Series 3 PID Temperature Controller

OPERATIONS MANUAL

P/N 31333

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Operations Manual

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Contents

Issue Status of this Manual

Issue 5 of this Handbook applies to software versions 2.09 and above for PID controller and 2.29 and above for Valve Position controllers and includes:

- Remote Setpoint Input Option RCL
- Triac output

It also applies to firmware versions 2.11 and includes new parameters:
Inverted status word
Rate of change alarms
Setpoint retransmission limits
Input filter

Issue 6 includes parameter 'AT.R2G'

Issue 7 corrects range limits. Change to definition of LOC.T. Correct description of enumerations for parameter IM.

Issue 8 includes the following changes:

A more detailed description of loop tuning.

Updates to Appendix A, Technical Specification.

Installation and Basic Operation What Instrument Do I Have?

Thank you for choosing this Series 3 Temperature Controller.

The Series 3 provides precise temperature control of industrial processes and is available in one standard DIN size:

- 1/4 DIN

A universal input accepts various thermocouples, RTDs or process inputs. Up to four outputs can be configured for control, alarm or re-transmission purposes. 485 communication is also available.

The controller may have been ordered pre-configured or setup with defualt configuration..

If the display shows SET 1 the controller was supplied without parameters and will need to be configured when it is first switched on.

This Manual takes you through all aspects of installation, wiring, configuration and use of the controller.

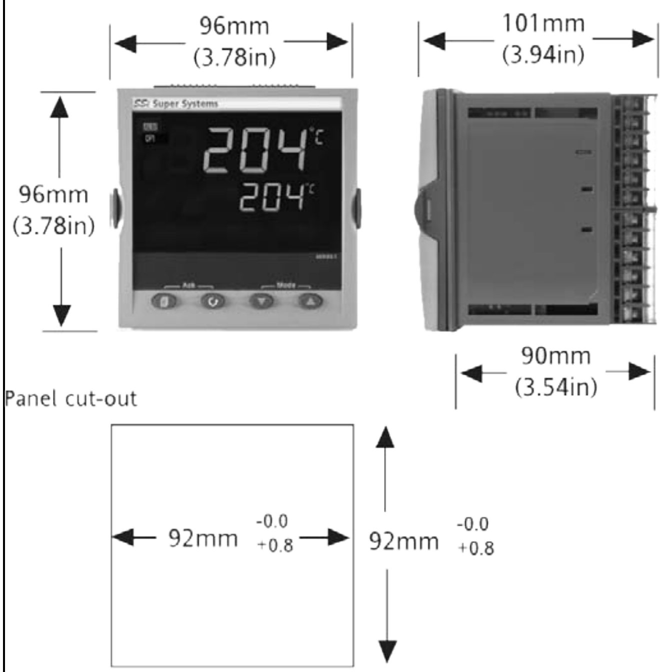
1.1 Unpacking Your Controller

The controller is supplied with

- Sleeve (with the controller fitted in the sleeve)
- Two panel retaining clips and sealing gasket mounted on the sleeve
- Component packet containing a snubber for relay output and a 2.49Ω resistor for current inputs.

1.2 Dimensions

General views of the controller are shown below together with overall dimensions.



1.3 Step 1: Installation

This instrument is intended for permanent installation, for indoor use only, and to be enclosed in an electrical panel

Select a location which is subject to minimum vibrations the ambient temperature is within 0 and 55°C (32 - 131°F) and humidity 5 to 95% RH non condensing.

The instrument can be mounted on a panel up to 15mm thick.

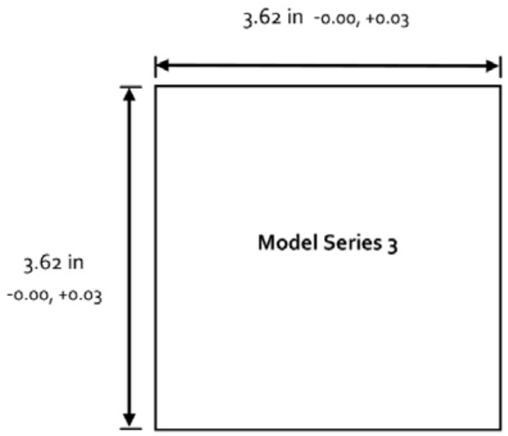
To ensure IP65 and NEMA 4 front protection, mount on a non-textured surface.

Please read the safety information in section 3 before proceeding.

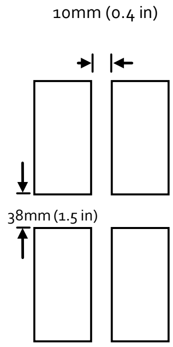
1.3.1 Panel Mounting the Controller

1. Prepare a cut-out in the mounting panel to the size shown. If a number of controllers are to be mounted in the same panel observe the minimum spacing shown.
2. Fit the sealing gasket behind the front bezel of the controller
3. Insert the controller through the cut-out
4. Spring the panel retaining clips into place. Secure the controller in position by holding it level and pushing both retaining clips forward.
5. Peel off the protective cover from the display.

1.3.2 Panel Cut Out Sizes



1.3.3 Recommended minimum spacing of controllers



(Not to scale)

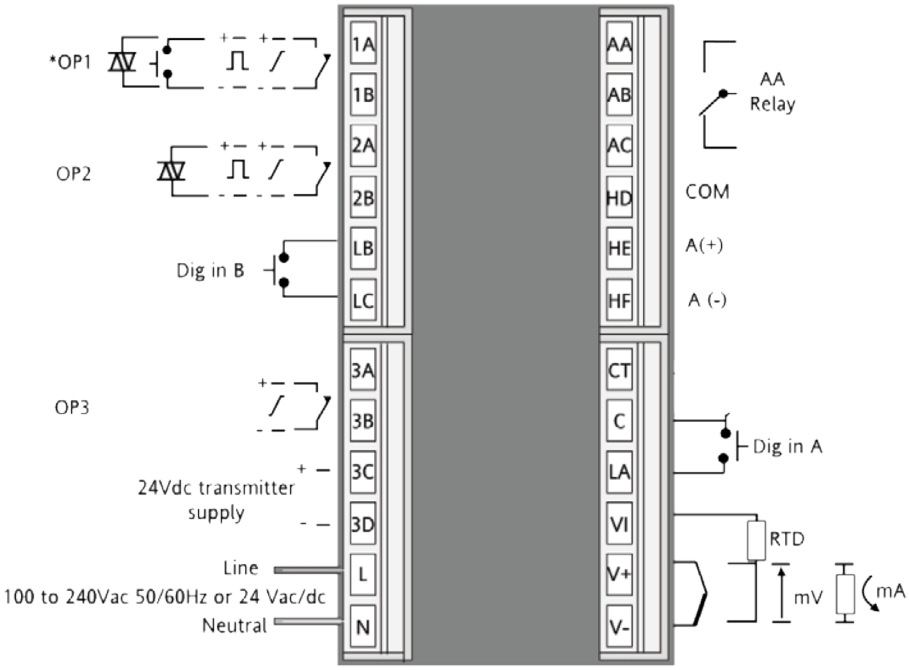
1.3.4 To Remove the Controller from its Sleeve

The controller can be unplugged from its sleeve by easing the latching ears outwards and pulling it forward out of the sleeve. When plugging it back into its sleeve, ensure that the latching ears click back into place to maintain the sealing

2. Step 2: Wiring

2.1 Terminal Layout Series 3 Controller

⚠	Ensure that you have the correct supply for your indicator



Key to symbols used in wiring diagrams					
	Logic (SSR drive) output		Relay output		Contact input
	mA analogue output		Triac output		Current transformer input

2.2 Wire Sizes

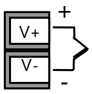
The screw terminals accept wire sizes from 0.5 to 1.5 mm (16 to 22AWG). Hinged covers prevent hands or metal making accidental contact with live wires. The rear terminal screws should be tightened to 0.4Nm (3.5lb in).

2.3 Precautions

- Do not run input wires together with power cables
- When shielded cable is used, it should be grounded at one point only
- Any external components (such as zener barriers, etc) connected between sensor and input terminals may cause errors in measurement due to excessive and/or un-balanced line resistance or possible leakage currents
- Not isolated from the logic outputs & digital inputs
- Pay attention to line resistance; a high line resistance may cause measurement errors

2.4 Sensor Input (Measuring Input)

2.4.1 Thermocouple Input

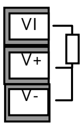


Positive

Negative

- Use the correct compensating cable preferably shielded

2.4.2 RTD Input



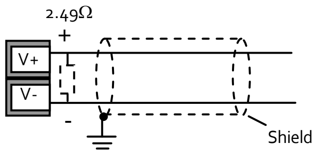
PRT

PRT

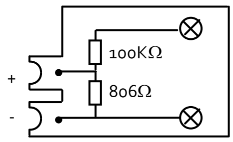
Lead compensation

- The resistance of the three wires must be the same. The line resistance may cause errors if it is greater than 22Ω

2.4.3 Linear Input (mA or mV)



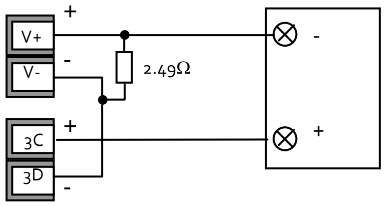
- If shielded cable is used it should be grounded in one place only as shown
- For a mA input connect the 2.49Ω burden resistor supplied between the V+ and V- terminals as shown
- For a 0-10Vdc input an external input adapter is required (not supplied).



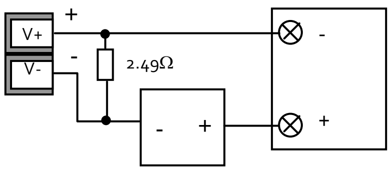
Sensor break alarm does not operate with this adaptor fitted.

2.4.4 Two-Wire Transmitter Inputs

Using internal 24V power supply (Series 3)



Using external power supply

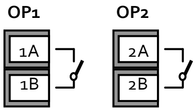


2.5 Input/Output 1 & Output 2

These outputs can be logic (SSR drive), or relay, or mA dc. In addition the logic output 1 can be used as a contact closure input.

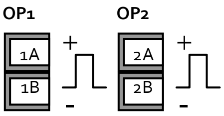
For input/output functions, see Quick Start Code in section 4.1.1.

2.5.1 Relay Output (Form A, normally open)



- Isolated output 240Vac CAT II
- Contact rating: 2A 264Vac resistive

2.5.2 Logic (SSR drive) Output



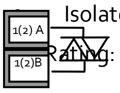
- Not isolated from the sensor input
- Output ON state: 12Vdc at 40mA max
- Output OFF state: <300mV, <100µA

- **The output switching rate must be set to prevent damage to the output device in use. See parameter 1.PLS or 2.PLS in section 5.**

2.5.3 DC Output

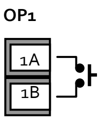
- Not isolated from the sensor input
- Software configurable: 0-20mA or 4-20mA.
- Max load resistance: 500Ω
- Calibration accuracy: ±(<1% of reading + <100µA)

2.5.4 Triac Output



- Isolated output 240Vac CATII
- Rating: 0.75A rms, 30 to 264Vac resistive

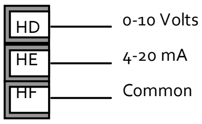
2.5.5 Logic Contact Closure Input (I/O 1 only)



- Not isolated from the sensor input
- Switching: 12Vdc at 40mA max
- Contact open > 500Ω. Contact closed < 150Ω

2.6 Remote Setpoint Input

- There are two inputs; 4-20mA and 0-10 Volts which can be fitted in place of digital communications

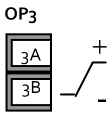


- It is not necessary to fit an external burden resistor to the 4-20mA input
- If the 4-20mA remote setpoint input is connected and valid (>3.5mA; < 22mA) it will be used as the main setpoint. If it is not valid or not connected the controller will try to use the Volts input. Volts sensor break occurs at <-1; >+11V. The two inputs are not isolated from each other
- If neither remote input is valid the controller will fall back to the internal setpoint, SP1 or SP2 and flash the alarm beacon. The alarm can also be configured to activate a relay or read over digital communications.
- To calibrate the remote setpoint, if required, see section 15.3.5
- A local SP trim value is available in access level 3.

2.7 Output 3

Output 3 will be a mA output.

DC Output



- Isolated output 240Vac CAT II
- Software configurable: 0-20mA or 4-20mA
- Max load resistance: 500Ω

- Calibration accuracy: 0.5%, ±100µA

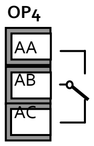
2.8 Summary of DC Outputs

OP1	Non-isolated
OP2	Non-isolated
OP3	Non-isolated
OP4	Non-isolated

2.9 Output 4 (AA Relay)

Output 4 is a relay..

For output functions, see Quick Start Code in section 4.1.1.



Relay Output (Form C)

- Contact rating: 2A 264Vac resistive
- Isolated output 240Vac CAT II

2.10 General Note About Relays and Inductive Loads

High voltage transients may occur when switching inductive loads such as some contactors or solenoid valves. Through the internal contacts, these transients may introduce disturbances which could affect the performance of the instrument.

For this type of load it is recommended that a 'snubber' is connected across the normally open contact of the relay switching the load. The snubber recommended consists of a series connected resistor/capacitor (typically 15nF/100Ω). A snubber will also prolong the life of the relay contacts.

A snubber should also be connected across the output terminal of a triac output to prevent false triggering under line transient conditions.

WARNING

When the relay contact is open or it is connected to a high impedance load, the snubber passes a current (typically 0.6mA at 110Vac and 1.2mA at 240Vac). You must ensure that this current will not hold on low power electrical loads. If the load is of this type the snubber should not be connected.

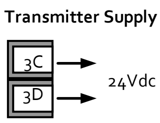
2.11 Digital Inputs A & B

Digital input A is an optional input in model Series 3. Digital input B is always fitted in model Series 3.

- Not isolated from the current transformer input or the sensor input
- Switching: 12Vdc at 40mA max
- Contact open > 500Ω. Contact closed < 200Ω
- Input functions: Please refer to the list in the quick codes.

2.12 Transmitter Power Supply

The Transmitter is fitted as standard in model Series 3.



- Output: 24Vdc, +/- 10%. 28mA max.
- inside the controller

2.13 Digital Communications

Optional.

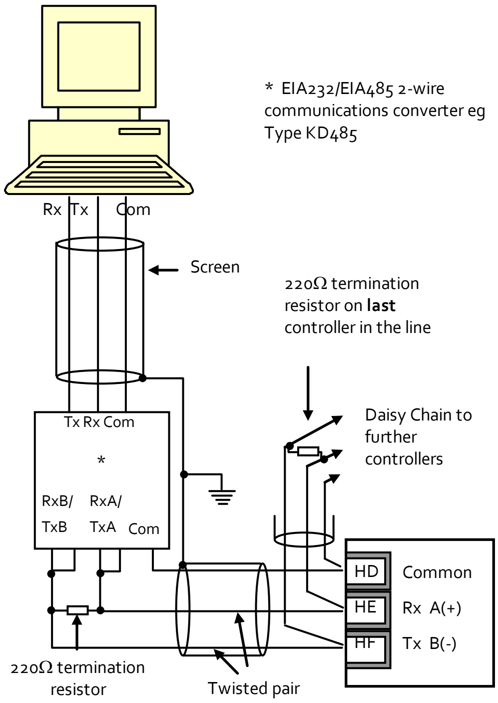
Digital communications uses the Modbus protocol. The interface comes standard as EIA485 (2-wire).

☺ Digital communications is not available if Remote Setpoint is fitted

☺ Cable screen should be grounded at one point only to prevent earth loops.

- Isolated 240Vac CAT II.

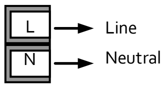
EIA485 Connections



2.14 Controller Power Supply

1. Before connecting the instrument to the power line, make sure that the line voltage corresponds to the description on the identification label.
2. Use copper conductors only.
3. For 24V the polarity is not important
4. The power supply input is not fuse protected. This should be provided externally

Power Supply

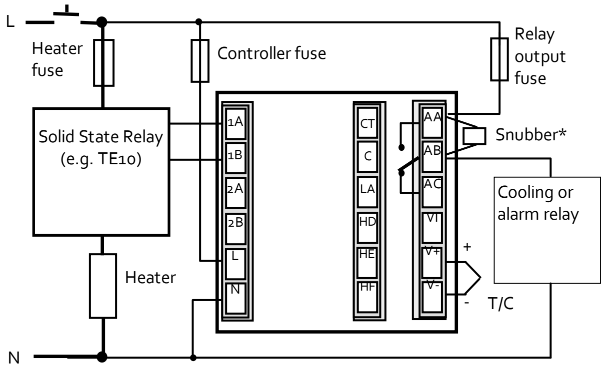


- High voltage supply: 100 to 240Vac, -15%, +10%, 48 to 62 Hz
- Recommended external fuse ratings are as follows:

  For 100-240Vac, fuse type: T rated 2A 250V.

2.15 Example Heat/Cool Wiring Diagram

This example shows a heat/cool temperature controller where the heater control uses a SSR and the cooling control uses a relay.



Safety requirements for permanently connected equipment state:

- A switch or circuit breaker shall be included in the building installation
- It shall be in close proximity to the equipment and within easy reach of the operator
- It shall be marked as the disconnecting device for the equipment

☺ A single switch or circuit breaker can drive more than one instrument

3. Safety and EMC Information

This controller is intended for industrial temperature and process control applications when it will meet the requirements of the European Directives on Safety and EMC. Use in other applications, or failure to observe the installation instructions of this handbook may impair safety or EMC. The installer must ensure the safety and EMC of any particular installation.

