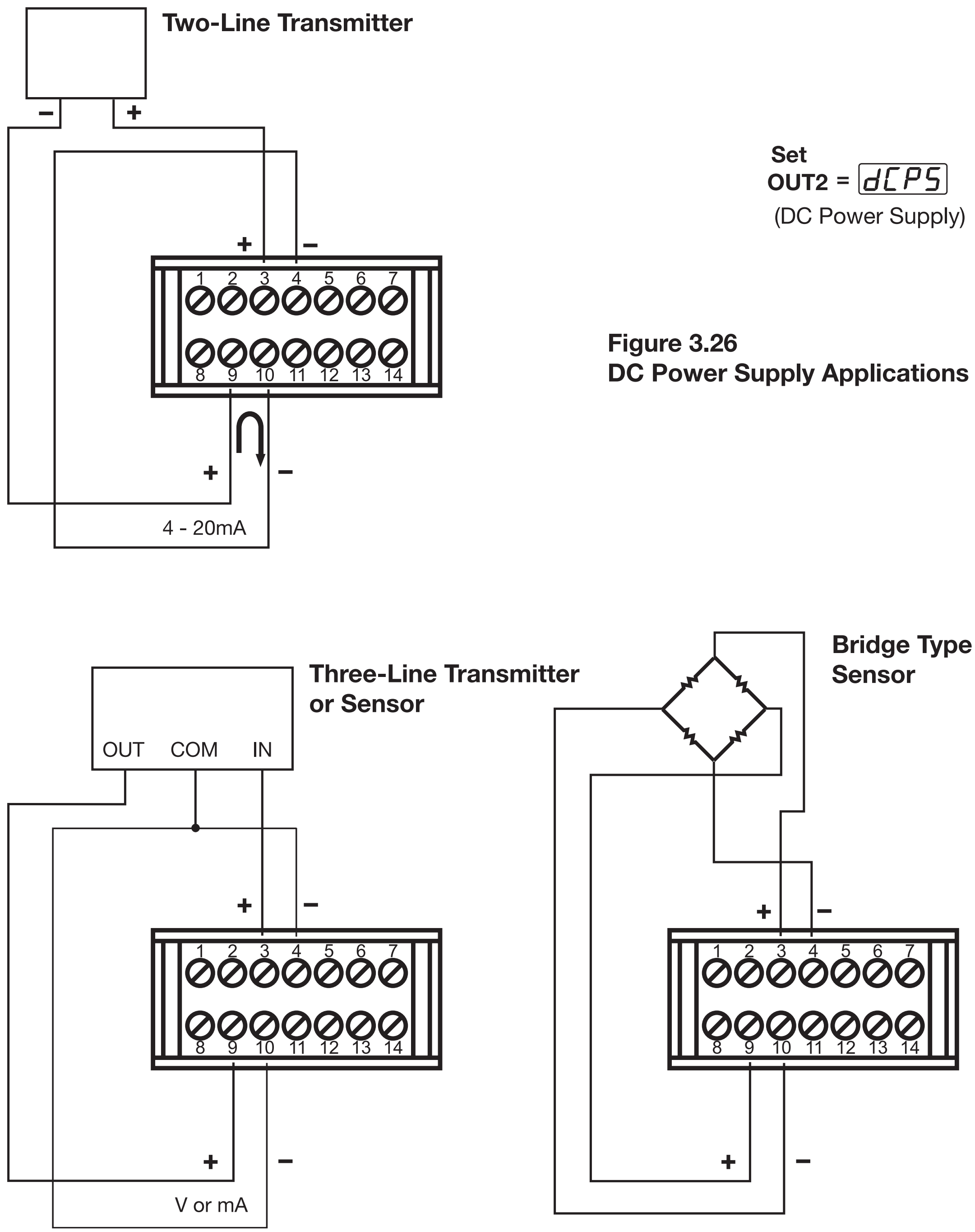


Figure 3.26
DC Power Supply Applications

Caution:
To avoid damage, don't use a DC power supply beyond its current rating. Purchase one with the correct voltage to suit your external devices. See the ordering code in section 1-2.

3–23 Manual Control

Manual control may be used for the following purposes:

1. To test the process characteristics to obtain a step response as well as an impulse response and use these data for tuning a controller.
2. To use manual control instead of a closed-loop control if the sensor fails or the controller's A-D converter fails. **NOTE** that bumpless transfer can not be used for an extended time. See section 3-18.
3. In certain applications, it is desirable to supply a process with a constant demand.

Operation:
Press and release [scroll] [down] until HAnd (hand control) appears on the display. Press [scroll] for 3 seconds, then release. The display will begin to flash and will show H - - -. The controller is now in manual control mode. Press [scroll]; the display will show C - - - and H - - - alternately where H - - - indicates output 1 (or heating) “on” time % and C - - - indicates output 2 (or cooling) “on” time %. Now you can use the up and down keys to adjust the percentage values for H or C. This percentage of “on” time is in relation to CYC1 for output 1 or CYC2 for output 2.

H38.4 **Means**
MV1=38.4% for OUT1 (or heating)
C7.63 **Means**
MV2=7.63% for OUT2 (or cooling)

The controller performs open loop control as long as it stays in manual control mode. The H value is exported to output 1 (OUT1) and C value is exported to output 2 provided that OUT2 is performing cooling function (i.e., OUT2 selects COOL).

Exception
If OUT1 is configured as ON-OFF control (i.e., PB1=0 if PB1 is assigned or PB2=0 if PB2 is assigned by event input), the controller will never perform manual control mode.

Exiting Manual Control
Press [up] [down] keys the and the controller will revert to its previous operating mode (may be a failure mode or normal control mode).

3–24 Display Mode

3–23 Manual Control

Manual control **may be used for the following purposes:**

1. To test the process characteristics to obtain a step response as well as an impulse response and use these data for tuning a controller.
2. To use manual control instead of a closed-loop control if the sensor fails or the controller's A-D converter fails. **NOTE** that bumpless transfer can not be used for an extended time. See section 3-18.
3. In certain applications, it is desirable to supply a process with a constant demand.

Operation:
Press ▽ until HAnd (hand control) appears on the display. Press for 3 seconds, then the upper display will begin to flash and the lower display will show H___. The controller is now in manual control mode. Press C___; the lower display will show C___ and H___ alternately where H___ indicates output 1 (or heating) control variable value MV1 and C___ indicates output 2 (or cooling) control variable value MV2. Now you can use the up and down keys to adjust the percentage values for H or C.

H38.4 **Means**
MV1=38.4% for OUT1 (or heating)
C7.63 **Means**
MV2=7.63% for OUT2 (or cooling)

The controller performs open loop control as long as it stays in manual control mode. The H value is exported to output 1 (OUT1) and C value is exported to output 2 provided that OUT2 is performing cooling function (i.e., OUT2 selects COOL).

Exception
If OUT1 is configured as ON-OFF control (i.e., PB1=0 if PB1 is assigned or PB2=0 if PB2 is assigned by event input), the controller will never perform manual control mode.

Exiting Manual Control
Press △ ▽ keys the and the controller will revert to its previous operating mode (may be a failure mode or normal control mode).

3–25 Heater Current Monitoring

TEC99999, a current transformer, can be equipped to measure the heater current. Select CT for IN2. The input 2 signal conditioner measures the heater current while the heater is powered and the current value will remain unchanged while the heater is unpowered. The PV2 will indicate the heater current. For information on how to read PV2 value, please refer to section 3-24.
Alarms and other actions can then be set using heater current as a process value

NOTES

If the heater to be measured is controlled by output 1, then CYC1 should be set for 1 second or longer and O1TY should use RELY, SSRD, or SSR. Similarly, if the heater to be measured is controlled by output 2, then CYC2 should be set for 1 second or longer and O2TY should use RELY, SSRD, or SSR to provide an adequate time for the A to D converter to measure the signal.

Since TEC99999 can detect a full-wave AC current only, a DC or half-wave AC current can't be measured.

Accessory installed:
TEC99999

Setup
IN2=CT
O1TY or O2TY=RELY, SSRD or SSR
CYC1 or CYC2≥1 second

Limitations

1. Linear output type can't be used.
2. CYC1 (or CYC2) should be set for 1 second or longer to detect heater current reliably.
3. Only full-wave AC current can be detected.

3–26 Reload Default Values

The default values listed in table 1.4 are stored in the memory when the product leaves the factory. On certain occasions, it is desirable to retain these values after the parameter values have been changed. Here is a convenient way to reload the default values.

Operation

Press several times until dEFt appears. Then press . The upper display will show FILE. Use the up and down keys to select 0 or 1. If °C units are required, select 0 for FILE and if °F units are required, select 1 for FILE. Then press for at least 3 seconds. The display will flash for a moment while the default values are reloaded.

CAUTION

The procedure mentioned above will change the previous setup data. Before performing it, make sure that it is really required.

FILE 0
°C default file

FILE 1
°F default file

Chapter 4 Full Function Programming

4–1 Event Input

Refer to section 2-10 for wiring an event input.
The event input accepts a digital type signal. Dry contacts or open collector pull low can be used to switch the event input.

One of ten functions can be chosen by using E,Fn (EIFN) in the setup menu.

NONE: Event input no function. If chosen, the event input function is disabled. The controller will use PB1, TI1, and TD1 for PID control and SP1 (or other values determined by SPMD) for the set point.

SP2: If chosen, the SP2 will replace the role of SP1 for control.

PID2: If chosen, the second PID set PB2, TI2, and TD2 will be used to replace PB1, TI1, and TD1 for control.

SP.P2: If chosen, SP2, PB2, TI2, and TD2 will replace SP1, PB1, TI1, and TD1 for control.

NOTE: If the second PID set is chosen during auto-tuning and/or self-tuning procedures, the new PID values will be stored in PB2, TI2, and TD2.

RS.A1: Resets alarm 1 as the event input is activated. However, if the alarm 1 condition is still existent, alarm 1 will be retriggered when the event input is released.

RS.A2: Resets alarm 2 as the event input is activated. However, if the alarm 2 condition is still existent, alarm 2 will be retriggered when the event input is released.

R.A1.2: Resets both alarm 1 and alarm 2 as the event input is activated. However, if alarm 1 and/or alarm 2 are still existent, alarm 1 and/or alarm 2 will be triggered again when the event input is released.

RS.A1, RS.A2, and R.A1.2 are particularly suitable to be used for latching and/or latching/holding alarms.

D.O1: Disables output 1 as the event input is activated.

D.O2: Disables output 2 as the event input is activated.

D.O1.2: Disables both output 1 and output 2.

When any of D.O1, D.O2, or D.O1.2 are selected for EIFN, output 1 and/or output 2 will revert to their normal conditions as soon as the event input is released.

LOCK: All parameters are locked to prevent them from being changed. See section 4-13 for more details.

Terminals:

11 Event input +
10 Event input –

EIFN

0 NONE
1 SP2
2 PID2
3 SP.P2
4 RS.A1
5 RS.A2
6 R.A1.2
7 D.O1
8 D.O2
9 D.O1.2
10 LOCK

SP2F Function: Defines the format of SP2 value. If ACTU is selected for SP2F in the setup menu, the event input function will use the SP2 value for its second set point. If DEVI is selected for SP2F, the SP1 value will be added to SP2. The sum of SP1 and SP2 (SP1+SP2) will be used by the event input function for the second set point value. In certain applications, it is desirable to move the second set point value with respect to the value of set point 1. The DEVI function for SP2 provides a convenient way to do this.

SP2F=Format of SP2 value
ACTU: SP2 is an actual value
DEVI: SP2 is a deviation value

Modification from RS-232 to event input:
Because of the limited number of pins, pin 11 is used for both event input and RS-232. If you want to change function of the TEC-2500 from RS-232 to event input, you must modify jumpers J51 and J52 on the CPU board by opening jumper J52 and shorting jumper J51. Refer to section 2-16 for the location of jumpers J51 and J52.

4–2 Second Set Point

In certain applications it is desirable to have the set point change automatically, without the need to adjust it. You can apply a signal to the event input terminals (pin 10 and pin 11). The signal applied to the event input may come from a **timer**, a **PLC**, an **alarm relay**, a **manual switch,** or other devices. Select SP2 for EIFN, which is in the setup menu. This is available only when SP1.2, MIN.R, or HR.R is used for SPMD, where MIN.R and HR.R are used for the ramping function. See section 4-4.

Apply Signal To
11 Event input +
10 Event input –

Setup
EIFN choose SP2 or SP.P2

Availability

SPMD choose
SP1.2
or MIN.R
or HR.R

Application 1: A process is required to be heated to a higher temperature as soon as its pressure exceeds a certain limit. Set SPMD=SP1.2, EIFN=SP2 (or SP.P2 if the second PID is required for the higher temperature too). The pressure gauge is switched ON as it senses a higher pressure. Connect the output contacts of the pressure gauge to the event input. SP1 is set for a normal temperature and SP2 is set for a higher temperature. Choose ACTU for SP2F.

Application 2: An oven is required to be heated to 300°C from 8:00AM to 6:00PM. After 6:00PM it should be maintained at 80°C. Use a programmable 24 hour cycle timer for this purpose. The timer output is used to control the event input. Set SPMD=SP1.2, and EIFN=SP2 (or SP.P2 if the second PID is required to be used for the second set point). SP1 is set at 300°C and SP2 is set at 80°C. Choose ACTU for SP2F. After 6:00PM the timer output is closed. The event input function will then select SP2 (=80°C) to control the process.

Format of SP2 Value
SP2F choose
ACTU Actual Value
or DEVI Deviation Value

Refer to section 4-1 for more descriptions about SP2F function.

