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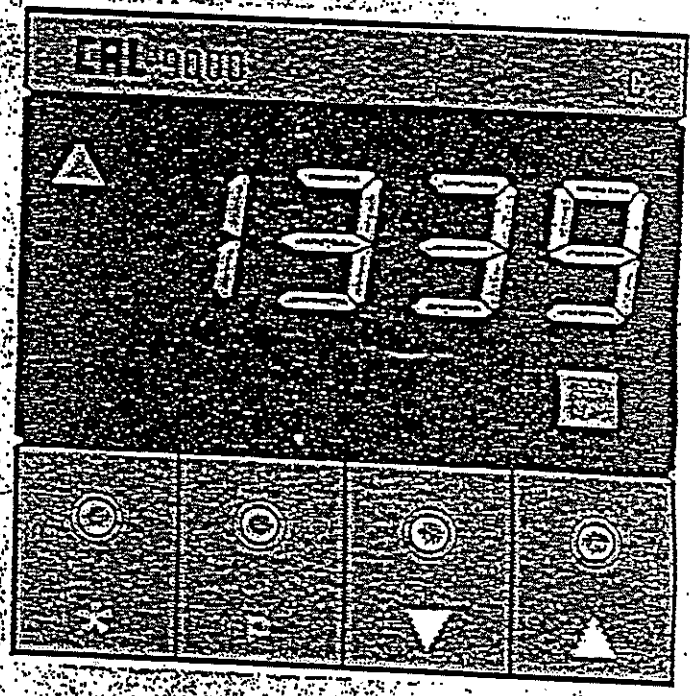
DISTRIBUTORS:

EH-AIM

TEMPERATURE CONTROLLER



OPERATING MANUAL

INTRODUCTION

The CAL 9000 temperature controller is based on proven temperature control techniques, but it incorporates substantial improvements due to the use of modern digital technology involving a microprocessor.

Good functional design ensures that the versatile features of the 9000 have made it simple to use. For the majority of applications it is only necessary to key in the sensor type. It will then automatically operate with Default (factory) settings for the PID control terms making it suitable for a wide range of applications which require a single setpoint, slow cycle, proportional output controller.

To use the 9000 with Default settings see Sections B1–B5.

For more complex or difficult applications the Default settings can be overridden by more appropriate values, alternative control modes or enabling of the second set point. When the appropriate parameters are keyed in, they can be 'locked' to prevent unauthorised adjustment. See Section B6–B9

Where applicable, order numbers are shown in green type.

INDEX

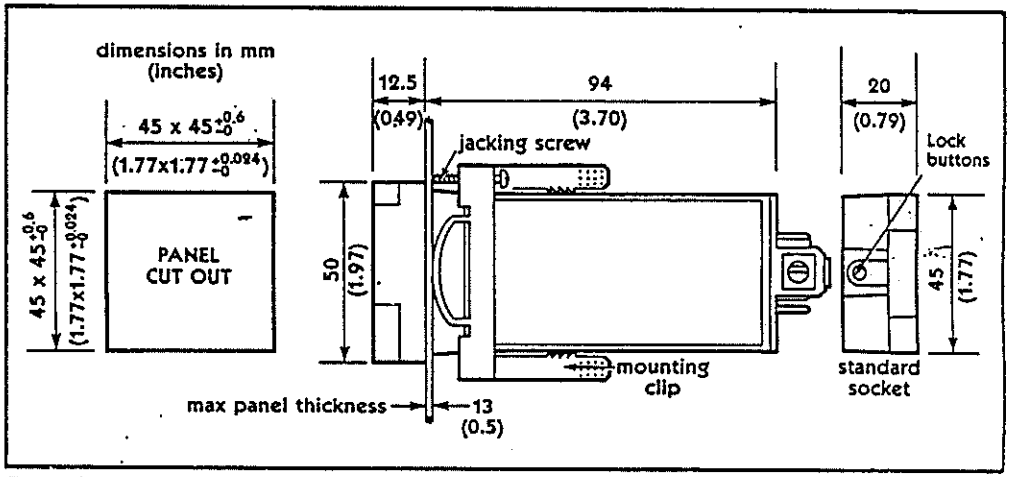
Section A — Installation and Connection Details

A1 : Mounting

The instrument is mounted in the panel through a 45mm square 1/16 DIN cut out using the special mounting clip provided.

The mounting clip should be pressed home until the ratchet holds the unit firmly in place. If necessary the mounting can be further tightened using the jacking screws.

To remove the unit from the panel, press the legs of the clips in opposite directions to release the ratchet.



To unplug socket, press in lock buttons and pull apart

A2 : Connections

Supply

Either 230V ± 15% 50–60 Hz
or 115V ± 15% 50–60 Hz

Changeable by internal link, refer to Section A6 VOLTAGE CONVERSION

IMPORTANT Check side label for supply voltage

Input Sensors — Key selectable from instrument front panel.

Thermocouple types J,K,N,R,S,T,E and Fe-CuNi DIN

PT100 RTD 2 wire

PT100 RTD 3 wire available by internal link change — refer to Section A6 PT100 RTD 2 to 3 WIRE CONVERSION

Connections for Thermocouple

Connections for 2 wire PT100/RTD

Connections for 3 wire PT100/RTD

Standard Outputs

SP1 Relay 5A/250V ac Resistive load SPDT
(energised to apply power to heating load)

SP2 Relay 3A/250V ac Resistive load SPDT
(slaved to SP1 — key selectable)
refer to SP2 OPERATION table Section A5 for relay coil status.

