Applicable Models

Omron's 1/4 DIN (E5AX) and 1/8 DIN (E5EX) temperature controllers are available with a wide range of features. The series includes furnace-temperature sensor input models (E5□X-NA) and Factory Mutual Class 3545 models (E5□X-FM) with a manual alarm reset button. All controllers use one plug-in interchangeable output. The E5AX models are available with communications capability. They have a board installed with a port on the back, or can use interchangeable communications boards.

The instructions that follow apply to the models below:

■ 1/4 DIN TEMPERATURE CONTROLLERS

Type	Description	Standard range	High-temperature
Part number	No communications	**E5AX-A-F**	**E5AX-NA-F**
	RS-232C communications	**E5AX-A01-F**	**E5AX-NA01-F**
	RS-422 communications	**E5AX-A02-F**	**E5AX-NA02-F**
	RS-485 communications	**E5AX-A03-F**	**E5AX-NA03-F**
	BCD communications	**E5AX-A20-F**	**E5AX-NA20-F**
	4-20 mA transmission output	**E5AX-AF-F**	**E5AX-NAF-F**
	Interchangeable communications board	**E5AX-AM-F**	**E5AX-NAM-F**
	Factory Mutual approved	**E5AX-A-FMF**	**E5AX-NA-FMF**

■ 1/8 DIN TEMPERATURE CONTROLLERS

Type	Description	Standard range	High-temperature
Part number	Standard	**E5EX-A-F**	**E5EX-NA-F**
	Factory Mutual approved	**E5EX-A-FMF**	**E5EX-NA-F**

■ CONTROL OUTPUT UNITS

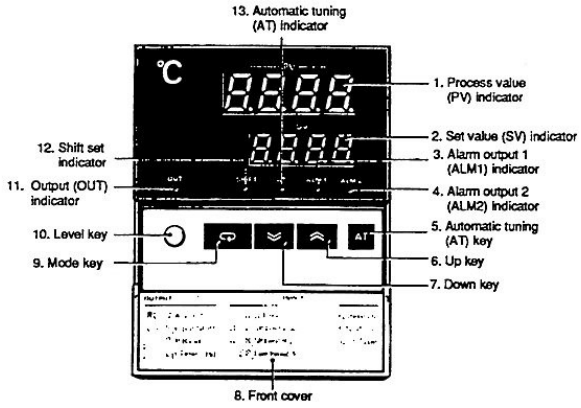
Output type	Relay output	SSR output	Voltage output (for driving SSR)			Current output
			12 VDC (NPN)	24 VDC (NPN)	24 VDC (PNP)	
Part number	**E53-R**	**E53-S**	**E53-Q**	**E53-Q3**	**E53-Q4**	**E53-C**

■ COMMUNICATIONS BOARDS FOR E5AX CONTROLLERS

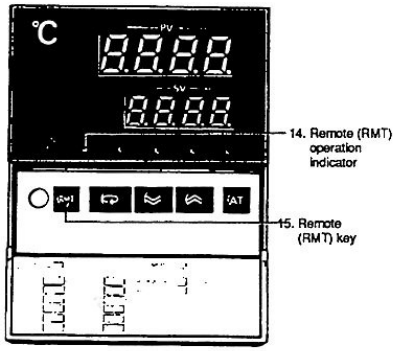
Output	Write to temperature controller	Read from temperature controller	**Part number**
RS-232C	Set temperature, alarm value	Set temperature, alarm value, proportional	**E53-X01**
RS-422	proportional band, integral time,	band, reset time, rate time, output variable	**E53-X02**
RS-485	rate time.	set limits, process value.	**E53-X03**
BCD	Set temperature, alarm value.	Set temperature, alarm value, process value, etc.	**E53-X20**
4 to 20 mA DC	Write disabled	Process value, output variable	**E53-XF**