4–3 Second PID Set

In certain applications the characteristics of a process are strongly related to its process value. The TEC-2500 provides two sets of PID values. When the process is changed to a different set point, the PID values can be switched to another set to achieve optimum conditions.

Apply signal to

⑪ Event input +

⑩ Event input –

Auto-tuning second PID

The optimal PID values for a process may vary with its process value and set point. Hence if a process is used for a wide range of set points, dual PID values are necessary to optimize control performance. If the first PID set is selected (event input is not applied) during auto-tuning procedure, the PID values will be stored in PB1, TI1, and TD1. Similarly, if the second PID set is selected (event input is applied while PID2 or SP.P2 is selected for EIFN) during auto-tuning, the PID values will be stored in PB2, TI2, and TD2 as soon as auto-tuning is completed.

Setup

EIFN choose PID2 or SP.P2

Application 1: programmed by the set point

Choose **SP.P2** for **EIFN** then both set point and PID values will be switched to another set simultaneously. The signal applied to the event input may come from a timer, a PLC, an alarm relay, a manual switch or other devices.

EIFN=SP.P2

Application 2: programmed by the process value

If the process value exceeds a certain limit, 500°C for example, it is desirable to use another set of PID values to optimize control performance. You can use a process high alarm to detect the limit of the process value. Choose PV1H for A1FN, NORM for A1MD, adjust A1SP to be equal to 500°C, and choose PID2 for EIFN. If the temperature is higher than 500°C, then alarm 1 is activated. If the alarm 1 output is connected to the event input, the PID values will change from PB1, TI1, and TD1 to PB2, TI2, and TD2.

EIFN=PID2

Alarm output controls the event input

Refer to section 5-9 for more details.

4–4 Ramp and Dwell

Ramp

The ramping function is performed during power up as well as any time the set point is changed. Choose MINR or HRR for SPMD, and the unit will perform the ramping function. The ramp rate is programmed by using RAMP, which is found in the user menu.

SPMD Choose

minr Unit / minute

or Hrr Unit / hour

Adjust

rAMP RAMP

Example without dwell timer

Select MINR for SPMD, °C for IN1U, 1-DP for DP1, and set RAMP=10.0. SP1 is set to 200°C initially, then changed to 100°C 30 minutes after power up. The starting temperature is 30°C. After power up, the process runs like the curve shown below:

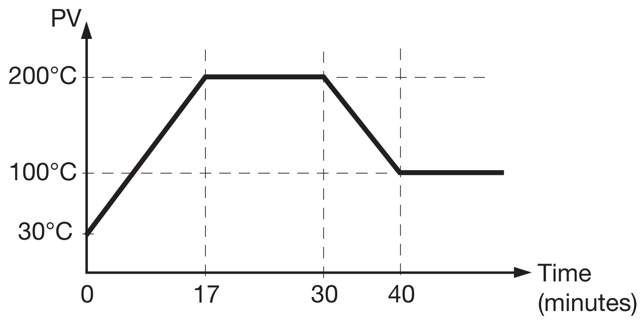


Figure 4.1 RAMP Function

Note: When the ramp function is used, the display will show the current process value. However, it will revert to show the set point value as soon as the up or down key is pressed for adjustment. Setting RAMP to zero means no ramp function at all.

Dwell

The dwell timer can be used separately or in conjunction with a ramp. If A1FN is set for TIMR, alarm 1 will act as a dwell timer. Similarly, alarm 2 will act as a dwell timer if A2FN is set for TIMR. The timer is programmed by using TIME which is in the user menu. The timer starts to count as soon as the process reaches its set point, and triggers an alarm when it times out. Here is an example.

A1FN or A2FN Choose

timr TIMER

Adjust

timE TIME

Example without ramp

Select TIMR for A1FN, °F for IN1U, NODP for DP1, and set TIME=30.0. SP1 is set to 400°F initially, and corrected to 200°F before the process reaches 200°F. As the process reaches the set point (i.e., 200°F), the timer starts to count. The TIME value can still be corrected without disturbing the timer before time out. TIME is changed to 40.0 28 minutes after the process has reached its set point. The behavior of the process value and alarm 1 are shown below.

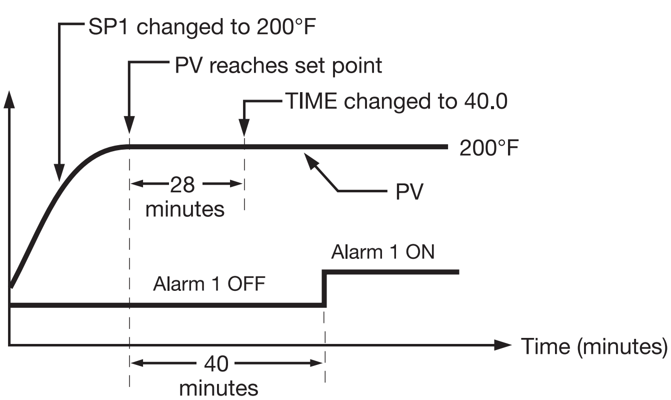


Figure 4.2 Dwell Timer

Once the timer output is energized, it will remain unchanged until power down or an event input programmed for resetting the alarm is applied.

Note: TIMR can't be chosen for A1FN and A2FN simultaneously, or an Er07 error code will result.

Er07 **Error code**

Ramp and dwell
A ramp may be accompanied with a dwell timer to control the process. Here is an example.

Example with ramp and dwell
Select HRR for SPMD, PU for IN1U, 2-DP for DP1, and set RAMP=60.00. Select TIMR for A2FN and set TIME=20.0. When power is applied, the process value starts at 0.00, SP1=30.00, and SP2=40.00. The timer output is used to control event input.

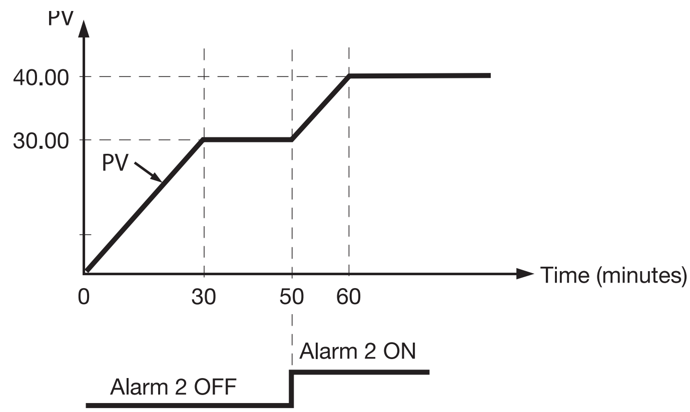


Figure 4.3 Ramp Accompanied with a Dwell Timer

4–5 Remote Set Point

Selecting PV1 or PV2 for SPMD will enable the TEC-2500 to accept a remote set point signal. If PV1 is selected for SPMD, the remote set point signal is sent to input 1, and input 2 is used for the process signal input. If PV2 is selected for SPMD, the remote set point signal is sent to input 2, and input 1 is used for the process signal. To achieve this, set the following parameters in the setup menu.

Setup
FUNC=FULL

SPMD=PV2, PVMD=PV1
or
SPMD=PV1, PVMD=PV2

Case 1: Use Input 2 to accept remote set point
FUNC=FULL
IN2, IN2U, DP2, IN2L, IN2H, are set according to remote signal.
PVMD=PV1
IN1, IN1U, DP1, are set according to the process signal
IN1L, IN1H if available, are set according to the process signal
SPMD=PV2

Case 2: Use Input 1 to accept remote set point
FUNC=FULL
IN1, IN1U, DP1, IN1L, IN1H, are set according to remote signal.
PVMD=PV2
IN2, IN2U, DP2, are set according to the process signal
IN2L, IN2H if available, are set according to the process signal
SPMD=PV1

Note 1: If PV1 is chosen for both SPMD and PVMD, an Er01 error code will appear.
If PV2 is chosen for both SPMD and PVMD, an Er02 error code will appear.
In either case, the TEC-2500 will not control properly.

Note 2: If PV1/PV2 is selected for SPMD, a signal loss will result in the controller reverting to manual mode with 0% output.

Error message
Er01
Er02

4–6 Differential Control

In certain applications it is desirable to control a second process such that its process value always deviates from the first process by a constant value. To achieve this, set the following parameters in the setup menu.

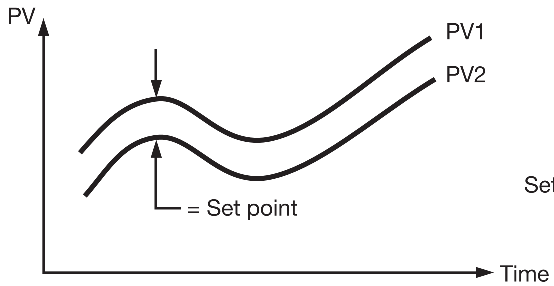
Setup

PVMD=P1-2
or PVMD=P2-1

SPMD=SP1.2

FUNC=FULL
IN1, IN1L, IN1H are set according to input 1 signal
IN2, IN2L, IN2H are set according to input 2 signal
IN1U, DP1, IN2U, DP2, are set according to input 1 and input 2 signal
PVMD=P1-2 or P2-1
SPMD=SP1.2

The response of PV2 will be parallel to PV1 as shown in the following diagram



PV = PV1 – PV2
or PV2 – PV1
Set point = SP1 or SP2

Figure 4.4
Relation between PV1 and PV2 for a Differential Control

The PV display will indicate PV1-PV2 value if P1-2 is chosen for PVMD, or PV2-PV1 value if P2-1 is chosen for PVMD. If you need PV1 or PV2 to be displayed instead of PV, you can use the display mode to select PV1 or PV2 to be viewed. See section 3-24.

Error messages
If P1-2 or P2-1 is selected for PVMD, while PV1 or PV2 is selected for SPMD, an Er03 error code will appear.
In this case the signals used for input 1 and input 2 should be the same unit and the same decimal point, that is, IN1U=IN2U, DP1=DP2, otherwise an Er05 error code will appear.

Error message

Er03
Er05

4–7 Output Power Limits

Menu

PL1
PL2

In certain systems the heater (or cooler) is over-powered such that the process is too heavily heated or cooled. To avoid an excessive overshoot and/or undershoot you can use the power limit function. Output 1 power limit PL1 is contained in the user menu. If output 2 is not used for cooling (that is, COOL is not selected for OUT2), then PL2 is **hidden**. If the controller is used for ON-OFF control, then both PL1 and PL2 are **hidden**.

Operation:
Press for 3 seconds, then press several times to reach PL1 and PL2. PL1 and PL2 are adjusted by using the up and down keys with range of 0–100%.

Example:
OUT2=COOL, PB1=10.0°C, CPB=50, PL1=50, PL2=80
Output 1 and output 2 will act as the following curves:

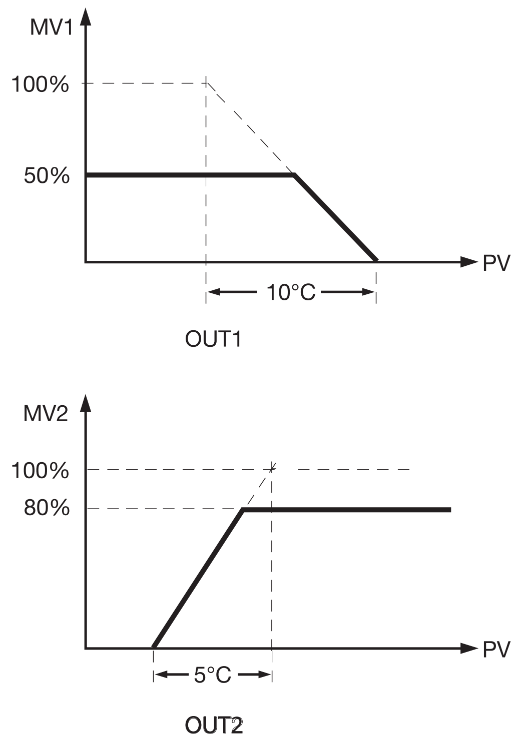


Figure 4.5
Power Limit Function

NOTE:
The adjustment range of MV1 (H) and MV2 (C) for manual control and/or failure transfer are not limited by PL1 and PL2.

4–8 Data Communication

Two types of interfaces are available for data communication. These are the RS-485 and RS-232 interfaces. Since RS-485 uses a differential architecture to drive and sense signal instead of a single ended architecture which RS-232 uses, RS-485 is less sensitive to noise and more suitable for communication over longer distances. RS-485 can communicate without error over a distance of 1km while RS-232 is not recommended for distances over 20 meters.

RS-485 Benefits:
Long distance
Multiple units

RS-232 Benefits:
Direct connection to a PC

Using a PC for data communication is the most economical method. The signal is transmitted and received through the PC communication port (generally RS-232). Since a standard PC can't support an RS-485 port, a network adapter (such as TEC99927 or TEC99928) has to be used to convert RS-485 to RS-232 for a PC. Up to 247 RS-485 units can be connected to one RS-232 port; therefore a PC with four comm ports can communicate with 988 units.

Setup
Enter the setup menu.
Select FULL (full function) for FUNC.
Select 485 for COMM if RS-485 is required, or 232 if RS-232 is required. Select RTU (i.e., Modbus protocol RTU mode) for PROT. Set individual addresses for any units that are connected to the same port. Set the baud rate (BAUD), data bit (DATA), parity bit (PARI) and stop bit (STOP) so that these values are accordant with the PC setup conditions.

NOTE: If the TEC-2500 is configured for RS-232 communication, the EI (event input) and input 2 are disconnected internally. The unit can no longer perform event input function (EIFN) or other input 2 functions.