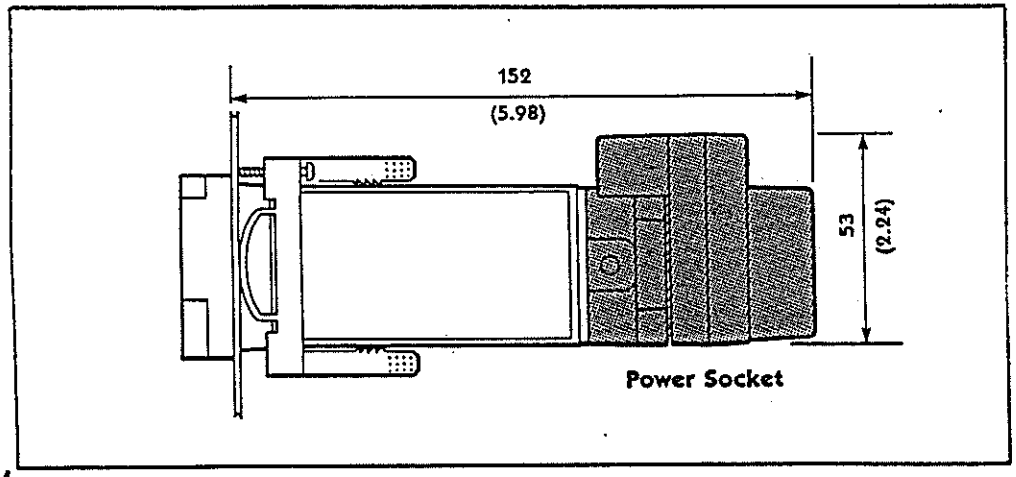
IMPORTANT — WHEN SWITCHING INDUCTIVE LOADS:
De-rate contacts and fit external suppression to ensure long contact life and minimum interference.

A3 : Optional Outputs SP1 and SP2

Order Code	SP1	SP2
9112	Relay	SSd
9121	SSd	Relay
9122	SSd	SSd

SSR drive (SSd) 5V 25mA unisolated — suitable to drive remote SSR available for either SP1, SP2 or both (as illustrated).

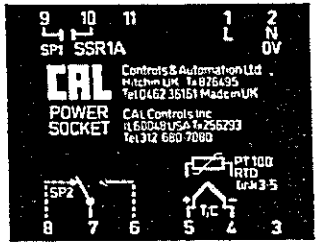
The following outputs for SP1 are available by using the appropriate plug-in **Power Socket** — illustrated.



Power Socket

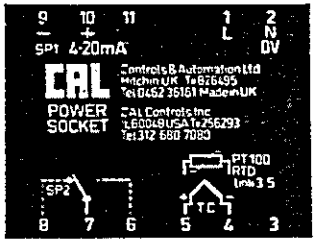
A3 : continued

SSR 1A/264V ac SPST
SP1 Terminals 9 and 10
Order Code: 9034/PS/SSR



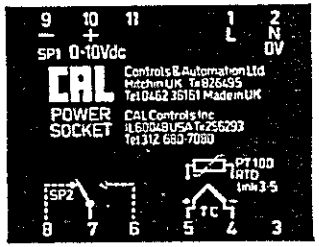
4–20 mA Isolated 500 ohms max
SP1 (−)ve Terminal 9
(+)ve Terminal 10
Order Code: 9035/PS/mA

Note: Inoperative until Function 4 Option 6 is selected



0–10V dc Isolated 20mA max
SP1 (−)ve Terminal 9
(+)ve Terminal 10
Order Code: 9036/PS/Vdc

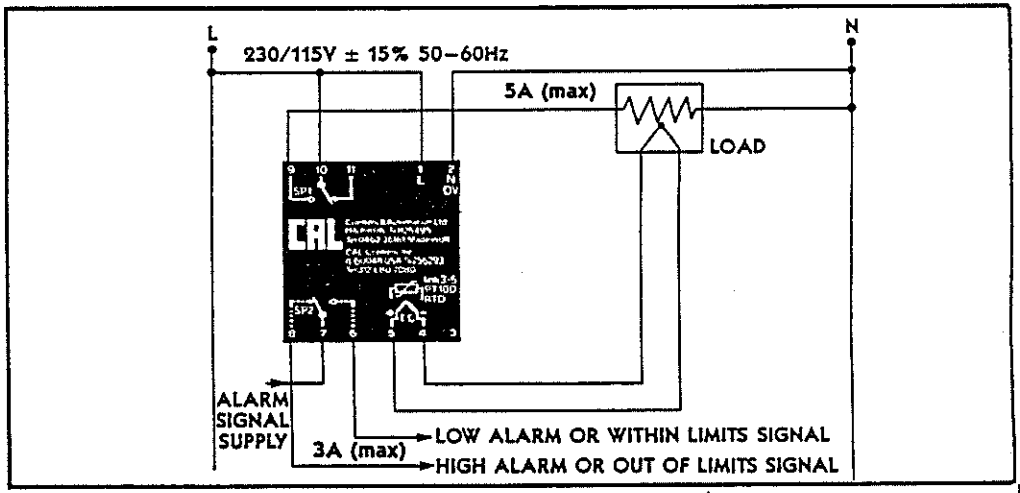
Note: Inoperative until Function 4 Option 6 is selected



A4 : Typical Wiring

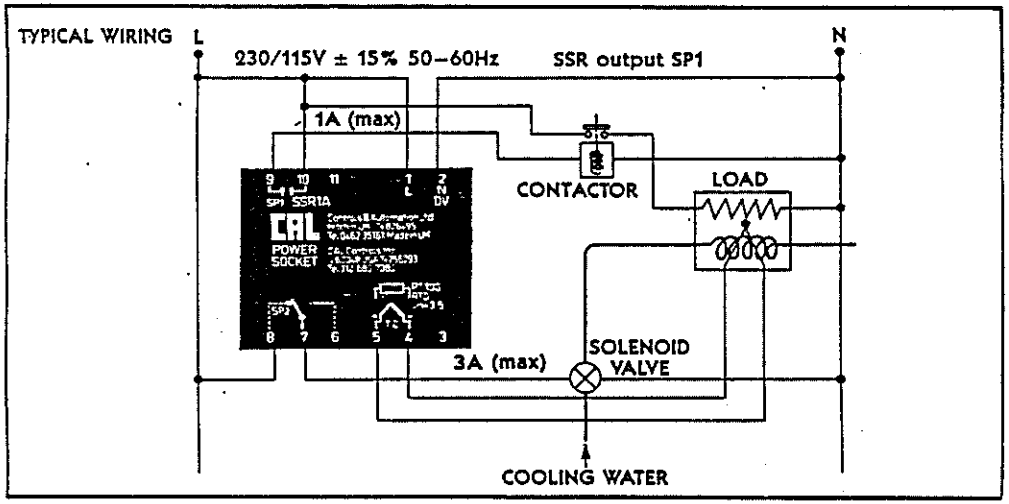
Showing optional uses of second set point (SP2)

