Fuzzy Logic Temperature Controller with 4-Digit LED Display

FCS-13A

48-DIN sized PID temperature controller with adaptive fuzzy self-tuning

- User-selectable for K, J, R, B, PL-II and N thermocouples and Pt100 resistance thermometers
- User adjustable temperature scale to suit application
- Two temperature alarm contacts independently programmable with 12 functions
- Alarm hysteresis adjustable from 0.1 to 100.0˚C or ˚F
- 3 levels of keypad security locking
- Selectable operation: PID with adaptive fuzzy logic, PID with auto-tune, PD or On/Off
- Anti-reset windup (ARW) to reduce overshoot
- Relay, voltage pulse, analogue 4-20mA or 0-10VDC output
- Very fast sampling period 0.125 seconds
- Adjustable PV filter to slow down response if required
- Wide 100-240 VAC or 24 VAC/DC supply voltage
- IP54 protection
- UL and CSA approved

Options and ordering codes

FCS-13A – R / M 100-240VAC

Fuzzy logic PID temperture controller with 4-digit display

Relay output	R
Signal voltage for SSR	S
Current output	A
Analogue voltage 0-10VDC	V

100-240VAC supply	
24VAC/DC supply	
Multisensor input	M

Optional extra: heater burnout alarm.
Please note: All models supplied with A2: Two alarms, BL: Screw mounting bracket, IP: IP54 protection.

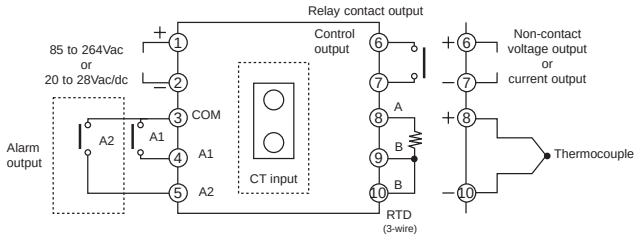
Specifications

Input type	K-thermocouple	J-thermocouple	R-thermocouple	B-thermocouple	PL-II thermocouple	N-thermocouple	DIN Pt100 RTD	J Pt100 RTD
Rated scale	–200 to 1370˚C	–200 to 1000˚C	0 to 1760˚C	0 to 1820˚C	0 to 1390˚C	0 to 1300˚C	–199.9 to 850.0˚C	–199.9 to 500.0˚C
Sensor resistance	100Ω or less						10Ω per wire or less	
Accuracy	±0.3% of full scale ± 1 digit (Type B thermocouple 0-300˚C, 0-600˚F accuracy not specified)							
Display	PV: 4-digit red LED, 8mm high; SV: 4-digit green LED, 8mm high							
Control action	User-selectable: Fuzzy self-tuning PID, PID with autotune, PD, On/Off							
Proportional band	0.1 to 100.0%, Factory set to 2.5%							
Integral time	1 to 3600 secs (off when set to 0), Factory set to 200 secs							
Derivative time	1 to 3600 secs (off when set to 0), Factory set to 50 secs							
Anti-reset windup	Automatic in PID modes							
Reset range in PD action	Within the proportional band, providing within –199.9 to 999.9˚C (˚F)							
Hysteresis in On/Off action	0.1 to 100.0˚C (˚F)							
Proportional cycle	1 to 120 seconds, Relay output type: Factory set to 30 secs; Signal voltage type: Factory set to 3 secs							
Output: relay types	SPNO: 250V, 3A resistive load; 250V, 1A inductive load, cos ø = 0.4							
Output: signal voltage types	12VDC +2VDC/–0VDC 40mA, short-circuit protected							
Output: analogue types	4 to 20mA DC - max. load resistance 550Ω, 0-10VDC – output impedance 500Ω							
Temperature alarm relay A1	SPNO: 250V 3A resistive load; 250V, 1A inductive load, cos ø = 0.4							
Temperature alarm relay A2	SPNO: 250V 3A resistive load; 250V, 1A inductive load, cos ø = 0.4							
Temp. alarms setting accuracy	±0.3% of full scale ±1 digit							
Temperature alarms action	ON/OFF action, hysteresis 0.1 to 100.0˚C (˚F), Factory set to 1.0˚C (˚F)							
High limit alarm (1)	Deviation from SV: ±200˚C (˚F)							
Low limit alarm (1)	Deviation from SV: ±200˚C (˚F)							
High/low limits alarm (1)	Deviation from SV: 1 to 200˚C (˚F)							
High/low limit range alarm (1)	Deviation from SV: 1 to 200˚C (˚F)							
Absolute value (process) alarm (1)	Input range minimum value to input range maximum value							
Absolute (process) reverse alarm (1)	Input range minimum value to input range maximum value							
Sensor correction (input shift)	–100.0 to 100.0˚C (˚F), Factory set to 0.0˚C (˚F)							
Sensor break protection	Upscale: Control output off							
Supply voltage	85 to 264VAC 50/60Hz (100-240 VAC+10%–15%); 20 to 28 VDC/AC 50/60Hz							
Power consumption	8VA approx.							
Ambient temperature	0 to 50˚C							
Ambient humidity	35 to 85% r.h. (non-condensing)							
Insulation resistance (2)	>10MΩ at 500VDC							
Dielectric strength (2)	1.5k VAC for 1 min between: Sensor input terminals and ground, Power terminals and ground, Control output terminals and ground, Alarm output terminals and ground, Sensor input terminals and Power terminals, Control output terminals and Power terminals, Alarm output terminals and Power terminals, Sensor input terminals and Control output terminals, Sensor input terminals and Alarm output terminals, Control output terminals and Alarm output terminals							
Mounting	Flush							
Front panel	Membrane sheet keyboard, IP54							
Weight	140g approx							
Case material	Light grey polycarbonate, flame retardant and self-extinguishing							