Safety

This controller complies with the European Low Voltage Directive 73/23/EEC, by the application of the safety standard EN 61010.

Electromagnetic compatibility

This controller conforms with the essential protection requirements of the EMC Directive 89/336/EEC, by the application of a Technical Construction File. This instrument satisfies the general requirements of the industrial environment defined in EN 61326. For more information on product compliance refer to the Technical Construction File.

GENERAL

The information contained in this manual is subject to change without notice. While every effort has been made to ensure the accuracy of the information, your supplier shall not be held liable for errors contained herein.

Unpacking and storage

The packaging should contain an instrument mounted in its sleeve, two mounting brackets for panel installation and an Installation & Operating guide.

If on receipt, the packaging or the instrument are damaged, do not install the product but contact Super Systems, Inc. If the instrument is to be stored before use, protect from humidity and dust in an ambient temperature range of -30°C to +75°C.

SERVICE AND REPAIR

This controller has no user serviceable parts. Contact Super Systems, Inc. for repair.

Caution: Charged capacitors

Before removing an instrument from its sleeve, disconnect the supply and wait at least two minutes to allow capacitors to discharge. It may be convenient to partially withdraw the instrument from the sleeve, then pause before completing the removal. In any case, avoid touching the exposed electronics of an instrument when withdrawing it from the sleeve.

Failure to observe these precautions may cause damage to components of the instrument or some discomfort to the user.

Electrostatic discharge precautions

When the controller is removed from its sleeve, some of the exposed electronic components are vulnerable to damage by electrostatic discharge from someone handling the controller. To avoid this, before handling the unplugged controller discharge yourself to ground.

Cleaning

Do not use water or water based products to clean labels or they will become illegible. Isopropyl alcohol may be used to clean labels. A mild soap solution may be used to clean other exterior surfaces of the product.

3.1 Installation Safety Requirements

Safety Symbols

Various symbols may be used on the controller. They have the following meaning:

⚠ Caution, (refer to accompanying documents)

☐ Equipment protected throughout by DOUBLE INSULATION

☺ Helpful hints

Personnel

Installation must only be carried out by suitably qualified personnel in accordance with the instructions in this handbook.

Enclosure of Live Parts

To prevent hands or metal tools touching parts that may be electrically live, the controller must be enclosed in an enclosure.

Caution: Live sensors

The controller is designed to operate if the temperature sensor is connected directly to an electrical heating element. However you must ensure that service personnel do not touch connections to these inputs while they are live. With a live sensor, all cables, connectors and switches for connecting the sensor must be mains rated.

Wiring

It is important to connect the controller in accordance with the wiring data given in this guide. Take particular care not to connect AC supplies to the low voltage sensor input or other low level inputs and outputs. Only use copper conductors for connections (except thermocouple inputs) and ensure that the wiring of installations comply with all local wiring regulations. For example in the UK use the latest version of the IEE wiring regulations, (BS7671). In the USA use NEC Class 1 wiring methods.

Power Isolation

The installation must include a power isolating switch or circuit breaker. This device should be in close proximity to the controller, within easy reach of the operator and marked as the disconnecting device for the instrument.

Overcurrent protection

The power supply to the system should be fused appropriately to protect the cabling to the units.

Voltage rating

The maximum continuous voltage applied between any of the following terminals must not exceed 264Vac:

- relay output to logic, dc or sensor connections;
- any connection to ground.

The controller must not be wired to a three phase supply with an unearthed star connection. Under fault conditions such a supply could rise above 264Vac with respect to ground and the product would not be safe.

Conductive pollution

Electrically conductive pollution must be excluded from the cabinet in which the controller is mounted. For example, carbon dust is a form of electrically conductive pollution. To secure a suitable atmosphere in conditions of conductive pollution, fit an air filter to the air intake of the cabinet. Where condensation is likely, for example at low temperatures, include a thermostatically controlled heater in the cabinet.

This product has been designed to conform to BSEN61010 installation category II, pollution degree 2. These are defined as follows:

Installation Category II (CAT II)

The rated impulse voltage for equipment on nominal 230V supply is 2500V.

Pollution Degree 2

Normally only non conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation shall be expected.

Grounding of the temperature sensor shield

In some installations it is common practice to replace the temperature sensor while the controller is still powered up. Under these conditions, as additional protection against electric shock, we recommend that the shield of the temperature sensor is grounded. Do not rely on grounding through the framework of the machine.

Over-temperature protection

When designing any control system it is essential to consider what will happen if any part of the system should fail. In temperature control applications the primary danger is that the heating will remain constantly on. Apart from spoiling the product, this could damage any process machinery being controlled, or even cause a fire.

Reasons why the heating might remain constantly on include:

- the temperature sensor becoming detached from the process
- thermocouple wiring becoming short circuit;
- the controller failing with its heating output constantly on
- an external valve or contactor sticking in the heating condition
- the controller setpoint set too high.

Where damage or injury is possible, we recommend fitting a separate over-temperature protection unit, with an independent temperature sensor, which will isolate the heating circuit.

Please note that the alarm relays within the controller will not give protection under all failure conditions.

Routing of wires

To minimise the pick-up of electrical noise, the low voltage DC connections and the sensor input wiring should be routed away from high-current power cables. Where it is impractical to do this, use shielded cables with the shield grounded at both ends. In general keep cable lengths to a minimum.

4. Switch On

The way in which the controller starts up depends on factors described below in sections 4.1, 4.2 and 4.3.

4.1 New Controller

If the controller is new AND has not previously been configured it will start up showing the 'Quick Configuration' codes. This is a built in tool which enables you to configure the input type and range, the output functions and the display format.

⚠ Incorrect configuration can result in damage to the process and/or personal injury and must be carried out by a competent person authorised to do so. It is the responsibility of the person commissioning the controller to ensure the configuration is correct

4.1.1 Quick Start Code

The quick start code consists of two 'SETS' of five characters. The upper section of the display shows the set selected, the lower section shows the five digits which make up the set.

Adjust these as follows:.

1. Press any button. The characters will change to '-', the first one flashing.
2. Press ▲ or ▼ to change the flashing character to the required code shown in the quick code tables – see below. Note: An X indicates that the option is not fitted.
3. Press ⟳ to scroll to the next character.

☺ You cannot scroll to the next character until the current character is configured.

☺ To return to the first character press ▤

4. When all five characters have been configured the display will go to Set 2.
5. When the last digit has been entered press ⟳ again, the display will show

6. Press ▲ or ▼ to

.

The controller will then automatically go to the operator level.

SET 1

K C H C 0

Input type	
Thermocouple	
B	Type B
J	Type J
K	Type K
L	Type L
N	Type N
R	Type R
S	Type S
T	Type T
C	Custom
RTD	
P	Pt100
Linear	
M	0-80mV
2	0-20mA
4	4-20mA

Range	
Full range	
C	°C
F	°F
Centigrade	
0	0-100
1	0-200
2	0-400
3	0-600
4	0-800
5	0-1000
6	0-1200
7	0-1400
8	0-1600
9	0-1800
Fahrenheit	
G	32-212
H	32-392
J	32-752
K	32-1112
L	32-1472
M	32-1832
N	32-2192
P	32-2552
R	32-2912
T	32-3272

Input/Output 1		Output 2		Output 4
X	Unconfigured			
H	PID Heating [logic, relay (1) or 4-20mA] or motor valve open [VC and VP only]			**Note (1)** O/P4 is relay only.
C	PID Cooling [logic, relay (1) or 4-20mA] or motor valve close [VC and VP only]			
J	ON/OFF Heating [logic or relay (1)], or PID 0-20mA heating			
K	ON/OFF Cooling [logic or relay (1)], or PID 0-20mA cooling			
Alarm (2): energised in alarm		**Alarm (2): de-energised in alarm**		
0	High alarm	5	High alarm	**Note (2)** OP1 = alarm 1 OP2 = alarm 2 OP3 = alarm 3 OP4 = alarm 4
1	Low alarm	6	Low alarm	
2	Deviation high	7	Deviation high	
3	Deviation low	8	Deviation low	
4	Deviation band	9	Deviation band	
DC Retransmission (not O/P4)				
D	4-20mA Setpoint	N	0-20mA Setpoint	
E	4-20mA Temperature	Y	0-20mA Temperature	
F	4-20mA output	Z	0-20mA output	
Logic input functions (Input/Output 1 only)				
W	Alarm acknowledge	V	Recipe 2/1 select	
M	Manual select	A	Remote UP button	
R	FEATURE UNAVAILABLE	B	Remote DOWN button	
L	Keylock	G	FEATURE UNAVAILABLE	
P	Setpoint 2 select	I	FEATURE UNAVAILABLE	
T	FEATURE UNAVAILABLE	Q	Standby select	
U	Remote SP enable			

SET 2

1 WRDT

Input CT Scaling	
X	Unconfigured
1	10 Amps
2	25 Amps
5	50 Amps
6	100 Amps

Digital Input A / Digital Input B (2)	
X	Unconfigured
W	Alarm acknowledge
M	Manual select
R	FEATURE UNAVAILABLE
L	Keylock
P	Setpoint 2 select
T	FEATURE UNAVAILABLE
U	Remote SP enable
V	Recipe 2/1 select
A	Remote UP button
B	Remote DOWN button
G	FEATURE UNAVAILABLE
I	FEATURE UNAVAILABLE
Q	Standby select

Output 3 (2)			
X	Unconfigured		
H	PID heating or motor valve open (3)		
C	PID cooling or motor valve close (3)		
J	ON/OFF heating (not shown if VC or VP)		
K	ON/OFF cooling (not shown if VC or VP)		
Alarm Outputs (1)			
Energised in alarm		De-energised in alarm	
0	High alarm	5	High alarm
1	Low alarm	6	Low alarm
2	Dev High	7	Dev High
3	Dev Low	8	Dev Low
4	Dev Band	9	Dev Band
DC outputs			
H	4-20mA heating		
C	4-20mA cooling		
J	0-20mA heating		
K	0-20mA cooling		
Retransmission output			
D	4-20 Setpoint		
E	4-20 Measured Temperature		
F	4-20mA output		
N	0-20 Setpoint		
Y	0-20 Measured Temperature		
Z	0-20mA output		

Lower Display	
T	Setpoint (std)
P	Output
R	Time remaining
E	Elapsed time
1	Alarm setpoint
A	Load Amps
D	Dwell/Ramp Time/Target
N	None
C	Setpoint with Output meter (2)
M	Setpoint with Ammeter (2)

Note (1)

OP1 = alarm 1 (I/O1)

OP2 = alarm 2

OP3 = alarm 3

OP4 = alarm 4 (AA)

Note (3)
VP, VC only

4.2 To Re-Enter Quick Code mode

If you need to re-enter the 'Quick Configuration' mode this can always be done as follows:

1. Power down the controller
2. Hold down the button, and power up the controller again.
3. Keep the button pressed until code is displayed.
4. Enter the configuration code (this is defaulted to 4 in a new controller)
5. The quick start codes may then be set as described previously

☺ Parameters may also be configured using a deeper level of access. This is described in later chapters of this handbook.

☺ If the controller is started with the button held down, as described above, and the quick start codes are shown with dots (e.g. J.C.X.X.X), this indicates that the controller has been re-configured in a deeper level of access and, therefore, the quick start codes may not be valid. If the quick start codes are accepted by scrolling to YES EXIT then the quick start codes are reinstated.

4.3 Pre-Configured Controller or Subsequent Starts

A brief start up sequence consists of a self test during which the software version number is shown followed briefly by the quick start codes.

It will then proceed to **Operator Level 1**..

You will see the display shown below. It is called the HOME display.

☺ If the quick start codes do not appear during this start up, it means that the controller has been configured in a deeper level of access, see the note in section 4.2. The quick start codes may then not be valid and are therefore not shown.

4.4 Front Panel Layout

ALM Alarm active (Red)

OP1 lit when output 1 is ON

OP2 lit when output 2 is ON

OP3 lit when output 3 is ON

OP4 lit when output 4 relay is ON

SPX Alternative setpoint in use (e.g. setpoint 2)

REM Remote digital setpoint. Also flashes when digital communications active

MAN Manual mode selected

Operator Buttons:

Referred to as the 'page' button. From any view - press to return to the HOME display

Referred to as the 'scroll' button. Press to select a new parameter. If held down it will continuously scroll through parameters.

Press and (ACK) together to acknowledge an alarm.

Referred to as the 'arrow down' button. Press to decrease a value

Referred to as the 'arrow up' button. Press to increase a value

Press and (MODE) together to toggle between Auto and Manual mode.

4.4.1 To Set The Target Temperature.

From the HOME display:

Press to raise the setpoint

Press to lower the setpoint

The new setpoint is entered when the button is released and is indicated by a brief flash of display.

4.4.2 Alarms

Process alarms may be configured using the Quick Start Codes. Each alarm can be configured for:

Full Scale Low	The alarm is shown if the process value falls below a set threshold
Full Scale High	The alarm is shown if the process value rises above a set threshold
Deviation Low	The alarm is shown if the process value deviates below the setpoint by a set threshold
Deviation High	The alarm is shown if the process value deviates above the setpoint by a set threshold
Deviation Band	The alarm is shown if the process value deviates above or below the setpoint by a set threshold

If an alarm is not configured it is not shown in the list of level 2 parameters.

Additional alarm messages may be shown such as CONTROL LOOP BROKEN. This occurs if the controller does not detect a change in process value following a change in output demand after a suitable delay time.

Another alarm message may be INPUT SENSOR BROKEN (SBr). This occurs if the sensor becomes open circuit; the output level will adopt a 'SAFE' value which can be set up in Operator Level 3..

☺ From firmware version 2.11 two further alarm types have been made available. These are:

Rising rate of change	An alarm will be detected if the rate of change (units/minute) in a positive direction exceeds the alarm threshold
Falling rate of change	An alarm will be detected if the rate of change (units/minute) in a negative direction exceeds the alarm threshold

These alarms cannot be configured by the Quick Start Code – they can only be configured in Configuration Mode..

4.4.3 Alarm Indication

If an alarm occurs, the red ALM beacon will flash. A scrolling text message will describe the source of the alarm. Any output (usually a relay) attached to the alarm will operate. An alarm relay can be configured using the Quick Start Codes to be energised or de-energised in the alarm condition. It is normal to configure the relay to be de-energised in alarm so that an alarm is indicated if power to the controller fails.

Press and (ACK) together to acknowledge an alarm.

If the alarm is still present the ALM beacon will light continuously otherwise it will go off.

The action which takes place depends on the type of alarm configured:

Non latching	A non latching alarm will reset itself when the alarm condition is removed. By default alarms are configured as non-latching, de-energised in alarm.
Auto Latching	An auto latching alarm requires acknowledgement before it is reset. The acknowledgement can occur BEFORE the condition causing the alarm is removed.
Manual Latching	The alarm continues to be active until both the alarm condition is removed AND the alarm is acknowledged. The acknowledgement can only occur AFTER the condition causing the alarm is removed.

By default alarms are configured as non-latching, de-energised in alarm. To configure latched alarms, refer to section 12.3.1.

4.4.4 Auto, Manual and Off Mode

The controller can be put into Auto, Manual or Off mode – see next section.

Auto mode is the normal operation where the output is adjusted automatically by the controller in response to changes in the measured temperature.

In Auto mode all the alarms and the special functions (auto tuning, soft start) are operative

Manual mode means that the controller output power is manually set by the operator. The input sensor is still connected and reading the temperature but the control loop is 'open'.

In manual mode the MAN beacon will be lit, Band and deviation alarm are masked

The power output can be continuously increased or decreased using the ▼ or ▲ buttons.

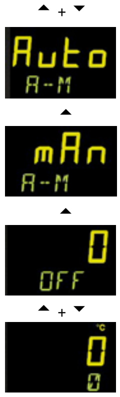
⚠ **Manual mode must be used with care. The power level must not be set and left at a value that can damage the process or cause over-heating. The use of a separate 'over-temperature' controller is recommended.**

Off mode means that the heating and cooling outputs are turned off. The process alarm and analogue retransmission outputs will, however, still be active while Band and deviation alarm will be OFF.

4.4.5 To Select Auto, Manual or Off Mode

Press and hold ▼ and ▲ (Mode) together for more than 1 second.

This can only be accessed from the HOME display.



1. Auto' is shown in the upper display. After 5 seconds the lower display will scroll the longer description of this parameter. ie 'loop mode – auto manual off'
2. Press ▲ to select 'mAn'. Press again to select 'OFF'. This is shown in the upper display.
3. When the desired Mode is selected, do not push any other button. After 2 seconds the controller will return to the HOME display.
4. If **OFF** has been selected, OFF will be shown in the lower display and the heating and cooling outputs will be off
5. If manual mode has been selected, the **MAN** beacon will light. The upper display shows the measured temperature and the lower display the demanded output power.

☺ The transfer from Auto to manual mode is 'bumpless'. This means the output will remain at the current value at the point of transfer. Similarly when transferring from Manual to Auto mode, the current value will be used. This will then slowly change to the value demanded automatically by the controller.

6. To manually change the power output, press ▼ or ▲ to lower or raise the output. The output power is continuously updated when these buttons are pressed
7. To return to Auto mode, press ▼ and ▲ together. Then press ▼ to select 'Auto'.

4.4.6 Level 1 Operator Parameters

A minimal list of parameters are available in operator Level 1 which is designed for day to day operation. Access to these parameters is not protected by a pass code.

Press to step through the list of parameters. The mnemonic of the parameter is shown in the lower display. After five seconds a scrolling text description of the parameter appears.