Mains Heater — with alarms



A4: continued

Heating and Cooling



A5: SP2 Operation Table **Note: It is not recommended that SP2 output is used as a safety circuit**

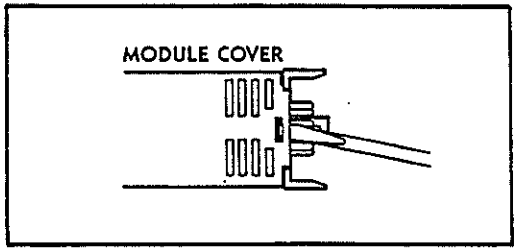
CONTROL MODE (FUNCTION 10)	OPERATING MODE (FUNCTION 19) SETTING COMPARED TO SP1	SP2 RELAY IS ENERGISED	SP2 LED IS ON	TYPICAL EXAMPLES OF USE
ON/OFF (OPTION 0)	HIGH (ABOVE SP1) OPTION 1	BELOW SP2 SETTING	ABOVE SP2 SETTING	DEVIATION ALARM HIGH
	LOW (BELOW SP1) OPTION 2	ABOVE SP2 SETTING	BELOW SP2 SETTING	DEVIATION ALARM LOW
	OUT OF LIMITS (ABOUT SP1) OPTION 3	WITHIN SET BAND AROUND SP1 SETTING	OUTSIDE SET BAND AROUND SP1 SETTING	DEVIATION ALARM HIGH AND LOW
PROPORTIONAL (OPTIONS 1–7)	HIGH (ABOVE SP1) OPTION 1	ABOVE SP2 SETTING	ABOVE SP2 SETTING	SP2 COOLING
	LOW (BELOW SP1) OPTION 2	BELOW SP2 SETTING	BELOW SP2 SETTING	SP1 COOLING SP2 HEATING

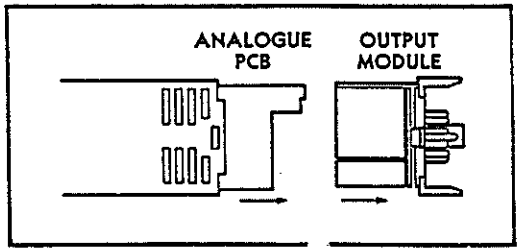
A6 : Link Changes for PT100 RTD 2 to 3 Wire, and 115V/230V Voltage Conversion

Both change of voltage and conversion from PT100 RTD 2 to 3 wire require wire solder link changes on the analogue PCB. **These modifications should be made by a qualified technician.** To remove analogue PCB proceed as follows:

i. Separate the output module assembly from the main module by gently levering the retaining clips from both slots in the cover with a screwdriver.

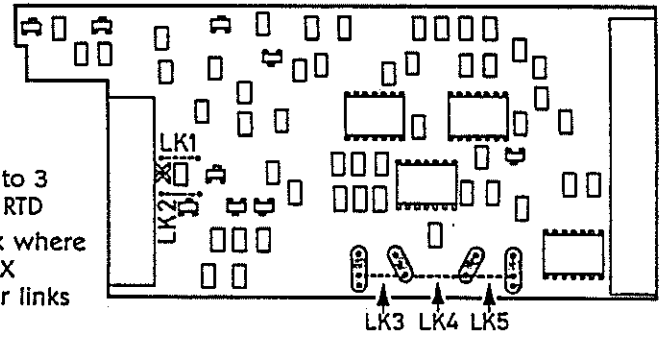
ii. Remove the output module and then pull the analogue PCB from the main module cover.





A6: continued

Voltage Change — PT100 RTD 2 Wire/ PT100 RTD 3 Wire Conversion



To convert to 3 wire PT100 RTD
a. Cut track where marked X
b. Fit solder links 1 and 2

To convert from 230V ac to 115V ac
a. Remove link 4
b. Fit solder links 3 and 5

To convert from 115V ac to 230V ac
a. Remove links 3 and 5
b. Fit solder link 4

* Use 22 SWG 19 AWG or 0.71 mm^2 tinned copper wire *

Note: Conversion to PT100 RTD 3 wire inhibits subsequent selection and use of thermocouples

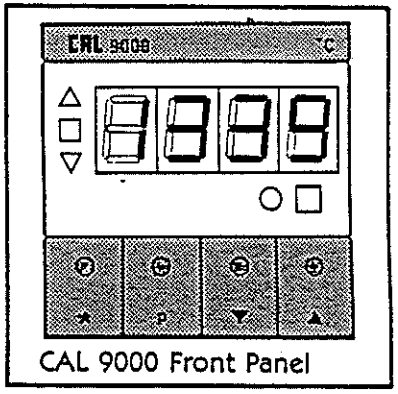
Section B Operating Instructions

B1 : Panel Displays

Digital Display

The four digit display normally shows process temperature to 1°C or 1°F and in high resolution 0.1°C or 0.1°F.

It is also used to display setpoint value (flashing) and the FUNCTION and OPTION list.



CAL 9000 Front Panel

Functions

are the available controller facilities
eg. Derivative time/Rate — Function 6

Options

are the available values for each Function
eg. Derivative value — 50 seconds — Option 4

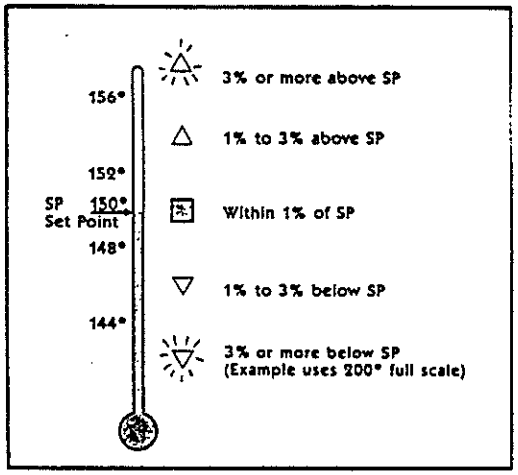
Function numbers are on the Right,
Option numbers are on the Left of the floating decimal point.
Parameters: are the selected Options from the Function list.