Nomenclature

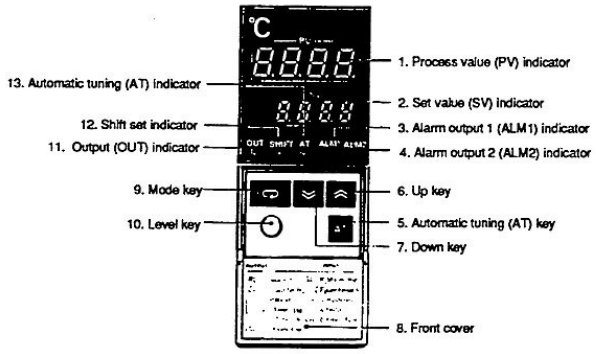
■ E5AX/E5AX-NA WITHOUT COMMUNICATIONS



■ E5AX/E5AX-NA WITH COMMUNICATIONS



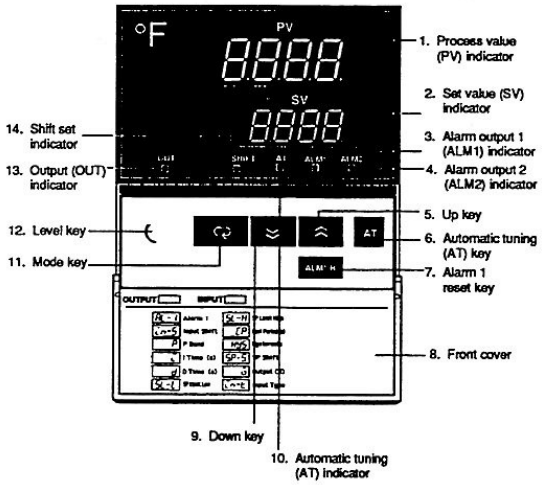
■ E5EX/E5EX-NA



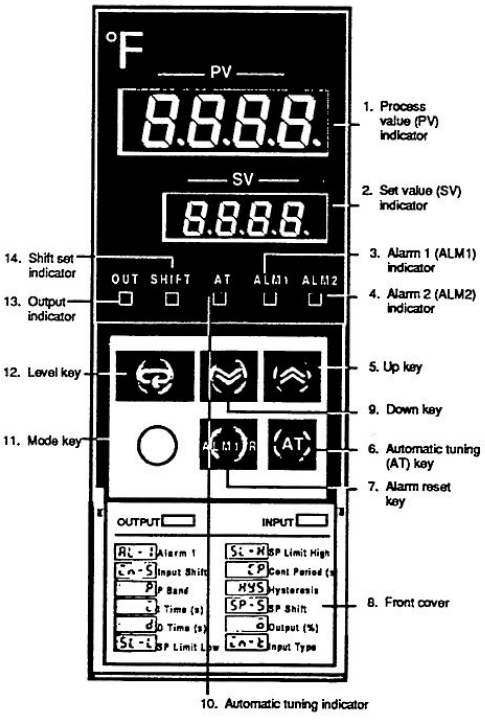
Key	Description	Key	Description
1	Process value indicator displays the present temperature, parameter being set and error messages.	9	Mode key changes the items to be set, such as alarm value, etc.
2	Set value indicator.	10	Level key, pressed for 2 seconds or more, selects the next of three parameter setting levels.
3	Indicator lights when alarm output 1 is ON.	11	Output indicator lights when control output is ON. It does not light when the output selector switch is set for a current output.
4	Indicator lights when alarm output 2 is ON.	12	Shift indicator lights while shift set function is in use.
5	Automatic tuning of parameters is executed when this key is pressed for 1 second or more.	13	Automatic tuning indicator flashes at 1-second intervals while tuning is executed, then stops when completed.
6	Up key increases the value of any parameter when pressed.	14*	Lights when remote operation occurs. For units with communications function only.
7	Down key decreases the value of any parameter when pressed.	15*	Remote key for units with communications only.
8	Front cover shows setting symbols.		

*Refer to E5AX Communications Manual for details.

■ E5AX-□-FM FACTORY MUTUAL TYPES



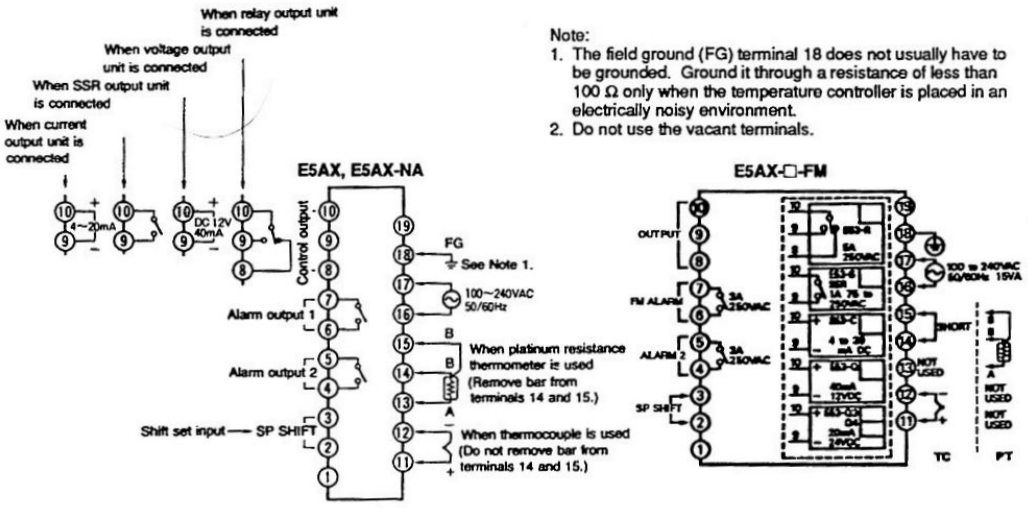
■ E5EX-□-FM FACTORY MUTUAL TYPES



Key	Description
1	Process value indicator displays the present temperature, parameter being set and error messages.
2	Set value indicator.
3	Indicator lights when alarm output 1 is ON.
4	Indicator lights when alarm output 2 is ON.
5	Up key increases the value of any parameter when pressed.
6	Automatic tuning of parameters is executed when this key is pressed for 1 second or more.
7	Alarm 1 reset key, required by Factory Mutual, lets the user manually reset the alarm from the controller's front panel.
8	Front cover shows setting symbols.
9	Down key decreases the value of any parameter when pressed.
10	Automatic tuning indicator flashes at 1-second intervals while tuning is executed, then stops when completed.
11	Mode key changes the items to be set, such as alarm value, etc.
12	Level key, pressed for 2 seconds or more, selects the next of three parameter setting levels.
13	Output indicator lights when control output is ON. It does not light when the output selector switch is set for a current output.
14	Shift set indicator lights while shift set function is in use.