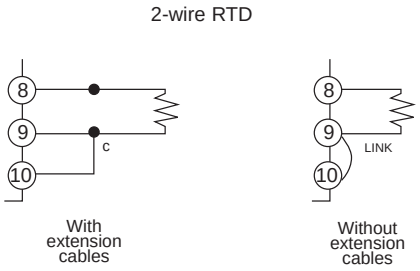
(1) All alarm types can be programmed to operate with or without 'standby' function

(2) Do not apply voltage between sensor input terminals and control output terminals of FCS-13A-A, FCS-13A-S and FCS-13A-V models

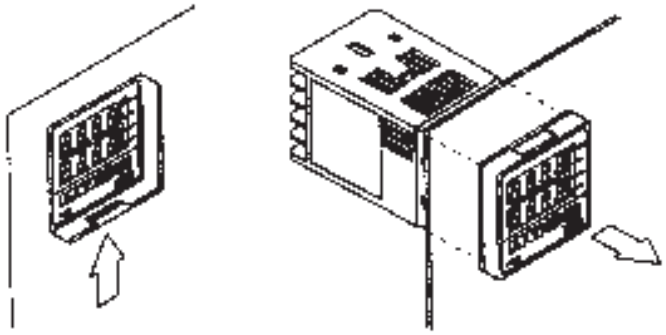
Wiring connections



CT input for heater burnout option only.