B1 : continued

Error Indicator

This is situated to the left of the digital display and the three LED's display the difference between setpoint and process temperatures in five steps, each one representing 2% of full scale value.

The error indicator can also be used in high resolution, ± 1% steps or low resolution, ± 4% steps



Output Indicators

The two separate LEDs beneath the digital display indicate:

□ Illuminated SP1 output ON (green)

○ Illuminated SP2 output (amber). On or Off depending on mode of operation selected — see Table A5

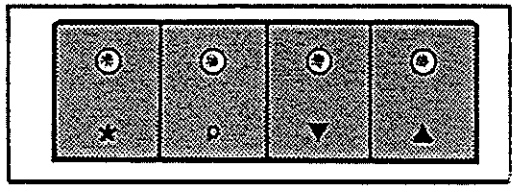
B2 : Control Keys

User Mode

✱ Displays Setpoint (flashing)

✱▲Keyed together increases setpoint

✱▼Keyed together decreases setpoint



digit rollover rate increases

Setter Mode

p Entry to Function and Option List and Exit to normal display and process temperature

▲▼ Indexes FUNCTION/OPTION number up or down in single digits

✱ Changes adjustment from Functions to Options and vice-versa (ie. toggling)

B3 : Default Settings

For ease of use in normal applications, the CAL 9000 has been preset with factory or DEFAULT settings in place of customers OPTIONS.

These preset parameters enable the instrument to operate in PID Control mode with single setpoint, slow cycle, proportional output.

This configuration should give good results where the heater is adequately rated and the control sensor is sited reasonably close to it.

B3 : continued

Default settings (for SP1 only) are:

Proportional Time/ Cycle rate	=30 secs
Proportional Band/ Gain	=2.5% of Default full scale
Derivative Time/Rate	=25 secs
Integral Time/Auto Reset	=350 secs

To use the controller with Default settings requires only that the Option number of the sensor, selected from the Sensor Default Range Table be keyed into the instrument.

The Default Range will limit the setpoint values only. The instrument will indicate process temperatures over the full linearised range shown in the table in Section B9.

It is important to ensure that the range maximum is compatible with safety.

Proceed as follows:

Apply power. All LED segments will be briefly illuminated during the self check routine, then the display will request sensor selection, ie. The Option number for Function 16, and will not respond to any further instructions until this is made.

B4 : Sensor Default Range Table

Option	Type		Min/Max °C	°F
1.	**J**	Iron Constantan Thermocouple	0– 400	32–800
2.	**K**	Chromel Constantan Thermocouple	0– 400	32–800
3.	**N**	Nicrosil Nisil	0– 400	32–800
4.	**R**	Pt13% Rh-Pt Thermocouple	0–1600	32–1999
5.	**S**	Pt 10% Rh-Pt Thermocouple	0–1600	32–1999
6.	**T**	Copper Constantan Thermocouple	0– 250	32–500
7.	**E**	Chromel Constantan Thermocouple	0– 500	32–1000
8.	**Fe-CuNi**	DIN Thermocouple	0– 400	32–800
9.	**PT100 RTD**	Platinum Resistance Thermometer	0– 200	32–400

Ranging

If the Default range maximum is not suitable it can be increased or decreased to any desired value within the linearised band.

Refer to Section B6 Parameter Adjustments.

B5 : Operation with Default Settings

STEP	ACTION	DISPLAY
1 **Install Unit. Power on.** Check that display reads:	Note: digits shown green are flashing	
2 **To key in the selected sensor type.** Example: OPTION 2, Type-K thermocouple: Check that display reads:	**PRESS ▲ TWICE**	
3 **To enter the selected thermocouple type into memory:** The display now reads sensor Temperature°, eg. Ambient (18°C).	**PRESS P ONCE**	
4 **To key in the set point value:** To increase the set point: To decrease the set point: It should be noted that the digit rollover rate increases (ie. accelerates). eg. Set Point 250°C.	**PRESS ✱ and HOLD** **PRESS ▲** **PRESS ▼**	 
When the keys in (4) above are released the unit will operate as a normal temperature controller. The square LED, is illuminated, showing that SP1 output is energised. To view the set point temperature:	**PRESS ✱**	
To adjust the set point value at any time:	**REPEAT STEP 4**	

Should a particular application require the use of additional features, for example: second setpoint output or High Resolution, refer to Section B6: PARAMETER ADJUSTMENTS.

This also applies where the Default settings prove to be unsuitable. The 9000 can be tuned for optimum performance by the adjustment of control parameters.

If guidance is needed to establish the appropriate settings, refer to Section C: TUNING.

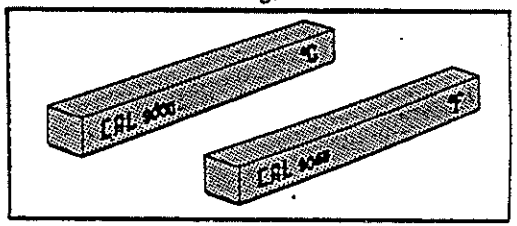
B6 : Parameter and Range Adjustments

NOTE: Because the following selections influence the values of other settings and can have a fundamental effect on control charactaristics, it is important that when required, they should be made during initial setting **and in the following order,** to avoid the need for re-tuning.

1. High Resolution (Function 18 Option 1)
2. °C/°F selection (Function 22)
3. Range adjustments

Selection C° or F° (Function 5)

If the temperature scale is changed it is essential to replace the upper fascia.

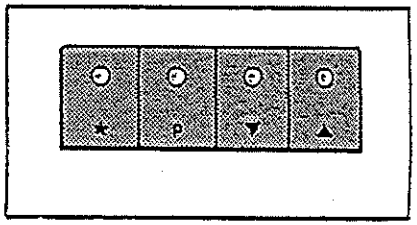


Range Adjustments

The Default full scale (automatically selected by the choice of sensor) may be altered to any value within the linearised band shown in table (Section B9). Use the following procedure:

1. Press **P** once and release.
2. Press **P** again and hold.
3. Press ✱ and hold.
4. Release **P** (hold ✱). Default full scale flashes
5. Either press ▲ or ▼ to adjust full scale value
6. Release ▲ or ▼
7. Release ✱

   Repeat steps 1–4 to view new full scale value.