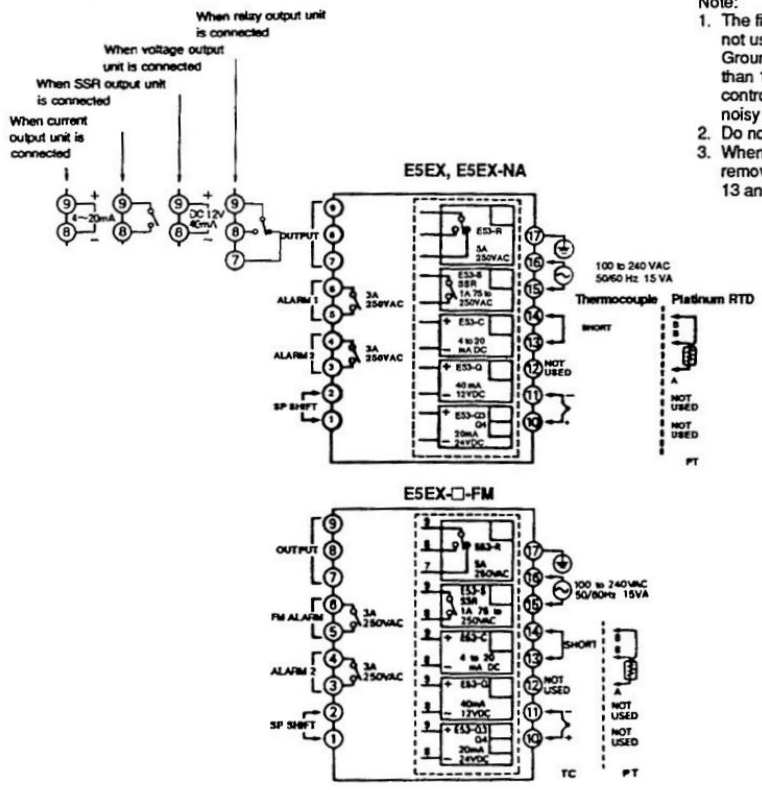
Connections

■ E5AX, E5AX-NA, E5AX-□-FM



Note:
1. The field ground (FG) terminal 18 does not usually have to be grounded. Ground it through a resistance of less than 100 Ω only when the temperature controller is placed in an electrically noisy environment.
2. Do not use the vacant terminals.

■ E5EX, E5EX-NA, E5EX-□-FM



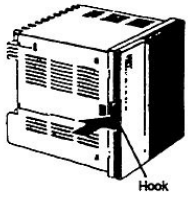
Note:
1. The field ground (FG) terminal 18 does not usually have to be grounded. Ground it through a resistance of less than 100 Ω only when the temperature controller is placed in an electrically noisy environment.
2. Do not use the vacant terminals.
3. When a thermocouple is used, do not remove the shorting bar from terminals 13 and 14.

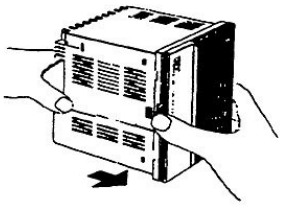
Settings (before applying power)

Before applying power to the temperature controller, install the control output units and set the internal switches, as described below, to specify the temperature sensor type, functions, and alarm mode.

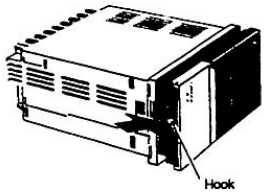
■ ACCESS TO INTERNAL SWITCHES

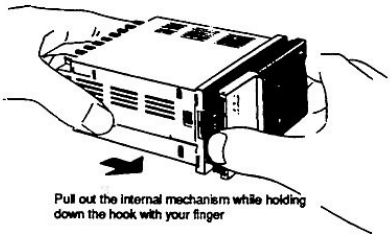
Press the hook at the bottom of the front panel as you draw out the internal mechanism from the housing.





Pull out the internal mechanism while holding down the hook with your finger

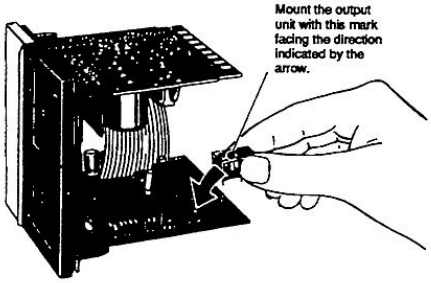


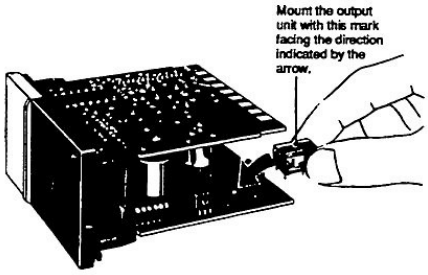


Pull out the internal mechanism while holding down the hook with your finger

■ INSTALLING THE OUTPUT UNIT

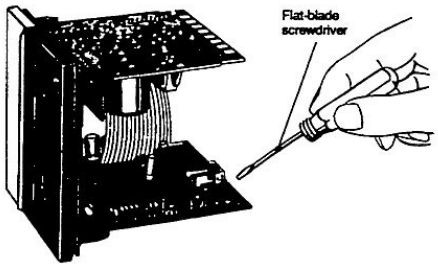
Plug an output unit into the vacant socket on the printed circuit board indicated in the figure below. A white square is marked on the output unit to indicate proper orientation for installation. Be sure to install the output unit with this mark facing the direction indicated by the arrow in the figure below. Next, set the Output Selector Switch (SW202) to the proper position for the type of output unit. For Relay, SSR, and voltage output units, set the switch to PULSE position; for a current output unit, set the switch to CURRENT position.