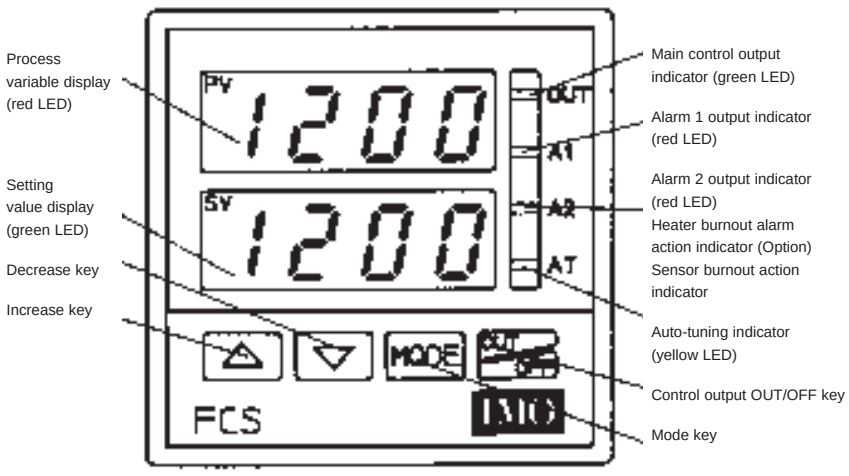


Notes:
- For ease of connection, especially when using cable trunking, all the terminals are designed to accept wires from the left (when looking from the rear of the unit).
- If using a pre-wired, 2-wire Pt100 RTD, without connecting extension cables, a link should be added between terminals 9 and 10. If using extension cables, a third wire should be added from point C, one of the joins, as in the diagram above and all three wires should be the same gauge and length. If a simple link is added between terminals 9 and 10 in this case, no compensation for lead length will be applied.
- As there is no fuse inside the temperature controller, it is recommended that one is provided in the external wiring to the power supply terminals.
- The sensor wires should not be run adjacent to an AC power supply or the wires to the power supply terminals.
- When using the relay contact output version it is recommended to provide an auxiliary relay to protect the contacts of the temperature controller's built-in relay, even if the intended load capacity is smaller than that of the built-in contacts.
- For ease of replacement without disconnecting the wiring, or to gain access to the internal programming switches, the unit can be withdrawn from the housing by pressing the release lever under the bezel and pulling firmly, holding the indents in the top and bottom of the bezel.



- When re-assembling, ensure that the unit is the correct way up and that the sealing gasket has not been dislodged.

Front panel



Features programmed using internal switches

The FCS is programmed partly through the front keypad and partly by internal switches. The following are set internally:

Multi-Sensor Input – 8 Types Selectable

The FCS can be user-selected for any of the following sensors:

Input	K	J	R	B	PL-II	N	DIN Pt100	J Pt100
Rated scale	–200 to 1370˚C	-200 to 1000˚C	0 to 1760˚C	0 to 1820˚C	0 to 1390˚C	0 to 1300˚C	-199.9 to 850.0˚C	-199.9 to 500.0˚C
	–320 to 2500˚F	-320 to 1800˚F	0 to 3200˚F	0 to 3300˚F	0 to 2500˚F	0 to 2300˚F	-199.9 to 999.9˚F	-199.9 to 900.0˚F

Control Action – 4 Operating Modes

The FCS can operate in four user-selectable control modes:

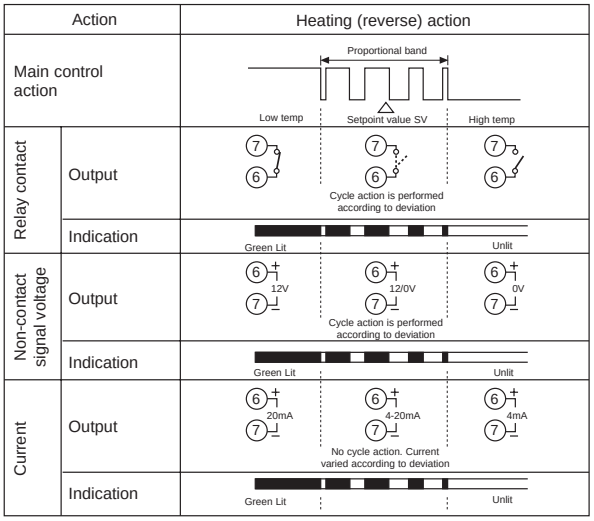
Adaptive Fuzzy-logic Self Tuning PID
In this mode, tuning is performed automatically if the setpoint is changed, if hunting (oscillation) occurs, if an offset is introduced or any deviation occurs due to external influences. In this way, the optimum P, I, D and ARW values are always used for initial ramp-up, normal level control or deviations from normal.