When you attach an RS-232 module (TEC-102-103) to the connectors on the CPU board (C250), you also need to modify jumpers J51 and J52 according to section 2-16. If you use a conventional 9-pin RS-232 cable instead of TEC99014, the cable should be modified for the proper operation of RS-232 communications according to section 2-16.

RS-485 Setup
FUNC=FULL
COMM=485
PROT=RTU
ADDR=Address
BAUD=Baud Rate
DATA=Data Bit Count
PARI=Parity Bit
STOP=Stop Bit Count

RS-485 Terminals
⑫ TX1
⑬ TX2

RS-232 Setup
FUNC=FULL
COMM=232
PROT=RTU
ADDR=Address
BAUD=Baud Rate
DATA=Data Bit Count
PARI=Parity Bit
STOP=Stop Bit Count

RS-232 Terminals
⑫ TX1
⑬ TX2
⑪ COM

4–9 Analog Retransmission

Analog retransmission is available for model number TEC-2500-XXXXXNX where N=3, 4 or 5. See ordering code in section 1-2.

Setup
Select FULL for FUNC in the setup menu.
Select a correct output signal for COMM which should be accordant with the retransmission option used. Five types of retransmission output are available. These are: 4–20mA, 0–20mA, 0–5V, 1–5V and 0–10V. There are eight types of parameters that can be retransmitted according to the analog function (AOFN) selected. These are: PV1, PV2, PV1–PV2, PV2–PV1, SV, MV1, MV2 and PV–SV. Refer to table 1.4 for a complete description. Select a value for AOLO corresponding to output zero and select a value for AOHI corresponding to output SPAN.

Setup Menu

FunC FUNC
Comm COMM
AoFn AOFN
AoLo AOLO
AoHi AOHI

Terminals

12 AO+
13 AO−

How to determine output signal:
AOLO and AOHI are set to scale output signal low SL (e.g., 4mA) and output signal high SH (e.g., 20mA) respectively. The analog output signal AOS, corresponding to an arbitrary value of parameter AOV, is determined by the following curve.

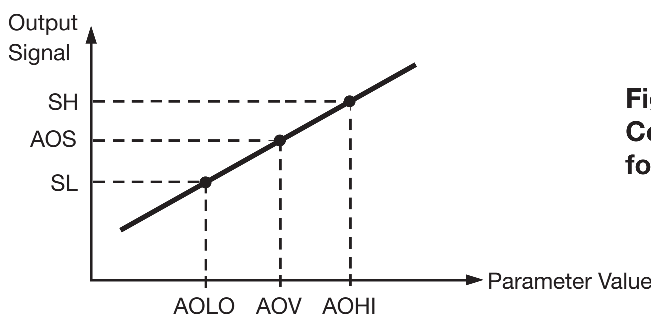


Figure 4.6
Conversion Curve for Retransmission

Formula: $AOS = SL + (AOV - AOLO)\dfrac{SH - SL}{AOHI - AOLO}$

$$AOV = AOLO + (AOS - SL)\dfrac{AOHI - AOLO}{SH - SL}$$

Notes:
The setup values used for AOHI and AOLO must not be equal, otherwise, incorrect values will occur. However, AOHI can be set either higher or lower than AOLO. If AOHI is set higher than AOLO it could result in a direct conversion. If AOHI is set lower than AOLO it could result in a reverse conversion.

NOTES

AOHI≠AOLO
AOHI>AOLO:
Direct conversion

AOHI<AOLO:
Reverse conversion

Example
A control uses a 4–20mA analog output to retransmit the difference value between input 1 and input 2 (PV1–PV2). It is required that if the difference value is -100, 4mA will be transmitted, and if the difference value is 100, 20mA will be transmitted. Make the following setup for TEC-2500:
IN1U=PU, DP1=NODP, IN2U=PU, DP2=NODP, FUNC=FULL, COMM=4-20, AOFN=P1-2, AOLO=-100, AOHI=100

4–10 Digital Filter

In certain applications the process value is too unstable to be read. A programmable low-pass filter incorporated in the TEC-2500 can be used to improve this. This is a first order filter with the time constant specified by the **FILT** parameter in the setup menu. The default value of FILT is set at 0.5 seconds. Adjust FILT to change the time constant from 0 to 60 seconds. 0 seconds means no filter is applied to the input signal. The filter is characterized by the following diagram.

Menu
FILt **FILT**

Filter is used to stabilize the process display.

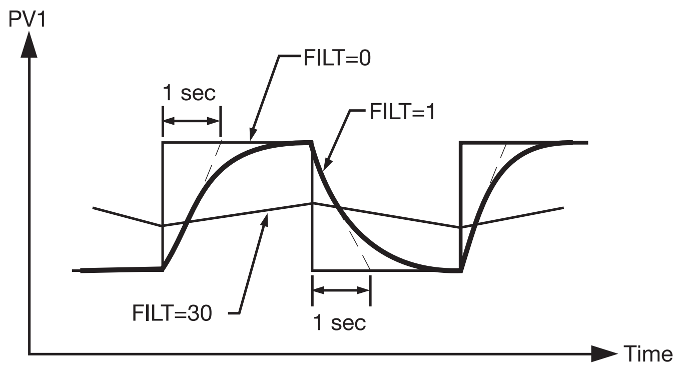


Figure 4.7
Filter Characteristics

Note
The filter is available only for PV1, and is performed for the displayed value only. The controller is designed to use unfiltered signal for control even if the filter is applied. A lagged (filtered) signal, if used for control, may produce an unstable process.

4–11 Sleep Mode

To enter sleep mode:
Set FUNC for FULL to provide full function.
Select YES for SLEP to enable sleep mode.
Press ⏶ ⏷ for 3 seconds; the unit will now enter sleep mode.
During sleep mode:

1. All displays are shut off except a decimal point which is lit periodically.
2. All outputs and alarms are shut off.

To exit sleep mode:

1. Press ⏶ ⏷ to leave the sleep mode.
2. Disconnect the power.

The sleep function can be used in place of a power switch to reduce the system cost.

Default: SLEP=NONE, sleep mode is disabled.

Note: If sleep mode is not required by your system, NONE should be selected for SLEP to disable sleep mode.

Sleep mode features:
Shut off display
Shut off outputs
Green power
Replaces power switch

Setup menu
FUNC=FULL
SLEP=YES

4–12 Pump Control

PUMP:
A cost effective solution

Pump control function is one of the unique features of the TEC-2500. Using this function, the pressure in a process can be excellently controlled. The pressure in a process is commonly generated by a pump driven by a variable speed motor. The complete system has the following characteristics which affect control behavior.
1. The system is very noisy.
2. The pressure changes very rapidly.
3. The pump characteristics are ultra nonlinear with respect to its speed.
4. The pump can't generate any more pressure if its speed is lower than half of its rating speed.
5. An ordinary pump may slowly lose pressure even if the valves are completely closed.

Obviously, a conventional controller can't fulfill the conditions mentioned above. Only the superior noise rejection capability in addition to the fast sampling rate possessed by the TEC-2500 can handle such an application. To achieve this, set the following parameters in the setup menu:

Key menu

SPMD
SP2F
REFC
SP2

FUNC=FULL
EIFN=NONE
PVMD=PV1
FILT=0.5
SELF=NONE
SPMD=PUMP
SP2F=DEVI

and program the following parameters in the user menu:

REFC=reference constant
SP2=a negative value added to SP1 to obtain the set point for the idle state

Pump control features:
1. Minimum oscillation of pressure
2. Rapidly stabilized
3. Guaranteed pump stop
4. Programmable pump stopping interval

Since the pump can't produce any more pressure at lower speeds, the pump may not stop running even if the pressure has reached the set point. If this happens, the pump will be overly worn and waste additional power. To avoid this, the TEC-2500 provides a reference constant REFC in the user menu.
If PUMP is selected for SPMD, the controller will periodically test the process by using this reference constant after the pressure has reached its set point. If the test shows that the pressure is still consumed by the process, the controller will continue to supply appropriate power to the pump. If the test shows that the pressure is not consumed by the process, the controller will gradually decrease the power to the pump until the pump stops running. When this happens, the controller enters an idle state. The idle state will use a lower set point which is obtained by adding SP2 to SP1 until the pressure falls below this set point. The idle state is provided for the purpose of preventing the pump from being restarted too frequently. The value of SP2 should be negative to ensure that the controller functions correctly.

The pump functions are summarized as follows:
1. If the process is demanding material (i.e., loses pressure), the controller will precisely control the pressure at the set point.
2. If the process no longer consumes material, the controller will shut off the pump for as long as possible.
3. The controller will restart the pump to control the pressure at the set point as soon as the material is demanded again when the pressure falls below a predetermined value (i.e., SP1+SP2).

Programming Guide for Pump Control:

1. Perform auto-tuning to the system under such conditions that the material (i.e., pressure) is exhausted at typical rate. A typical value for PB1 is about 10Kg/cm≈, TI1 is about 1 second, TD1 is about 0.2 seconds.
2. If the process oscillates around the set point after auto-tuning, then increase PB1 until the process can be stabilized at the set point. The typical value of PB1 is about half to two times the range of the pressure sensor.
3. Increasing FILT (filter) can further reduce the oscillation amplitude. But a value of FILT higher than 5 (seconds) is not recommended. A typical value for FILT is 0.5 or 1.
4. Close the valves and observe whether the controller can shut off the pump each time. The value of REFC should be adjusted as little as possible so that the controller can shut off the pump each time when all the valves are closed. A typical value for REFC is between 3 and 5.
5. An ordinary pump may slowly lose pressure even if the valves are completely closed. Adjust SP2 according to the rule that a more negative value of SP2 will allow the pump to be shut off for a longer time when the valves are closed. A typical value for SP2 is about -0.50Kg/cm≈.

An example for pump control is given in section 5-1.

4–13 Remote Lockout

The parameters can be locked to prevent them from being changed by using either **hardware lockout** (see section 1-3), **remote lockout**, or **both**. If you need the parameters to be locked by using an external switch (remote lockout function), then connect a switch to terminals 10 and 11 (see section 2-10), and choose LOCK for EIFN (see section 4-1).

Remote Lockout:
1. Connect external switch to terminal 10 and 11.
2. Set LOCK for EIFN
3. Lock all parameters

If remote lockout is configured, all parameters will be locked when the external switch is closed. When the switch is left open, the lockout condition is determined by internal DIP switch (hardware lockout, see section 1-3).

Hardware lockout: Can be used only during initial setup.
Remote lockout: Can be used any time.

Chapter 5 Applications

5–1 Pump/Pressure Control

Regulated water supply systems are widely used in residential areas, water plants, chemical plants, electrical plants, semiconductor plants, etc. By taking advantage of its PUMP function, the TEC-2500 can be used to create an economical yet versatile solution for these applications. Here is an example:

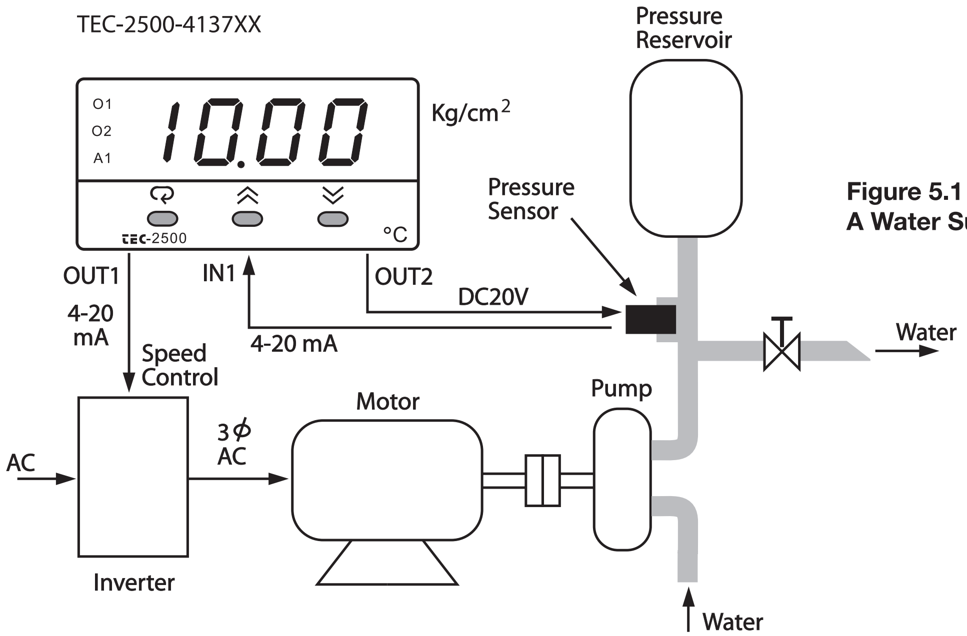


Figure 5.1
A Water Supply System

The water pressure in this example must be controlled at 10Kg/cm^2. To achieve this, the following devices are used for this example:

Inverter: To supply a variable frequency AC voltage to the motor.

Motor: A 3-phase induction motor.

Pump: Any appropriate economical type of pump.

Pressure Sensor: A three-wire or two-wire type of pressure transducer with a 0–20Kg/cm^2 range.

Pressure Reservoir: Provides smoother pressure for the system.

TEC-2500: Order a TEC-2500 with standard input, 4–20mA output 1, 20V DC output 2 for sensor power.