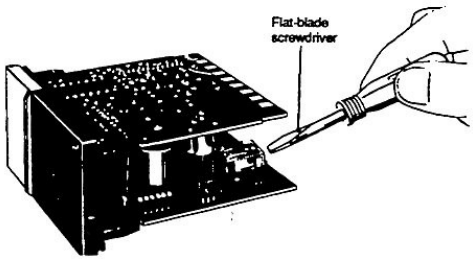




■ REMOVING AN OUTPUT UNIT

To remove the output unit, pry it up with the tip of a flat-blade screwdriver as illustrated.





■ LOCATIONS OF INTERNAL SWITCHES

Four sets of internal switches are located on the top right side of the controller.

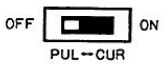
The **temperature sensor selector switch** (rotary DIP type) is SW206, located on the bottom right side.

The **function selector switch** SW201 (in-line DIP type) determines control mode, normal/reverse output, input shift, scale indication (°C or °F), and PID constant indication where manual fine-tuning may be desirable.

The two **alarm mode selector switches** select from the nine alarm functions available, including upper and lower limit alarms, upper limit alarm only, lower limit alarm only, upper and lower limit range alarm, alarms with standby sequence that eliminates nuisance alarms during start-up, event alarm and proportional alarm.

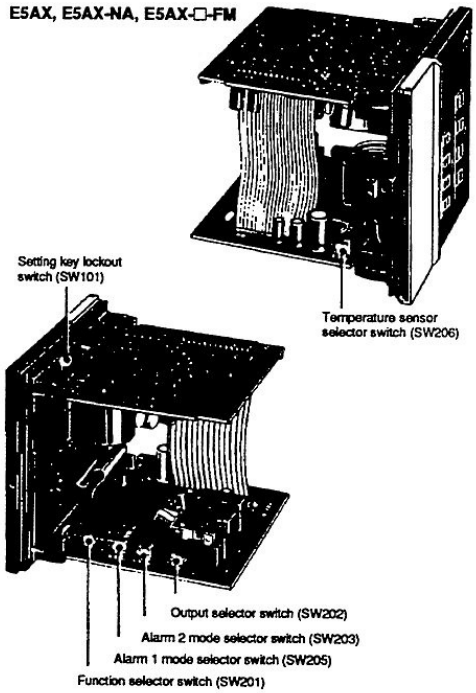
The **output selector switch** SW202 (a slide switch) must be set to the proper position for the type of output unit installed. For Relay, SSR, and voltage output units, set the switch to PULSE position (OFF marking); for a current output unit, set the switch to CURRENT position (ON marking).

Output selector switch (SW202)

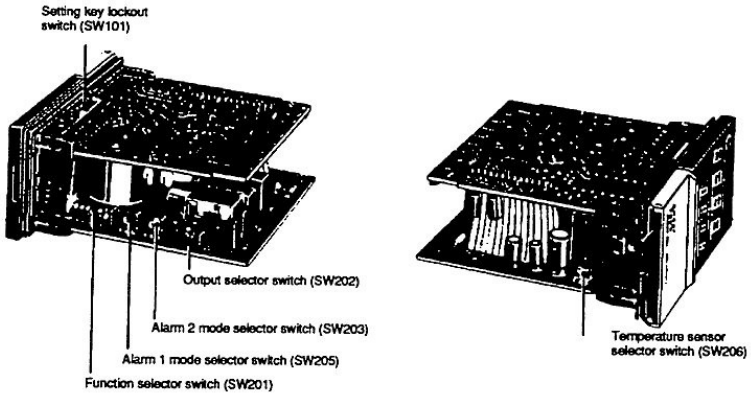


Output	Setting
Current	ON
Pulse	OFF

E5AX, E5AX-NA, E5AX-□-FM



E5EX, E5EX-NA, E5EX-□-FM



■ TEMPERATURE SENSOR SELECTION

Switch SW206 selects the temperature sensor to be used. The following table lists the switch positions, temperature sensor types available and the ranges available. The unit of measure for all thermocouple inputs is 1° (F or C); for platinum RTD inputs the unit of measure is 0.1° (F or C). The factory-set conditions are shown below:

E5□X-A controller SW206 Sensor

E5□X-NA controller SW206 Sensor

E5EX-A General-Purpose Controller

Switch position	Temperature sensor type	Temperature range	
		°C	°F
0	R	0 to 1,700	0 to 3,000
1	S	0 to 1,700	0 to 3,000
2	K	-200 to 1,300	-300 to 2,300
3	J	-100 to 900	-100 to 1,600
4	T	-200 to 400	-300 to 700
5	E	0 to 600	0 to 1,100
6	Pt (JIS)	-99.9 to 450.0	-99.9 to 800.0
7	Pt (DIN)	-99.9 to 450.0	-99.9 to 800.0
8	L	-100 to 850	-100 to 1,500
9	U	-200 to 400	-300 to 700

