

1/8 DIN Controllers Combine Fuzzy and PID Control For Fast Response to Process Disturbances

- Advanced PID control for optimal response during start-up and steady-state operation
- Fuzzy and PID control work together to correct a process upset quickly, with minimal overshoot
- Fuzzy parameters can be changed to adjust fuzzy control's impact on the process
- Accuracy to $\pm 0.3\%$ of set value
- Field-selectable temperature ranges, °F/°C scaling, and sensor input types
- Plug-in outputs for field interchangeability
- Communications function, heater burnout alarm and 8-bank models available
- 3-year warranty



Ordering Information

■ TEMPERATURE CONTROLLERS

Order one control output separately below. For example, **E5EF-A02TC-F** with **E53-S** SSR output unit. For heater burnout models, be sure to order a current transformer. To order models marked for degrees Celsius, omit the "F" at the end of the part number.

Controller type	Part number			
	Standard		Heater burnout type*	
Input type	Thermocouple (10 types)	Platinum RTD	Thermocouple (10 types)	Platinum RTD
No communications	E5EF-ATC-F	E5EF-AP-F	E5EF-AHTC-F	E5EF-AHP-F
RS-422 communications	E5EF-A02TC-F	E5EF-A02P-F	E5EF-AH02TC-F	E5EF-AH02P-F
RS-485 communications	E5EF-A03TC-F	E5EF-A03P-F	E5EF-AH03TC-F	E5EF-AH03P-F
8-bank program memory	E5EF-BATC-F	E5EF-BAP-F	E5EF-BAHTC-F	E5EF-BAHP-F

* Current Output E53-C may not be used with heater burnout type controllers.

Temperature Ranges

Sensor input type		Thermocouple						
		Type K	Type J/L	Type T/U	Type E	Type R/S	Type B	Type N
Temperature range	°C	-200 to 1,300	-100 to 850	-200 to 400	0 to 600	0 to 1,700	100 to 1,800	0 to 1,300
	°F	-300 to 2,300	-100 to 1,500	-300 to 700	0 to 1,100	0 to 3,000	300 to 3,200	0 to 2,300
Unit of measure		1° C or F, main setting and alarm						

Sensor input type		Platinum RTD (Pt100 or JPt100)						
Temperature range	°C	-99.9 to 450.0						
	°F	-99.9 to 800.0						
Unit of measure		0.1° C or F, main setting and alarm						

■ 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

Advanced PID Control Improved with Fuzzy Control

Omron's E5EF temperature controllers combine advanced PID control with Fuzzy Logic control to improve responsiveness to external process disturbances, events that cause a clear offset between the process and set temperatures.

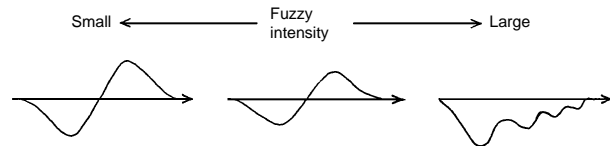
Omron's advanced PID control and Fuzzy Logic control operate in parallel. The PID control operates during normal conditions, while the Fuzzy Logic control operates only when there has been an external disturbance to the process. The start-up and

stable state operation is identical to Omron's conventional PID controllers. The output of the E5EF is the sum total of the output of the PID and fuzzy control functions. Both PID and fuzzy scale parameters can be set automatically by auto-tuning, or may be manually set.

There are three fuzzy parameters users can set, and the illustrations show the impact of each one:

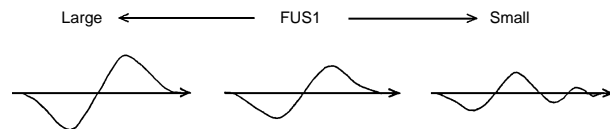
■ FUZZY INTENSITY

Fuzzy intensity (FU1) determines the impact of the Fuzzy Logic section of the control algorithm, on the final control output percentage. This parameter is the nominal value which can be set from 0 to 99%. Default setting is 50%. When set to 0%, fuzzy control will have no influence, and the unit will function as a PID controller (like Omron's E5EX). As this value is increased, the corrective actions taken by the controller will become larger. The FU1 value should be increased in applications where quicker neutralization of a process disturbance is required, and/or overshoot on the recovery from the disturbance needs to be further minimized.



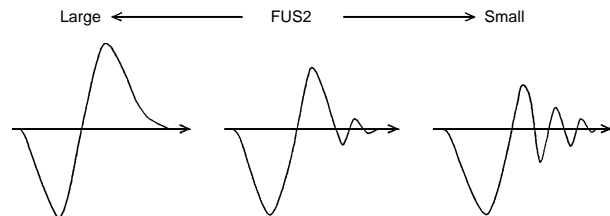
■ FUZZY SCALE 1

Fuzzy Scale 1 (FUS1) controls the magnitude of error "membership function". This value corresponds to what the controller should consider to be a "large" error and can be set in a range of 0.2° to 999.9° (C or F). Default setting is 40°. For every sample the controller compares the present error to FUS1 value in order to make a subjective decision about the size of the error. Decreasing this value makes the controller more sensitive to error, and will decrease the response time for returning the process back to set value.