Parameter Adjustments

STEP	ACTION	DISPLAY
1 Ensure that the link behind the lower front bezel is in the Parameter Setting position (see Parameter Lock Section B11).		
2 **To convert main display from temperature read-out into FUNCTION and OPTION listing mode:** FUNCTION numbers appear to the right of, and OPTION numbers to the left of, the floating decimal point, starting with FUNCTION 3.	**PRESS P**	

OPTION 0

FUNCTION 3 (FLASHING)

The FUNCTION listing has been arranged to give easiest access to those which are most frequently used.

When indexing in a positive (▲) direction, FUNCTION 23 is followed by FUNCTION 3.

FUNCTIONS 2 and 1 can be accessed from FUNCTION 3 by indexing in a negative (▼) direction. FUNCTION 1 is followed by FUNCTION 18

STEP	ACTION	DISPLAY

3 **To index sequentially.** The FUNCTION digit(s) will flash indicating that the FUNCTIONS can be indexed sequentially from 3 to 23 enabling previously entered or Default OPTIONS to be viewed: e.g. FUNCTION 12 OPTION 2.

PRESS ▲ OR ▼

4 **To alter an OPTION:** To cause the flashing of the display to shift from the FUNCTION column to the OPTION column to the left of the decimal point. Note that it is the flashing digit(s) that can be altered.

PRESS ✱

To change OPTION number:

PRESS ▲ ▲ ▲

OR PRESS ▼

To return to FUNCTION indexing:

PRESS ✱

When all required OPTIONS have been selected for each FUNCTION, to place in memory and commence control under the new instructions:

PRESS P

B7 : Examples of Parameter Adjustments

STEP	ACTION	DISPLAY

Changing SP1 Proportional Time/Cycle Rate

To change SP1 proportional time from 30 secs (Default setting) to 20 secs: FUNCTION 4: Change OPTION 0 to OPTION 4

1 **To display OPTION/FUNCTION List:** Ensure that link behind lower bezel is in 'unlocked' position.

PRESS P

2 **To index the FUNCTION number to 4:**

PRESS ▲

3 **Change to OPTION numbers:**

PRESS ✱

4 **To alter OPTION number 0 to OPTION number 4:**

PRESS ▲ ▲ ▲ ▲

STEP	ACTION	DISPLAY

5 **To place in memory:**

PRESS P

STEP	ACTION	DISPLAY

Use of Manual Reset

P, PD and ON/OFF mode. When the system has settled, if a discrepancy exists between Set Point and Process Temperature, the 'offset' can be removed by the use of Manual Reset. For example, if the process temperature is 252°C and the set point is 250°C.

Process temperature is —

1 **To view the set point temperature:**

PRESS ✱

2 **To correct 'offset' of −2°C. Display shows FUNCTION 3, OPTION 0:**

PRESS P

3 **To index to FUNCTION 1:**

PRESS ▼ ▼

4 **Change to OPTION numbers flashing:**

PRESS ✱

5 **To key in the 'offset' temperature (−2°C):**

PRESS ▼ ▼

6 **To place in memory:** The Process temperature reading will settle from 252°C to 250°C.

PRESS P

B8 : Functions and Options Table

All adjustable Parameters are held in memory and are shown in the Functions and Options Table below.

For each Function, Option 0 is the Default (factory) Setting.

Function Number	Option Number	Parameter	
1		**Manual Reset**	
	Adjusting Offset. Key in Correction (in degrees)	+/– 1° steps Range: Prop Band + 2 (max 99°)	
2		**SP2 Adjust**	
	Key in setting (from SP1) in degrees	1° steps Range: 0° to 99° (inoperative until Option selected at Function 19)	
3		**SP1 Lock**	
	0	Unlocked	
	1	Locked	
4		**SP1 Proportional Time**	
	0	30 sec	
	1	1s	
	2	5s	
	3	10s	
	4	20s	
	5	60s	
	6	0.05s	
	7	ON/OFF	
5		**SP1 Prop Band**	**Hysterisis**
	0	2.5%	1.25%
	1	0.5%	0.25%
% of span	2	1%	0.5%
	3	2%	1.0%
	4	3%	1.5%
	5	5%	2.5%
	6	10%	5.0%
	7	20%	10.0%
		Maximum Prop. Band: PD,P mode : 255° (25.5° in Hi-Res) PID mode : 127° (12.7° in Hi-Res)	
6		**SP1 Derivative Time**	
	0	25 sec	
	1	OUT	
	2	5s	
	3	10s	
	4	50s	
	5	100s	
	6	200s	

Function Number	Option Number	Parameter	
7		**SP1 Derivative Approach Control**	
	0	1.5 x Proportional Band	
	1	0.5	
	2	1.0	
	3	2.0	
	4	2.5	
	5	3.0	
	6	4.0	
	7	5.0	
8		**SP1 Integral Time**	
	0	350 sec	
	1	OUT	
	2	25s	
	3	50s	
	4	100s	
	5	200s	
	6	600s	
	7	1000s	
9		**Display Bias**	
10		**SP2 Proportional Time**	
	0	ON/OFF	
	1	1 sec	
	2	5s	
	3	10s	
	4	20s	
	5	60s	
	6	0.05s	
	7	30s	
11		**SP2 Prop Band**	**Hysterisis**
	0	2.5%	1.25%
	1	0.5%	0.25%
% of span	2	1%	0.5%
	3	2%	1.0%
	4	3%	1.5%
	5	5%	2.5%
	6	10%	5.0%
	7	20%	10.0%
		Maximum Prop. Band: PD,P mode : 255° (25.5° in Hi-Res) PID mode : 127° (12.7° in Hi-Res)	