Note: JIS (Japanese Industrial Standards) 1981: 100°C, 139.16Ω
DIN standard (equivalent to JIS 1989): 100°C, 138.5Ω

E5□X-NA High-Temperature Controller

Switch position	Temperature sensor type	Temperature range	
		°C	°F
0	B	100 to 1,800	300 to 3,200
1	W/Re 5-26	0 to 2,300	0 to 4,100
2	N	0 to 1,300	0 to 2,300
3	Platinel II	0 to 1,300	0 to 2,300

■ FUNCTION SELECTION

In-line DIP switch SW201 selects the functions listed below:

SW201 Functions

Function		Switch number					
		1	2	3	4	5	6
Control mode	ON/OFF action	ON					
	PID action	OFF					
Control output	Normal (cooling)		ON				
	Reverse (heating)		OFF				
Input shift	Setting enabled			ON			
	Setting disabled			OFF			
Temperature sensor standard	DIN				ON		
	JIS				OFF		
Scale indication	°F					ON	
	°C					OFF	
PID constant indication	Enabled						ON
	Disabled						OFF

■ SETTING KEY LOCKOUT SWITCH

Protect the controller against unauthorized setting changes. When the setting key lockout switch (SW101) is set to the ON position, the level key, up and down keys, and the auto-tuning (AT) key cannot be operated. In effect, the temperature controller is write-protected and only the set values (such as alarm values) can be read out.

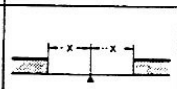
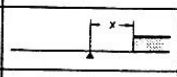
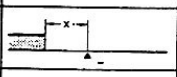
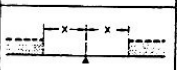
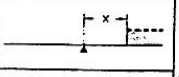
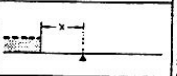
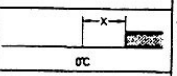
Protect (SW101)

■ ALARM MODE SELECTION

Two alarm mode selector switches are provided: ALM1 (SW205) and ALM2 (SW203). Nine alarm modes, listed in the table below, can be selected using these switches. Both switches are factory-set to position 2 for Upper Limit Alarm.

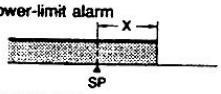

Alarm 1 (SW205)


Alarm 2 (SW203)

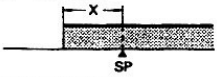
Switch position	ALM1 (SW205) Function	ALM1 (SW205) Monitor display	ALM2 (SW203) Function	ALM2 (SW203) Monitor display	Alarm output (▲: set temperature)	Setting range
0	No alarm function	No indication	No alarm function	No indication	OFF	—
1	Upper- and lower-limit alarms	3--C	Upper- and lower-limit alarms	3--C		Thermocouple: 0 to 9,999 Platinum resistance thermometer: 0 to 999.9
2	Upper-limit alarm	---C	Upper-limit alarm	---C		(See Note 1.) Thermocouple: −999 to 9,999 Platinum resistance thermometer: −99.9 to 999.9
3	Lower-limit alarm	3---	Lower-limit alarm	3---		
4	Upper- and lower-limit range alarm	-C3-	Upper- and lower-limit range alarm	-C3-		Thermocouple: 0 to 9,999 Platinum resistance thermometer: 0 to 999.9
5	Upper- and lower-limit alarm with standby sequence	3--E	Upper- and lower-limit alarm with standby sequence	3--E		
6	Upper-limit alarm with standby sequence	---E	Upper-limit alarm with standby sequence	---E		
7	Lower-limit alarm with standby sequence	3---	Lower-limit alarm with standby sequence	3---		(See Note 1.) Thermocouple: −999 to 9,999 Platinum resistance thermometer: −99.9 to 999.9
8	Event alarm	1--C	Event alarm	1--C	 0°C	
9	Proportional alarm	Pro	No alarm function	No indication	See Note 2.	

Note:
1. If a negative value is set as X, the operation will be as follows:

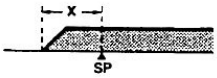
Lower-limit alarm



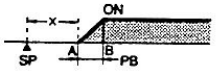
Upper-limit alarm



Proportional alarm



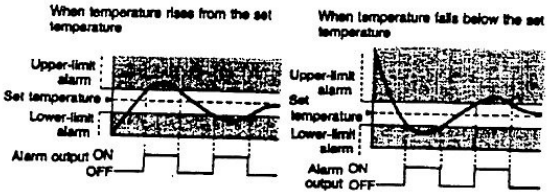
2. Alarm mode selector switch 1 can be used to select proportional alarm mode, but switch 2 cannot.
The proportional alarm function is initiated when the temperature reaches a set alarm point (A in the figure below), which is the lower limit of a proportional band. When the temperature rises to the upper limit of the proportional band (point B in the figure), the alarm output is turned on. This alarm function is convenient when the main setting is used for heating control, while the proportional alarm function is used for cooling control, so that heating and cooling control actions can be easily performed.



Proportional band (fixed at 42°C)
Proportional period is 20 seconds
The operation of the alarm function is not affected by pin 2 of the function selector switch (SW201).