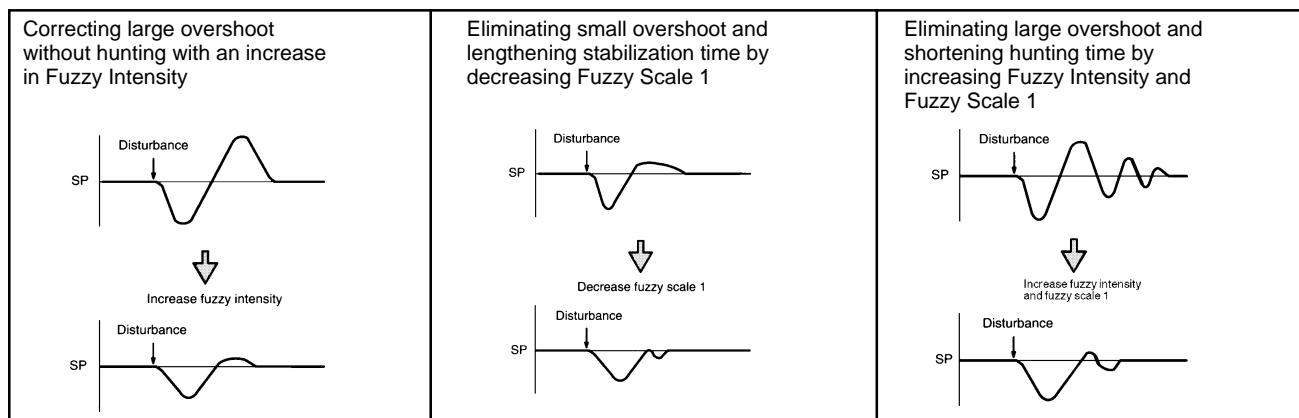


■ FUZZY SCALE 2

Fuzzy Scale 2 (FUS2) controls the rate-of-change "membership function". This value corresponds to what the controller should consider a "large" rate of change, and can be set in a range from 0.20° to 99.9° (C or F) per second. For every sample the controller compares the present rate-of-change to the FUS2 value in order to make a subjective decision about the size of the change. Decreasing this value will make the controller more sensitive to change. Because small changes in this value can cause a large increase in oscillations, best results can usually be achieved by manually setting FU1 and FUS1 and leaving FUS2 at the auto-tuned value.



■ COMBINED EFFECTS OF FUZZY ADJUSTMENTS



Specifications

Supply voltage		100 to 240 VAC, 50/60 Hz	
Operating voltage		85 to 110% of rated supply voltage	
Power consumption		Approx. 10 VA at 100 VAC to 15 VA at 240 VAC	
Control output	Number	One output unit, ordered separately; mounts in internal socket of Standard E5EF-A and heater burnout E5EF-AH types	
	Type	Relay*	SPDT, 5 A, 250 VAC (resistive load) using E53-R output unit
		SSR	SPST-NO, 1 A, 75 to 250 VAC using E53-S output unit
	Voltage	40 mA, 12 VDC, NPN, using E53-Q output unit with short-circuit protection 20 mA, 24 VDC, NPN, using E53-Q3 output unit with short-circuit protection 20 mA, 24 VDC, PNP, using E53-Q4 output unit with short-circuit protection	
	Current	4 to 20 mA DC, 600 Ω max. load, 8-bit resolution using E53-C output unit. Current output unit cannot be used with heater burnout type E5EF-AH.	
	Isolation	All output units are optically isolated from the internal circuits	
	Hysteresis	0.0 to 999.9 $^{\circ}\text{C}/^{\circ}\text{F}$ in units of 0.1 (during ON/OFF control action)	
	Update time	Output	500 ms for pulse output
		Display	500 ms
	Service life	100,000 electrical operations minimum for relay output unit E53-R 10 million mechanical operations minimum for relay output unit E53-R	
Alarm output	Number	Two SPST-NO relays, 3 A, 250 VAC for E5EF-A; one SPST-NO relay for E5EF-AH	
	Setting range	Thermocouple: -999 to 9,999 $^{\circ}\text{C}/^{\circ}\text{F}$ Platinum RTD: -99.9 to 999.9 $^{\circ}\text{C}/^{\circ}\text{F}$	
Heater burnout output E5EF-H only	Type	SPST-NO relay, 1 A, 250 VAC	
	Setting range	0.1 to 49.9 A in units of 0.1 A 0.0 setting disables the output 50.0 setting turns output ON continuously	
	Minimum detectable ON time	200 ms; heater current is not measured when the control output is ON less than 200 ms	
Indication accuracy	General	$\pm 0.3\%$ of set value or $\pm 1^{\circ}$, whichever is greater, ± 1 digit maximum	
	Exceptions	Accuracy of types T and U thermocouples is $\pm 2^{\circ}\text{C}$ (3.6°F) from -150° to 400°C (-240 to 700°F), ± 1 digit. Accuracy is not guaranteed below -150°C (-240°F). Accuracy of types R and S thermocouples is $\pm 3^{\circ}\text{C}$ ($\pm 5.4^{\circ}\text{F}$) from 0° to 200°C (32° to 400°F), ± 1 digit. Accuracy of type B thermocouples is not guaranteed at or below 400°C (750°F).	
	Heater burnout	$\pm 5\%$ of full scale, ± 1 digit maximum of heater current	
	Display Range	-9999 to 9999 (limited by input type)	
Setting accuracy	Set value coincides with the indicated value, since no relative error exists between both values		
Control modes	Type	ON/OFF or auto-tuning PID and fuzzy control to prevent overshoot	
	Proportional band	P = 0.0 to 999.9 $^{\circ}\text{C}/^{\circ}\text{F}$ in units of 0.1 $^{\circ}$	
	Reset time	I = 0 to 3,999 seconds in units of 1 second	
	Rate time	D = 0 to 3,999 seconds in units of 1 second	
	Control period	Pulse output: 1 to 99 seconds in units of 1 second	
	Sampling period	500 ms	
	Fuzzy intensity	FU = 0 to 99% in units of 1%; factory set to 50% for general-purpose control applications	
	Fuzzy scale 1	FUS1 = 0.2 to 999.9 $^{\circ}\text{C}$ or $^{\circ}\text{F}$ in units of 0.1 $^{\circ}$; factory set to 40.0 $^{\circ}\text{C}$	
Fuzzy scale 2	FUS2 = 0.20 to 99.99 $^{\circ}\text{C}$ or $^{\circ}\text{F}/\text{sec}^2$ in units of 0.01 $^{\circ}\text{F}$ or $^{\circ}\text{C}/\text{sec}^2$; factory set to 0.47 $^{\circ}\text{C}/\text{sec}^2$		
Memory protection	Non-volatile memory (EEPROM)		
Other functions	Shift set input E5EF-A only	Sets a second set point. Requires no-voltage contact signal with input impedance of 100 Ω max. Thermocouple range: -999 to 9,999 $^{\circ}\text{C}/^{\circ}\text{F}$ Platinum RTD range: -99.9 to 999.9 $^{\circ}\text{C}/^{\circ}\text{F}$	
	Input shift, all models	Offsets input value and display value to accommodate a sensor input that deviates by a known value. Thermocouple range: -999 to 9,999 $^{\circ}\text{C}/^{\circ}\text{F}$ Platinum RTD range: -99.9 to 999.9 $^{\circ}\text{C}/^{\circ}\text{F}$	
	Miscellaneous	Upper and lower set value limits, setting key disable, $^{\circ}\text{C}/^{\circ}\text{F}$ selectable internally, input shift, shift set (not on heater burnout models) Normal and Reverse output selection, Watchdog function to detect CPU failure and restore CPU to normal operation.	