The value of the parameter is shown in the upper display. Press or to adjust this value. If no key is pressed for 30 seconds the controller returns to the HOME display

The parameters that appear depend upon the functions configured. They are:

Parameter Mnemonic	Scrolling Display and Description	Alterability
WRK.OP	WORKING OUTPUT The active output value	Read only. Appears when the controller is in AUTO or OFF mode.
WKG.SP	WORKING SETPOINT The active setpoint value.	Read only. Only shown when the controller is in MAN or OFF mode.
SP1	SETPOINT 1	Alterable
SP2	SETPOINT 2	Alterable
T.REMN	TIME REMAINING Time to end of set period	Read only 0:00 to 99.59 hh:mm or mm:ss
A1.xxx	ALARM 1 SETPOINT	Read only. Only shown if the alarm is configured. xxx = alarm type as follows: HI = High alarm LO = Low alarm d.HI = Deviation high d.LO = Deviation low d.HI = Deviation high rrc = Rising rate of change (units/minute) Frc = Falling rate of change (units/minute)
A2.xxx	ALARM 2 SETPOINT	
A3.xxx	ALARM 3 SETPOINT	
A4.xxx	ALARM 3 SETPOINT	
LD.AMP	LOAD CURRENT	Read only. Only shown if CT is configured

5. Operator Level 2

Level 2 provides access to additional parameters. Access to these is protected by a security code.

5.1 To Enter Level 2

1. From any display press and hold .
2. After a few seconds the display will show

3. Release .

(If no button is pressed for about 45 seconds the display returns to the HOME display)

4. Press or to choose Lev 2 (Level 2)

5. After 2 seconds the display will show

6. Press or to enter the pass code. Default = '2'

- If an incorrect code is entered the controller reverts to Level 1.

5.2 To Return to Level 1

1. Press and hold
2. Press to select LEv 1

The controller will return to the level 1 HOME display. Note: A security code is not required when going from a higher level to a lower level.

5.3 Level 2 Parameters

Press to step through the list of parameters. The mnemonic of the parameter is shown in the lower display. After five seconds a scrolling text description of the parameter appears.

The value of the parameter is shown in the upper display. Press or to adjust this value. If no key is pressed for 30 seconds the controller returns to the HOME display

Backscroll is achieved when you are in this list by pressing while holding down .

The following table shows a list of parameters available in Level 2.

Mnemonic	Scrolling Display and description	Range	
WKG.SP	**WORKING SETPOINT** is the active setpoint value and appears when the controller is in Manual mode. It may be derived from SP1 or SP2, or, if the controller is ramping (see SP.RAT), it is the current ramp value.	SP.HI to SP.LO	
WRK.OP	**WORKING OUTPUT** is the output from the controller expressed as a percentage of full output. It appears when the controller is in Auto mode. For a time proportioning output, 50% = relay or logic output on or off for equal lengths of time. For On/Off control: OFF = <1%. ON = >1%	Read only value 0 to 100% for heating 0 to –100% for cooling -100 (max cooling) to 100% (max heating	
T.STAT	**FEATURE UNAVAILABLE**	rES	Reset
		run	Running
		hoLd	Hold
		End	Timed out
UNITS	**DISPLAY UNITS** Temperature display units. 'Percentage' is provided for linear inputs	°C	Degrees C
		°F	Degrees F
		°k	Degrees K
		nonE	None
		PErc	Percentage
SP.HI	**SETPOINT HIGH** High setpoint limit applied to SP1 and SP2.	Alterable between range limits	
SP.LO	**SETPOINT LOW** Low setpoint limit applied to SP1 and SP2		
	By default the remote setpoint is scaled between SP.HI and SP.LO. Two further parameters (REM.HI and REM.LO) are available in access level 3 to limit the Remote SP range if required.		
SP1	**SETPOINT 1** allows control setpoint 1 value to be adjusted	Alterable: SP.HI to SP.LO	
SP2	**SETPOINT 2** allows control setpoint 2 value to be adjusted	Alterable: SP.HI to SP.LO	
SP.RAT	**SETPOINT RATE LIMIT** Rate of change of setpoint value.	OFF to 3000 display units per minute	
	The next section applies to the Timer only.		
TM.CFG	**FEATURE UNAVAILABLE**	none	None
		Dwel	Dwell
		DeLy	Delayed switch on
		sfst	Soft start
TM.RES	**FEATURE UNAVAILABLE**	Hour	Hours
		min	Minutes
THRES	**FEATURE UNAVAILABLE**	OFF or 1 to 3000	
END.T	**FEATURE UNAVAILABLE**	OFF	Control OP goes to zero
		Dwel	Control continues at SP1
		SP2	Go to SP2
SS.PWR	**FEATURE UNAVAILABLE**	-100 to 100%	
SS.SP	**FEATURE UNAVAILABLE**	Between SP.HI and SP.LO	
DWELL	**FEATURE UNAVAILABLE**	0:00 to 99.59 hh:mm: or mm:ss	
T.REMN	**FEATURE UNAVAILABLE**	0:00 to 99.59 hh:mm: or mm:ss	
	The following parameters are available when the timer is configured as a programmer.		
SERVO	**FEATURE UNAVAILABLE**	SP	Setpoint
		PV	Process variable
		SP.rb	Ramp back to SP
		PV.rb	Ramp back to PV
TSP.1	**TARGET SETPOINT 1**. To set the target value for the first setpoint		
RMP.1	**FEATURE UNAVAILABLE**	OFF, 0:01 to 3000 units per min or hour as set by TM.RES	

Mnemonic	Scrolling Display and description	Range
DWEL.1	**FEATURE UNAVAILABLE**	OFF, 0:01 to 99:59 hh:mm or mm:ss as set by TM.RES
The above three parameters are repeated for the next three program segments, i.e. TSP.2 (3 & 4), RMP.2 (3 & 4), DWEL.2 (3 & 4)		
This section applies to Alarms only If an alarm is not configured the parameters do not appear		
A1.--- - to A4.---	**ALARM 1 (2, 3 or 4) SETPOINT** sets the threshold value at which an alarm occurs. Up to four alarms are available and are only shown if configured. The last three characters in the mnemonic specify the alarm type: L o – Full Scale Low; H i – Full Scale High dHi – Deviation High; dLo – Deviation Low; Bnd – Deviation Band	SP.HI to SP.LO
	rrc – Rising rate of change; Frc – Falling rate of change	1 to 9999 units/minute
This section applies to control the parameters. A further description of theses parameters is given in section 11		
A.TUNE	**AUTOTUNE** automatically sets the control parameters to match the process characteristics.	Off – Disable On – Enable
PB	**PROPORTIONAL BAND** sets an output which is proportional to the size of the error signal. Units may be % or display units.	1 to 9999 display units Default 20
TI	**INTEGRAL TIME** removes steady state control offsets by ramping the output up or down in proportion to the amplitude and duration of the error signal.	Off to 9999 seconds Default 360
TD	**DERIVATIVE TIME** determines how strongly the controller will react to the rate of change in the process value. It is used to prevent overshoot and undershoot and to restore the PV rapidly if there is a sudden change in demand.	Off to 9999 seconds Default 60 for PID control Default 0 for VP control
MR	**MANUAL RESET** applies to a PD only controller i.e. the integral term is turned off. Set this to a value of power output (from +100% heat, to -100% cool which removes any steady state error between SP and PV.	-100 to 100% Default 0
R2G	**RELATIVE COOL GAIN** adjusts the cooling proportional band relative to the heating proportional band. Particularly necessary if the rate of heating and rate of cooling are very different. **(Heat/Cool only**)	0.1 to 10.0 Default 1.0
HYST.H	**HEATING HYSTERESIS** Sets the difference in temperature units between heating turning off and turning on when ON'OFF control is used. **Only appears if channel 1(heating) control action is On/Off**	0.1 to 200.0 display units 0.2 Default 1.0
HYST.C	**COOLING HYSTERESIS** Sets the difference in temperature units between cooling turning off and turning on when ON/OFF control is used. **Only appears if channel 2 (cooling) control action is On/Off**	0.1 to 200.0 display units Default 1.0
D.BAND	**CHANNEL 2 DEADBAND** adjusts a zone between heating and cooling outputs when neither output is on. Off = no deadband. 100 = heating and cooling off. **Only appears if On/Off control configured.**	OFF or 0.1 to 100.0% of the cooling proportional band
OP.HI	**OUTPUT HIGH** limits the maximum heating power applied to the process or a minimum cooling output.	+100% to OP.LO
1. (2, 3 or 4) PLS.	**OUTPUT 1 (2, 3 or 4) MINIMUM PULSE TIME** Sets the minimum on and off time for the control output. ⚠ **Ensure this parameter is set to a value that is suitable for the output switching device in use. For example, if a logic output is used to switch a small relay, set the value to 5.0 seconds or greater to prevent damage to the device due to rapid switching.**	Relay outputs 0.1 to 150.0 seconds – default 5.0. Logic outputs Auto to 150.0 - Default Auto = 55ms
This section applies to current transformer input only. The CT option is not available on the Series 3.		
LD.AMP	**LOAD CURRENT** is the measured load current when the power demand is on	CT Range
LK.AMP	**LEAK CURRENT** is the measured leakage current when the power demand is off.	CT Range
LD.ALM	**LOAD CURRENT THRESHOLD** Sets a low alarm on the load current measured by the CT. Used to detect partial load failure.	CT Range
LK.ALM	**LEAK CURRENT THRESHOLD** sets a high alarm on the leakage current measured by the CT.	CT Range
HC.ALM	**OVERCURRENT THRESHOLD** Sets a high alarm on the load current measured by the CT	CT Range
ADDR	**ADDRESS** - communications address of the controller. 1 to 254	1 to 254
HOME	**HOME DISPLAY** Defines the parameter which appears in the lower section of the	STD – Standard

Mnemonic	Scrolling Display and description	Range	
	HOME display.	OP	Output power
		Tr	Time remaining
		ELAP	Time elapsed
		AL	First alarm setpoint
		CT	Load current
		CLr	Clear (blank)
		TMr	Combined setpoint and time display
ID	**CUSTOMER ID** Sets a number from 0 to 9999 used as a custom defined identification number for the controller.	0 to 9999	
REC.NO	**FEATURE UNAVAILABLE**	none or 1 to 5 or FaiL if no recipe set stored	
STORE	**FEATURE UNAVAILABLE**	none or 1 to 5 done when stored	

☺ Press at any time to return immediately to the HOME screen at the top of the list.

☺ Hold down to continuously scroll through the above list

6. Access to Further Parameters

Parameters are available under different levels of security and are defined as Level 1 (Lev1), Level 2 (Lev2), Level 3 (Lev 3) and Configuration (Conf).

Level 1 has no passcode since it contains a minimal set of parameters generally sufficient to run the process on a daily basis.

Level 2 allows access to parameters which may used in commissioning a controller or settings between different products or batches.

Level 1 and Level 2 operation has been described in the previous sections.

Level 3 and Configuration level parameters are also available as follows:

6.1.1 Level 3

Level 3 makes all operating parameters available and alterable (if not read only). It is typically used when commissioning a controller.

Examples of parameters available in Level 3 are:

Range limits, setting alarm levels, communications address.

The instrument will continue to control when in Levels 1, 2 or 3.

6.1.2 Configuration Level

This level makes available all parameters including the operation parameters so that there is no need to switch between configuration and operation levels during commissioning. It is designed for those who may wish to change the fundamental characteristics of the instrument to match the process.

Examples of parameters available in Configuration level are:

Input (thermocouple type); Alarm type; Communications type.

WARNING

Configuration level gives access to a wide range of parameters which match the controller to the process. Incorrect configuration could result in damage to the process being controlled and/or personal injury. It is the responsibility of the person commissioning the process to ensure that the configuration is correct.

In configuration level the controller is not controlling the process or providing alarm indication. Do not select configuration level on a live process.

Operating Level	Home List	Full Operator	Configuration	Control
Level 1	✓			Yes
Level 2	✓			Yes
Level 3	✓	✓		Yes
Conf	✓	✓	✓	No

6.1.3 To Select Access Level 3 or Configuration Level

Do This	The Display You Should See	Additional Notes
1. From any display press and hold for more than 5 seconds	**To Select Level 3** Lev 3 goto 0 CODE	The display will pass from the current operating level, for example, Lev 1 to Lev 3 as the button is held down. (If no button is then pressed for about 50 seconds the display returns to the HOME display)
2. Press or to enter the passcode for Level 3	3 code	The default code is 3: If an incorrect code is entered the display reverts to 'goto'. The controller is now in the level 3 will then revert to the HOME display
3. When the LEV3 GOTO view is shown, as in paragraph 1 above, press to select 'Conf'	**To Select Configuration level** Conf goto 0 CODE	Note: must be pressed quickly before the controller requests the code for level 3
4. Press or to enter the passcode for Configuration level	4 code Conf	The default code is 4: If an incorrect code is entered the display reverts to 'goto'. The controller is now in Configuration level will now show Conf
5. Press and hold for more than 3 seconds 6. Press to select the required level eg LEV 1	**To Return to a Lower Level** Conf goto Lev1 goto	The choices are: LEV 1 Level 1 LEV 2 Level 2 LEV 3 Level 3 ConF Configuration It is not necessary to enter a code when going from a higher level to a lower level. Alternatively, press and scroll to the Acces list header, then press to select the required level. The display will then flash 'ConF' for a few seconds and the controller will then go through its start up sequence, starting in the level selected. Do not power down while Conf is flashing. If a power down does occur an error message will appear – see 'Diagnostic Alarms'

☺ A special case exists if a security code has been configured as '0'. If this has been done it is not necessary to enter a code and the controller will enter the chosen level immediately.

☺ When the controller is in configuration level the ACCESS list header can be selected from any view by holding down the button for more than 3 seconds. Then press again to select 'ACCES'

6.2 Parameter lists

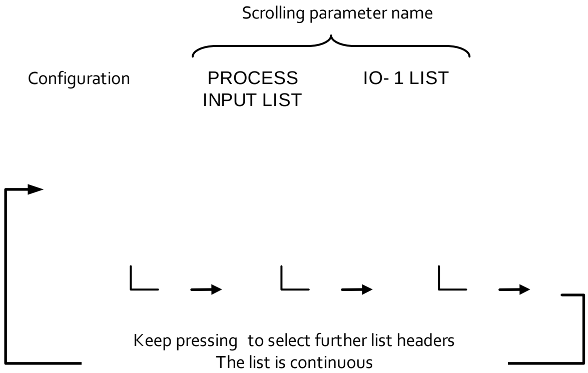
Parameters are organised in lists. The top of the list shows the list header only. The name of the list header describes the generic function of the parameters within the list. For example, the list header 'ALARM' contains parameters which enable you to set up alarm conditions.

6.2.1 To Choose Parameter List Headers

Press ⊜. Each list header is selected in turn every time this key is pressed.

The name of the list header appears in the lower display, followed, after a few seconds, by a scrolling longer description of the name.

The following example shows how to select the first two list headers.



6.2.2 To Locate a Parameter

Choose the appropriate list, then press ⟳. Each parameter in the list is selected in turn each time this button is pressed. The following example shows how to select the first two parameters in the ALARM List. All parameters in all lists follow the same procedure.

Alarm List Header

Parameter 'Value'. In this case set to Full Scale High Alarm

Parameter mnemonic 'a1.typ' followed by a scrolling message 'alarm1 type'

Parameter 'Value'. In this case an 'numerical' value, set to '112'

Parameter mnemonic 'a1.HI' followed by a scrolling message 'alarm 1 setpoint'

Further parameters

☺ Press ⊜ to jump back to the list header

6.2.3 How Parameters are Displayed

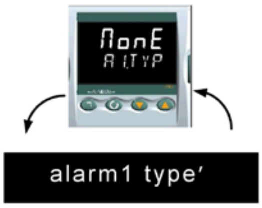
As shown above. whenever a parameter is selected it is displayed as a mnemonic, of four or five characters, for example 'A1.TYP'.

After a few seconds this display is replaced by a scrolling banner which gives a more detailed description of the parameter. In this example 'A1.TYP' = 'alarm 1 type'. The scrolling banner is only shown once after the parameter is first accessed.

The name of the list header is also displayed in this way.

The upper part of the display shows the value of the parameter.

The lower part shows its mnemonic followed by the scrolling name of the parameter



6.2.4 To Change a Parameter Value

With the parameter selected, press ⏶ to increase the value, press ⏷ to decrease the value. If either key is held down the analogue value changes at an increasing rate.

The new value is entered after the key is released and is indicated by the display blinking. The exception to this is output 'Power' when in manual. In this case the value is entered continuously.

The upper display shows the parameter value the lower display shows the parameter name.

6.2.5 To Return to the HOME Display

Press ⊜ + ⟳.

On release of the keys the display returns to the HOME list. The current operating level remains unchanged.