Standby Sequence

Alarm functions with standby sequence suppress nuisance alarms when the controller is first powered up. As shown in the temperature charts below, the alarm output is suppressed until the temperature exceeds the alarm band or alarm limit one time.

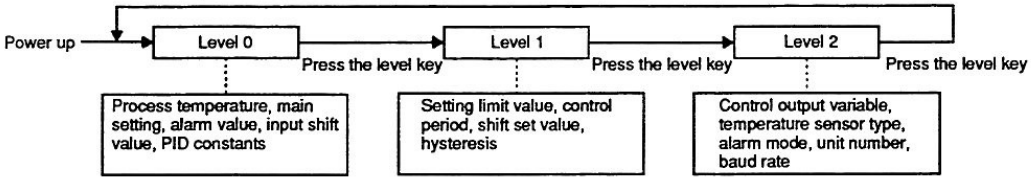


Factory Mutual ALM1 Reset

Temperature controllers with the Factory Mutual alarm 1 output require an operator to reset the alarm manually using the front panel reset button. Other controllers automatically reset when the alarm condition has passed.

Programming

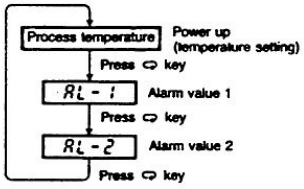
The temperature controller has three indication levels, 0 to 2, in which only specific parameters can be set. Level 0 is the default and is automatically set during power up. To change the mode to manipulate a different group of parameters, hold down the level key for 2 seconds or more. The indication level mode changes as shown below.



■ LEVEL 0

In this mode, parameters such as alarm values, temperature values at which alarm outputs are to be produced, PID constants, and input shift values can be set or changed. When these parameters are being set or changed, the new values are displayed on the SV indicator. The parameter to be manipulated is selected by pressing the mode key the required number of times. Note that the PID constants can be displayed only when the switch 1 on the function selector DIP switch (SW201) is set to the OFF position and switch 6 to the ON position.

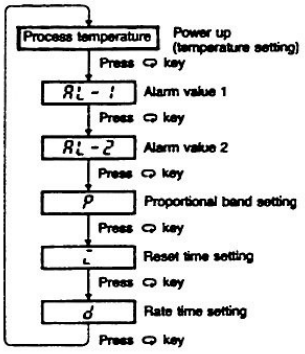
1. On power up, the process temperature is displayed on the PV indicator. When the mode key is pressed, the message "AL-1" is displayed on the PV indicator. The message "AL-2" is then displayed when the mode key is pressed again.



Alarm 1 AL - 1
Alarm 2 AL -2

When the message "AL-1" or "AL-2" is displayed on the PV indicator, the alarm value for alarm outputs 1 or 2 can be set on the SV indicator. When the temperature exceeds or falls below the set alarm value, the corresponding alarm output is produced and the ALM indicator on the front panel lights. Usually, the alarm value is set as a deviation from the set temperature (set point), but it can also be set as an absolute value when the event alarm mode is selected. Set the alarm value by using the up or down key while the message "AL-1" or "AL-2" is displayed. Note that the message is not displayed if the corresponding alarm mode selector switch is set to "No Alarm" position 0.

2. After the message "AL-2" has been displayed, press the mode key again. Then the PID constants can be manually set or changed, provided switch 6 on the internal function selector DIP switch (SW201) has been set to the ON position. The message displayed on the PV indicator changes as shown below each time the mode key is pressed.



Proportional Band P

While the character "P" is displayed on the PV indicator, the proportional band (P constant) can be set or changed using the up or down key. The new value is displayed on the SV indicator. The P constant can be set in a range from 0.0° to 999.9°C/°F in units of 0.1°C/°F. The factory setting is 40.0°C/°F.

Reset Time I

The reset time (I constant) can be changed when the character "i" is displayed on the PV indicator. Use the up or down key to set or change the I constant. The allowable range is from 1 to 3,999 seconds in units of 1 second. The factory setting is 240 seconds.

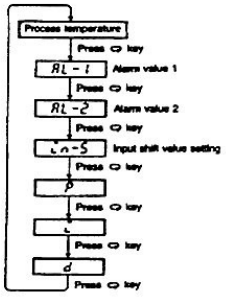
Rate Time d

The rate time (D constant) can be changed when the character "d" is displayed on the PV indicator. Use the up or down key to set or change the D constant. The allowable range is from 0 to 3,999 seconds in units of 1 second. The factory setting is 60 seconds.

3. When switch 3 on the internal function selector DIP switch (SW201) is set to the ON position, the input shift function can be used. This function is used to shift the temperature display from a measured value to a desired value, as illustrated by the examples in the following table.

Set input shift value	Temperature measured by sensor	Displayed temperature
0 (without shift)	100°C	100°C
10 (offset by 10°C)	100°C	110°C
-10 (offset by -10°C)	100°C	90°C

This function can be used mainly for fine-tuning compensation, while leaving unaffected the set temperature. Select this function by pressing the Mode key three times in display level 0 as follows:



Input Shift Value in-S

While the message (in-S) is displayed on the PV indicator, the input shift value, a value by which the measured temperature is shifted and displayed, can be set and displayed on the SV indicator. The range in which the input shift value can be set differs depending on the type of sensor selected (thermocouple or platinum RTD) as shown below:

Sensor input	Setting range	Units
Thermocouple	-999 to 9,999°C/°F	1°C/°F
Platinum RTD	-99.99 to 999.9°C/°F	0.1°C/°F

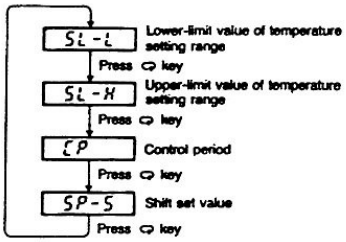
The input shift function remains effective even if switch 3 on the function selector DIP switch (SW201) is changed to the OFF position after the input shift value has been set.