*Note: If control period is less than 5 seconds, use solid state relay or voltage relay.

SPECIFICATIONS (continued)

Indicators		Present Value (green LED), 11 mm H (0.43 in); Set Value (red LED), 8 mm H (0.32 in); Bank Number (orange LED), 8 mm H (0.32 in); LED indicators for all functions
Materials		Plastic case
Mounting		Fits 1/8 DIN panel cutouts; includes two panel mounting brackets
Connections		Plated steel screw terminals mounted on rear of unit
Weight		Approx. 310 g (10.9 oz.), with communications 360 g (12.7 oz.)
Enclosure ratings	Front panel	IEC IP50, NEMA 4 with optional cover Y92A-49N
	Rear panel	IEC IP20
	Terminals	IEC IP00
Approvals	UL	Recognized, File Number E68481 (all models)
	CSA	Certified, File Number LR59623 (all models)
Ambient temperature	Operating	-10° to 55°C (14° to 131°F)
	Storage	-25° to 65°C (-13° to 149°F)
Humidity		35 to 85% RH
Insulation resistance		20 MΩ minimum at 500 VDC, measured with an output unit installed
Dielectric strength		2,000 VAC, 50/60 Hz for 1 minute between terminals of different polarity, measured with an output unit installed
Vibration	Mechanical durability	10 to 55 Hz, 0.75 mm (0.03 in) in X, Y, and Z directions for 2 hours each
	Malfunction durability	2 to 5 Hz, 2 G, in X, Y, and Z directions for 10 minutes each
Shock	Mechanical durability	300 m/s ² in 6 directions, 3 times each
	Malfunction durability	200 m/s ² in 6 directions, 3 times each

■ COMMUNICATIONS FEATURES

Output type	RS-422	RS-485
Transmission method	4-wire half duplex	2-wire half-duplex
Maximum cable length	500 m (1,640 ft)	
Synchronization method	Start-stop	
Transmission rate	150/300/600/1,200/2,400/4,800/9,600 bps	
Transmission code	ASCII (7 bits)	
Write to controller functions	Set temperature, alarm value, proportional band, integral time, rate time, auto-tuning start/stop, fuzzy intensity, fuzzy scales 1 and 2, heater burnout alarm set value (E5EF-H)	
Read from controller functions	Set temperature, alarm value, proportional band, reset time, rate time, output variable, process value, fuzzy intensity, fuzzy scales 1 and 2, heater burnout current and current transformer input value (E5EF-H)	
System limits	A maximum of 32 temperature controllers can be connected to one host computer in serial communication	

■ CURRENT TRANSFORMERS (for E5EF-H)

Heater current	Maximum 50 A continuous service, single-phase	
Weight	Approx. 11.5 g (0.41 oz.) for E54-CT1; approx. 50 g (1.8 oz.) for E54-CT3	
Dielectric strength	1,000 VAC	
Vibration	50 Hz (approx. 10 G)	