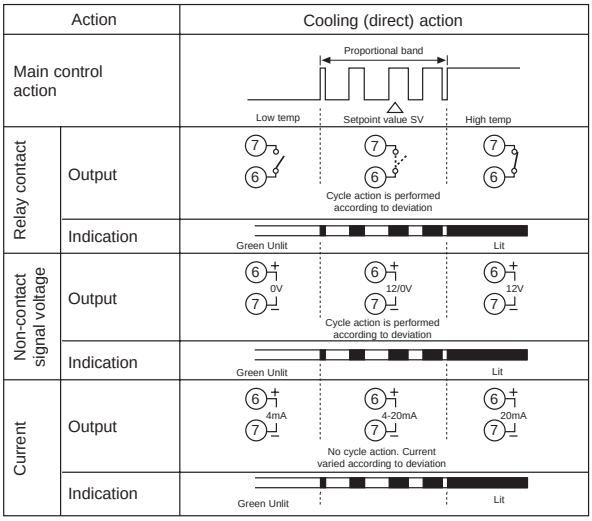
PID with Autotune
The P, I and D values can be manually set through the front keypad or the autotune can be activated to calculate and program them automatically, together with the ARW. The FCS has several pre-programmed algorithms within its microprocessor and chooses the most suitable one to calculate the values according to when the autotune is activated.
For example, if autotune is started when the system is first turned on, an algorithm is chosen to set the P, I and D values that give the minimum overshoot. If the autotune is started when approximately level control is achieved, a different algorithm is chosen to ensure that the most accurate, stable temperature is maintained. The autotune is activated through the front keypad.

PD control with reset function
PD control can be selected, e.g., in low thermal-mass systems where an integral function can cause overshoots and oscillations. The inherent offset between PV and SV caused by PD control can be eliminated by the reset function which is selectable in 0.1˚C or ˚F increments. The reset value can be adjusted via the front keypad.

On/Off Control with Adjustable Hysteresis
If On/Off control is required, the hysteresis can be set in 0.1˚C or ˚F increments up to 100.0˚C or ˚F via the front keypad.

Heating or Cooling Operation
According to the process required, heating or cooling modes can be selected.





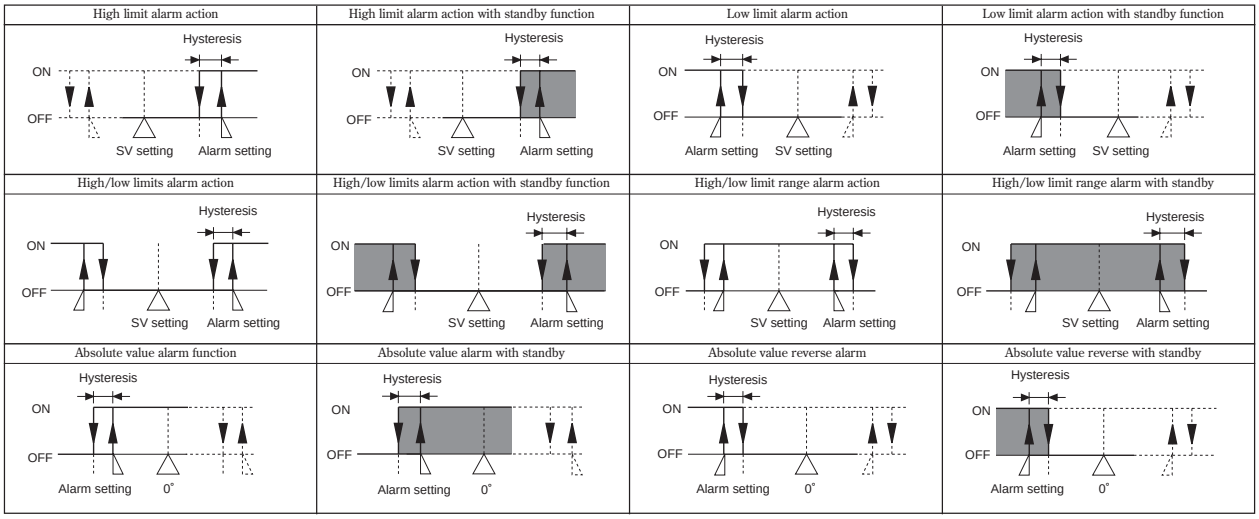
˚C or ˚F Scales

When ˚C or ˚F are selected, the rated scale values change accordingly as do all other setting value ranges: Alarm values, Reset function, etc.

Features programmed using internal switches (continued)

Alarm 1 – Programmable With 12 Functions
Alarm 2 – Programmable With 12 Functions

There are two alarm contacts which are independently programmable with the 12 functions shown below:



In ▭ parts, the standby function operates.