6.2.6 Time Out

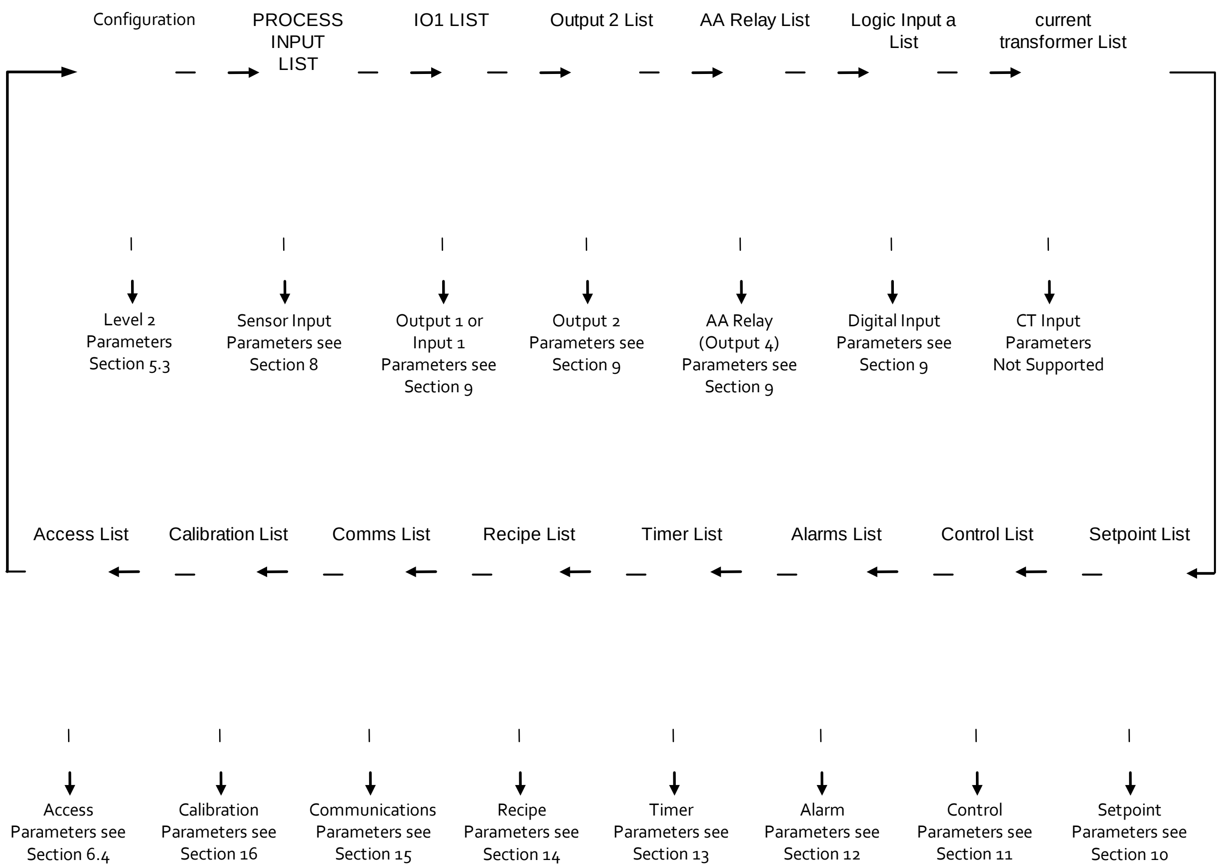
A time out applies to the 'Go To' and 'Control Mode' parameters. If no key presses are detected within a period of 5 seconds the display will revert back to the HOME list.

☺ Press and hold ⟳ to scroll parameters forward through the list. With ⟳ depressed, press ⏶ to scroll parameters backward.

6.3 Navigation Diagram

The diagram below shows the all list headings available in configuration level for Series 3 controllers.

The parameters in a list are shown in tables in the following sections of this manual together with explanations of their meanings and possible use.



For Series 3 controllers additional lists are available, for example Output 3 and Digital Input B

6.4 Access Parameters

The following table summarizes the parameters available under the ACCESS list header

⚠ The Access List can be selected at any time when in configuration level by holding key down for 3 seconds, then press or with still held down.

ACCESS LIST		'ACCS'				
Name	Scrolling Display	Parameter Description	Values Allowed		Default	Access Level
GOTO	SELECT ACCESS LEVEL	Allows you to change the access level of the controller. Passwords prevent unauthorised change	Lev.1	Operator level 1	Lev.1	Conf
			Lev.2	Operator level 2		
			Lev.3	Operator level 3		
			Conf	Configuration level		
LEV2.P	LEVEL 2 PASSCODE	The Level 2 passcode	0-9999 0 = no passcode will be requested		2	Conf
LEV3.P	LEVEL 3 PASSCODE	The Level 3 passcode			3	Conf
CONF.P	CONFIG PASSCODE	To set a Configuration level passcode			4	Conf
ID	CUSTOMER ID	To set the identification of the controller	0-9999			Conf
HOME	HOME DISPLAY See Note 1	To configure the parameter to be displayed in the lower line of the HOME display	Std	Setpoint	Std	Conf
			OP	Output demand		
			Tr	Time remaining		
			ELAP	Time elapsed		
			AL	Alarm 1 setpoint		
			Ct	Current transformer		
			CLr	No parameter		
			tmr	Time remaining		
			t.sp	Target setpoint		
			no.PV	PV is not displayed		
			Stby	PV is not displayed when the controller is in standby mode		
K.LOC	KEYBOARD LOCK	To limit operation of the front panel buttons when in operator levels. ☺ If ALL has been selected, then to restore access to the keyboard, power up the controller with the button held down and enter the configuration level passcode. This will take you to the Quick Code mode. Press to EXIT and select YES. The front panel buttons can then be operated as normal.	none	Unlocked	none	Conf
			ALL	All buttons locked		
			Edit	Edit keys locked See Note 2		
			Mod	Mode keys locked See Note 3		
			Man	Manual mode locked		
			Stby	Press and to toggle between normal operation and standby mode		
			tmr	FEATURE UNAVAILABLE		
COLD	COLD START ENABLE/ DISABLE	**Use this parameter with care.** When set to yes the controller will return to factory settings on the next power up	No	Disable	No	Conf
			YES	Enable		
stby.t	STANDBY TYPE	Turn ALL outputs off when the controller is in standby mode. Typical use when event alarms are used to interlock a process.	Abs.a	Absolute alarms to remain active	abs.a	Conf
			Off	All alarms off in standby		
meter	METER CONFIGURATION See Note 4	To configure the analogue meter to indicate any one of the parameters listed.	OFF	Meter display disabled		Conf
			HEAT	Heat Output demand		
			COOL	Cool output demand		
			w.sp	Working setpoint		
			pV	Process value		
			Op	Heat output demand		
			C.OP	Cool output demand		
			err	Error (SP – PV)		
			amps	Output current		
			LCur	Load current from CT		

Note 1

Home Display Configuration

The upper display always shows PV, the lower display is configurable.

Std In automatic control the lower display shows setpoint. In manual mode output power is shown.

OP Output power is shown in both automatic and manual modes.

AL1 First configured alarm setpoint

Ct CT current

CLr Blank display

no.pv The upper display is blank

Stby The upper display blanks when the controller is in standby mode.

Note 2

Edit keys locked. Parameters cannot be changed but viewed only.

Note 3

Mode key locked. Auto/Manual cannot be operated from the Mode key.

The following sections in this handbook describe the parameters associated with each subject. The general format of these sections is a description of the subject, followed by the table of all parameters to be found in the list, followed by an example of how to configure or set up parameters.

Note 4

Meter Configuration

HEAT The meter shows a representation of the heat output being applied by the control loop to the load. It is scaled between 0 and 100% full scale deflection.

Op The meter displays the current Control Output setting scaled between the low and high output power limits.

COOL The meter shows a representation of the cool output being applied by the control loop to the load. It is scaled between 0 and 100% full scale deflection.

C.OP The meter displays the current output power setting scaled between -100 and 100%, so that a value of zero is centred in the display. This indicates whether the controller is currently applying heating or cooling.

w.sp The meter shows a representation of the current working setpoint, scaled between the setpoint high and low limits. It may be used to indicate at what point in the setpoint range the instrument is currently operating.

PV The meter displays the current Process Variable scaled between the range high and low values. Provides an indication of the current temperature relative to the range of a process.

Err The meter displays the process error (i.e. the difference between the current temperature and the setpoint), scaled between +10 degrees and -10 degrees. This provides a visual indication of whether the process is close to setpoint.

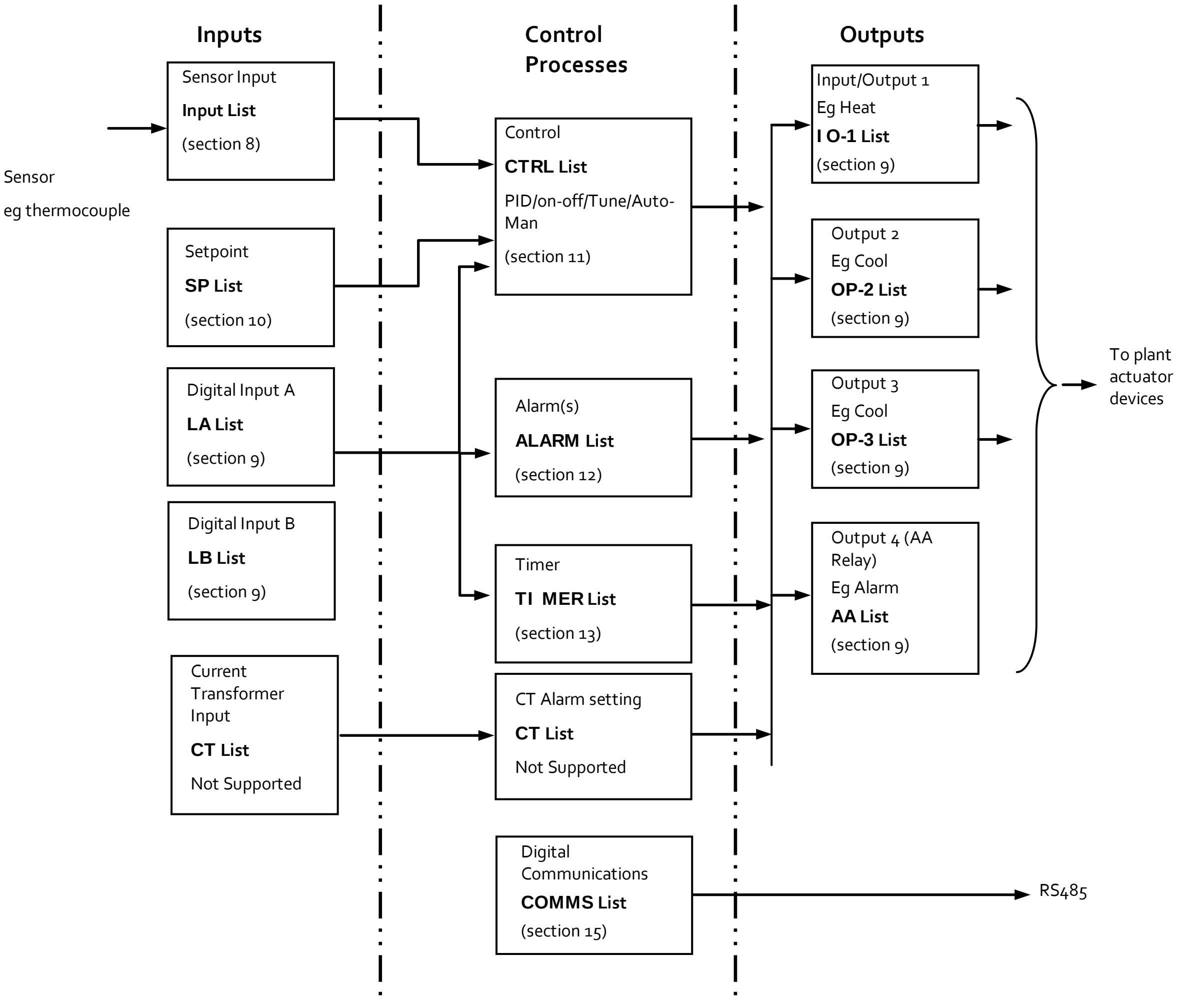
Amps The meter shows a representation of the instantaneous current through a load monitored using a current transformer, scaled between 0 Amps and the configured range of the Current Transformer. It may be used to visually indicate the health of the heating elements, since in normal use it will tend to flick from a low reading when the heating is off, to a higher reading when the heating is on. If the needle does not return to a low value, the SSR may be conducting regardless of the logic signal driving it. If the needle does not reach the expected level it is likely that one or more of the heater elements has burned out.

Lcur The meter displays a representation of the On State Current in a load monitored by the current transformer option. In normal operation it will tend to remain static and provides an alternative means of monitoring the health of a heating element to the 'Amps' option.

7. Controller Block Diagram

The block diagram shows the simple building blocks which make up the controller. Each block has a list of parameters headed by a list name. For example the 'Input List' contains parameters which define the input type.

The quick start code automatically sets the parameters to match the hardware.



The Temperature (or Process Value, PV) is measured by the sensor and compared with a Setpoint (SP) set by the user.

The purpose of the control block is to reduce the difference between SP and PV (the error signal) to zero by providing a compensating output to the plant via the output driver blocks.

The timer blocks may be made to operate on a number of parameters within the controller, and digital communications provides an interface to data collection and control.

The way in which each block performs is defined by its internal parameters. Some of these parameters are available to the user so that they can be adjusted to suit the characteristics of the process which is to be controlled.

These parameters are found in lists and the name of each list corresponds with the name of the function block shown in the above diagram.

8. Temperature (or Process) Input

Parameters in the input list configure the input to match your sensor. These parameters provide the following features:

Input Type and linearisation	Thermocouple (TC) and 3-wire resistance thermometer (RTD) temperature detectors Linear input (-10 to +80mV). 0-10V using external voltage divider. mA assumes a 2.49Ω external shunt. See the table in section 8.1.1. for the list of input types available
Display units and resolution	The change of display units and resolution will all the parameters related to the process variable
Input filter	First order filter to provide damping of the input signal. This may be necessary to prevent the effects of excessive process noise on the PV input from causing poor control and indication. More typically used with linear process inputs.
Fault detection	Sensor break is indicated by an alarm message 'Sbr'. For thermocouple it detects when the impedance is greater than pre-defined levels; for RTD when the resistance is less than 12Ω.
User calibration	Either by simple offset or by slope and gain. See section 8.2. for further details.
Over/Under range	When the input signal exceeds the input span by more than 5% the PV will flash indicating under or over range. If the value is too high to fit the number of characters on the display 'HHHH' or 'LLLL' will flash. The same indications apply when the display is not able to show the PV, for example, when the input is greater than 999.9°C with one decimal point.

8.1 Process Input Parameters

INPUT LIST	I NPUT					
Name	Scrolling Display	Parameter Description	Value		Default	Access Level
IN.TYP	INPUT TYPE	Selects input linearisation and range	See section 8.1.1. for input types available			Conf L3 R/O
UNITS	DISPLAY UNITS	Display units shown on the instrument	none	No units - only for custom linearisation	°C	L3
			°C	Celsius		
			°F	Fahrenheit		
			°k	Kelvin		
			PErc	%		
DEC.P	DISPLAY POINTS	Decimal point position	nnnn	No DP	nnnn	Conf L3 R/O
			nnn.n	One DP		
			nn.nn	Two DP		
RNG.HI	RANGE HIGH LIMIT	Range high limit for thermocouple RTD and mV inputs	From the high limit of the selected input type to the 'Low Range Limit' parameter minus one display unit.			Conf L3 R/O
RNG.LO	RANGE LOW LIMIT	Range low limit for thermocouple RTD and mV inputs	From the low limit of the selected input type to the 'High Range Limit' parameter minus one display unit.			Conf L3 R/O
PV.OFS	PV OFFSET	A simple offset applied to all input values. See section 8.2.	Generally one decimal point more than PV			L3
FILT.T	FILTER TIME	Input filter time	OFF to 100.0 seconds		1.6	L3
CJ.typ	CJC TYPE	Configuration of the CJC type	Auto		Automatic	Auto
			0°C		Fixed at 0°C	
SB.typ	SENSOR BREAK TYPE	Defines the action which is applied to the control output if the sensor breaks (open circuit). See also section 8.1.2	50°C	Fixed at 50°C	on	Conf and if T/C L3 R/O
			oFF	No sensor break will be detected		
			on	Open circuit sensor will be detected		
CJC.in Pv.in	CJC TEMPERATURE PV INPUT VALUE	Temperature measured at the rear terminal block. Used in the CJC calculation Current measured temperature	Lat	Latching	Conf L3 R/O and if T/C Conf L3 R/O	Conf L3 R/O
			Read only			
			Minimum display to maximum display range			
mv.in	MILLIVOLT INPUT VALUE	Millivolts measured at the rear PV Input terminals	xx.xx mV - read only			Conf L3 R/O

INPUT LIST	I NPUT				
Name	Scrolling Display	Parameter Description	Value	Default	Access Level
Rc.ft	ROC FILTER TIME	This provides a first order filter for the rate of change filtering function and can be used to avoid nuisance alarm triggers due to short duration noise on the calculated rate of change,	oFF to 0.1 to 999.9 minutes Off means no filtering applied	1.6	L3
RC.PV	PV DERIVATIVE	Provides a measure of the calculated rate of change of the temperature or measurement input as used by the Rate of Change Alarm functions. Useful when commissioning to determine the level of filtering required on the Rate of Change alarm.			L3

8.1.1 Input Types and Ranges

Input Type		Min Range	Max Range	Units	Min Range	Max Range	Units
J.tc	Thermocouple type J	-210	1200	°C	-346	2192	°F
k.tc	Thermocouple type K	-200	1372	°C	-328	2502	°F
L.tc	Thermocouple type L	-200	900	°C	-328	1652	°F
r.tc	Thermocouple type R	-50	1700	°C	-58	3092	°F
b.tc	Thermocouple type B	0	1820	°C	32	3308	°F
n.tc	Thermocouple type N	-200	1300	°C	-328	2372	°F
t.tc	Thermocouple type T	-200	400	°C	-328	752	°F
S.tc	Thermocouple type S	-50	1768	°C	-58	3215	°F
Rtd	Pt100 resistance thermometer	-200	850	°C	-328	1562	°F
mv	mV or mA linear input	-10.00	80.00				
Cms	Value received over digital communications (modbus address 203). This value must be updated every 5 seconds or the controller will show sensor break						

8.1.2 Operation of Sensor Break

Sensor break type (SB.TYP) can be set to operate in three different modes:

1. Off
2. On
3. Latching

SB.TYP = Off

Type of Output	Output in Sensor Break	Alarm State
For heat + cool, OP.HI and OP.LO can be set between ±100%	OP.HI (100%) Safe value has no effect	No alarm indication will be displayed
For heat only OP.HI and OP.LO can be set between 0.0% and +100%	OP.HI (100%) Safe value has no effect	
For cool only OP.HI and OP.LO can be set between -100.0% and 0%	OP.HI (0%) Safe value has no effect	

SB.TYP = on

Type of Output	Output in Sensor Break	Alarm State
For heat + cool, OP.HI and OP.LO can be set between ±100%	'SAFE' value provided it is not set outside the output limits, otherwise it will adopt OP.HI	ALM beacon flashes when an alarm occurs. Output alarm relay activates. ACK has no effect. When the sensor break condition is no longer applicable the alarm indication and output cancel.
For heat only OP.HI and OP.LO can be set between 0.0% and +100%		
For cool only OP.HI and OP.LO can be set between -100.0% and 0%		

SB.TYP = Lat (Alarm latching)

Type of Output	Output in Sensor Break	Alarm State
For heat + cool, OP.HI and OP.LO can be set between ±100%	'SAFE' value provided it is not set outside the output limits. i.e. the same as Sbrk = on	ALM beacon flashes when an alarm occurs. Output alarm relay activates. ACK has no effect. When the sensor break condition is no longer applicable it is necessary to press ACK to cancel the alarm.
For heat only OP.HI and OP.LO can be set between 0.0% and +100%		
For cool only OP.HI and OP.LO can be set between -100.0% and 0%		

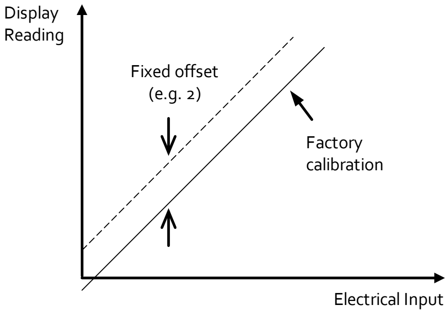
Note: When the SAFE output value is outside the OP.LO and OP.HI limits it will be clipped into range and the controller will use the value (i.e. adjusting OP.LO or OP.HI changes the SAFE value so that it is in range).