■ CURRENT TRANSFORMERS FOR HEATER-BURNOUT CONTROLLERS

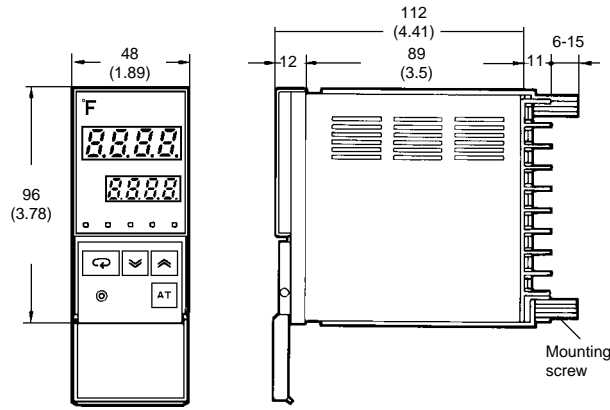
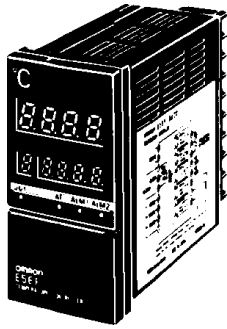
Hole diameter	5.8 mm (0.23 in)	12.0 mm (0.47 in)
Part number	E54-CT1	E54-CT3

*Note: If control period is less than 5 seconds, use solid state relay or voltage relay.

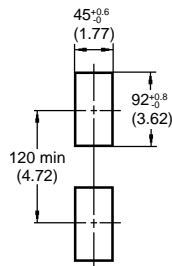
Dimensions

Unit: mm (inch)

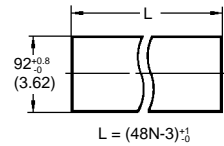
■ TEMPERATURE CONTROLLERS



Panel cutout



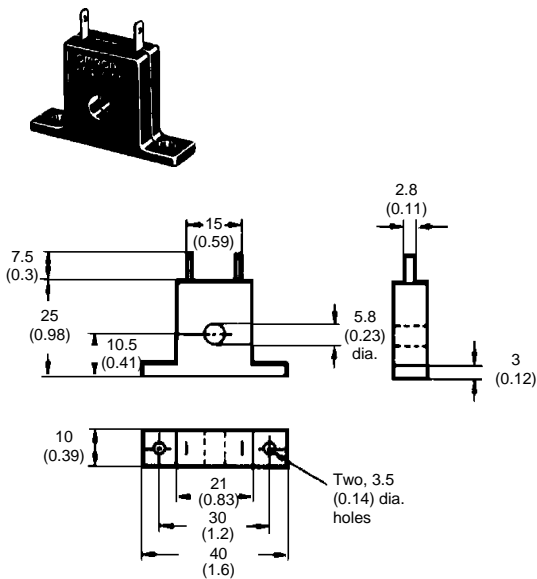
Side-by-side mounting of several controllers



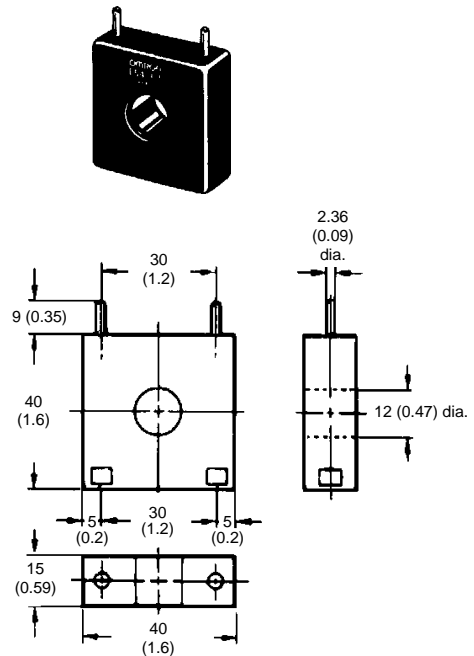
For side-by-side mounting:
 $L = 48 \text{ mm} \times \text{Number of units} - 3 \text{ mm}$
 $= (1.89 \text{ in} \times \text{Number of units} - 0.12 \text{ in})$

■ CURRENT TRANSFORMERS (for E5EF-H)