Set the following parameters in the setup menu:

FUNC=FULL
COMM: optional
IN1=4-20
IN1U=PU
DP1=2-DP
IN1L=0
IN1H=20.00
IN2=NONE
OUT1=REVR
O1TY=4-20
O1FT=0
OUT2=DCPS
A1FN: optional
EIFN=NONE
PVMD=PV1
FILT=1
SELF=NONE
SLEP=NONE
SPMD=PUMP
SP1L=5.00
SP1H=15.00
SP2F=DEVI

Adjust the following parameters in the user menu:

A1SP: optional
REFC=3
PB1=10.00
TI1=1
TD1=0.2
SP2=-0.50
PL1=100

Key menu:
SPMD
SP2F
REFC
SP2

Refer to section 4-12 for more details.

5–3 Heat Only Control

An oven is designed to dry the products at 150°C for 30 minutes and then stay unpowered for another batch. A TEC-2500 equipped with **dwell timer** is used for this purpose. The system diagram is shown as follows:

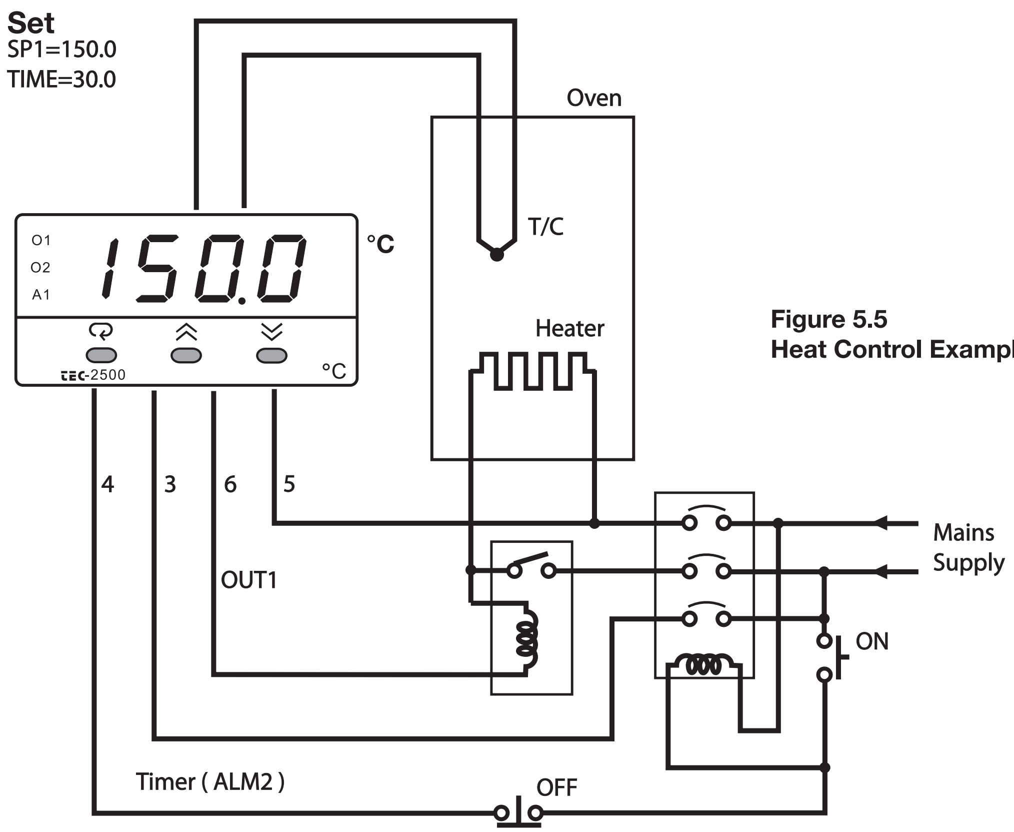


Figure 5.5
Heat Control Example

To achieve this function, set the following parameters in the setup menu.

FUNC=BASC (basic function)
IN1=K_TC
IN1U=°C
DP1=1_DP
OUT1=REVR
O1TY=RELY
CYC1=18.0
O1FT=0.0
A2FN=TIMR
A2FT=ON
SELF=NONE

Auto-tuning is performed at 150°C for a new oven.

5–4 Cool Only Control

A TEC-2500 is used to control a refrigerator with the temperature below 0°C. To avoid set point adjustment beyond the desired range, SP1L is set at -10°C and SP1H is set at 0°C. Because the temperature is lower than the ambient, a cooling action is required, so select DIRT for OUT1. Since output 1 is used to drive a magnetic contactor, select RELY for O1TY. Because a small temperature oscillation is tolerable, use ON-OFF control to reduce the over-all cost. To achieve ON-OFF control, PB1 is set to zero and O1HY is set at 0.1°C.

Setup Summary:

FUNC= BASC
IN1= PT.DN
IN1U= °C
DP1= 1-DP
OUT1= DIRT
O1TY= RELY
SP1L= -10°C
SP1H= 0°C

User Menu:

PB1=0
O1HY=0.1

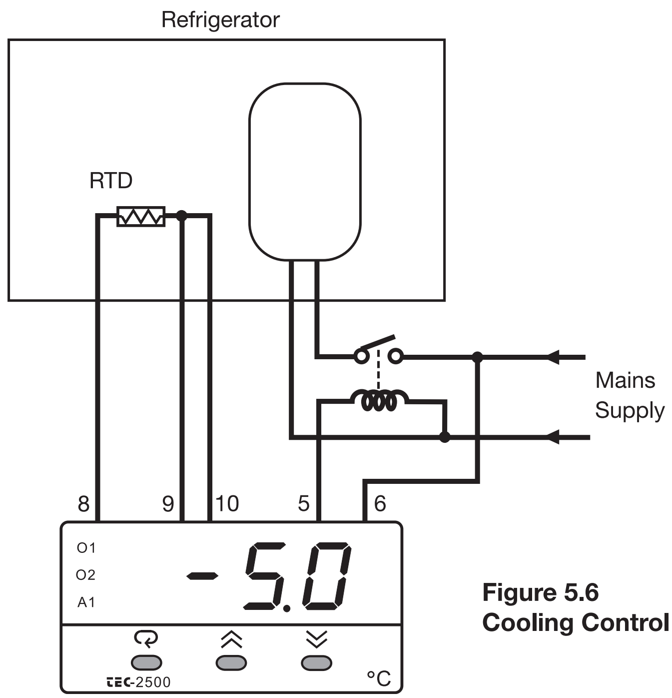


Figure 5.6
Cooling Control Example

5–5 Heat-Cool Control

An injection mold is required to be controlled at 120°C to ensure a consistent quality for the parts. An oil pipe is buried in the mold. Since plastics are injected at a higher temperature (e.g., 250°C), the circulation oil needs to be cooled as its temperature rises. Here is an example:

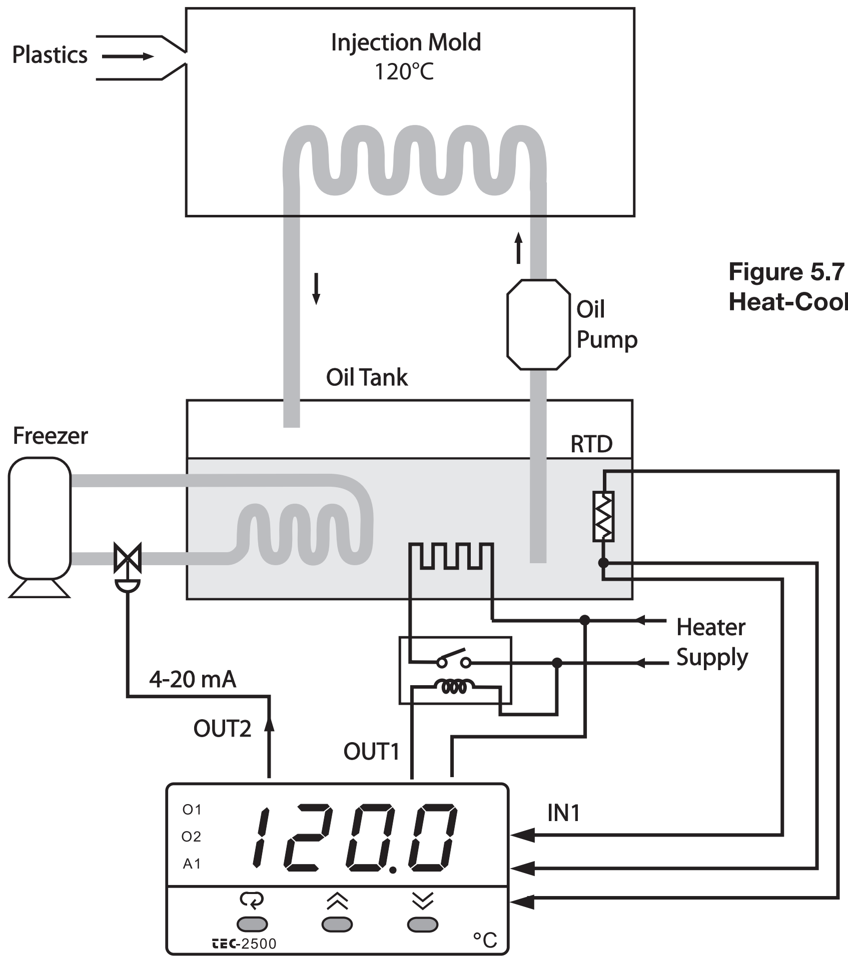


Figure 5.7
Heat-Cool Control Example

PID heat-cool is used for the above example.
To achieve this, set the following parameters in the setup menu:

FUNC=BASC
IN1=PT.DN
IN1U=°C
DP1=1-DP
OUT1=REVR
O1TY=RELY
CYC1=18.0 (seconds)
O1FT=0.0
OUT2=COOL
O2TY=4–20
O2FT=0.0
SELF=YES

Adjust SP1 to 120.0°C, CPB to 125 (%) and DB to -4.0 (%).

Apply auto-tuning at 120°C for a new system to get optimal PID values. See section 3-20.

Adjustment of CPB is related to the cooling medium used. If water is used as the cooling medium instead of oil, the CPB should be set at 250 (%). If air is used as the cooling medium instead of oil, the CPB should be set at 100 (%).

Adjustment of DB is dependent on the system requirements. A more positive value of DB will prevent unwanted cooling action, but will increase the temperature overshoot, while a more negative value of DB will achieve less temperature overshoot, but will increase unwanted cooling action.

5–6 Ramp and Dwell

Example 1: Temperature cycling chamber
A chamber is used to test the temperature cycling effect on personal computers. An external cycle timer is used to control the event input for switching the set point. The products under test are required to stay at 60°C for 1 hour and -10°C for 30 minutes. The transition interval between the high and low temperatures is required to be 5 minutes. Make the following setup:

EIFN=SP.P2
A1FN=TIMR
OUT1=REVR, relay output
OUT2=COOL, 4–20mA output
SPMD=MINR
IN1U=°C
DP1=1-DP

The circuit diagram and its temperature profile are shown below:

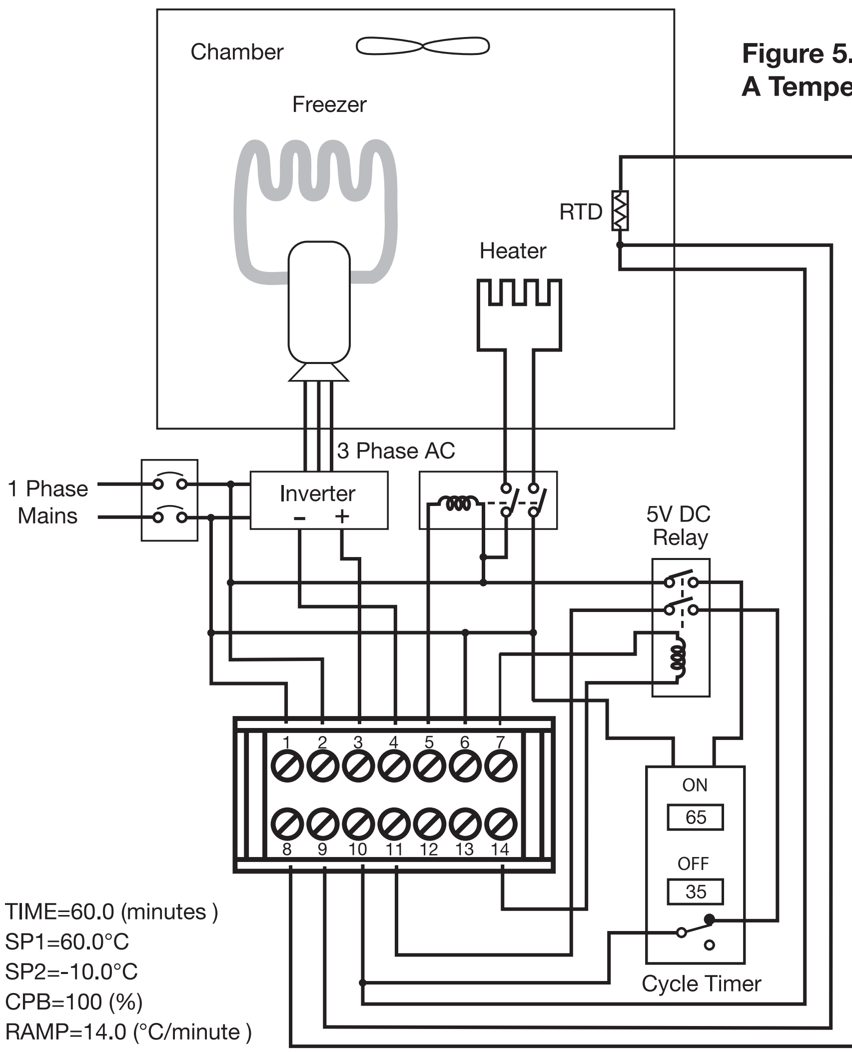


Figure 5.8
A Temperature Cycling Chamber

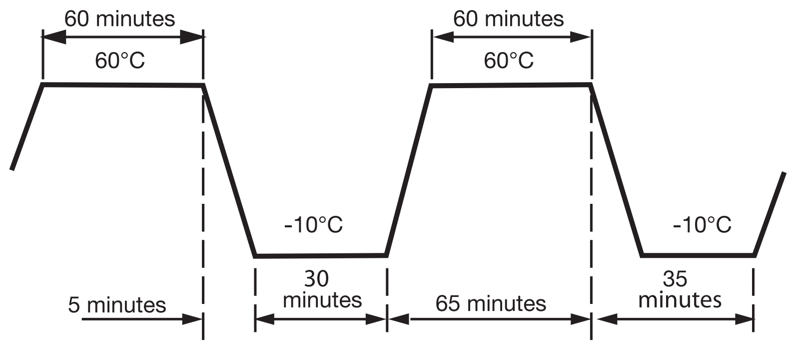


Figure 5.9
Temperature Profile of Chamber

The TEC-2500 provides a 4–20mA signal to control the speed of the inverter. SP.P2 is chosen for EIFN in order to create a dual PID control. You can perform auto-tuning twice at SP1 and SP2 for the initial setup for the dual PID values. Refer to sections 3-20 and 4-3.