It could take either the lower or higher OP limit depending on its value and which limit has changed. Therefore, if SAFE = 0 and OP.LO is changed to 10, SAFE will also be set to 10. If SAFE = 50 and OP.HI is changed to 40, SAFE will change to 40.

8.2 PV Offset

All ranges of the controller have been calibrated against traceable reference standards. This means that if the input type is changed it is not necessary to calibrate the controller. There may be occasions, however, when you wish to apply an offset to the standard calibration to take account of known errors within the process, for example, a known sensor error or a known error due to the positioning of the sensor. In these instances it is not advisable to change the reference (factory) calibration, but to apply a user defined offset.

PV Offset applies a single offset to the temperature or process value over the full display range of the controller and can be adjusted in Level 3. It has the effect of moving the curve up a down about a central point as shown in the example below:



8.2.1 Example: To Apply an Offset:

Connect the input of the controller to the source device which you wish to calibrate to

Set the source to the desired calibration value

The controller will display the current measurement of the value

If the display is correct, the controller is correctly calibrated and no further action is necessary. If you wish to offset the reading:

Do This	Display	Additional Notes
1. Select Level 3 or Conf. Then press to select 'INPUT'	INPUT	Scrolling display 'process input list'
2. Press to scroll to 'PV/OFS' 3. Press or to adjust the offset to the reading you require	2.0 pv.ofs	Scrolling display 'p v offset' In this case an offset of 2.0 units is applied

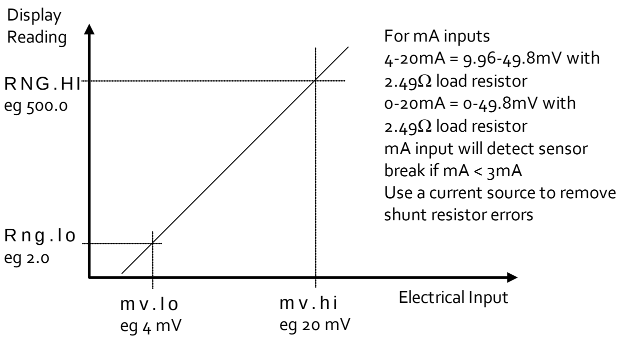
It is also possible to apply a two point offset which adjusts both low and high points. This is done in Level 3 using the CAL List, and the procedure is described in the Calibration section 15.

8.3 PV Input Scaling

Input scaling applies to the linear mV input range only. This is set by configuring the INPUT TYPE parameter to mV and has an input range of –10 to 80mV. Using an external burden resistor of 2.49Ω, the controller can be made to accept 4-20mA from a current source. Scaling of the input will match the displayed reading to the electrical input levels from the transducer. PV input scaling can only be adjusted in Configuration level and is not provided for direct thermocouple or RTD inputs.

The graph below shows an example of input scaling, where it is required to display 2.0 when the input is 4mV and 500.0 when the input is 20mV .

If the input exceeds ±5% of the mV.Lo or mV.Hi settings, sensor break will be displayed.



8.3.1 Example: To Scale a Linear Input

Select Configuration level as described in section 6.1.3. Then:

Do This	Display	Additional Notes
1. Then press to select 'INPUT'	input	Scrolling display 'process input list'
2. Press to scroll to 'IN.TYP' 3. Press or to 'mV'	mv in.typ	Scrolling display 'input type'
4. Press to scroll to 'MV.HI' 5. Press or to '20.00'	20.00 mv.hi	Scrolling display 'linear input high'
6. Press to scroll to 'MV.LO' 7. Press or to '4.00'	4.00 mv.lo	Scrolling display 'linear input low'
8. Press to scroll to 'RHG.HI' 9. Press or to '500.0'	500.0 rhg.hi	In operator level the controller will read 500.0 for a mV input of 20.00
10. Press to scroll to 'RNG.LO' 11. Press or to '2.0'	2.0 rhg.lo	In operator level the controller will read 2.0 for a mV input of 4.00

9. Input/Output

This section refers to:

- Digital Inputs
- Relay/Logic Outputs.

The availability of these is shown in the following table:

Name	Output	Input	Output Function	I/O Sense	Beacon (lit when active)	Terminal
I/O-1	✓	✓	Heat Cool Alarm	Normal Inverted	OP1	1A, 1B
OP-2	✓		Heat Cool Alarm	Normal Inverted	OP2	2A, 2B
OP-3	✓		Heat Cool Retransmission (setpoint, temperature, output)		OP3	3A, 3B
OP4 (AA Relay)	✓		Heat Cool Alarm	Normal Inverted	OP4	AA, AB, AC
LA		✓		Normal Inverted		C, LA
LB		✓		Normal Inverted		LB, LC
Digital Comms						HD, HE, HF

9.1 Input/Output Parameters

9.1.1 Input/Output 1 List (IO-1)

May be configured as relay, logic ON/OFF. Connections are made to terminals 1A and 1B. OP1 beacon is operated from the IO-1 channel when it is configured as an output.

INPUT/OUTPUT LIST 1 'I O -1 '						
Name	**Scrolling Display**	**Parameter Description**	**Value**		**Default**	**Access Level**
1.i d	I/O 1 TYPE	I/O channel 1 hardware type defined by the hardware fitted			As ordered	Read only
1.FUNC	I/O 1 FUNCTION	I/O channel function. If the instrument is ordered as valve positioner (codes VC or VP), only options available are , none, d.out, UP, or dwn **Note: If output 1 is set to Up ensure the other valve position output is set to dwn and vice versa**	none	Disabled. If disabled no further parameters are shown	As ordered	Conf
			d.out	Digital output		
			Heat	Heat output		
			CooL	Cool output		
1.SRC.A	I/O 1 SOURCE A	These parameters only appear when the channel function is a Digital output, i.e. 1.FUNC = d.out Selects an event status to be connected to the output channel. The output status is the result of an OR of Src A, Src B, Src C, and Src D Up to four events can, therefore, operate the output	none	No event connected to the output	none	Conf
1.SRC.B	I/O 1 SOURCE B		AL1	Alarm 1		
			AL2	Alarm 2		
1.SRC.C	I/O 1 SOURCE C		AL3	Alarm 3		
			AL4	Alarm4		
			ALL.A	All alarms		
			nw.AL	Any new alarm		
			Ct.AL	CT alarm, load, leak & overcurrent		
			Lbr	Loop break alarm		
			Sbr	Sensor break alarm		
			t.End	FEATURE UNAVAILABLE		
			t.run	FEATURE UNAVAILABLE		
			mAn	Manual status		
			rmt.F	Remote fail		
			Pwr.f	Power fail		
			prg.e	FEATURE UNAVAILABLE		
1.SENS	I/O 1 SENSE	To configure the sense of the input or output channel	nor Inv	Normal Inverted	nor	Conf

Note 1:

A DC output may require calibration. This is described in section 15.

9.1.2 Remote Digital Setpoint Select and Remote Fail

These parameters were added in software version 1.11, and subsequent versions, and are associated with the retransmission of remote setpoint through master comms. 'rmt' allows the remote setpoint to be selected via a digital input and 'rmt.F' is a flag which is set if no comms activity is detected for 5 seconds or more when writing to the remote setpoint. The flag is reset when writing to the remote setpoint resumes.

9.1.3 Sense

If the module is an output, 'normal' means a relay output is energised for 100% PID demand. For a heating or cooling output, set this parameter to 'nor'.

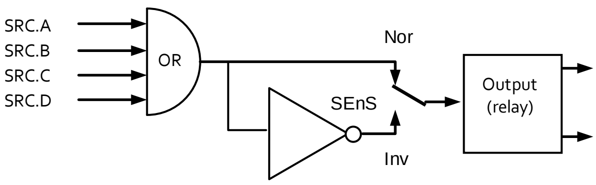
'Inverted' means a relay output is energised for 0% PID demand

For an alarm output set this parameter to 'Inv' so that it de-energises to the alarm state.

If the module is an input, 'normal' means the function is activated when the input contact is closed, and 'inverted' means the function is activated when the input contact is open.

9.1.4 Source

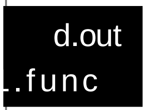
The four parameters SOURCE A, SOURCE B, SOURCE C, and SOURCE D appear when the output is configured as a digital output i.e. '-.FUNC' = 'd.Out' and provide the facility to connect up to four alarms or events to operate a single output (normally configured as a relay). If any one of the events becomes true then the output relay will operate.



9.1.5 Power Fail

An output, configured as a digital output, can be made to operate following a power fail. It can be acknowledged in the same manner as an alarm but no alarm message is given.

9.1.6 Example: To Configure IO-1 Relay to Operate on Alarms 1 and 2:

Do This	Display	Additional Notes
1. From any display, press (page button) as many times as necessary to select 'I O -1'		Scrolling display '**i o - 1 list**'
2. Press (scroll button) to scroll to '1. I D '		This is the identification of the hardware fitted and cannot be adjusted.
3. Press (scroll button) to scroll to '1. F U N C ' 4. Press (up) or (down) to select '**d.out**'		The output is configured as a digital output function. Scrolling display '**i o 1 functi o n**'
5. Press (scroll button) to scroll to '1. S R C . A' 6. Press (up) or (down) to select the event which you want to operate the output, eg '**AL.1**'		The output will activate if either alarm 1 or alarm 2 occur . Scrolling display '**i o 1 source a**'
7. If a second event is required to operate the same output, press (scroll button) to select '1. S R C . B' 8. Press (up) or (down) to select the second event which you want to operate the output, eg '**AL.2**'		Scrolling display '**i o 1 source b**' Continue to select up to four events if required using 1.**SRC.C** and **1.SRC.D**
9. Press (scroll button) to scroll to '1. **S E N S**' 10. Press (up) or (down) to select '**Inv**'		'Inverted' means a relay output is energised for 0% PID demand 'Normal' means a relay output is energised for 100% PID demand Scrolling display '**io 1 sense**'

9.1.7 Output List 2 (OP-2)

This is an optional normally open relay and is available on terminals 2A and 2B. The way in which this output operates is determined by parameters in the OP- 2 List. OP2 beacon is operated from this output channel.

OUTPUT LIST 2 'op-2'						
Name	**Scrolling Display**	**Parameter Description**	**Value**		**Default**	**Access Level**
2.i d	OUTPUT 2 TYPE	Output channel 2 hardware type	reLy	Relay output	As ordered	Read only
2.FUNC	FUNCTION	Output channel 2 function If the instrument is ordered as valve positioner (codes VC or VP), only options available are , none, d.out, UP, or dwn **Note: If output 2 is set to Up ensure the other valve position output is set to dwn and vice versa**	none	Disabled. If disabled no further parameters are shown	As ordered	Conf
			d.out	Digital output		
			Heat	Heat output		
			CooL	Cool output		
2.SRC.A	I/O 2 SOURCE A	These parameters only appear when the channel function is a Digital OP, i.e. 2.FUNC = d.Out	none	No event connected to the output	none	Conf
			AL1	Alarm 1 *		
2.SRC.B	I/O 2 SOURCE B		AL2	Alarm 2 *		
			AL3	Alarm 3 *		
2.SRC.C	I/O 2 SOURCE C	Selects an event status to be connected to the output channel.	AL4	Alarm4 *		
			ALL.A	All alarms		
2.SRC.D	I/O 2 SOURCE D		nw.AL	Any new alarm		
		The output status is the result of an OR of Src A, Src B, Src C, and Src D	Ct.AL	CT alarm, load, leak & overcurrent		
			Lbr	Loop break alarm		
			Sbr	Sensor break alarm		
		Up to four events can, therefore, operate the output	mAn	Manual status		
			rmt.F	Remote fail		
			Pwr.f	Power fail		
			prg.e	FEATURE UNAVAILABLE		
2.SENS	SENSE	To configure the polarity of output channel 2	nor	Normal	nor	Conf

* The mnemonic for the alarm will change depending upon the alarm configuration.

9.1.8 Output List 3 (OP-3)

This is a normally 4-20 or 0-20mA isolated dc output. The way in which this output operates is determined by parameters in the OP- 3 List. OP3 beacon is operated from this output channel.

OUTPUT LIST 3 'op-3'						
Name	**Scrolling Display**	**Parameter Description**	**Value**		**Default**	**Access Level**
3.i d	OUTPUT 3 TYPE	Output channel 3 hardware type	nonE	Output not fitted	As ordered	Read only
			dC.Op	0-20mA output See note 1		
3.FUNC	FUNCTION	Output channel 3 function If the instrument is ordered as valve positioner (codes VC or VP), only options available are , none, d.out, UP, or dwn **Note: If output 3 is set to Up ensure the other valve position output is set to dwn and vice versa**	none	Disabled. If disabled no further parameters are shown	d.out	Conf
			Heat	Heat output		
			CooL	Cool output		
			w.sp	Working setpoint re-transmission	Shown if I/O 3 TYPE = dc.OP Retransmission	
			pV	Process variable re-transmission		
			Op	Output re-transmission		
			Inv	Inverted		
3.rng	DC OUTPUT RANGE	DC output calibration. Only shown if 3.i d = dC.Op	4.20	4-20mA	4.20	Conf
			0.20	0-20mA		

Note 1: A DC output may require calibration.

9.1.9 AA Relay (AA) (Output 4)

This is a changeover relay. Connections are made to terminals AA, AB, and AC. The way in which this relay operates is determined by parameters in the AA List. OP4 beacon is operated from the AA relay output channel.

AA RELAY 'aa'						
Name	**Scrolling Display**	**Parameter Description**	**Value**		**Default**	**Access Level**
4.TYPE	OUTPUT 4 TYPE	Output channel 4 hardware type	reLy	Relay output	reLy	Read only
4.FUNC	FUNCTION	Output channel 4 function If the instrument is ordered as Valve Position (codes VC or VP), only values none, d.out, UP, or dwn are available **Note: If output 4 is set to up ensure the other valve position output is set to dwn and vice versa**	none	Disabled	d.OUt	Conf
			d.OUt	Digital output		
			Heat	Heat output		
			CooL	Cool output		
4.SRC.A	I/O 4 SOURCE A	These parameters only appear when the channel function is a Digital OP, i.e. 4.FUNC = d.Out Selects an event status to be connected to the output channel. The output status is the result of an OR of Src A, Src B, Src C, and Src D Up to four events can, therefore, operate the output	none	No event connected to the output	none	Conf
			AL1	Alarm 1 *		
4.SRC.B	I/O 4 SOURCE B		AL2	Alarm 2 *		
			AL3	Alarm 3 *		
4.SRC.C	I/O 4 SOURCE C		AL4	Alarm4 *		
			ALL.A	All alarms		
4.SRC.D	I/O 4 SOURCE D		nw.AL	Any new alarm		
			Ct.AL	CT alarm, load, leak & overcurrent		
			Lbr	Loop break alarm		
			Sbr	Sensor break alarm		
			mAn	Manual status		
			rmt.F	Remote fail		
			Pwr.f	Power fail		
			prg.e	FEATURE UNAVAILABLE		
4.SENS	SENSE	To configure the polarity of output channel 4	nor	Normal	nor	Conf
			Inv	Inverted		

* The mnemonic for the alarm will change depending upon the alarm configuration.

9.1.10 Digital Input Parameters

Digital Input A. This is an optional input wired to terminals C and LA. The input is typically from a voltage free contact, which can be configured to operate a number of functions as determined by parameters in the LA List.

Note: Terminal C is common to the CT input and is, therefore, not isolated from the CT.

Digital Input B. This is wired to terminals LB and LC.