Note: Functions 9, 14 and 23 are factory settings

Function Number	Option Number	Parameter	
12		**Error Indication Resolution**	
	0	Normal (2% x FS per segment)	
	1	High (1% x FS per segment)	
	2	Low (4% x FS per segment)	
13		**Spare**	
14		**Derivative Polling Ratio**	
	0	0.5x Derivative Time	
	1	0.2	
	2	0.7	
	3	1.0	
15		**Reset all Functions to Default**	
	0	Normal	
	1	Reset	
16		**Sensor Select**	
	0	None-Controller Inoperable	
	1	J	
	2	K	
	3	N	
	4	R	
	5	S	
	6	T	
	7	E	
	8	Fe-CuNI	
	9	PT100/RTD	

Function Number	Option Number	Parameter	
17		**Negative Temperature ranging**	
	0	Disabled	
	1	Enabled	
18		**High Resolution**	
	0	Normal	
	1	Hi-res (–99.9 to 199.9) Settings in 1° increments become 0.1° increments in High Resolution.	
19		**SP2 Operating Mode**	
	0	OUT	
	1	High (above SP1)	
	2	Low (below SP1)	
	3	Out of Limits	
20		**SP1 Sensor Burnout Protection**	
	0	SP1 output OFF (UPSCALE)	
	1	SP1 output ON (DOWNSCALE)	
21		**SP2 Sensor Burnout Protection**	
	0	SP2 output OFF (UPSCALE)	
	1	SP2 output ON (DOWNSCALE)	
22		**°C/°F**	
	0	°C	
	1	°F	
23	1	Version No.	

Note: The use of Option 1 at Function 15 will return all settings to Default except for Function 22 (°C/°F) and factory set functions 9, 14, 23.

B9 : Linearised Sensor Range Table

OPTION No.	SENSOR TYPE	DEFAULT RANGE °C MIN	DEFAULT RANGE °C MAX	DEFAULT RANGE °F MIN	DEFAULT RANGE °F MAX	LINEARISED RANGE °C MIN	LINEARISED RANGE °C MAX	LINEARISED RANGE °F MIN	LINEARISED RANGE °F MAX
1	J	0	400	32	800	0	800	32	1470
2	K	0	400	32	800	0	1200	32	1999
3	N	0	400	32	800	0	1200	32	1999
4	R	0	1600	32	1999	0	1600	32	1999
5	S	0	1600	32	1999	0	1600	32	1999
6	T	0	250	32	500	–90	250	–130	480
7	E	0	500	32	1000	0	600	32	1110
8	Fe-CuNI	0	400	32	800	0	800	32	1470
9	PT100/RTD	0	200	32	400	–90	400	–130	750

Range adjustments (including Default) only limit setpoint values. Process temperatures will be displayed over the full linearised range. To clear SP2 to Default 'out' use F19 or F15,

B10 : Negative Temperature Ranging

The following sensor types can be used for negative temperatures.

The negative value shown against each type is automatically set by the choice of sensor (Function 16) and requires enabling with Function 17. Option 1.

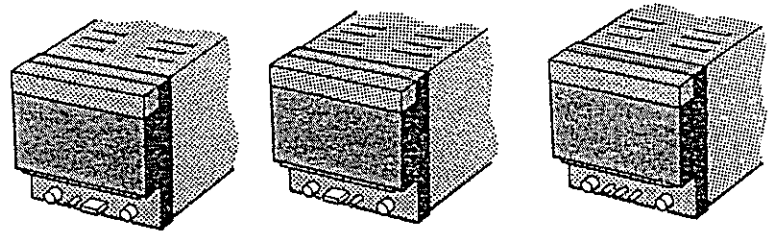
Type T thermocouple	−90°C, − 130°F
PT100/RTD	−100°C, − 150°F
Type N thermocouple	−50°, − 58°F non linearised
Type K thermocouple	

B11 : Parameter Lock

The chosen parameters may be permanently locked into memory by removing or altering the position of the link behind the lower front fascia as shown below.

When the Parameter lock has been applied, only the setter adjustments are possible (see Section B12).

Note that locked positions (2) and (3) are alternatives and that the link socket is in the 'inactive' position in (2).



Parameter Setting Position (1) Locked Position (2) Locked Postion (3)

Note: It is important to switch off briefly after changing link position

B12 : Setter Adjustments (When Parameter Lock applied)

The setter can perform the following operations by depressing the recessed key P.

1. Adjust manual reset (PD, P and ON/OFF modes only) — see Section B7 for key sequences.
2. Adjust the second set point — SP2. (assuming Function 19 either Options 1, 2 or 3 have been selected).
3. Lock the main set point — SP1 to prevent adjustment by the operator.

B13 : Fault Indication

Depending on the selection made at Functions 20 and 21, the SP1 and SP2 outputs are turned ON or OFF. The main temperature display, on a fault indication, is replaced by 'EE' flashing, followed by a digit. This indicates that an error has been detected in the system. Action should be taken as follows:

EE1 — Sensor burnout
Check sensor and/or connections then key ✱

EE2 — Temporary System Error
Self clearing

EE8 — Loss of calibration
EE9 — NVM data fault (non volatile memory)
} Consult CAL

Note: Repair and Recalibration
Due to the nature of its design, the 9000 can only be repaired and recalibrated by using special equipment and should be returned to CAL or their agents if found to be faulty.

SECTION C — Tuning

C1 : The Simplified Method

If the preset PID DEFAULT values prove to be unsuitable for a particular application, the following method can be used to establish new settings which should be acceptable and which can be adjusted to give optimum control. This method of tuning may differ from that used on other controllers.

The first step is to control the system with the instrument in ON/OFF mode and use these results to calculate the new Parameter values for SP1.

Check that all settings are in DEFAULT. If required, range adjustments should be made first. Refer to Section B6.

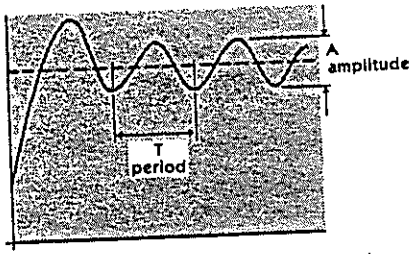
Check that Parameter Lock is in the Parameter Setting position (Section B11) and proceed as follows:

i. Adjust Proportioning Time to ON/OFF
(This switches off all other control terms and sets Hystersis to 1.25% of full scale).

ii. Key in Set-point temperature.

iii. Switch on and allow the process to stabilise. Then monitor process temperature, ideally using a chart recorder, or alternatively by taking readings from the display at regular intervals, as frequently as possible.