Example 2: Programmable bread baking oven

Bread is baked in batches. A ramp is incorporated to control the thermal gradient to suit for making the bread. A dwell timer is used to shut off the oven power and announce this to the baker. The system is configured as shown in the following diagram.

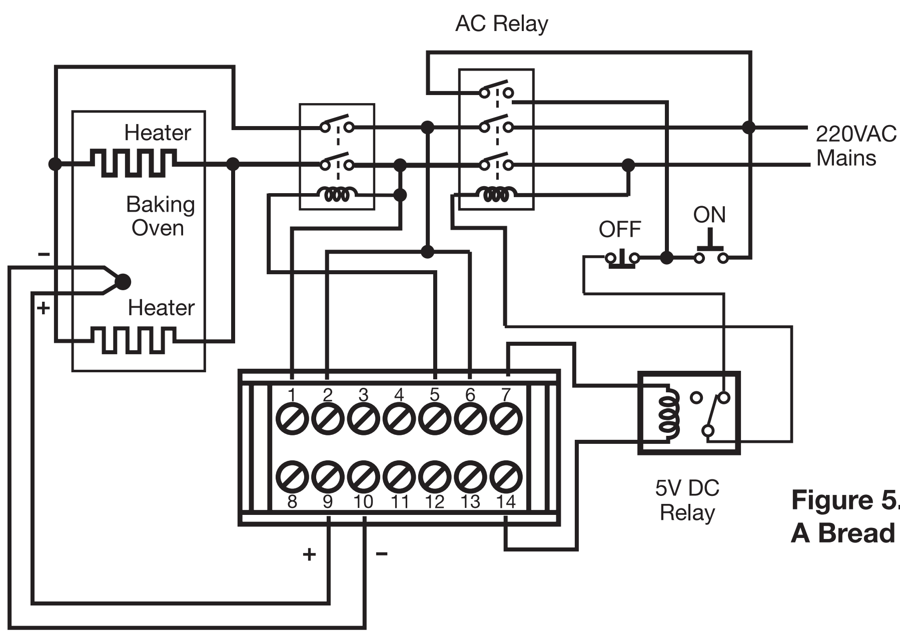
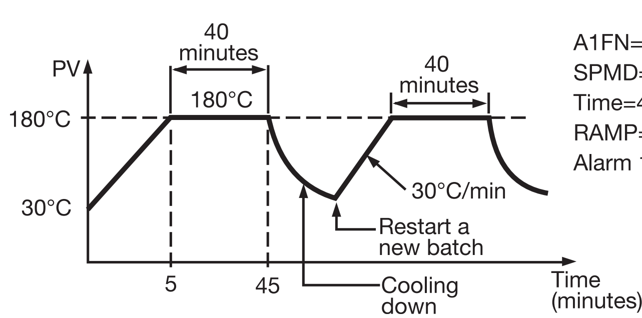


Figure 5.10
A Bread Baking Oven

Push the ON switch to start a batch. The temperature will rise with a ramp rate determined by the RAMP value. The bread is baked with the set point temperature for a predetermined amount of time which is set in the TIME value, and then the power is shut off. The temperature profile is shown in the following figure.



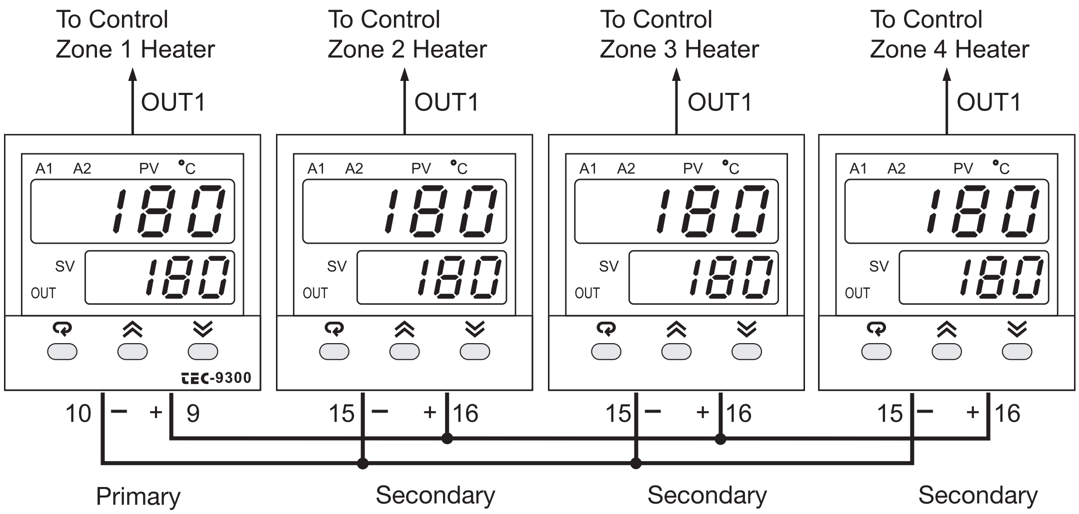
A1FN=TIMR
SPMD=MINR
Time=40.0 (minutes)
RAMP=30.0 (°C/min)
Alarm 1: Form B Relay (NC)

Figure 5.11
Temperature Profile of Baking Oven

5–7 Remote Set Point

An on-line multiple zone oven is used to dry paint. Since heat demand varies at different positions in the production line, multiple zones with individual controls should be used to ensure a consistent temperature profile. If you order a TEC-2500 with a retransmission unit for the primary controller, and retransmit its set point to input 2 on the rest of the secondary controllers, each zone will be synchronized with the same temperature. Here is an example:

Figure 5.12 Remote Set Point Application



Set the following parameters in the setup menu:

For the primary unit	**For the secondary units**
FUNC=FULL	FUNC=FULL
COMM=1–5V	IN2=1–5V
AOLO=0°C	IN2L=0°C
AOHI=300°C	IN2H=300°C
PVMD=PV1	PVMD=PV1
SPMD=SP1.2	SPMD=PV2

Note: AOHI and IN2H should be set with values higher than the set point range used.

5–8 Differential Control

In certain applications it is desirable to control a second process so that its process value always deviates from the first process value by a constant amount. Water tank 1 is 5.12 meters in height, and the level in water tank 2 needs to be maintained at 1 meter lower than the tank 1 level.

Set the following parameters in the setup menu:

FUNC=FULL
IN1, IN1L, IN1H: According to sensor 1 signal
IN1U=PU
DP1=2-DP
IN2, IN2L, IN2H: According to sensor 2 signal (current signal has to be converted to a voltage signal through a shunt resistor before sending to the controller input)
IN2U=PU
DP2=2-DP
OUT1=REVR
O1TY=4–20
PVMD=P1-2
SPMD=SP1.2

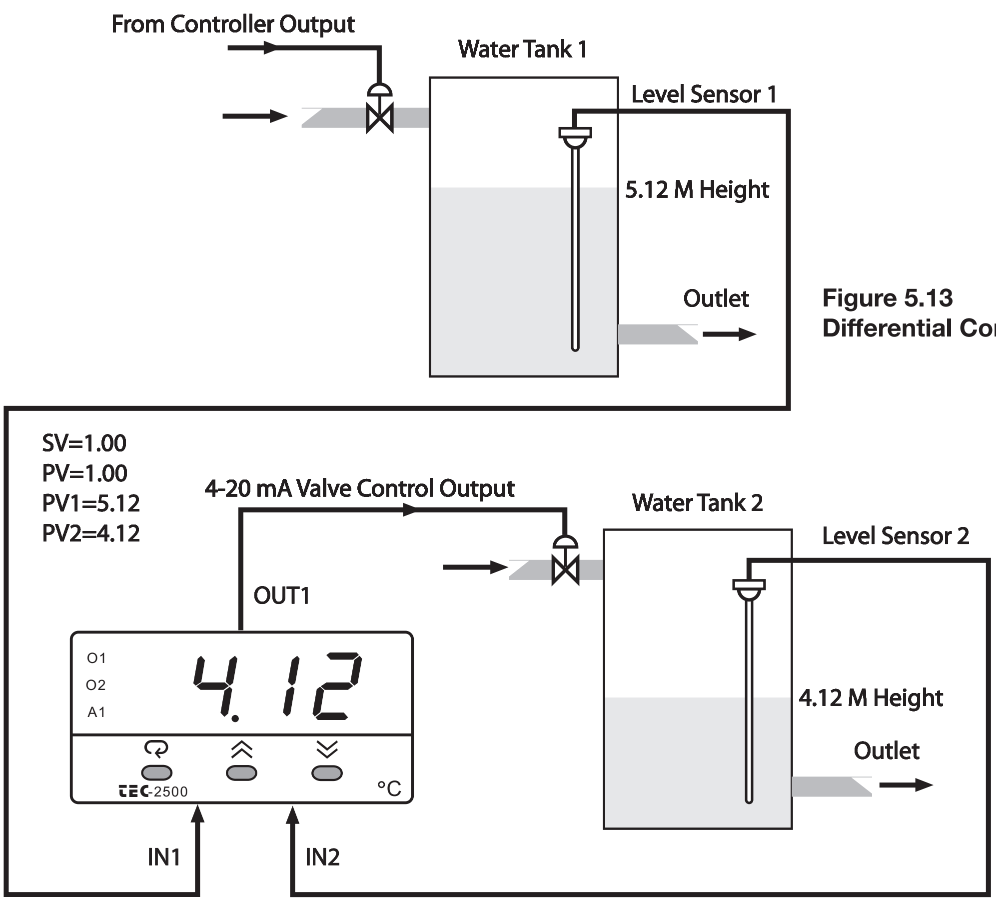


Figure 5.13
Differential Control Example

Adjust SP (here it is 1.00) to control the difference between PV1 and PV2. Choose P1-2 for PVMD; the PV display will show the difference value (PV1-PV2) between PV1 and PV2, and this value will be stabilized at the set point (here it is 1.00). If you need PV1 or PV2 instead of PV, you can use the display mode to select PV1 or PV2 for display. See section 3-24. The above diagram indicates PV2 instead of PV.

5–9 Dual Set Point/PID

The TEC-2500 will switch between the two PID sets based on the process value, the set point, or either of the event inputs. As the control ramps up to the higher process value, the process characteristics change. When this happens, the original PID values are no longer valid. To achieve optimal control over the entire range, a second PID set is used.

Example 1: Single set point/dual PID

A heat treating furnace is used over the range of 400°C to 1200°C.

1. Set the following parameters in the setup menu:
   FUNC=FULL
   A1FN=PV1H
   A1MD=NORM
   EIFN=PID2
   PVMD=PV1
   SPMD=MINR
2. Adjust the following parameters in the user menu:
   A1SP=800°C
   A1HY=1.0°C
   PL1=100(%)
   RAMP: According to the process requirement
   SP1: According to the process requirement
3. Tune the first PID set at SP1=50°C and tune the second PID set at SP1=1100°C, or set the proper values for PB1, TI1, TD1, PB2, TI2, and TD2 directly according to previous records to eliminate the auto-tuning sequence.