The first eight alarm types are deviation alarms. The alarm turns on if the PV (Process variable) deviates from the SV (Setpoint value) by the amount programmed in the alarm, e.g. if a High Limit Alarm is set at 10˚C and SV = 40˚C, the alarm turns on when PV rises above 50˚C. If the alarm is set at –10˚C and SV = 40˚C, the alarm turns on when PV rises above 30˚C.
In the four absolute alarms, the actual value of alarm required is programmed, e.g. to alarm at PV=50˚C, the alarm should be set at 50˚C.
The standby function prevents the alarm from registering if an alarm condition exists when power is initially applied to the controller. This also happens if the setpoint value, SV, is changed to a level which places the current PV into an alarm. When PV has moved out of the alarm level into the normal control area, then any further alarms will be registered.
The alarm function is set using internal switches, but the actual value at which the alarm occurs is programmed via the front keypad.

Features programmed using the front keypad

3 Levels of Keypad Security Locking

To prevent unauthorised modifications to the programming, one of three levels of keypad security locking can be set, to give partial or no access to change the parameters:

Level 1 – No setting values can be changed.
Level 2 – Only the setpoint can be changed, all others are locked.
Level 3 – All setting values can be changed temporarily. When the power is turned off and on again, all settings return to their former values.

Adjustable Setpoint Limits

The setpoint can normally be programmed within the full range which varies according to the chosen sensor, e.g. –200 to +1370˚C for type K thermocouples. The upper and lower limits can be restricted to prevent unauthorised or accidental changes beyond these points.

% Output Power Display

The FCS normally shows the actual process temperature on the PV display and the required setpoint on the SV display, but can be programmed to show the equivalent output power in % on the SV display if required with a resolution of 0.1%. The decimal point flashes as a reminder that it is not a setpoint. This value reflects the ON time of proportional control as a percentage of the total cycle time for the relay and voltage output models, or the mA output as a percentage of full scale for the current output model.

Features programmed using the front keypad (continued)

Wide Alarm Setting Adjustment
The setting values of the two alarms are programmed independently and are variable over the full scale span, e.g. for type K thermocouples:

Deviation alarms ±200˚C or ±200˚F
Absolute alarms –200 to +1370˚C or –320 to +2500˚F

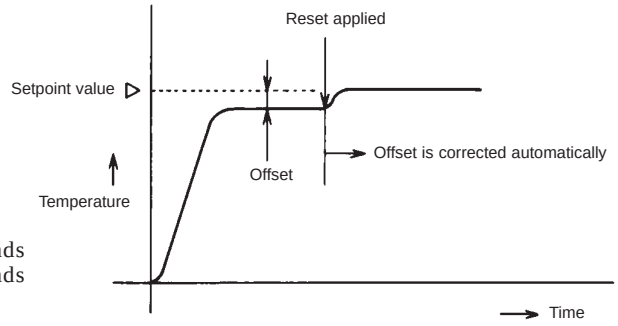
Adjustable Alarm Hysteresis
The hysteresis between the points at which the alarm turns on and resets can be adjusted in 0.1˚C or ˚F increments between 0.1 and 100.0˚C or ˚F.

Control Output Off
If the control is required to stop, or one of several FCS models in a process is not used, the control action can be turned off, with the PV display showing 'OFF' as a clear indication. This setting is retained, even if power is turned off and on again, until it is cancelled.

Sensor Correction (Input Shift)
This function can be used when a sensor cannot be located at the ideal position for control and is placed where the temperature may deviate from that in the ideal position. Also, when using several temperature controllers, this function can be used to correct the apparent temperature difference due to the tolerances of the sensors and the controllers.

PV Filter Time Constant Setting
If the PV is found to fluctuate due to external disturbances to systems with short time constants then the PV filter feature of the FCS can be used to slow down the response of the whole system (not just the display).

Variable Reset in PD Control
If the FCS is set for PD control action, a reset function is available to correct the inherent offset associated with this form of control. This is programmable in 0.1˚C or 0.1˚F increments.