E54-CT1

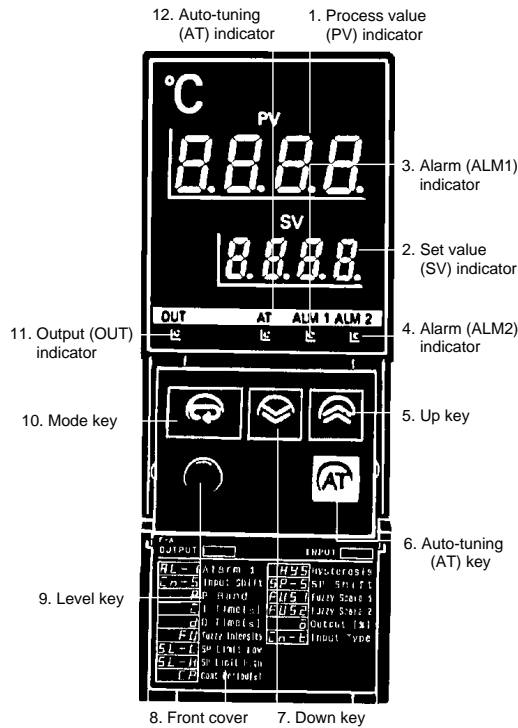


E54-CT3



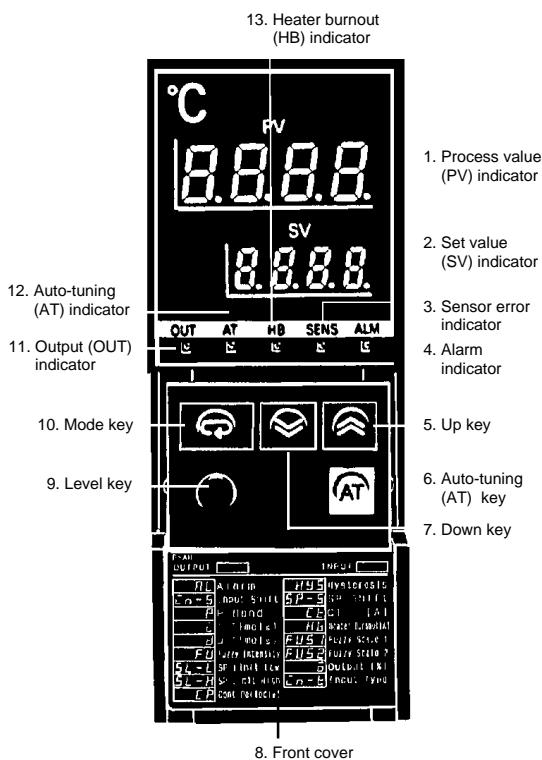
Nomenclature

■ E5EF-A STANDARD CONTROLLERS



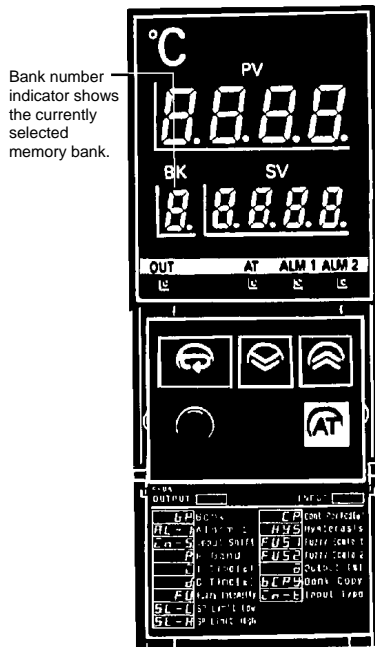
Key	Description
1.	Process value indicator displays the process temperature and indicates the parameter being displayed on the SV (Set Value) display and error messages.
2.	Set value indicator.
3.	Indicator lights when alarm 1 output is ON.
4.	Indicator lights when alarm 2 output is ON.
5.	Up key increases the value of any parameter when pressed.
6.	Automatic tuning of parameters is executed when the AT key is pressed for 1 second or more. To stop auto-tuning press the key for 1 second or more.
7.	Down key decreases the value of any parameter when pressed.
8.	Front cover shows setting symbols.
9.	Level key, pressed for 2 seconds or more, selects the next of three parameter setting levels.
10.	Mode key changes the items to be set, such as alarm value, etc.
11.	Output indicator lights when control output is ON.
12.	Automatic tuning indicator flashes at 1-second intervals while tuning is executed, then stops when completed.

■ E5EF-AH STANDARD HEATER BURNOUT TYPE

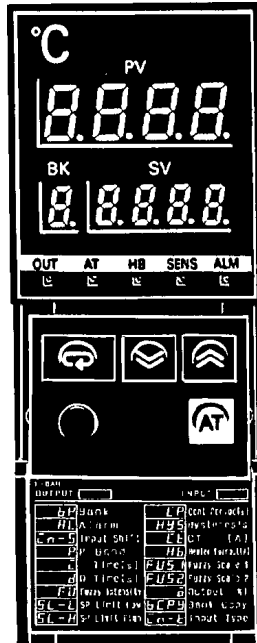


Key	Description
1.	Process value indicator displays the process temperature and indicates the parameter being displayed on the SV (Set Value) display and error messages.
2.	Set value indicator.
3.	Lights when sensor error is detected.
4.	Indicator lights when alarm output is ON.
5.	Up key increases the value of any parameter when pressed.
6.	Automatic tuning of parameters is executed when the AT key is pressed for 1 second or more. To stop auto-tuning press the key for 1 second or more.
7.	Down key decreases the value of any parameter when pressed.
8.	Front cover shows setting symbols.
9.	Level key, pressed for 2 seconds or more, selects the next of three parameter setting levels.
10.	Mode key changes the items to be set, such as alarm value, etc.
11.	Output indicator lights when control output is ON.
12.	Automatic tuning indicator flashes at 1-second intervals while tuning is executed, then stops when completed.
13.	Lights when a heater burnout is detected and stays lit until reset.

■ E5EF-BA 8- BANK TYPE

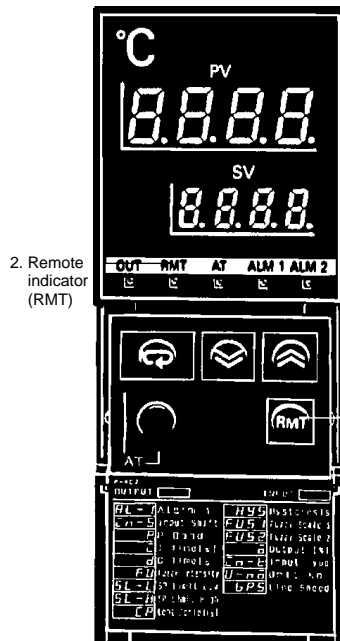


■ E5EF-BAH HEATER BURNOUT TYPE WITH 8- BANK MEMORY

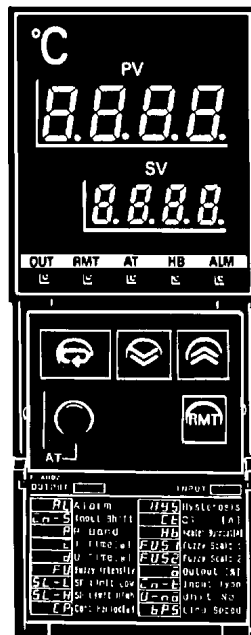


Note:
Models with 8-bank program memory have the same indicators and keys as standard models. The bank number (BK) display is to the left of the set value (SV) display.