The results should look similar to the example.



iv. Using the figures obtained for the oscillation period (T) seconds and amplitude (A) degrees, the following Parameter values can be calculated.

a. Proportional Time/Cycle Rate = $\frac{T}{20}$ If 10 seconds or less use SSR.

b. Proportional Band %/ = $\frac{A \times 1.5 \times 100}{\text{full scale}}$ Set to next LARGER % setting.
Gain %

c. Derivative Time/ Rate = $\frac{T}{10}$ Set to next SHORTER time setting.

d. Integral Time/Auto Reset = T Set to next LONGER time setting.

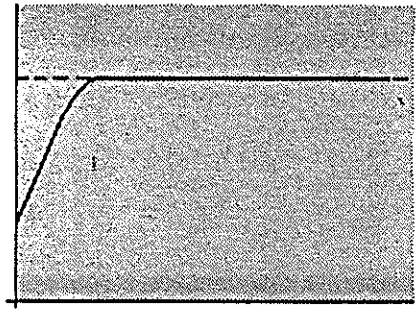
* (Approach control will be activated in DEFAULT setting = 1.5 x prop. band. If the warm up characteristic is unacceptable, refer to Section C6).

v. Enter these new values and restart the process from cold.

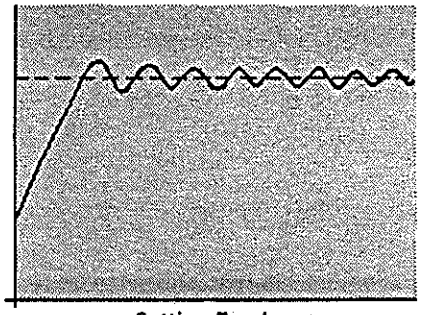
The above settings can be further adjusted to give optimum performance. The following curves and notes will provide guidance for tuning the individual control terms.

C2 : Proportional Time/Cycle Rate (Functions 4, 10)

Setting determines the cycle rate of the output device. In the interest of long contact life this should be the slowest (longest setting) possible if relay output is being used. Otherwise there is no disadvantage in using faster settings.



Ideal Setting

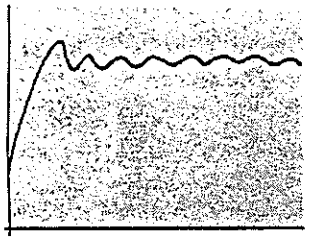


Setting Too Long

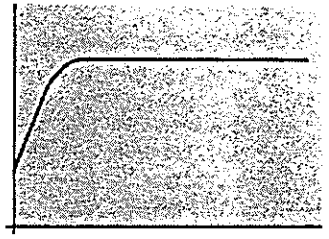
C3 : Proportional Band/Gain (Functions 5, 11)

This term is employed to smooth out the oscillating control characteristic typical of ON/OFF control.

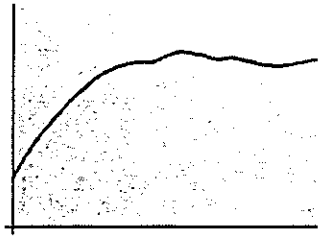
A feature of proportional control is that the system may run at a slightly different temperature to the set-point (Offset), and have a slower reaction to disturbances.



Setting too narrow system oscillates



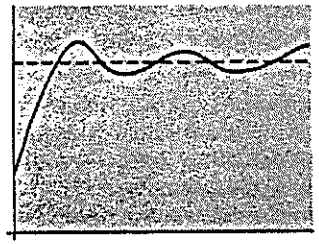
Setting Ideal



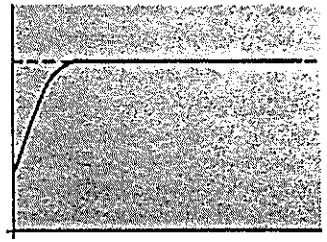
Setting too wide slow warm up and poor control

C4 : Integral Time/Auto Reset (Function 8)

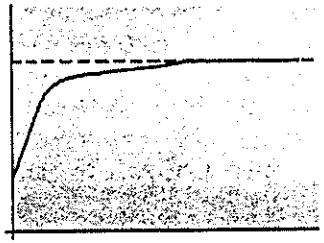
The purpose of the integral term is to automatically correct for offset errors caused by the introduction of PROPORTIONAL control. If incorrectly set this can cause instability or increase warm up time.



Setting too short



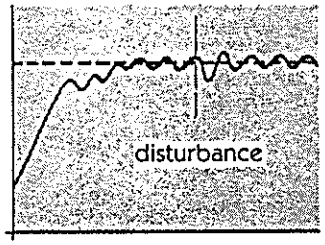
Ideal setting



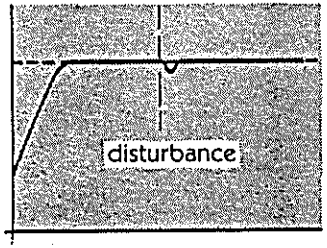
Setting too long

C5 : Derivative Time/Rate (Function 6)

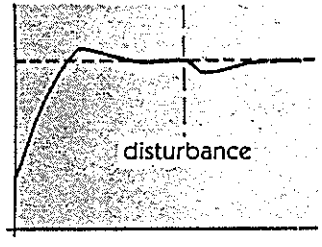
The derivative term is added to PROPORTIONAL control action to speed up response to disturbances and to suppress overshoot. In applications where these two requirements would need different settings, the use of Derivative Approach Control for adjusting warm up characteristics allows the Derivative setting to be biased in favour of disturbance behaviour.