The parameter lists for LB are identical as shown below:

LOGIC INPUT LIST 'l a ' / 'LB'						
Name	**Scrolling Display**	**Parameter Description**	**Value**		**Default**	**Access Level**
L.TYPE	LOGIC INPUT TYPE	Input channel type	L.IP	Logic input		Conf Read only
L.d.i n	LOGIC INPUT FUNCTION	To configure the function of the digital input	none	Input not used	Ac.AL	Conf
			Ac.AL	Alarm acknowledge		
			SP2	Setpoint 2 select		
			Loc.b	Front keypad disable		
			Man	Manual status		
			Sby	Standby mode. In this mode control outputs go to zero demand		
			rmt	To allow a remote setpoint to be selected through the LA digital input.		
			UP	Remote key 'Up'		
			dwn	Remote key 'Down'		
L.SENS	LOGIC INPUT SENSE	To configure the polarity of the input channel	nor	Normal	nor	Conf
			Inv	Inverted		

9.2 Current Transformer Input Parameters (Current Transformer is not available)

This is not available on Series 3 controllers.

Measures, via an external current transformer, the current flowing through the electrical load when the heat output is 'on' (load current) and also when it is 'off' (leakage current).

Alarm	If the load current is lower than a threshold limit or the leakage current is higher than a threshold limit, then an alarm triggers. The hysteresis to exit from either of these alarm conditions is fixed at 2% of the current transformer span.
Full scale value	Selectable from 10 to 1000A

CURRENT TRANSFORMER LIST 'CT-iNP'						
Name	**Scrolling Display**	**Parameter Description**	**Value**		**Default**	**Access Level**
Ct.Id	MODULE TYPE	CT module identity	Ct.In	CT input circuit fitted		Conf read only
CT.SRC	CT SOURCE	Selects the output controlling the current measured by the CT input. The source can only be selected if the output has been configured for Heat or Cool	none	None		
			IO-1	Input/output 1		
			OP-2	Output 2		
			aa	AA Relay		
CT.RNG	CT RANGE	Sets the CT inputs range	0 to CT full scale value (1000)			Conf
CT.LAT	CT ALARM LATCH TYPE	To configure the latch mode of the CT input alarm. A description of alarm latching is given in the alarm section	nonE	No latching	no	Conf if CT alarm enabled
			Auto	Latched with automatic reset		
			man	Latched with manual reset		
Ld.alm	LOAD CURRENT THRESHOLD	Load open circuit alarm threshold – low alarm	Off to CT full scale value (settable to 3000)			Read only
LK.ALM	LEAK CURRENT THRESHOLD	Leakage current in the off state alarm threshold – high alarm	Off to CT full scale value (settable to 3000)			Read only
Hc.alm	OVER CURRENT THRESHOLD	Overcurrent threshold – high alarm	Off to CT full scale value (settable to 3000)			
LD.AMP	LOAD CURRENT	Measured load current				L3 if CT input enabled
LK.AMP	LEAK CURRENT	CT input leakage current				L3 if CT input enabled
CT.MTR	CT METER RANGE	To set the range of the meter.	0 to 1000			L3

10. Setpoint Generator

The setpoint generator provides the target value at which it is required to control the process. It is shown in the controller block diagram. The following functions are available:

Number of setpoints	Two - setpoint 1 (SP1) and setpoint 2 (SP2). Each may be selected by a dedicated parameter or externally switched via a digital input suitably configured. An application example might be to use SP1 for normal operation and SP2 to maintain a low overnight temperature.
Setpoint limits	High and low limits can be pre-set to prevent inadvertent adjustment of the setpoint beyond that allowable for the process
Set point rate limit	Allows the setpoint to change from its current level to a new level at a fixed rate.
Direct setpoint access	The selected setpoint is accessible directly from the HOME display by pressing the raise or lower buttons

10.1 Setpoint Parameters

SETPOINT LIST 'SP'						
Name	**Scrolling Display**	**Parameter Description**	**Value**		**Default**	**Access Level**
S P . S E L	SETPOINT SELECT	This enables the main or secondary setpoint to be selected form the front panel buttons	SP1	Setpoint 1 selected	SP1	L3
			SP2	Setpoint 2 selected		
S P 1	SETPOINT 1	Main or normally selected setpoint	Low to high setpoint limits		0	L3
S P 2	SETPOINT 2	Secondary or standby setpoint	Low to high setpoint limits		0	L3
S P . H I	SETPOINT HIGH LIMIT	Maximum allowable setpoint setting	Setpoint low limit (SP.LO) to high range limit. Also limited by the rng.hi and rng.lo parameters		Range High Limit	L3
S P . L O	SETPOINT LOW LIMIT	Minimum allowable setpoint setting	Low range limit to Setpoint high limit (SP.HI). Also limited by the rng.hi and rng.lo parameters		Range Low Limit	L3
r E m . s p	REMOTE SETPOINT	Reads the current remote setpoint value when remote setpoint is in use				Read only
l - r	REMOTE SETPOINT SELECT	To select the remote digital communications setpoint	No	Not selected	no	Conf
			YES	Selected		
S P . R A T	SETPOINT RATE LIMIT	Limits the rate of change of the setpoint. Operates on both SP1 and SP2	Step change (OFF) or 0.1 to 3000 display units per minute. Resolution one decimal place more than PV		Off	L3
r a m p u	SETPOINT RAMP UNITS	To set the units for the setpoint rate limit	min	Minutes	min	L3
			Hour	Hours		
			SEC	Seconds		
l o c . t	LOCAL SETPOINT TRIM	Local trim on remote setpoint. Applies a fixed offset to the remote setpoint	-199.9 to 300.0		0.0	L3
R E M . H I	REMOTE INPUT HIGH SCALAR	Sets the maximum scale limit for the remote setpoint	Between Setpoint High and Low Limits up to firmware version 2.11. From 2.11 the values can be varied within the entire instrument range. This allows, for example, a 0-5V device to be used with a 0-10V input such that the 5V can correspond to the full setpoint range.			L3
R E M . l o	REMOTE INPUT LOW SCALAR	Sets the minimum scale limit for the remote setpoint				
R o p . h i	SETPOINT RETRANS HIGH	Sets the upper limit for the setpoint retransmission	These two parameters have been added from firmware version 2.11. They replace Setpoint High and Low Limits as the outer limits for a retransmitted setpoint. In versions prior to 2.11 the transmitted setpoint is scaled against its full range. Setpoint Retrans High & Low allow the retransmitted setpoint to be scaled against a sub-range. The values correspond to the setpoint transmitted at 4 and 20mA – if the setpoint is outside this range then it is clipped.			L3
R o p . l o	SETPOINT RETRANS LOW	Sets the lower limit for the setpoint retransmission				L3

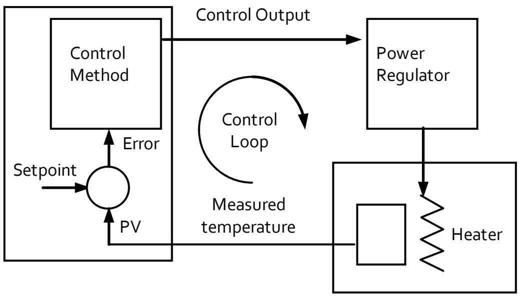
10.2 Example: To Set Ramp Rate

This is available in Level 3.

Do This	The Display You Should See	Additional Notes
1. Press as many times as necessary to select **'SETPOINT LIST'**	SP	
2. Press as many times as necessary to scroll to 'SP1' 3. Press or to adjust setpoint 1	73.00 sp1	This step can be repeated for the lower setpoint limit 'SP.LO'
4. Press to scroll to 'SP2' 5. Press or to adjust setpoint 2	50.00 sp2	
6. Press as many times as necessary to scroll to 'SP.RAT' 7. Press or to set the rate at which you require the setpoint to change	6.000 Sp.rat	Whenever the setpoint is changed, the controller will ramp from its current setpoint to the new value at the rate set in units per second, minute or hours as set by the 'RAMPU' parameter. It will also change at the same rate when switching between SP2 and SP1 (but not between SP1 and SP2) The setpoint rate resolution is generally one decimal point more than setpoint/PV resolution

11. Control

Parameters in this section allow the control loop to be set up for optimum control conditions. An example of a temperature control loop is shown below:



The actual temperature measured at the process (PV) is connected to the input of the controller. This is compared with a setpoint (or required) temperature (SP). If there is an error between the set and measured temperature the controller calculates an output value to call for heating or cooling. The calculation depends on the process being controlled but normally uses a PID algorithm. The output(s) from the controller are connected to devices on the plant which cause the heating (or cooling) demand to be adjusted which in turn is detected by the temperature sensor. This is referred to as the control loop or closed loop control.

11.1 Types of Control

Three types of control loop may be configured. These are On/Off control or PID control.

11.1.1 On/Off Control

On/Off control is the simplest means of control and simply turns heating power on when the PV is below setpoint and off when it is above setpoint. As a consequence, On/Off control leads to oscillation of the process variable. This oscillation can affect the quality of the final product and may be used on non-critical processes. A degree of hysteresis must be set in On/Off control if the operation of the switching device is to be reduced and relay chatter is to be avoided.

If cooling is used, cooling power is turned on when the PV is above setpoint and off when it is below.

It is suitable for controlling switching devices such as relays, contactors, triacs or digital (logic) devices.

11.1.2 PID Control

PID, also referred to as 'Three Term Control', is an algorithm which continuously adjusts the output, according to a set of rules, to compensate for changes in the process variable. It provides more stable control but the parameters need to be set up to match the characteristics of the process under control.

The three terms are:

Proportional band	PB
Integral time	TI
Derivative time	TD

The output from the controller is the sum of the contributions from these three terms. The combined output is a function of the magnitude and duration of the error signal, and the rate of change of the process value.

It is possible to turn off integral and derivative terms and control on proportional only (P), proportional plus integral (PI) or proportional plus derivative (PD).

PI control might be used, for example, when the sensor measuring an oven temperature is susceptible to noise or other electrical interference where derivative action could cause the heater power to fluctuate wildly.

PD control may be used, for example, on servo mechanisms.

In addition to the three terms described above, there are other parameters which determine how well the control loop performs. These include Cutback terms, Relative Cool Gain,and Manual Reset and are described in detail in subsequent sections.

11.2 Control Parameters

The control loop is configured by the parameters listed in the following table:

CONTROL LIST	'CTRL'				
Parameter Name	Parameter Description (Scrolling Display)	Value		Default	Access Level
CTRL.H	HEATING TYPE Selects the channel 1 control algorithm. Different algorithms may be selected for channels 1 and 2. In temperature control applications, Ch1 is usually the heating channel, Ch2 is the cooling channel.	Pid	PID		Conf
		off	Heating off		
		on.of	On/Off		
		MTr	Valve position control (n/a)		
CTRL.C	COOLING TYPE Selects the channel 2 Control algorithm. Different algorithms may be selected for channels 1 and 2. This is not available if the instrument is a valve position controller	oFF	Cooling disable		Conf
		pid	PID		
		on.of	On/Off		
CTRL.A	CONTROL ACTION Selects the direction of the control. i.e reverse or direct acting.	rev	Reverse acting. Output decreases as PV increases	rev	Conf
		dir	Direct acting. Output increases as PV decreases		
PB.UNT	PROPORTIONAL BAND UNITS	enG	In engineering units		
		Perc	In percent		
ATUNE	AUTO-TUNE ENABLE	OFF	Auto-tune off	OFF	L3
		On	Set to 'on' to start auto-tuning		
		FaiL	Displayed if Autotune cannot be completed		
AT.R2G	AUTOTUNE CONFIGURES R2G	YES	R2G will be set by Auto-tune	yes	Conf
		No	Allows a value for R2G to be entered manually		
PB	PROPORTIONAL BAND	0.1 to 9999 display units or 1 to 999.9% if proportional band expressed as %		20	L3
TI	INTEGRAL TIME	Off to 9999 seconds		360 sec	L3
TD	DERIVATIVE TIME	Off to 9999 seconds TD defaults to OFF for valve position control		60 sec	L3
R2G	RELATIVE COOL GAIN	0.1 to 10.0		1.0	L3
CBHi	CUTBACK HIGH	Auto or 1to 3000 display units		Auto = 3xPb	L3
CBLo	CUTBACK LOW	Auto or 1 to 3000 display units		Auto = 3XPb	L3
MR	MANUAL RESET	0.0 to 100.0% (heat only) -100.0 to 100.0% (heat/cool)		0.0%	L3
LBT	LOOP BREAK TIME The loop break alarm attempts to detect loss of restoring action in the control loop by checking the control output, the process value and its rate of change. Loop break detection works for all control algorithms: PID, VP and ON-OFF. Note: This is not to be confused with load failure and partial load failure.	Off	Setting loop Break Time to OFF disables the Loop Break Alarm	OFF	L3
		1 to 9999 minutes			
OP.HI	OUTPUT HIGH Adjust to limit the maximum heating power applied to the process	±100.0%		100.0%	L3

CONTROL LIST 'CTRL'

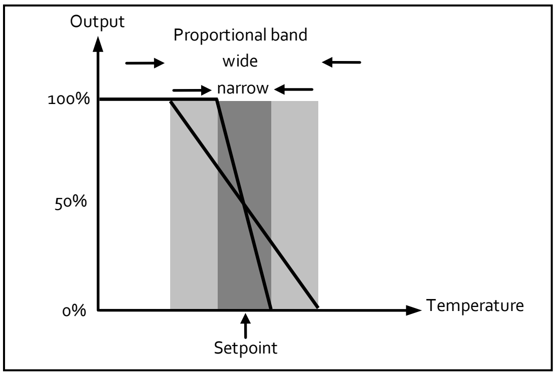
Parameter Name	Parameter Description (Scrolling Display)	Value		Default	Access Level
OP.LO	OUTPUT LOW Adjust to limit the maximum cooling power applied to the process or to apply a minimum heating power	±100.0%		0.0 (heat only) -100 (cool)	L3
D.BAND	CHANNEL 2 DEAD BAND Period when no output is demanded from either channel 1 or channel 2 Adjust, for example, to increase the period when no heating or cooling power is applied	Off or 0.1 to 100.0% of the cooling proportional band		OFF	L3
HYST.H	HEATING HYSTERESIS	1 to 9999 display units		1	L3 On/off only
HYST.C	COOLING HYSTERESIS			1	
SAFE	SAFE OUTPUT POWER To set the output level in a sensor break (open circuit) condition	-100.0 to 100.0% limited by OP.HI and OP.LO		0.0%	L3
F.MOD	FORCED MANUAL OUTPUT MODE Selects how the loop behaves on transfer from Auto to Manual. Transfer from Manual to Auto is always bumpless.	none	Transfer between Auto/Manual/Auto is bumpless	none	L3
		SteP	Transfer from Auto to Manual, the output goes to a pre-set value (F.OP)		
		Last	Transfer from Auto to Manual, the output goes to the previously set manual value		
Cool.t	NON-LINEAR COOLING TYPE This selects an algorithm most suited to the type of cooling. Typically used in extruders.	Lin	Linear		Conf
		OIL	Oil cooling		
		H20	Water cooling		
		Fan	Forced air cooling		
F.OP	FORCED OUTPUT To pre-set a value for the Manual output when F.MOD = STEP	-100.0 to 100.0% limited by OP.HI and OP.LO		0.0	L3
A-M	LOOP MODE – AUTO MANUAL OFF	Auto	To select automatic operation		L3
		Man	To select manual operation		
		OFF	Control outputs inhibited		
lbr	LOOP BREAK STATUS	No	Shows the current status of loop break.		Read only
		YES			
TU.HI	TUNE HIGH LIMIT. Set this to limit the maximum heating output during autotune		Range between OP.HI and OP.LO ±100.0		L3
TU.LO	TUNE LOW LIMIT. Set this to limit the maximum cooling output during autotune				

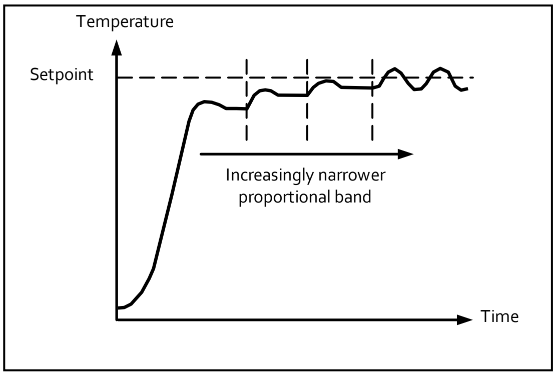
Parameters are further described in the following sections.

11.2.1 Proportional Band 'PB'

The proportional band, or gain, delivers an output which is proportional to the size of the error signal. It is the range over which the output power is continuously adjustable in a linear fashion from 0% to 100% (for a heat only controller). Below the proportional band the output is full on (100%), above the proportional band the output is full off (0%) as shown in the diagram below.

The width of the proportional band determines the magnitude of the response to the error. If it too narrow (high gain) the system oscillates by being over responsive. If it is too wide (low gain) the control is sluggish. The ideal situation is when the proportional band is as narrow as possible without causing oscillation.





The diagram also shows the effect of narrowing proportional band to the point of oscillation. A wide proportional band results in straight line control but with an appreciable initial error between setpoint and actual temperature. As the band is narrowed the temperature gets closer to setpoint until finally becoming unstable.