■ E5EF-A02/A03 SERIAL COMMUNICATIONS TYPE



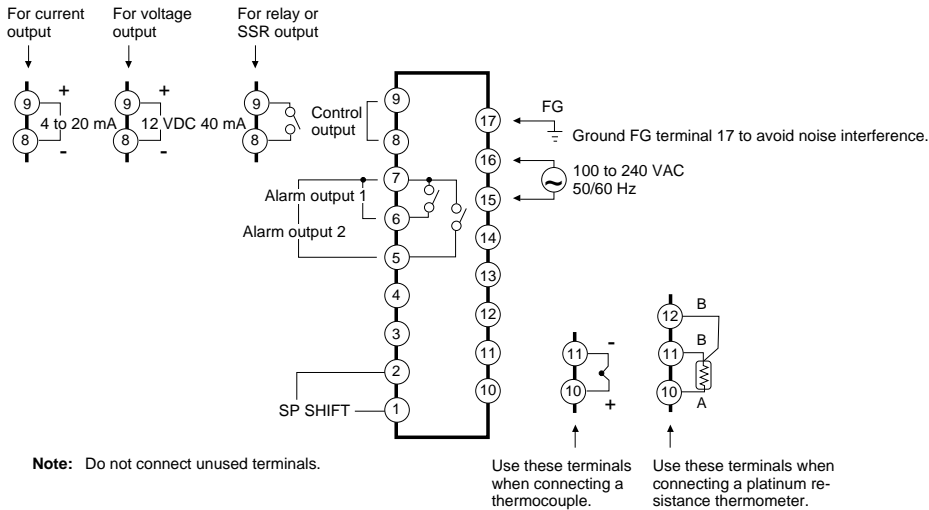
■ E5EF-AH02/AH03 HEATER BURNOUT TYPE WITH SERIAL COMMUNICATIONS



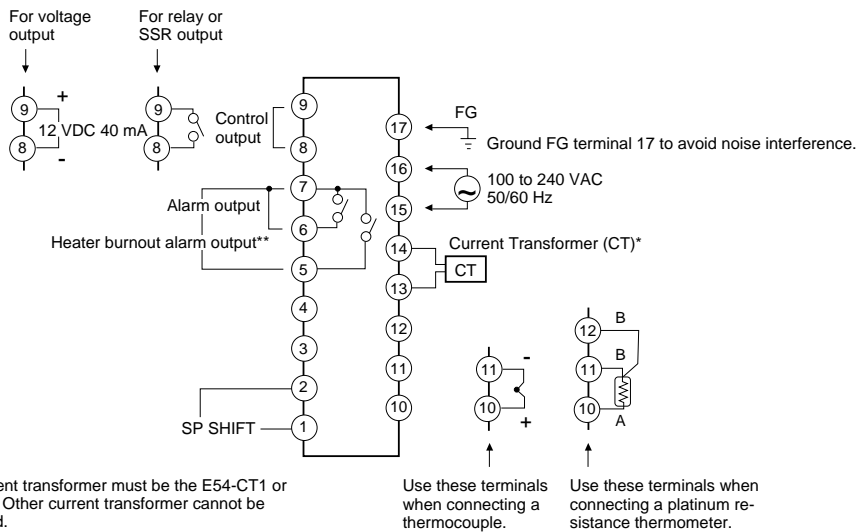
Key	Description
1.	The Remote (RMT) key initiates and breaks on-line communications.
2.	Remote mode indicator stays lit during on-line communications.
Note	Automatic tuning of parameters is executed when the Mode and Level keys are pressed simultaneously for 1 second or more. To stop auto-tuning press both keys for 1 second or more.

Connections

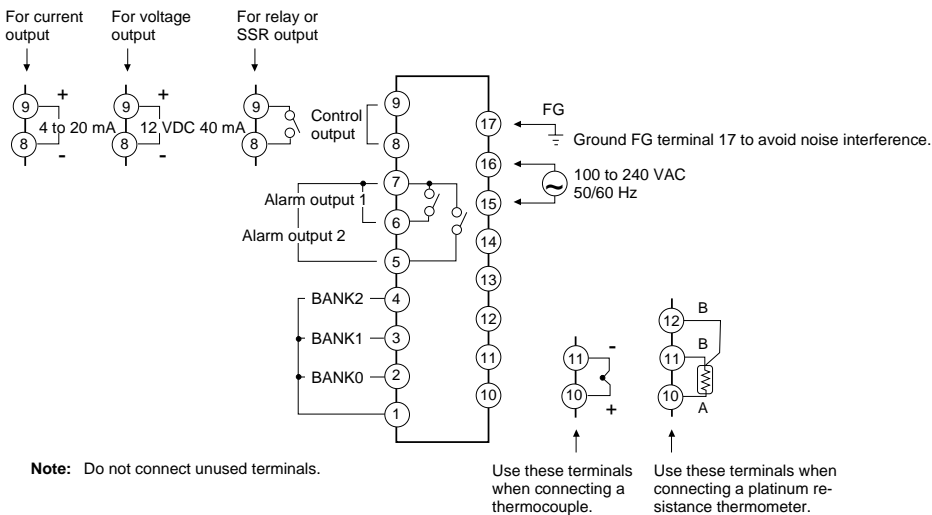
STANDARD CONTROLLERS (E5EF-A)