Setting too long



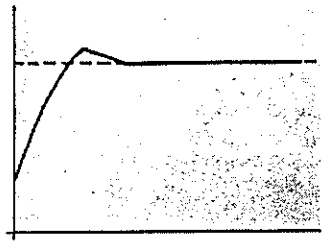
Ideal setting



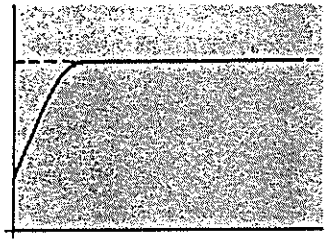
Setting too short

C6 : Derivative Approach Control (Function 7)

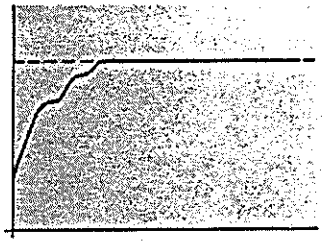
This feature allows the warm up characteristics to be tuned separately from normal running conditions and is particularly useful for applications where the sensor is some distance from the heater. The setting determines where the derivative action starts with respect to set-point. The smaller the setting, the closer to set-point.



Setting too small



Setting ideal



Setting too large

Where a given application cannot be tuned to give acceptable results over the required range of process temperatures and conditions, it is possible that better results may be obtained with Proportional, Derivative and Approach Control terms only.

C7 : Heating and Cooling

Ideal settings for these systems are very dependant on the application, and are often best determined by experiment.

The following general points may prove useful for initial consideration.

A common characteristic is that there is a considerable difference between the system response to the input of heating and of cooling energy.

In general, both channels can be set independantly using the Tuning guidelines for settings for Proportional Time and Proportional Band, and where it is known that one channel has a dominating and rapid effect on system temperature, the employment of narrow hysteresis ON/OFF settings for this may give excellent results.

Where both setpoints are required to be set close together (small deadband), wide proportional or hysteresis band settings will overlap allowing simultaneous operation of outputs, which may give the best overall control.

C8 : Series 9000 Specification

• Electrical

Suppy voltage Dual 230/115V ±15% 50-60Hz
Factory set, link changeable

& consumption 5VA

Output modules
Standard — dual output

SP1 Relay 5A/250V ac. Resistive load SPDT (contacts de-rated from 16A to give extended life)

SP2 Relay 3A/250V ac. Resistive load SPDT

Options — SP1 and SP2
SSR drive (SSd)
Unisolated 5V 25mA

Order Code	SP1	SP2
9112	Relay	SSd
9121	SSd	Relay
9122	SSd	SSd

Options — SP1 only Using plug-in output POWER SOCKET

SSR 1A/264V SPST

4–20mA Isolated, 500 ohm max

0–10V dc Isolated, 20mA max

• Accuracy

Calibration accuracy
±0.25% of range ±1°C (±0.5°C in Hi-res)

Control stability
Typically ±0.15% of full scale, dependent on application

Sampling time
3 samples per second
Re-zero of CJC and auto calibrate every 5 seconds

Temperature coefficient
<150ppm/°C of max linearised range typical

Reference conditions
22°C ±2°C, 230/115V ±5%, after 30 minutes settling time

• Sensors

Thermocouples

J/K/R/S/T/E	IPTS 1968
N	Nicrosil-Nisil
Fe-CuNi	DIN 43710
External resistance	Max 100 ohms
Cold junction compensation	Rejection typically 20:1 (0.05°C/°C)

Resistance thermometers

Pt100/RTD	100 ohms at 0°C, plat. DIN 43760/BS1904
Standard	2 wire
Optional	3 wire (change internal links), reduces display error when lead length over 10M/30'
Bias current	<0.2mA
Sensor burnout	Automatic protection *Fault displayed*
SP1 and SP2	Default upscale (output off), key downscale
Common mode	Negligible effect up to 264V rms 50/60Hz (140 dB)
Series mode	>1000:1 negligible effect up to 50mV 50Hz (60 dB)

• General

Ambient temperature
0-50°C (32-130°F)

Noise immunity
Tested for mains interference on Schaffner 200/222 Interference Simulator. No effect on stored data. Normal control resumed immediately following interference or 'brown outs'.

Data retention
10 years with instrument unpowered

Safety standards
Designed in accordance with:
UL 873 — Industrial Temperature Controllers, CSA C22.2/24-1981, VDE 0411 Class 1
Mouldings in flame retardent polycarbonate.

Degree of protection
Designed in accordance with:
IEC 529:1976 BS 5490:1977
Bezel assembly IP-54 'Protected against splashing water and dust'
Case inside panel IP-30 'Protected against >2.5mm dia objects'

Dimensions
Bezel 48x48x13mm/1.89"x1.89"x0.5"
Depth behind panel 115mm/4.4" overall
Weight 380g/13oz

• Control Modes

Default mode (factory) settings

SP1 PID	Proportional + Integral + Derivative Proportional Time/Cycle Rate — 30 sec Proportional Band/Gain 2.5% of Span Derivative Time/Rate — 25 sec. Integral Time/Auto Reset — 350 sec.
SP2 Off	Inactive

Key selectable modes

SP1	PID or PD with Approach Control
SP2	Deviation Alarm High, Low or 'Out of Limits' Adjustable ±0°–99°C/F about SP1 setting Control modes — on/off, or Proportional

Key selectable parameters—SP1			Default
Tp1	Prop Time/Cycle Rate, 50ms, 1, 5, 10, 20, 30, 60 secs • Fast cycle <10sec, SSR recommended • Prop Time / Cycle rate >1 sec, min on/off times 0.5% x Tp1 • Linear dc, internal/external, key 50ms cycle rate		30 sec
Xp1	Prop Band/Gain	0.5, 1, 2, 2.5, 3, 5, 10, 20% x span	2.5%
Td1	Derivative Time/Rate	off, 5, 10, 25, 50, 100, 200 sec	25 sec
Ac	Approach control	off, 0.5, 1, 1.5, 2, 2.5, 3, 4, 5 x XP1 Derivative, activated-about SP1	1.5
Tv	Integral Time/ Auto Reset	off, 25, 50, 100, 200, 350, 600, 1000 sec	350 sec
MR	Manual reset	PD, P & on/off modes, ±99°C/F about SP1	0°
Xsd1	Hysteresis	0.25, 0.5, 1, 1.25, 1.5, 2.5, 5, 10%x span On/off mode only	None

Key selectable parameters—SP2		Default
Tp2/Xp2/xsd2	Prop Time/Prop Band and hysteresis as SP1	None