The circuit diagram and its temperature profile are shown as follows:

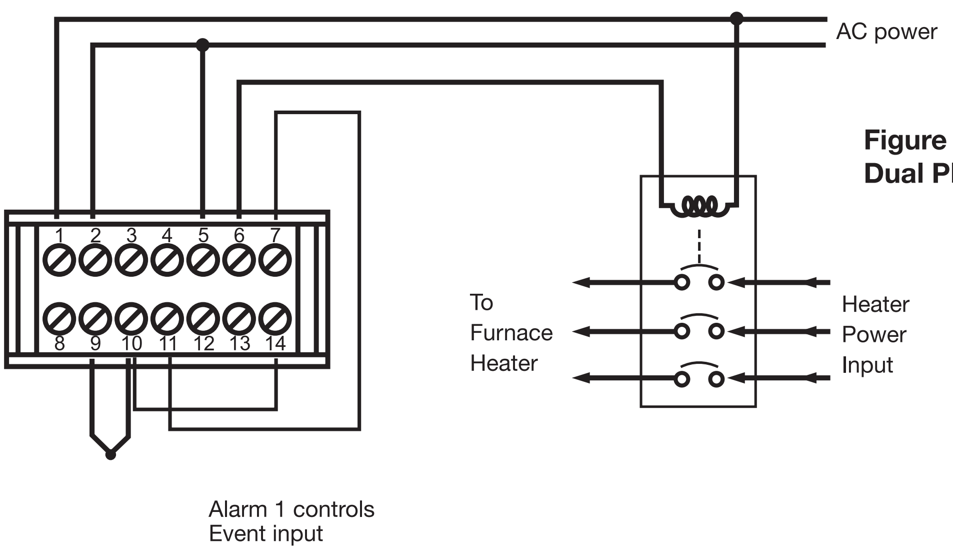


Figure 5.14
Dual PID Furnace

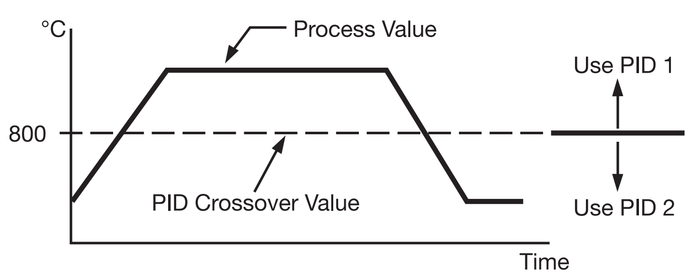


Figure 5.15
Dual PID Crossover

Example 2: Dual set point/PID

A heat treating furnace is required to harden the mold at a high temperature (1000°C) for 30 minutes, then the mold is cooled down with a programmable ramp (20°C/minute) to a lower set point (200°C). Use the dual set point/PID and ramp/dwell functions for this application.

1. Set the following parameters in the setup menu:
   FUNC=FULL
   A1FN=TIMR
   EIFN=SP.P2
   PVMD=PV1
   SPMD=MINR
2. Adjust the following parameters in the user menu:
   TIME=30.0 (minutes)
   RAMP=20.0 (°C/minute)
   SP1=1000°C
   SP2=200°C
   PL1=100(%)
3. Set the proper values for PB1, TI1, TD1, PB2, TI2, and TD2 directly according to previous records. For a new system, tune the first PID set at SP1=800°C and tune the second PID set at SP2=400°C.

The circuit diagram is the same as shown in figure 5.14. The temperature profile is shown below:

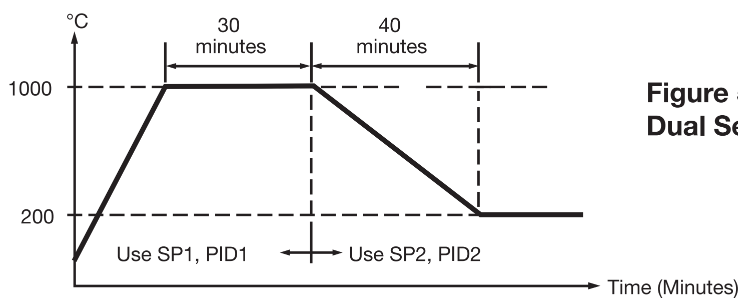


Figure 5.16
Dual Set Point/PID Profile

5–10 RS-485

A tile making plant has five production lines. Each production line is equipped with 16 TEC-2500 units to control the temperature for the kiln. They want to program the controllers and monitor the process from the control room to improve quality and productivity. A cost-effective solution for the above application would be to use 80 TEC-2500 units plus a TEC99014 smart network adapter and DAQ (TEC99923) PC-based software for this purpose.

The system is installed as shown in the following diagram.

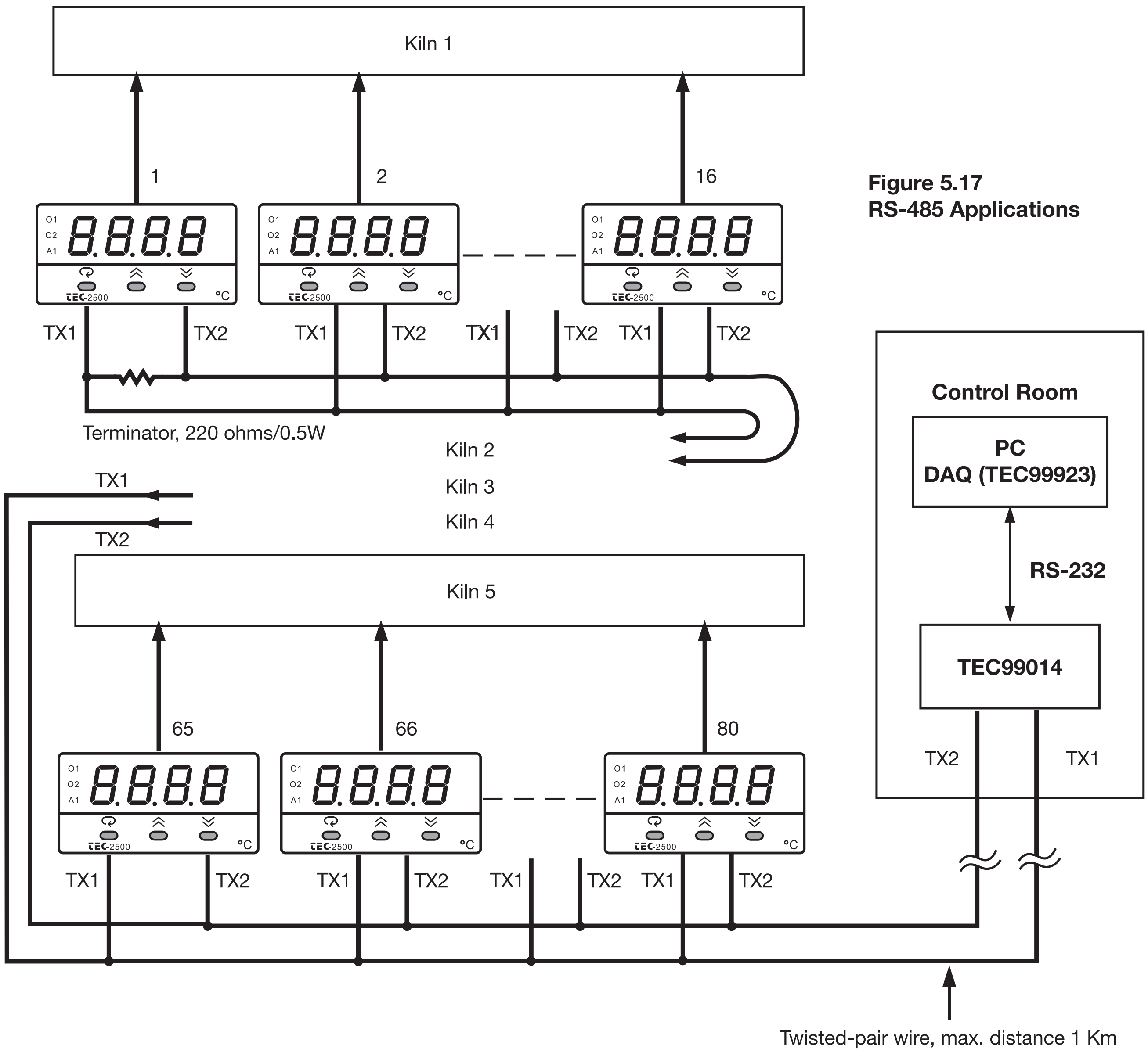


Figure 5.17
RS-485 Applications

Setup

Enter setup mode to configure each TEC-2500. Choose FULL for FUNC, 485 for COMM, RTU for PROT, and select a different address (ADDR) for each unit. Use the same values of BAUD, DATA, PARI, and STOP for the TEC-2500's, TEC99001 and DAQ (TEC99923). Also refer to section 2-15 and section 4-8.

Taking advantage of DAQ (TEC99923) software, the operator can monitor the process on the PC screen, program the set point as well as other control parameters such as PID values, download the ramp and soak profile to the controllers, execute the manual control or trigger auto-tuning, etc., and print out reports as required. The historical data can be saved on the hard drive, on a CD or any other permanent storage media.

Setup menu
FUNC
COMM
PROT
ADDR
BAUD
DATA
PARI
STOP

5–11 RS-232

Suppose a chemical experiment is performed in a laboratory, and an engineer wants to find the relationship between the chemical reaction and temperature. He uses a TEC-2500 to control the temperature of the solution being tested. He is particularly interested in generating a test report containing the relationship between the concentration and temperature.

For a single unit application, it is adequate to order a TEC-2500 with RS-232 communication and DAQ (TEC99923) software. Using the DAQ (TEC99923) software, the temperature data can be viewed and stored in a file. The user can program the temperature as well as other control parameters such as PID values. He can set up the controller, download a ramp and soak profile, execute manual control or auto-tuning procedure, etc. The results can be printed out or stored in a file for future reference.

Refer to section 2-16 for installation and section 4-8 for setup procedure.

Setup menu
FUNC
COMM
PROT
ADDR
BAUD
DATA
PARI
STOP

5–12 Retransmit

An air-conditioned room uses two TEC-2500 units to control the temperature and humidity. The temperature and humidity must be recorded on a chart recorder. The preferred ranges for these two parameters are: 20°C to 30°C and 40% RH to 60% RH. The recorder inputs accept a 0–5V signal.

To achieve this, set the following parameters in the setup menu.

UNIT 1:	**UNIT 2:**
FUNC=FULL	FUNC=FULL
COM=0–5V	COMM=0–5V
AOFN=PV1	AOFN=PV1
AOLO=20.0(°C)	AOLO=40.0(%)
AOHI=30.0(°C)	AOHI=60.0(%)
IN1=PTDN	IN1=0–1V (according to humidity sensor)
IN1U=°C	IN1U=PU
DP1=1-DP	DP1=1-DP

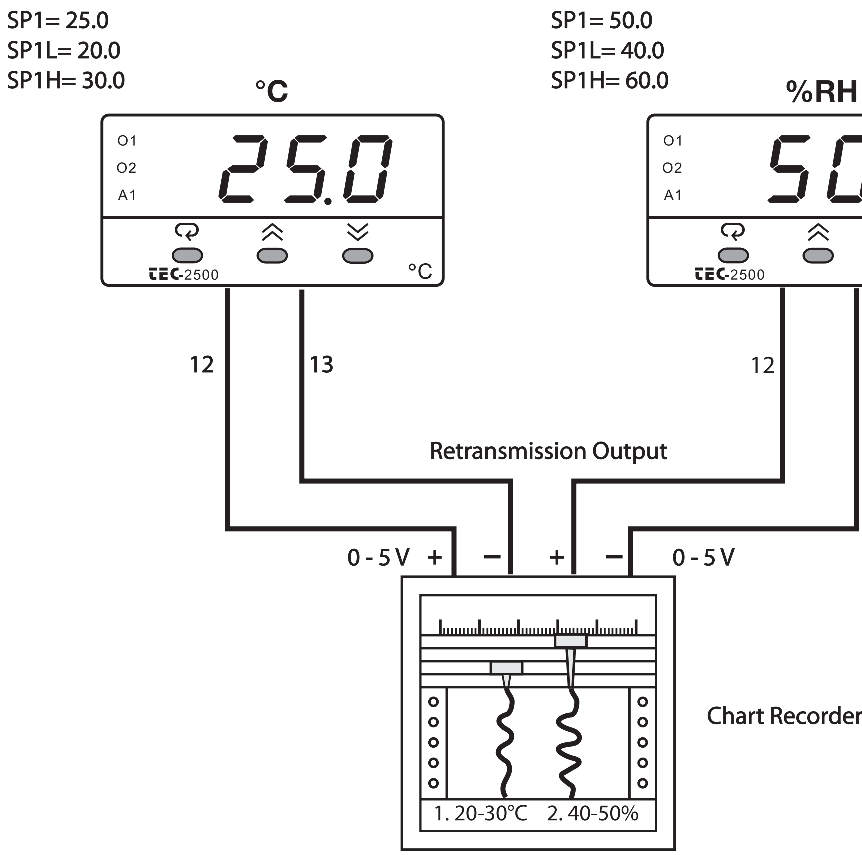


Figure 5.18
Retransmission Application

SP1L and SP1H are used to limit the adjustment range of the set point.

Chapter 6 Error Codes and Troubleshooting

⚠ This procedure requires access to the circuitry of a unit under live power. Accidental contact with line voltage is possible. Only qualified personnel should perform these procedures. Potentially lethal voltages are present.

Troubleshooting procedures:

1. If an error message is displayed, refer to table 6.1 to see what caused it and what action to take to correct the problem.

2. Check each point listed below. Experience has proven that many control problems are caused by a defective instrument.
   - Line wires are improperly connected
   - No voltage between line terminals
   - Incorrect voltage between line terminals
   - Connections to terminals are open, missing, or loose
   - Thermocouple is open at tip
   - Thermocouple lead is broken
   - Shorted thermocouple leads
   - Short across terminals
   - Open or shorted heater circuit
   - Open coil in external contactor
   - Burned out line fuses
   - Burned out relay inside control
   - Defective solid-state relays
   - Defective line switches
   - Burned out contactor
   - Defective circuit breakers

3. If the points listed on the above chart have been checked and the controller still does not function properly, it is recommended that the instrument be returned to the factory for inspection. Do not attempt to make repairs without a qualified engineer and proper technical information, as damage may result. It is also recommended to use adequate packing materials to prevent damage during transportation. Contact Tempco for an Return Authorization Number (RMA).