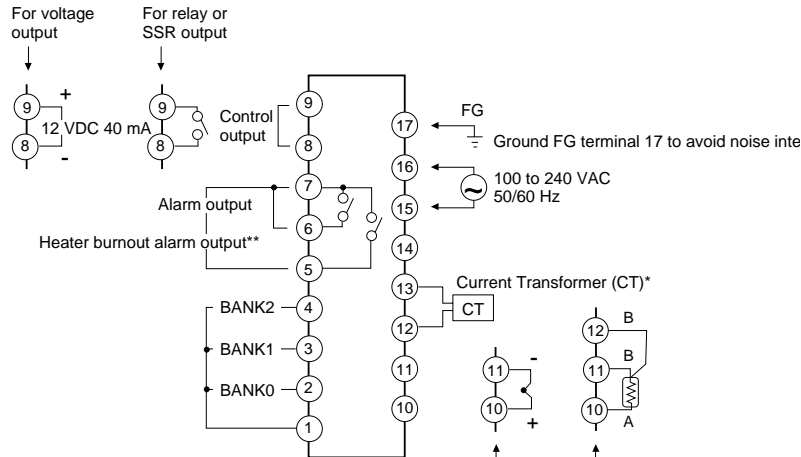
HEATER BURNOUT TYPE STANDARD CONTROLLERS (E5EF-AH)



8-BANK TYPES (E5EF-BA-F)



■ 8-BANK TYPES WITH HEATER BURNOUT (E5EF-BAH-F)

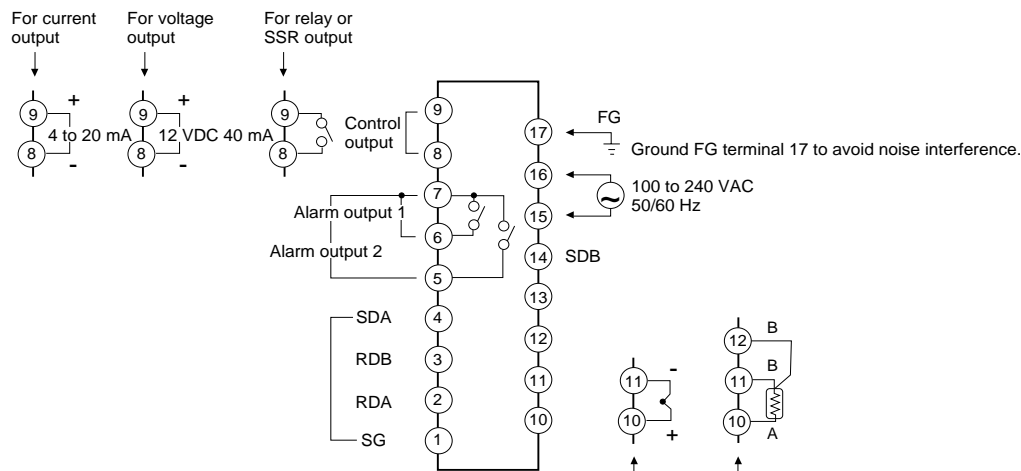


Note: *The current transformer must be the E54-CT1 or E54-CT3. Other current transformer cannot be connected.
 **The heater burnout alarm goes ON when the E5EF detects a sensor failure or heater burnout.

Use these terminals when connecting a thermocouple.

Use these terminals when connecting a platinum resistance thermometer.

■ RS-422 COMMUNICATIONS (E5EF-A02-F)

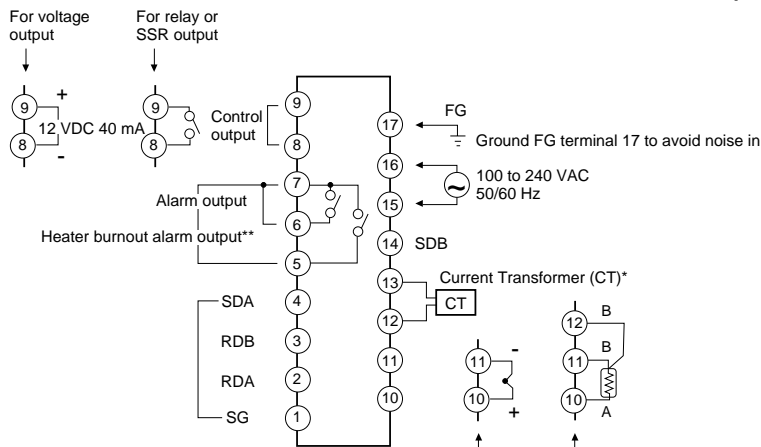


Note: Do not connect unused terminals.

Use these terminals when connecting a thermocouple.

Use these terminals when connecting a platinum resistance thermometer.