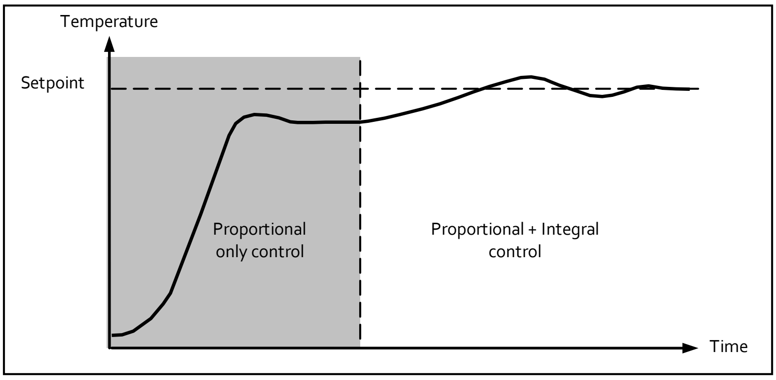
The proportional band may be set in engineering units or as a percentage of the controller range.

11.2.2 Integral Term 'TI'

In a proportional only controller, an error between setpoint and PV must exist for the controller to deliver power. Integral is used to achieve **zero** steady state control error.

The integral term slowly shifts the output level as a result of an error between setpoint and measured value. If the measured value is below setpoint the integral action gradually increases the output in an attempt to correct the error. If it is above setpoint integral action gradually decreases the output or increases the cooling power to correct the error.

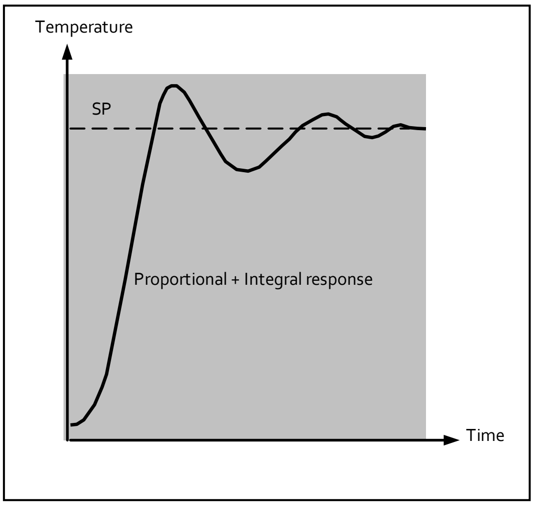
The diagram below shows the result of introducing integral action.

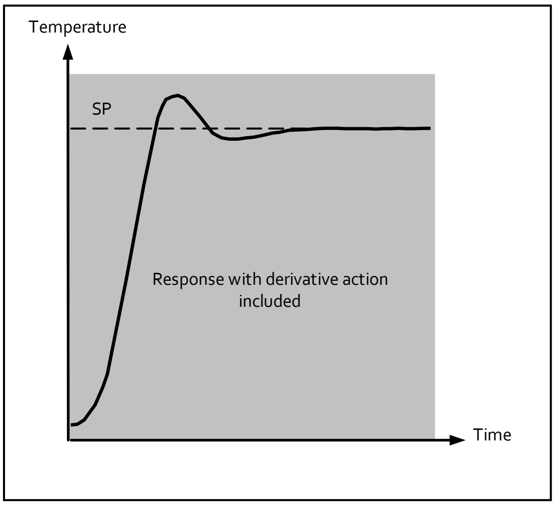


The units for the integral term are measured in time (1 to 9999 seconds in Series 3 controllers). The longer the integral time constant, the more slowly the output is shifted and results in a sluggish response. Too small an integral time will cause the process to overshoot and even oscillate. The integral action may be disabled by setting its value to Off.

11.2.3 Derivative Term 'TD'

Derivative action, or rate, provides a sudden shift in output as a result of a rapid change in error. If the measured value falls quickly, derivative provides a large change in output in an attempt to correct the perturbation before it goes too far. It is most beneficial in recovering from small perturbations.





The derivative modifies the output to reduce the rate of change of error. It reacts to changes in the PV by changing the output to remove the transient. Increasing the derivative time will reduce the settling time of the loop after a transient change.

Derivative is often mistakenly associated with overshoot inhibition rather than transient response. In fact, derivative should not be used to curb overshoot on start up since this will inevitably degrade the steady state performance of the system. Overshoot inhibition is best left to the approach control parameters, High and Low Cutback.

Derivative is generally used to increase the stability of the loop, however, there are situations where derivative may be the cause of instability. For example, if the PV is noisy, then derivative can amplify that noise and cause excessive output changes. In these situations it is often better to disable the derivative and re-tune the loop.

If set to Off(0), no derivative action will be applied.

In Series 3 controllers, derivative is calculated on change of PV. For applications such as furnace temperature control, it is common practice to use Derivative on PV to prevent thermal shock caused by a sudden change of output as a result of a change in setpoint.

11.2.4 Relative Cool Gain 'R2G'

The proportional band parameter 'PB' adjusts the proportional band for the heating output. Relative cool gain adjusts the cooling proportional band relative to the heating proportional band. If the rate of heating and rate of cooling are widely different, it may be necessary to manually adjust Relative Cool Gain to achieve the optimum settings for the cooling proportional band. A nominal setting of around 4 is often used.

Note, this parameter is set automatically when Auto-tune is used unless the parameter 'AT.R2G' is set to 'No'.

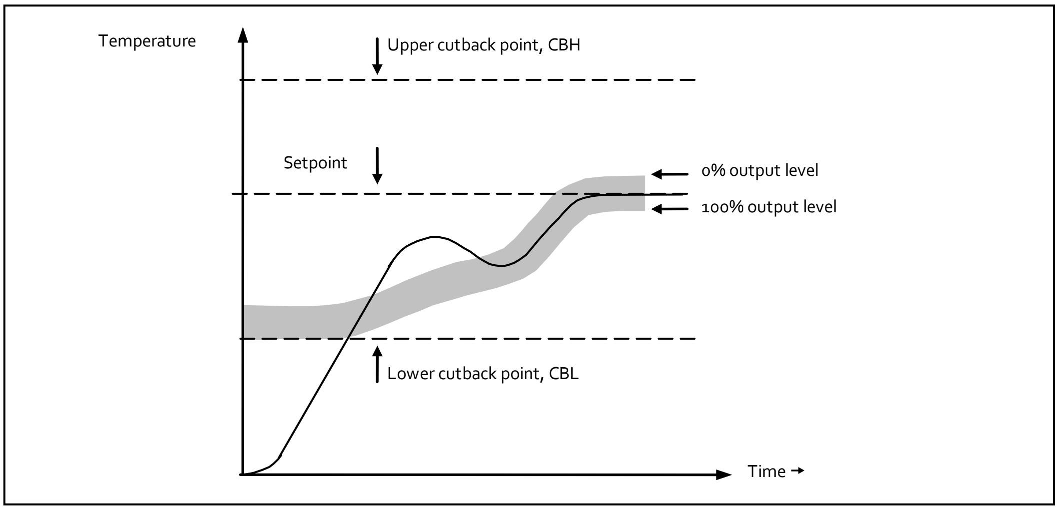
11.2.5 High and Low Cutback

Cutback high **'CBHI'** and Cutback low '**CBLO**' are values that modify the amount of overshoot, or undershoot, that occurs during large step changes in PV (for example, under start-up conditions). They are independent of the PID terms which means that the PID terms can be set for optimal steady state response and the cutback parameters used to modify any overshoot which may be present.

Cutback involves moving the proportional band towards the cutback point nearest the measured value whenever the latter is outside the proportional band and the power is saturated (at 0 or 100% for a heat only controller). The proportional band moves downscale to the lower cutback point and waits for the measured value to enter it. It then escorts the measured value with full PID control to the setpoint. In some cases it can cause a 'dip' in the measured value as it approaches setpoint, as shown in the diagram below, but generally decreases the time needed to bring the process into operation.

The action described above is reversed for falling temperature.

If cutback is set to Auto the cutback values are automatically configured to 3*PB.



11.2.6 Manual Reset

In a full three-term controller (that is, a PID controller), the integral term automatically removes the steady state error from the setpoint. If the controller is set as a PD controller, the integral term will be set to 'OFF'. Under these conditions the measured value may not settle precisely at setpoint. The Manual Reset parameter (MR) represents the value of the power output that will be delivered when the error is zero. You must set this value manually in order to remove the steady state error.

11.2.7 Control Action

When set to reverse (REV) the output increases when the PV is below setpoint. This is the best setting for heating control.

For cooling control only set Control Action to direct (DIR).

11.2.8 Loop Break

The loop is considered to be broken if the PV does not respond to a change in the output. Since the time of response will vary from process to process the **Loop Break Time** parameter allows a time to be set before a **Loop Break Alarm** is initiated. In these circumstances the output power will drive to high or low limit. For a PID controller, if the PV has not moved by 0.5 x Pb in the loop break time the loop is considered to be in break. The loop break time is set by the Auto-tune, a typical value is 12 x Td. For an On/Off controller Loop Break Time is not shown and loop break alarm is inhibited.

11.2.9 Cooling Algorithm

The method of cooling may vary from application to application.

For example, an extruder barrel may be cooled by forced air (from a fan), or by circulating water or oil around a jacket. The cooling effect will be different depending on the method. The cooling algorithm may be set to linear where the controller output changes linearly with the PID demand signal, or it may be set to water, oil or fan where the output changes non-linearly against the PID demand. The algorithm provides optimum performance for these methods of cooling.

11.3 Tuning

In tuning, you match the characteristics (PID parameters) of the controller to those of the process being controlled in order to obtain good control. Good control means:

- Stable, 'straight-line' control of the PV at setpoint without fluctuation
- No overshoot, or undershoot, of the PV setpoint

- Quick response to deviations from the setpoint caused by external disturbances, thereby rapidly restoring the PV to the setpoint value.

Tuning involves setting the following parameters:

Proportional Band 'PB', Integral Time 'TI', Derivative Time 'TD', Cutback High 'CBHI', Cutback Low 'CBLO', and Relative Cool Gain 'R2G' (applicable to heat/cool systems only).

The controller is shipped with these parameters set to either the customer's specifications or default values. In many cases the default values will give adequate stable straight line control, however, the response of the loop may not be ideal. Because the process characteristics are fixed by the design of the process it is necessary to adjust the parameters in the controller to achieve best control. To determine the optimum values for any particular loop or process, it is necessary to carry out a procedure called loop tuning. If significant changes are later made to the process that affect the way in which it responds, it may be necessary to retune the loop.

Users have the choice of tuning the loop automatically or manually. Both procedures require the loop to oscillate and both are described in the following sections.

11.3.1 Loop Response

If we ignore the situation of loop oscillation, there are three categories of loop performance:

Under Damped - In this situation the terms are set to prevent oscillation but do lead to an overshoot of the Process Value followed by decaying oscillation to finally settle at the Setpoint. This type of response can give a minimum time to Setpoint but overshoot may cause problems in certain situations and the loop may be sensitive to sudden changes in Process Value. This will result in further decaying oscillations before settling once again.

Critically Damped - This represents an ideal situation where overshoot to small step changes does not occur and the process responds to changes in a controlled, non oscillatory manner.

Over Damped - In this situation the loop responds in a controlled but sluggish manner which will result in a loop performance which is non ideal and unnecessarily slow.

The balancing of the P, I and D terms depends totally upon the nature of the process to be controlled.

In a plastics extruder, for example, a barrel zone will have a different response to a die, casting roll, drive loop, thickness control loop or pressure loop. In order to achieve the best performance from an extrusion line, all loop tuning parameters must be set to their optimum values.

11.3.2 Initial Settings

In addition to the tuning parameters listed above, there are a number of other parameters which can have an effect on the way in which the loop responds. Ensure that these are set before either manual or automatic tuning is initiated. Parameters include, but are not limited to:

Setpoint. Set this as closely as practicable to the actual setpoint in normal operation.

Load Conditions. Set the load conditions as closely as possible to those which will be met in practice. For example, in a furnace or oven application a representative load should be included, an extruder should be running, etc.

Heat/Cool Limits. The minimum and maximum power delivered to the process may be limited by the parameters 'OUTPUT LOW' and 'OUTPUT HIGH' both of which are found in the Control list. For a heat only controller the default values are 0 and 100%. For a heat/cool controller the defaults are -100 and 100%. Although it is expected that most processes will be designed to work between these limits there may be instances where it is desirable to limit the power delivered to the process. For example, if driving a 220V heater from a 240V source the heat limit may be set 80% to ensure that the heater does not dissipate more than its maximum power.

☺ The measured value *must* oscillate to some degree for the tuner to be able to calculate values. The limits must be set to allow oscillation about the setpoint.

Channel 2 Deadband. In controllers fitted with a second (cool) channel a parameter 'D.BAND' is also available in the Control list, which sets the distance between the heat and cool proportional bands. The default value is 0% which means that heating will turn off at the same time as cooling turns on. The deadband may be set to ensure that there is no possibility of the heat and cool channels being on together, particularly when cycling output stages are installed.

Minimum Pulse Time. If either or both of the output channels is fitted with a relay, triac or logic output, the parameter **'-.PLS'** will appear in the relevant output list (IO-1 list, OP-2 list, OP-3 list or AA Relay Output list). This is the cycling time for a time proportioning output and should be set correctly before tuning is started.

Input Filter Time Constant. The parameter 'FILTER TIME' should be set before tuning the loop. It is found in the INPUT List.

Valve Travel Time. If the output is a motor valve positioner the parameter 'MTR.T' (Control List) should be set to the time that it takes for the motor to travel from its fully closed to its fully open position.

Other Considerations

- If a process includes adjacent interactive zones, each zone should be tuned independently.
- It is always better to start a tune when the PV and setpoint are far apart. This allows start up conditions to be measured and cutback values to be calculated more accurately.

11.3.3 Automatic Tuning

Auto Tune automatically sets the following parameters:

Proportional Band '**PB**'	
Integral Time '**Ti**'	If '**Ti**' and/or '**Td**' is set to OFF, because you wish to use PI, PD or P only control, these terms will remain off after an autotune.
Derivative Time '**Td**'	
Cutback High '**CBHI**'	If CBH and/or CBL is set to '**Auto**' these terms will remain at Auto after an autotune, i.e. 3*PB.
Cutback Low '**CBLO**'	For autotune to set the cutback values, CBHI and CBLO must be set to a value (other than Auto) before autotune is started. Autotune will never return cutback values which are less than 1.6*PB.
Relative Cool Gain '**R2G**'	R2G is only calculated if the controller is configured as heat/cool. Following an autotune, '**R2G**' is always limited to between 0.1 and 10. If the calculated value is outside this limit a 'Tune Fail' alarm is given.
Loop Break Time '**LBT**'	Following an autotune, '**LBT**' is set to 2*Ti (assuming the integral time is not set to OFF). If 'Ti' is set to OFF then 'LBT' is set to 12*Td.

Auto tune uses the 'one-shot' tuner which works by switching the output on and off to induce an oscillation in the process value. From the amplitude and period of the oscillation, it calculates the tuning parameter values. The autotune sequence for different conditions is described in section 11.

11.3.4 To Start Autotune

In operator levels 2 or 3, set the 'AUTO-TUNE ENABLE' parameter to 'On'.

Press the Page and Scroll buttons together to return to the Home display. The display will flash 'Tune' to indicate that tuning is in progress.

A One-shot Tune can be performed at any time, but normally it is performed only once during the initial commissioning of the process. However, if the process under control subsequently becomes unstable (because its characteristics have changed), it may be necessary to tune again for the new conditions.

The auto tune algorithm reacts in different ways depending on the initial conditions of the plant. The explanations given in this section are for the following conditions:

1. Initial PV is below the setpoint and, therefore, approaches the setpoint from below for a heat/cool control loop
2. Initial PV is below the setpoint and, therefore, approaches the setpoint from below for a heat only control loop
3. Initial PV is at the same value as the setpoint. That is, within 0.3% of the range of the controller if '**PB.UNT**' is set to '**percent**' or ±1 engineering unit (1 in 1000) if the '**PB.UNT**' is set to '**Eng**'. Range is defined as 'Range High Limit' to 'Range Low Limit' for process inputs or the range defined for temperature inputs.

☺ If the PV is just outside the range stated above the autotune will attempt a tune from above or below SP.

☺ If the controller is autotuning and sensor break occurs, the autotune will abort. Autotune must be re-started when the sensor break condition is no longer present.

☺ If an Autotune cannot be performed an error message, Etun, will be flashed in the display

11.3.5 Autotune from Below SP – Heat/Cool

The point at which Automatic tuning is performed (Tune Control Point) is designed to operate just below the setpoint at which the process is normally expected to operate (Target Setpoint). This is to ensure that the process is not significantly overheated or overcooled. The Tune Control Point is calculated as follows:

Tune Control Point = Initial PV + 0.75(Target Setpoint – Initial PV).