Table 6.1 Error Codes and Corrective Actions

Error Code	Display Symbol	Error Description	Corrective Action
1	Er01	Illegal setup values been used: PV1 is used for both PVMD and SPMD. It is meaningless for control.	Check and correct setup values of PVMD and SPMD. PV and SV can't use the same value for normal control
2	Er02	Illegal setup values been used: PV2 is used for both PVMD and SPMD. It is meaningless for control	Same as error code 1
3	Er03	Illegal setup values been used: P1-2 or P2-1 is used for PVMD while PV1 or PV2 is used for SPMD. Dependent values used for PV and SV will create incorrect result of control	Check and correct setup values of PVMD and SPMD. Difference of PV1 and PV2 can't be used for PV while PV1 or PV2 is used for SV
4	Er04	Illegal setup values been used: Before COOL is used for OUT2, DIRT (cooling action) has already been used for OUT1, or PID mode is not used for OUT1 (that is PB1 or PB2 = 0, and TI1 or TI2 = 0)	Check and correct setup values of OUT2, PB1, PB2, TI1, TI2 and OUT1. IF OUT2 is required for cooling control, the control should use PID mode (PB ≠ 0, TI ≠ 0) and OUT1 should use reverse mode (heating action), otherwise, don't use OUT2 for cooling control
5	Er05	Illegal setup values been used: unequal IN1U and IN2U or unequal DP1 and DP2 while P1-2 or P2-1 is used for PVMD or, PV1 or PV2 is used for SPMD or, P1.2.H, P1.2.L, D1.2.H or D1.2.L are used for A1FN or A2FN.	Check and correct setup values of IN1U, IN2U, DP1, DP2, PVMD, SPMD, A1FN or A2FN. Same unit and decimal point should be used if both PV1 and PV2 are used for PV, SV, alarm 1 or alarm 2.
6	Er06	Illegal setup values been used: OUT2 select =AL2 but A2FN select NONE	Check and correct setup values of OUT2 and A2FN. OUT2 will not perform alarm function if A2FN select NONE.
7	Er07	Illegal setup values been used: Dwell timer (TIMR) is selected for both A1FN and A2FN.	Check and correct setup values of A1FN and A2FN. Dwell timer can only be properly used for single alarm output.
10	Er 10	Communication error: bad function code	Correct the communication software to meet the protocol requirements.
11	Er 11	Communication error: register address out of range	Don't issue an over-range register address to the slave.
12	Er 12	Communication error: access a non-existent parameter	Don't issue a non-existent parameter to the slave.
14	Er 14	Communication error: attempt to write a read-only data	Don't write a read-only data or a protected data to the slave.
15	Er 15	Communication error: write a value which is out of range to a register	Don't write an over-range data to the slave register.
26	AtEr	Fail to perform auto-tuning function	1.The PID values obtained after auto-tuning procedure are out of range. Retry auto-tuning. 2.Don't change set point value during auto-tuning procedure. 3. Don't change Event input state during auto-tuning procedure. 4.Use manual tuning instead of auto-tuning.
29	EEPE	EEPROM can't be written correctly	Return to factory for repair.
38	Sb2E	Input 2 (IN2) sensor break, or input 2 current below 1 mA if 4-20 mA is selected, or input 2 voltage below 0.25V if 1 - 5V is selected	Replace input 2 sensor.
39	Sb1E	Input 1 (IN1) sensor break, or input 1 current below 1 mA if 4-20 mA is selected, or input 1 voltage below 0.25V if 1 - 5V is selected	Replace input 1 sensor.
40	AdEr	A to D converter or related component(s) malfunction	Return to factory for repair.

Table 6.2 Common Failure Codes and Corrective Actions

Symptom	Probable Causes	Corrective Actions
1) Keypad no function	-Bad connection between PCB & keypads	- Clean contact area on PCB - Replace keypads
2) LED's will not light	- No power to instrument - Power supply defective	- Check power line connections - Replace power supply board
3) Some segments of the display or LED lamps not lit or lit erroneously.	- LED display or LED lamp defective - Related LED driver defective	- Replace LED display or LED lamp - Replace the related transistor or IC chip
4) Display Unstable	- Analog portion or A-D converter defective - Thermocouple, RTD or sensor defective - Intermittent connection of sensor wiring	- Replace related components or board - Check thermocouple, RTD or sensor - Check sensor wiring connections
5) Considerable error in temperature indication	- Wrong sensor or thermocouple type, wrong input mode selected. - Analog portion of A-D converter defective	- Check sensor or thermocouple type and if proper input mode was selected - Replace related components or board
6) Display goes in reverse direction (counts down scale as process warms)	- Reversed input wiring of sensor	- Check and correct
7) No heat or output	- No heater power (output), incorrect output device used - Output device defective - Open fuse outside of the instrument	- Check output wiring and output device - Replace output device - Replace output fuse
8) Heat or output stays on but indicator reads normal	- Output device shorted, or power service shorted	- Check and replace
9) Control abnormal or operation incorrect	- CPU or EEPROM (non-volatile memory) defective. Key switch defective - Incorrect setup values	- Check and replace - Read the setup procedure carefully
10) Display blinks; entered values change by themselves	- Electromagnetic interference (EMI), or Radio Frequency interference (RFI) - EEPROM defective	- Suppress arcing contacts in system to eliminate high voltage spike sources. Separate sensor and controller wiring from " dirty " power lines, ground heaters - Replace EEPROM

Chapter 7 Specifications

Power

90–264VAC, 47–63Hz, 15VA, 7W maximum
11–26 VAC/VDC, 15VA, 7W maximum

Input 1 resolution: 18 bits
Sampling rate: 5x/second
Maximum rating: -2VDC minimum, 12VDC maximum (1 minute for mA input)
Temperature effect: ±1.5uV/°C for all inputs except mA input
±3.0uV/°C for mA input
Sensor lead resistance effect:

T/C: 0.2uV/ohm
3-wire RTD: 2.6°C/ohm of resistance difference of two leads
2-wire RTD: 2.6°C/ohm of resistance sum of two leads

Common mode rejection ratio (CMRR): 120dB
Normal mode rejection ratio (NMRR): 55dB
Sensor break detection:

Sensor open for TC, RTD, and mV inputs, below 1mA for 4–20mA input, below 0.25V for 1–5V input, unavailable for other inputs.

Sensor break responding time:

Within 4 seconds for TC, RTD, and mV inputs, 0.1 second for 4–20mA and 1–5V inputs.

Characteristics:

Type	Range	Accuracy @ 25°C	Input Impedance
J	-120°C to 1000°C (-184°F to 1832°F)	±2°C	2.2 MΩ
K	-200°C to 1370°C (-328°F to 2498°F)	±2°C	2.2 MΩ
T	-250°C to 400°C (-418°F to 752°F)	±2°C	2.2 MΩ
E	-100°C to 900°C (-148°F to 1652°F)	±2°C	2.2 MΩ
B	0°C to 1820°C (32°F to 3308°F)	±2°C (200°C to 1820°C)	2.2 MΩ
R	0°C to 1767.8°C (32°F to 3214°F)	±2°C	2.2 MΩ
S	0°C to 1767.8°C (32°F to 3214°F)	±2°C	2.2 MΩ
N	-250°C to 1300°C (-418°F to 2372°F)	±2°C	2.2 MΩ
L	-200°C to 900°C (-328°F to 1652°F)	± 2°C	2.2 MΩ
PT100 (DIN)	-210°C to 700°C (-346°F to 1292°F)	± 0.4°C	1.3 KΩ
PT100 (JIS)	-200°C to 600°C (-328°F to 1112°F)	± 0.4°C	1.3 KΩ
mV	-8mV to 70mV	± 0.05%	2.2 MΩ
mA	-3mA to 27mA	± 0.05%	70.5 Ω
V	-1.3V to 11.5V	± 0.05%	302 KΩ

Input 2
Resolution: 18 bits
Sampling rate: 1.66x/second
Maximum rating: -2VDC minimum, 12VDC maximum
Temperature effect: ±1.5uV/°C
Common mode rejection ratio (CMRR): 120dB
Sensor break detection:
below 0.25V for 1–5V input, unavailable for other inputs.
Sensor break responding time: 0.5 seconds
Characteristics:

Type	Range	Accuracy @25°C	Input Impedance
TEC99999	0 − 50.0 A	±2% of Reading ±0.2 A	265 KΩ
V	-1.3V − 11.5V	±0.05%	265 KΩ

Input 3 (event input)
Logic low: -10V minimum, 0.28V maximum.
Logic high: open or 0.32V minimum, 10V maximum
External pull-down resistance: 200K│ maximum
External pull-up resistance: not necessary
Functions: select second set point and/or PID, reset alarm 1 and/or alarm 2, disable output 1 and/or output 2, remote lockout.

Output 1/Output 2
Relay rating: 2A/240 VAC, life cycles 200,000 for resistive load
Pulsed voltage: source voltage 5V, current limiting resistance 66│.
Linear output characteristics:

Type	Zero Tolerance	Span Tolerance	Load Capacity
4-20mA	3.8-4mA	20-21mA	500Ω max.
0-20mA	0 mA	20-21mA	500Ω max.
0 – 5 V	0 V	5 – 5.25 V	10 KΩ min.
1 – 5 V	0.9 – 1 V	5 – 5.25 V	10 KΩ min.
0 – 10 V	0 V	10 –10.5 V	10 KΩ min.

Linear Output
Resolution: 15 bits
Output regulation: 0.01% for full load change
Output settling time: 0.1 second (stable to 99.9%)
Isolation breakdown voltage: 1000VAC
Temperature effect: ±0.0025% of SPAN/°C

Triac (SSR) Output
Rating : 1A/240VAC
Inrush Current : 20A for 1 cycle
Min. Load Current : 50mA rms
Max. Off-state Leakage : 3mA rms
Max. On-state Voltage : 1.5V rms
Insulation Resistance : 1000Mohms min. at 500VDC
Dielectric Strength : 2500VAC for 1 minute

DC voltage supply characteristics (installed at output 2)

Type	Tolerance	Max. Output Current	Ripple Voltage	Isolation Barrier
20 V	± .5 V	25 mA	0.2 Vp-p	500 VAC
12 V	± 0.3 V	40 mA	0.1 Vp-p	500 VAC
5 V	± 0.15 V	80 mA	0.05 Vp-p	500 VAC

Alarm 1/Alarm 2
Alarm 1: 5V DC logic output, max. source current 100mA, short circuit unprotected.
Alarm 2 relay: Form A, max. rating 2A/240VAC, 200,000 life cycles for resistive load.
Alarm functions: Dwell timer,
Deviation high/low alarm,
Deviation band high/low alarm,
PV1 high/low alarm,
PV2 high/low alarm,
PV1 or PV2 high/low alarm,
PV1-PV2 high/low alarm,
Loop break alarm,
Sensor break alarm.
Alarm mode: Normal, latching, hold, latching/hold.
Dwell timer: 0–6553.5 minutes

Data Communication
Interface: RS-232 (1 unit), RS-485 (up to 247 units)
Protocol: Modbus protocol RTU mode
Address: 1–247
Baud Rate: 0.3~38.4Kbits/sec
Data Bits: 7 or 8 bits
Parity Bit: None, even or odd
Stop Bit: 1 or 2 bits
Communication Buffer: 50 bytes

Analog Retransmission
Functions: PV1, PV2, PV1-PV2, PV2-PV1, set point, MV1, MV2, PV-SV deviation value
Output Signal: 4–20mA, 0–20mA, 0–1V, 0–5V, 1–5V, 0–10V
Resolution: 15 bits
Accuracy: ±0.05% of span ±0.0025%/°C
Load Resistance: 0–500ohms (for current output)
10Kohms minimum (for voltage output)
Output Regulation: 0.01% for full load change
Output Settling Time: 0.1 sec. (stable to 99.9%)
Isolation Breakdown Voltage: 1000VAC min.
Integral linearity error: ±0.005% of span
Temperature effect: ±0.0025% of span/°C

Saturation low: 0mA (or 0V)
Saturation high: 22.2mA (or 5.55V, 11.1V min.)
Linear output range: 0–22.2mA(0–20mA or 4–20mA), 0–5.55V (0–5V, 1–5V), 0–11.1V (0–10V)

User Interface
Dual 4-digit LED displays: Upper 0.4" (10mm), lower 0.3" (8mm)
Keypad: 3 keys
Programming port: For automatic setup, calibration, and testing
Communication port: Connection to PC for supervisory control

Control Mode
Output 1: Reverse (heating) or direct (cooling) action
Output 2: PID cooling control, cooling P band 1~255% of PB
ON-OFF: 0.1–100.0(°F) hysteresis control (P band=0)
P or PD: 0–100.0% offset adjustment
PID: Fuzzy logic modified
Proportional band 0.1~900.0°F
Integral time 0–1000 seconds
Derivative time 0–360.0 seconds
Cycle time: 0.1–100.0 seconds
Manual control: Heat (MV1) and cool (MV2)
Auto-tuning: Cold start and warm start
Self-tuning: Select NONE or YES
Failure mode: Auto-transfer to manual mode while sensor break or A-D converter damage
Sleep mode: Enable or disable
Ramping control: 0–900.0°F/minute or 0–900.0°F/hour ramp rate
Power limit: 0–100% output 1 and output 2
Pump/pressure control: Sophisticated functions provided
Remote set point: Programmable range for voltage or current input
Differential control: Control PV1-PV2 at set point

Digital Filter
Function: First order
Time constant: 0, 0.2, 0.5, 1, 2, 5, 10, 20, 30, 60 seconds programmable