■ HEATER BURNOUT TYPES WITH RS-422 COMMUNICATIONS (E5EF-AH02-F)

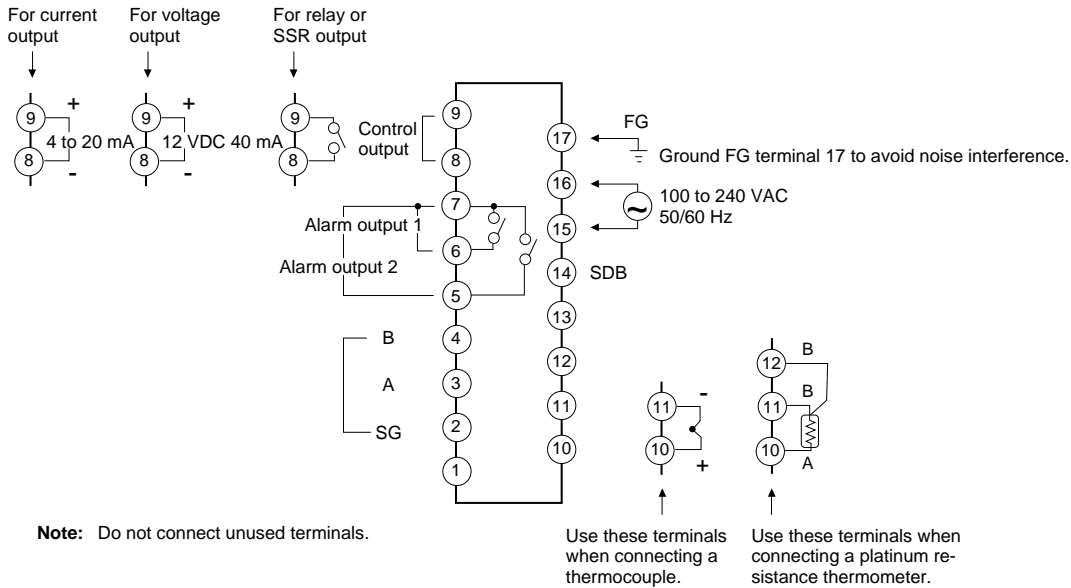


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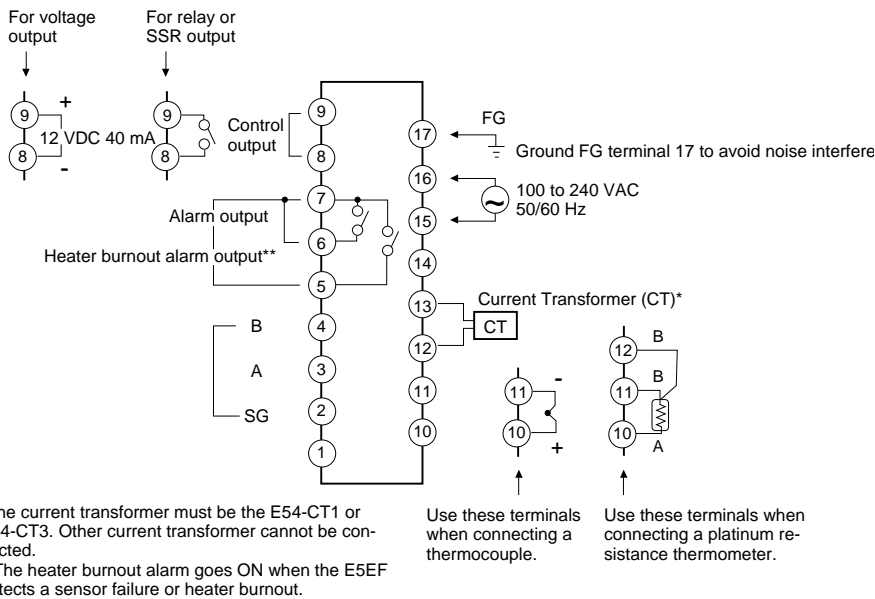
Use these terminals when connecting a thermocouple.

Use these terminals when connecting a platinum resistance thermometer.

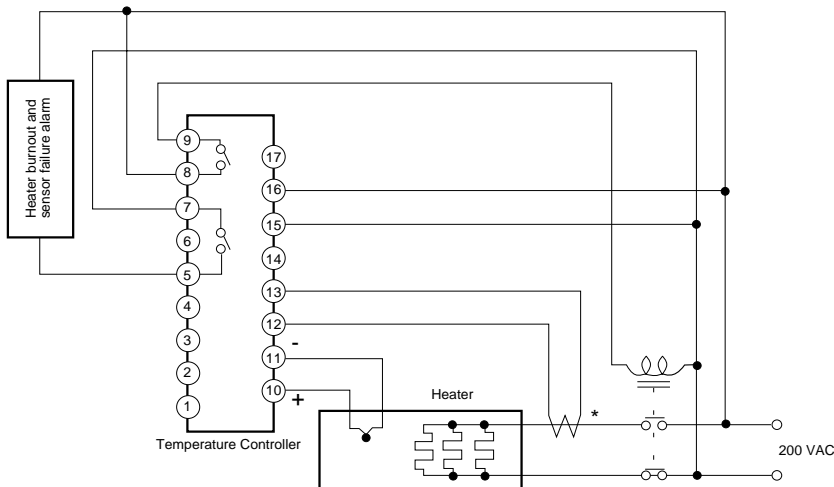
■ RS-485 COMMUNICATIONS (E5EF-A03-F)



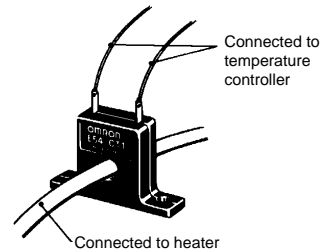
■ HEATER BURNOUT TYPES WITH RS-485 COMMUNICATIONS (E5EF-AH03-F)



■ E5EF-AH OVERALL SYSTEM CONNECTIONS



Current Transformer



This wiring must be passed through the hole of the current transformer. The current transformer can be connected to the temperature controller in any polarity.



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