If the displayed temperature does not need to be shifted, set 0°C/°F in response to the message (in-S).

■ LEVEL 1

In this level, parameters such as upper- and lower-limit values of the temperature setting range, control period, shift set value, and hysteresis can be set.

1. When switch 1 on the function selector DIP switch (SW201) is set to the OFF position (PID action), the temperature setting range limit values, control period, and shift set value can be set or changed. Any of these parameters can be selected by pressing the Mode key the required number of times as follows:



Lower-limit value of temperature setting range SL-L
Upper-limit value of temperature setting range SL-H

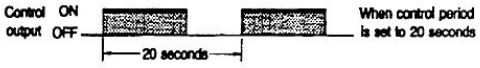
The temperature sensor selected determines the temperature range. For example, a type K thermocouple provides a measurable range from -200° to 1,300°C. However, the temperature range can be narrowed for your specific application, such as 0° to 400°C.

To do this, set the lower-limit value of the temperature setting range, in this case 0°C, on the SV indicator by using the UP or DOWN key while the message "SL-L" is displayed on the PV indicator. Then set the upper-limit value, 400°C, while the message "SL-H" is displayed.

If the process temperature falls below the set lower-limit value or exceeds the set upper-limit value, it will be displayed on the PV indicator provided the temperature is within the range of the selected temperature sensor.

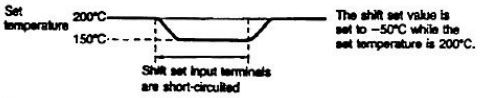
Control Period CP

Switch 1 on the function selector DIP switch (SW201) is set to the OFF position and output selection switch to pulse position, when the message "CP" is displayed on the PV indicator, the control period can be set or changed in a range from 1 to 99 seconds and in units of 1 second. The factory setting is 20 seconds. When a voltage or SSR output is used, it is recommended that the control period be set to 20 seconds or less (ideally, about 2 seconds), so that the control action can be performed more accurately.



Shift Set Value SP-S

When the message "SP-S" is displayed on the PV indicator, an alternate set point or shift set value can be set or changed. The shift set function shifts the set point temperature by a specified value as illustrated below.

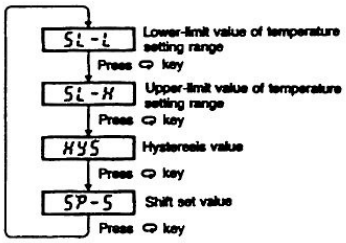


The shift set value can be set by using the UP or DOWN key. The range differs depending on the temperature sensor used.

Sensor input	Setting range	Units
Thermocouple	-999 to 9,999°C/°F	1°C/°F
Platinum RTD	-99.99 to 999.9°C/°F	0.1°C/°F

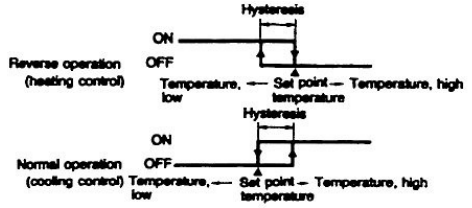
When the shift set input terminals are short-circuited, the SHIFT indicator lights. The shift set value is factory set to 0.

2. When switch 1 on the function selector DIP switch (SW201) is set to the ON position, selecting the ON/OFF control action, or proportional band is set to 0°C/°F, the hysteresis value can be set or changed. To do this, press the mode key the required number of times as follows:



Hysteresis HYS

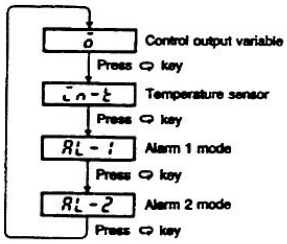
The hysteresis value for the ON/OFF control action can be set in a range from 0.0° to 999.9°C/°F while the message "HyS" is displayed on the PV indicator. Use the up or down key to do this. The factory setting is 0.8°C/°F.



■ LEVEL 2

Level 2 functions are exclusively for monitoring and do not set any of the parameters. The control output variable, selected temperature sensor, and modes for alarm outputs 1 and 2 can be monitored.

When the level key is depressed for more than 2 seconds after power up, the message "SL-L" is displayed on the PV indicator. After this message has been displayed, holding down the Level key again for 2 seconds or more causes the message "o" to be displayed on the PV indicator. When this message has been displayed, the control output variable, selected temperature sensor, and alarm modes can be monitored each time the mode key is pressed, as follows:



Control Output Variable o

When the temperature controller enters level 2, the control output variable is displayed on the SV indicator in a range of 0.0 to 100.0%

Temperature Sensor in-t

When the message "in-t" is displayed on the PV indicator, a message identifying the selected temperature sensor, or the present setting of the temperature sensor selector switch (SW206) is displayed on the SV indicator. The following table shows the messages that may be displayed.