Environmental and Physical
Operating temperature: -10°C to 50°C
Storage temperature: -40°C to 60°C
Humidity: 0 to 90% RH (non-condensing)
Insulation resistance: 20Mohms min. (at 500VDC)
Dielectric strength: 2000VAC, 50/60Hz for 1 minute
Vibration resistance: 10–55Hz, 10m/s for 2 hours
Shock resistance: 200m/s (20g)
Moldings: Flame retardant polycarbonate
Dimensions: 50mm(W) × 26.5mm(H) × 110.5mm(D), 98.0mm depth behind panel
Weight: 120 grams

Approval Standards
Safety: UL873 (11th edition, 1994), EN61010-1 (IEC1010-1)
Protective class: NEMA 4X (IP65) front panel, indoor use, IP 20 housing and terminals
EMC: EN61326

A–1 Menu Existence Conditions

Menu Existence Conditions Table (Page 1 of 3)

Menu	Parameter Notation	Existence Conditions
User Menu	SP1	Exists unconditionally
	TIME	Exists if A1FN selects TIMR or A2FN selects TIMR
	A1SP	Exists if A1FN selects PV1H, PV1L, PV2H, PV2L, P12H, P12L, D12H or D12L
	A1DV	Exists if A1FN selects DEHI, DELO, DBHI, or DBLO
	A2SP	Exists if A2FN selects PV1H, PV1L, PV2H, PV2L, P12H, P12L, D12H or D12L
	A2DV	Exists if A2FN selects DEHI, DELO, DBHI, or DBLO
	RAMP	Exists if SPMD selects MINR or HRR
	OFST	Exists if TI1 is used for control (depends on Event input and EIFN selection) but TI1= 0 and PB1≠0 or if TI2 is used for control (depends on Event input and EIFN selection) but TI2= 0 and PB2≠0
	REFC	Exists if SPMD selects PUMP
	SHIF PB1	Exists unconditionally
	TI1 TD1	Exists if PB1≠0
	CPB, DB	Exists if OUT2 select COOL
	SP2	Exists if EIFN selects SP2 or SPP2, or if SPMD selects PUMP
	PB2	Exists if EIFN selects PID2 or SPP2
	TI2 TD2	Exists if EIFN selects PID2 or SPP2 provided that PB2≠0
	O1HY	If PID2 or SPP2 is selected for EIFN, then O1HY exists if PB1= 0 or PB2 = 0. If PID2 or SPP2 is not selected for EIFN, then O1HY exists if PB1= 0
	A1HY	Exists if A1FN selects DEHI, DELO, PV1H, PV1L, PV2H, PV2L, P12H, P12L, D12H, or D12L
	A2HY	Exists if A2FN selects DEHI, DELO, PV1H, PV1L, PV2H, PV2L, P12H, P12L, D12H, or D12L
	PL1	If PID2 or SPP2 is selected for EIFN, then PL1 exists if PB1≠0 or PB2≠0. If PID2 or SPP2 is not selected for EIFN, then PL1 exists if PB1≠0
	PL2	Exists if OUT2 selects COOL

Continued…

Menu Existence Conditions Table (Page 2 of 3)

Menu	Parameter Notation	Existence Conditions
Setup Menu	FUNC	Exists unconditionally
	COMM	Exists if FUNC selects FULL
	PROT ADDR BAUD DATA PARI STOP	Exists if COMM selects 485 or 232
	AOFN	Exists if COMM selects 4-20, 0-20, 0-1V, 0-5V, 1-5V, or 0-10
	AOLO AOHI	Exists if COMM selects 4-20, 0-20, 0-1V, 0-5V, 1-5V, or 0-10 and AOFN is not MV1 and MV2
	IN1 IN1U DP1	Exists unconditionally
	IN1L IN1H	Exists if IN1selects 4-20, 0-20, 0-1V, 0-5V, 1-5V, or 0-10
	IN2	Exists if FUNC selects FULL
	IN2U DP2 IN2L IN2H	Exists if IN2 selects 4-20, 0-20, 0-1V, 0-5V, 1-5V, or 0-10
	OUT1 O1TY CYC1 O1FT OUT2	Exists unconditionally
	O2TY CYC2 O2FT	Exists if OUT2 selects COOL

Menu Existence Conditions Table (Page 3 of 3)

Menu	Parameter Notation	Existence Conditions
Setup Menu	A1FN	Exists unconditionally
	A1MD	Exists if A1FN selects DEHI, DELO, DBHI, DBLO, PV1H, PV1L, PV2H, PV2L, P12H, P12L, D12H, D12L, LB or SENB
	A1FT	Exists if A1FN is not NONE
	A2FN	Exists unconditionally
	A2MD	Exists if A2FN selects DEHI, DELO, DBHI, DBLO, PV1H, PV1L, PV2H, PV2L, P12H, P12L, D12H, D12L, LB or SENB
	A2FT	Exists if A2FN is not NONE
	EIFN PVMD FILT	Exists if FUNC selects FULL
	SELF	Exists unconditionally
	SLEP SPMD	Exists if FUNC selects FULL
	SP1L SP1H	Exists unconditionally
	SP2F	Exists if EIFN selects SP2 or SPP2, or if SPMD selects PUMP
	SEL1 SEL2 SEL3 SEL4 SEL5	Exists unconditionally

A–2 Factory Menu Description

Parameter Notation	Display Format	Parameter Description	Range				Default Value
EROR	Eror	Current Error Code	Low:	0	High:	40	—
PROG	ProG	Program Identification Code Contains Program Number and Version Number	Low:	0	High:	15.99	—
MODE	nodE	Contains Lockout Status Code and Current System Mode	Low:	0	High:	3.5	—
CMND	Cnnd	Command Password	Low:	0	High:	65535	—
JOB	Job	Job Password	Low:	0	High:	65535	—
DRIF	d---	Warm-up Drift Calibration Factor	Low:	-5.0°C	High:	5.0°C	—
AD0	Ad0	A to D Zero Calibration Coefficient	Low:	-360	High:	360	—
ADG	AdG	A to D Gain Calibration Coefficient	Low:	-199.9	High:	199.9	—
V1G	v1.G	Voltage Input 1 Gain Calibration Coefficient	Low:	-199.9	High:	199.9	—
CJTL	CJt.L	Cold Junction Low Temperature Calibration Coefficient	Low:	-5.00°C	High:	40.00°C	—
CJG	CJ.G	Cold Junction Gain Calibration Coefficient	Low:	-199.9	High:	199.9	—
REF1	rEF.1	Reference Voltage 1 Calibration Coefficient for RTD 1	Low:	-199.9	High:	199.9	—
SR1	Sr.1	Serial Resistance 1 Calibration Coefficient for RTD 1	Low:	-199.9	High:	199.9	—
MA1G	nA1.G	mA Input 1 Gain Calibration Coefficient	Low:	-199.9	High:	199.9	—
V2G	v2.G	Voltage Input 2 Gain Calibration Coefficient	Low:	-199.9	High:	199.9	—
SIG1 *	SiG1	Point 1 Signal Value of Special Sensor	Low:	-19999	High:	45536	—
IND1 *	ind1	Point 1 Indication Value of Special Sensor	Low:	-19999	High:	45536	—
SIG2 *	SiG2	Point 2 Signal Value of Special Sensor	Low:	-19999	High:	45536	—
IND2 *	ind2	Point 2 Indication Value of Special Sensor	Low:	-19999	High:	45536	—
SIG3 *	SiG3	Point 3 Signal Value of Special Sensor	Low:	-19999	High:	45536	—
IND3 *	ind3	Point 3 Indication Value of Special Sensor	Low:	-19999	High:	45536	—
SIG4 *	SiG4	Point 4 Signal Value of Special Sensor	Low:	-19999	High:	45536	—
IND4 *	ind4	Point 4 Indication Value of Special Sensor	Low:	-19999	High:	45536	—
SIG5 *	SiG5	Point 5 Signal Value of Special Sensor	Low:	-19999	High:	45536	—
IND5 *	ind5	Point 5 Indication Value of Special Sensor	Low:	-19999	High:	45536	—
SIG6 *	SiG6	Point 6 Signal Value of Special Sensor	Low:	-19999	High:	45536	—
IND6 *	ind6	Point 6 Indication Value of Special Sensor	Low:	-19999	High:	45536	—
SIG7 *	SiG7	Point 7 Signal Value of Special Sensor	Low:	-19999	High:	45536	—
IND7 *	ind7	Point 7 Indication Value of Special Sensor	Low:	-19999	High:	45536	—
SIG8 *	SiG8	Point 8 Signal Value of Special Sensor	Low:	-19999	High:	45536	—
IND8 *	ind8	Point 8 Indication Value of Special Sensor	Low:	-19999	High:	45536	—
SIG9 *	SiG9	Point 9 Signal Value of Special Sensor	Low:	-19999	High:	45536	—
IND9 *	ind9	Point 9 Indication Value of Special Sensor	Low:	-19999	High:	45536	—
TYPE *	tYPE	Signal Type of Special Sensor	Low:	0	High:	3	—
DATE	dAtE	Manufacturing Date of Product	Low:	0	High:	3719	—
NO	no	Serial Number of Product	Low:	1	High:	999	—
HOUR	Hour	Working Hour Value	Low:	0	High:	65535 Hours	—
HRLO	Hr.Lo	Fractional Hour Value	Low:	0	High:	0.9 Hour	—
ERR1	Err1	Historical Error Record 1	Low:	0	High:	FFFF	0
ERR2	Err2	Historical Error Record 2	Low:	0	High:	FFFF	0
DELI	dELi	ASCII Input Delimiter	Low:	0000	High:	007F	000A
BPL1	bPL.1	OUT1 Bumpless Transfer Value	Low:	0	High:	100.00 %	—
BPL2	bPL.2	OUT2 Bumpless Transfer Value	Low:	0	High:	100.00 %	—
CJCL	CJC.L	Sense Voltage of Cold Junction Calibration Low	Low:	31.680	High:	40.320 mV	—

* These parameters are available only if IN1 selects SPEC.

A–5 Memo

Use the following table as a priamry copy for your settings. (page 1 of 2)

Contained in	Parameter Notation	Display Format	Your setting
User Menu	SP1		
	TIME	ti n̄E	
	A1SP	A 1.SP	
	A1DV	A 1.dV	
	A2SP	A2.SP	
	A2DV	A2.dV	
	RAMP	rAn̄P	
	OFST	oFSt	
	REFC	rEFC	
	SHIF	SHi F	
	PB1	Pb 1	
	TI1	ti 1	
	TD1	td 1	
	CPB	C.Pb	
	DB	db	
	SP2	SP2	
	PB2	Pb2	
	TI2	ti 2	
	TD2	td2	
	O1HY	o 1.HY	
	A1HY	A 1.HY	
	A2HY	A2.HY	
	PL1	PL 1	
	PL2	PL2	
Setup Menu	FUNC	FunC	

Contained in	Parameter Notation	Display Format	Your setting
Setup Menu	COMM	Con̄n̄	
	PROT	Prot	
	ADDR	Addr	
	BAUD	bAud	
	DATA	dAtA	
	PARI	PAri	
	STOP	StoP	
	AOFN	Ao.Fn	
	AOLO	Ao.Lo	
	AOHI	Ao.Hi	
	IN1	in 1	
	IN1U	in 1.u	
	DP1	dP 1	
	IN1L	in 1.L	
	IN1H	in 1.H	
	IN2	in2	
	IN2U	in2.u	
	DP2	dP2	
	IN2L	in2.L	
	IN2H	in2.H	
	OUT1	out 1	
	O1TY	o 1.tY	
	CYC1	CYC 1	
	O1FT	o 1.Ft	

Use the following table as a primary copy for your settings (page 2 of 2).

Contained in	Parameter Notation	Display Format	Your setting
Setup Menu	OUT2	out2	
	O2TY	o2.tY	
	CYC2	CYC2	
	O2FT	o2.Ft	
	A1FN	A1.Fn	
	A1MD	A1.md	
	A1FT	A1.Ft	
	A2FN	A2.Fn	
	A2MD	A2.md	
	A2FT	A2.Ft	
	EIFN	Ei.Fn	
	PVMD	Pv.md	
	FILT	FiLt	
	SELF	SELF	
	SLEP	SLEP	
	SPMD	SP.md	
	SP1L	SP1.L	
	SP1H	SP1.H	
	SP2F	SP2F	
	DISF	diSF	
	SEL1	SEL1	
	SEL2	SEL2	
	SEL3	SEL3	
	SEL4	SEL4	
	SEL5	SEL5	

Contained in	Parameter Notation	Display Format	Your setting
Calibration Mode Menu	AD0	Ad0	
	ADG	AdG	
	V1G	v1.G	
	CJTL	CJt.L	
	CJG	CJ.G	
	REF1	rEF.1	
	SR1	Sr.1	
	MA1G	mA1.G	
	V2G	v2.G	
	MA2G	mA2.G	
Display Mode Menu	PVHI	Pv.Hi	
	PVLO	Pv.Lo	
	MV1	H___	
	MV2	C___	
	DV	dv	
	PV1	Pv1	
	PV2	Pv2	
	PB	Pb	
	TI	ti	
	TD	td	
	CJCT	CJCt	
	PVR	Pvr	
	PVRH	Pvr.H	
	PVRL	Pvr.L	

RETURNS

No product returns can be accepted without a completed Return Material Authorization (RMA) form.

TECHNICAL SUPPORT

Technical questions and troubleshooting help is available from Tempco. When calling or writing please give as much background information on the application or process as possible.

E-mail: techsupport@tempco.com
Phone: 630-350-2252
800-323-6859

Note: Information in this manual was deemed correct at the time of printing. The policy of Tempco is one of continuous development and product improvement, and we reserve the right to modify specifications and designs without prior notice. Not responsible for typographical errors.

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