Wide Adjustment of P, I and D Values

P – Proportional Band	0.1 to 100.0%
I – Integral time	1 to 3600 seconds
D – Derivative time	1 to 3600 seconds

Fully Variable Proportional Cycle

Proportional Cycle	1 to 120 seconds

Other features

Warm-up Indication
When power is first applied to the controller, the PV and SV displays show the type of sensor selected, ˚C or ˚F selected and the scale maximum value in ˚C or ˚F accordingly for approximately 2 seconds, as shown in the table below:

Input	PV display			SV display			
				when˚C	when˚F	when˚C	when˚F
K	tC			C	F	1370	2500
J	JC			C	F	1000	1800
R	rC			C	F	1760	3200
B	bC			C	F	1820	3300
PL-II	PL	'2		C	F	1390	2500
N	nC			C	F	1300	2300
DIN Pt100	Pr			C	F	850.0	999.9
JPt100	JPr			C	F	500.0	900.0

Other features (continued)

Fast Sampling
The sampling period is how often the temperature of the process is measured and the display updated. The FCS has a sampling period of 0.125 seconds, four times as fast as conventional controllers for closer process control.

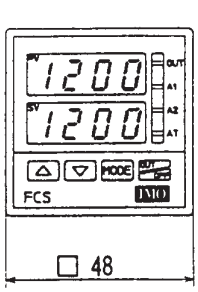
Sensor Break/Overscale/Underscale Indication
If the sensor breaks or burns out, or the input temperature exceeds the scale maximum value +5% of the scale span, the PV display flashes ---- and the control output turns off. At the same time, the A2 alarm turns on, e.g. for type K, 1370+(5% x 1570)=1448.5˚C.
If the input temperature falls below the scale minimum value –1% of the scale span, the PV display flashes ---- and the control output turns off, e.g. for type K, –200 – (1% x 1570) = –215.7˚C.

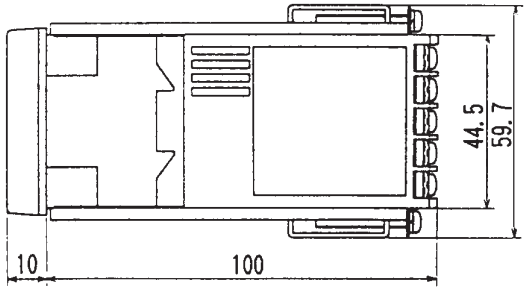
Heater Burnout
The FCS is available with heater burnout detection as an optional extra which must be specified at the time of ordering. This function monitors the current through the load heater elements via a current transformer. If the current falls below a user-programmed level, alarm A2 turns on and latches and will only be reset if the fault is rectified and then the power to the FCS turned off and on again.

Accessories

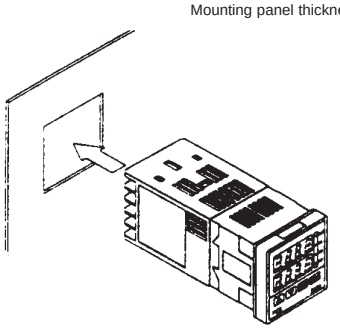
FCSTC	Finger-touch protection cover for the screw terminals.
FC-48-S	Clear silicone rubber cover to enclose the complete bezel to give IP66 protection. Installed by placing over the bezel before the controller is panel mounted. Mounting then traps the cover between the controller and the panel for complete sealing. Operation of the keypad is still possible through the cover.

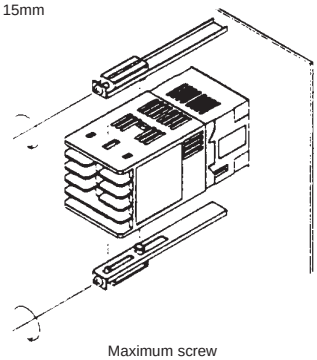
Dimensions and mounting



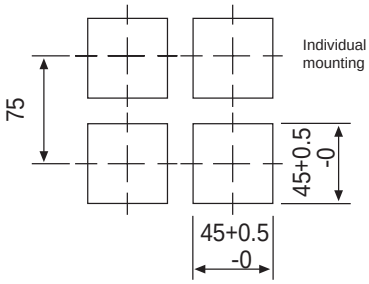


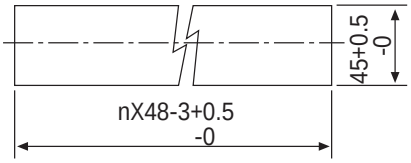
Mounting panel thickness 1 to 15mm





Maximum screw torque 1.2 kgcm





Close mounting of n units