Display characters	Sensor type
r Pr	Thermocouple type R
S Pr	Thermocouple type S
K CA	Thermocouple type K
J CC	Thermocouple type J
t CC	Thermocouple type T
E Cr	Thermocouple type E
JPt	Platinum RTD (JIS 1981)
Pt	Platinum RTD (DIN)
L CC	Thermocouple type L
U CC	Thermocouple type U

Alarm 1 Mode (AL-1) AL-1
Alarm 2 Mode (AL-2) AL-2

When the message "AL-1" or "AL-2" is displayed on the PV indicator in level 2, a message identifying the mode for alarm outputs 1 and 2, or the present setting of the corresponding alarm mode selector switches (SW205 and SW203) is displayed on the SV indicator. The following table shows the messages that may be displayed.

Display characters	Alarm mode
No indication	No alarm function
J--C	Upper- and lower-limit alarms
---C	Upper limit alarm
J---	Lower limit alarm
-CJ-	Upper- and lower-limit range alarm
J--E	Upper- and lower-limit alarm with standby sequence
---E	Upper limit alarm with standby sequence
J---	Lower limit alarm with standby sequence
I--C	Event alarm
Pro	Proportional alarm

Controller Number Un-o

This setting assigns a controller number (integers from 0 to 99) to each temperature controller to allow the host computer to distinguish one temperature controller from the others in the same system during communications. When "un–o" appears on the process value display, use the Up Key or Down Key to input a set value. The controller number is factory set to 0. Do not give identical controller numbers to temperature controllers in the same system, as this will interfere with communications.

Baud Rate bPS

This sets the speed for communications with the host computer. When "bps" appears on the process value display, use the UP Key or Down Key to input a set value. The baud rate can be set to 150, 300, 600, 1200, 2400, 4800 or 9600 bps. The rate is factory set to 9600 bps. The set value becomes effective only after the controller's power is turned OFF once and then ON again.

Operation

■ POWER UP

When power is turned ON, temperature control is carried out for each level using previously-set parameters or the factory-set parameters even while new parameters are being input.

To operate the temperature controller after all of the new parameters are input, turn the power OFF once then ON again.

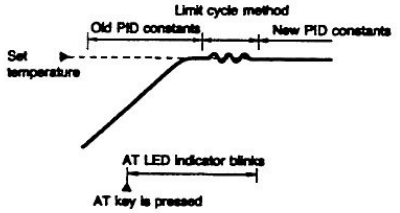
■ AUTOMATIC TUNING OF PID

When the automatic tuning (AT) key is pressed for 1 second or more, the temperature controller automatically starts tuning the PID constants. While the automatic tuning is taking place the "AT" indicator on the front panel flashes.

The temperature controller executes control based on the previously-set or factory-set PID constants until the temperature of the controlled system reaches the set temperature. Factory-set PID constants are as follows:

Constant	Value
P	40°C
I	240 seconds
D	60 seconds

After the tuning period, the temperature controller automatically adjusts the PID constants using the limit cycle method. After automatic tuning the AT indicator goes off.



Limit cycle method: The optimum PID constants are calculated by this method by varying the control variable and generating external oscillation.

The automatic tuning can be carried out regardless of whether the temperature controller is performing reverse (heating) or normal (cooling) operation. To stop automatic tuning, hold down the AT key again for 1 second or more. Automatic tuning can be executed at any time: on power up, while the temperature is rising, and after control action has stabilized.

■ CONTINUOUS SELF-RECALIBRATION

The electrical parts in the analog circuit of temperature controllers are affected by temperature drift and deterioration from age. Omron's E5□X controllers have a built-in recalibration circuit that continuously monitors and calculates an offset value for the op-amp circuit. The calibration input voltage is applied every 3 seconds to keep the controller constantly calibrated. Factory recalibration is eliminated to reduce controller maintenance.

Error Messages

Message	Cause	Control output		Alarm output
		With output unit other than current output unit	With current output unit	
FFFF	Input temperature has risen beyond the upper limit of the temperature range by more than 20°C (68°F).*	OFF during reverse (heating) action ON during normal (cooling) action	4 mA during reverse (heating) action 20 mA during normal (cooling) action	Issues alarm outputs in accordance with the set alarm mod
----	Input temperature has fallen below the lower limit of the temperature range by more than 20°C (68°F).**	ON during reverse (heating) action OFF during normal (cooling) action	20 mA during reverse (heating) action 4 mA during normal (cooling) action	Issues alarm outputs in accordance with the set alarm mod
S.Err (flashes)	The thermocouple has burned out or short-circuit bar has been removed. The platinum RTD has burned out or A and B have been short-circuited.	OFF	Approx. 1 mA	Issues alarm outputs in accordance with the set alarm mode. Proportional alarm output is OFF.
E111 E333 (flashes)	Memory failure (E111) or analog-to-digital converter failure (E333) has occurred. Temperature controller must be repaired if recovery is not made by turning power off once and on again.	OFF	Approx. 1 mA	OFF

* When the type J thermocouple is used, this error message is not displayed until the temperature has risen above the normal operating temperature range by more than 70°C (158°F).

** When the platinum RTD sensor is used, this message is displayed when the temperature has fallen to -99.9°C (-147.82°F).