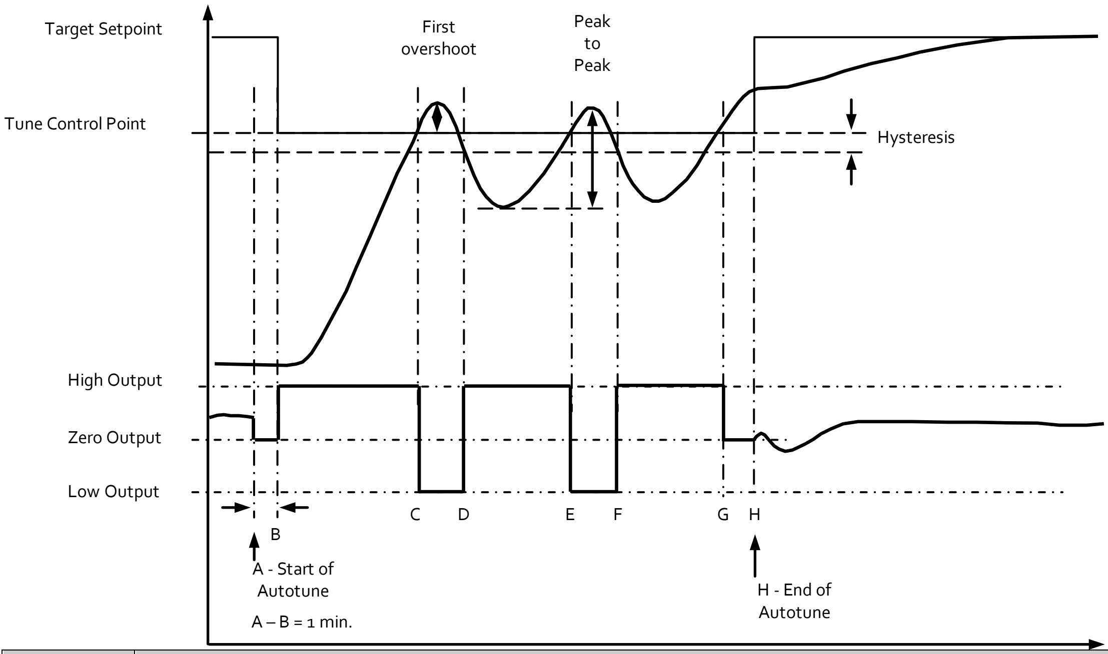
The Initial PV is the PV measured at 'B' (after a 1 minute settling period)

Examples: If Target Setpoint = 500^{O}C and Initial PV = 20^{O}C, then the Tune Control Point will be 380^{O}C.

If Target Setpoint = 500^{O}C and Initial PV = 400^{O}C, then the Tune Control Point will be 475^{O}C.

This is because the overshoot is likely to be less as the process temperature is already getting close to the target setpoint.

The sequence of operation for a tune from below setpoint for a heat/cool control loop is described below:



Period	Action
A	Start of Autotune
A to B	Both heating and cooling power remains off for a period of 1 minute to allow the algorithm to establish steady state conditions.
B to D	First heat/cool cycle to establish first overshoot. 'CBLO' is calculated on the basis of the size of this overshoot (assuming it is not set to Auto in the initial conditions).
B to F	Two cycles of oscillation are produced from which the peak to peak response and the true period of oscillation are measured. PID terms are calculated
F to G	An extra heat stage is provided and all heating and cooling power is turned off at G allowing the plant to respond naturally. Measurements made during this period allow the relative cool gain 'R2G' to be calculated. 'CBHI' is calculated from CBLO*R2G.
H	Autotune is turned off at and the process is allowed to control at the target setpoint using the new control terms.

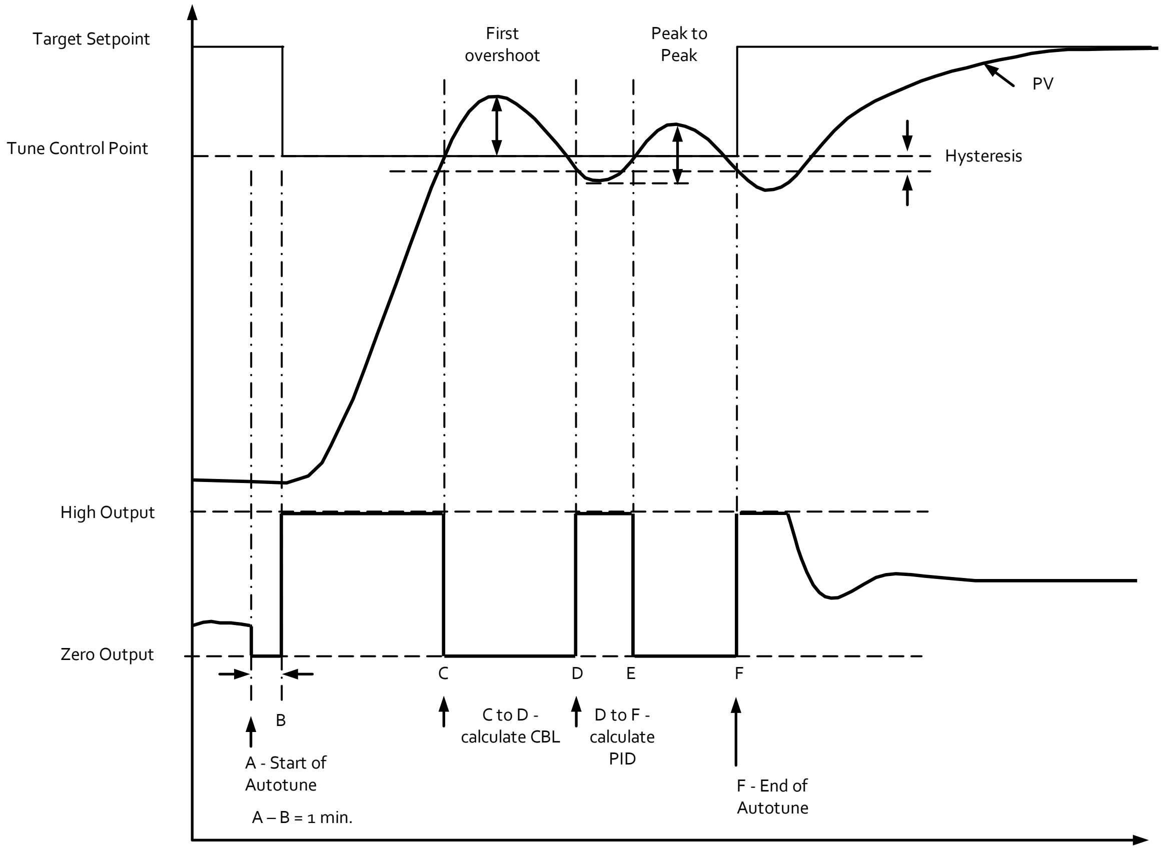
Autotune can also occur when the initial PV is above SP. The sequence is the same as tuning from below setpoint except that the sequence begins with full cooling applied at 'B' after the first one minute settling time.

11.3.6 Autotune From Below SP – Heat Only

The sequence of operation for a heat only loop is the same as that previously described for a heat/cool loop except that the sequence ends at 'F' since there is no need to calculate 'R2G'.

At 'F' autotune is turned off and the process is allowed to control using the new control terms.

Relative cool gain, **'R2G',** is set to 1.0 for heat only processes.



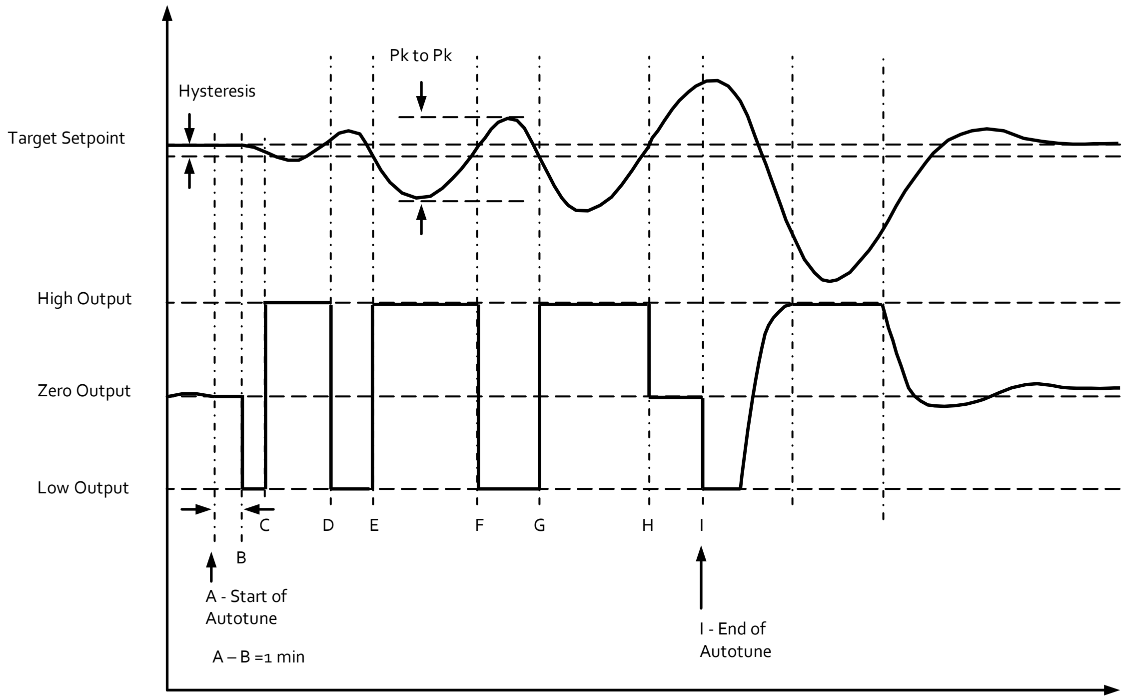
For a tune from below setpoint **'CBLO'** is calculated on the basis of the size of the overshoot (assuming it was not set to Auto in the initial conditions). CBHI is then set to the same value as CBLO.

Note: As with the heat/cool case, Autotune can also occur when the initial PV is above SP. The sequence is the same as tuning from below setpoint except that the sequence starts with natural cooling applied at 'B' after the first one minute settling time.

In this case CBHI is calculated – CBLO is then set to the same value as CBHI.

11.3.7 Autotune at Setpoint – Heat/Cool

It is sometimes necessary to tune at the actual setpoint being used. This is allowable in Series 3 series controllers and the sequence of operation is described below.



Period	Action
A	Start of Autotune. A test is done at the start of autotune to establish the conditions for a tune at setpoint. The conditions are that the SP must remain within 0.3% of the range of the controller if 'PB.UNt' is set to 'Percent'. If 'PB.UNT' is set to 'Eng' then the SP must remain within +1 engineering unit (1 in 1000). Range is defined as 'RNG.HI' – 'RNG.LO' for process inputs or the range defined in section 8.1.1 for temperature inputs.
A to B	The output is frozen at the current value for one minute and the conditions are continuously monitored during this period. If the conditions are met during this period autotune at setpoint is initiated at B. If at any time during this period the PV drifts outside the condition limits a tune at setpoint is abandoned. Tuning is then resumed as a tune from above or below setpoint depending on which way the PV has drifted. Since the loop is already at setpoint there is no need to calculate a Tune Control Setpoint – the loop is forced to oscillate around the Target Setpoint
C to G	Initiate oscillation - the process is forced to oscillate by switching the output between the output limits. From this the period of oscillation and the peak to peak response is measured. PID terms are calculated
G to H	An extra heat stage is provided and all heating and cooling power is turned off at H allowing the plant to respond naturally. Measurements made during this period allow the relative cool gain 'R2G' to be calculated.
I	Autotune is turned off and the process is allowed to control at the target setpoint using the new control terms.

For a tune at setpoint autotune does not calculate cutback since there was no initial start up response to the application of heating or cooling. The exception is that the cutback values will never be returned less than 1.6*PB.

11.3.8 Manual Tuning

If for any reason automatic tuning gives unsatisfactory results, you can tune the controller manually. There are a number of standard methods for manual tuning. The one described here is the Ziegler-Nichols method.

Adjust the setpoint to its normal running conditions (it is assumed this will be above the PV so that heat only is applied)

Set the Integral Time 'TI' and the Derivative Time 'TD' to 'OFF'.

Set High Cutback 'CBHI' and Low Cutback 'CBLO' to 'Auto'.

Ignore the fact that the PV may not settle precisely at the setpoint.

If the PV is stable, reduce the proportional band so that the PV just starts to oscillate. Allow enough time between each adjustment for the loop to stabilise. Make a note of the proportional band value 'PB' and the period of oscillation 'T'. If PV is already oscillating measure the period of oscillation 'T', then increase the proportional band until it just stops oscillating. Make a note of the value of the proportional band at this point.

Set the proportional band, integral time and derivative time parameter values according to the calculations given in the table below:

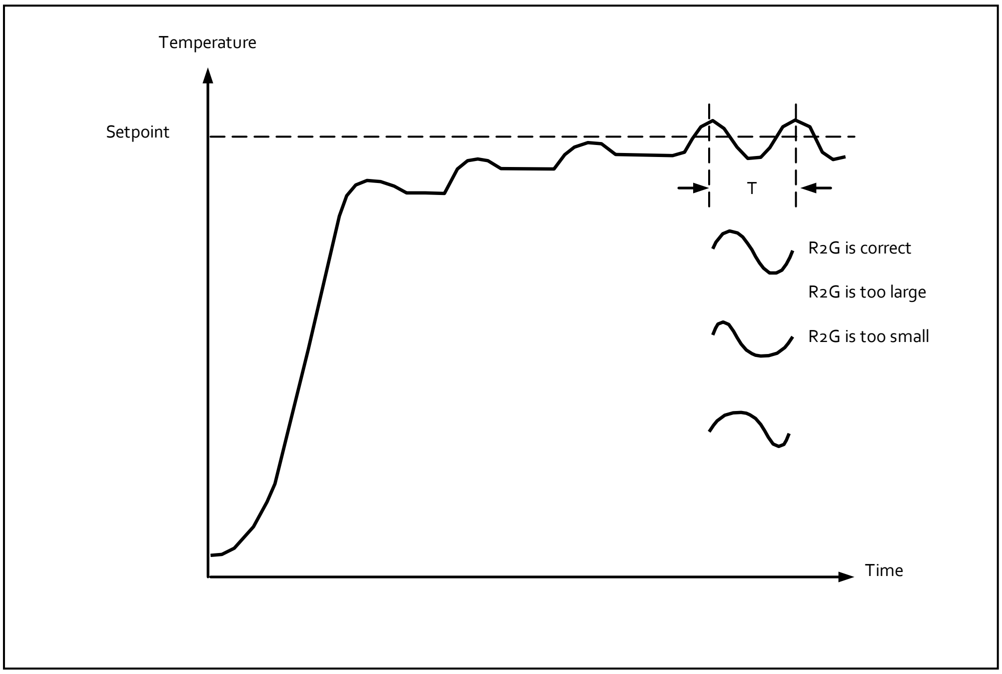
Type of control	Proportional band (PB)	Integral time (TI) seconds	Derivative time (TD) seconds
Proportional only	2xPB	OFF	OFF
P + I control	2.2xPB	0.8xT	OFF
P + I + D control	1.7xPB	0.5xT	0.12xT

11.3.9 Manually Setting Relative Cool Gain

The cool channel should be enabled before the PID values calculated from the table above are entered.

Observe the oscillation waveform and adjust R2G until a symmetrical waveform is observed.

Then enter the values from the table above.



11.3.10 Manually Setting the Cutback Values

Enter the PID terms calculated from the table in section 11.3.8 before setting cutback values.

The above procedure sets up the parameters for optimum steady state control. If unacceptable levels of overshoot or undershoot occur during start-up, or for large step changes in PV, then manually set the cutback parameters.

Proceed as follows:

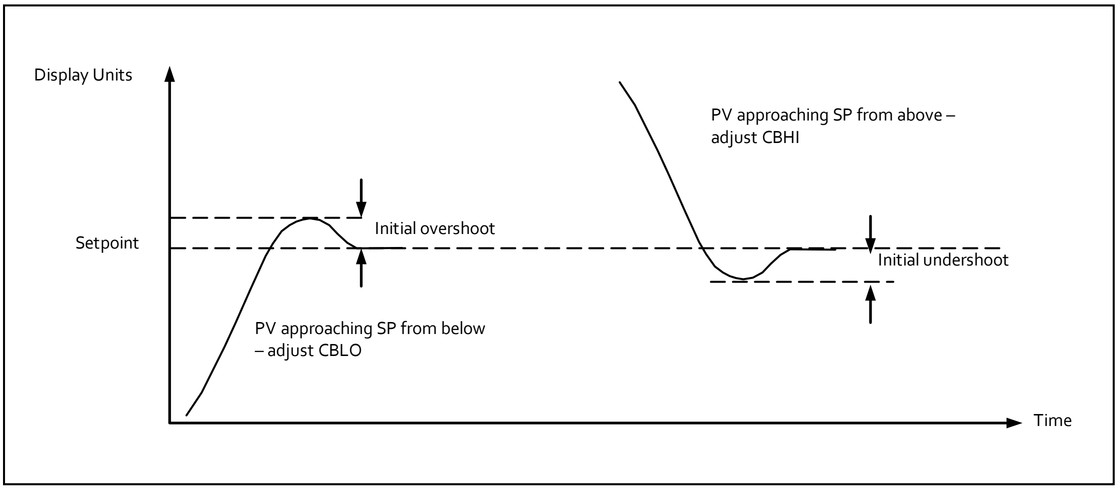
Initially set the cutback values to one proportional bandwidth converted into display units. This can be calculated by taking the value in percentage that has been installed into the parameter 'PB' and entering it into the following formula:

PB/100 * Span of controller = Cutback High and Cutback Low

For example, if PB = 10% and the span of the controller is 0 -1200^{O}C, then

Cutback High and Low = 10/100 * 1200 = 120

If overshoot is observed following the correct settings of the PID terms increase the value of 'CBLO' by the value of the overshoot in display units. If undershoot is observed increase the value of the parameter 'CBHI' by the value of the undershoot in display units.



11.4 Auto-tune Configures R2G

In a system which controls both heating and cooling the parameter R2G sets the cooling proportional band to compensate for differences between the power available to heat, and that available to cool a process.

There are certain load conditions where auto-tune may set an incorrect value for R2G. This will be seen as instability in the control of the process after an auto-tune has been completed. In these circumstances check the value of R2G. If it is low (approaching 0.1) AND the process is unstable it is necessary to manually determine a value of R2G and enter this before carrying out a second auto-tune.

Note: it is only necessary to do this if the process causes the condition described above.

A parameter has been added (in Series 3 controllers) which provides the option to suppress the auto tuning of R2G allowing it to be set manually. The parameter is called AT.R2G (Auto-tune R2G) and may be set to YES or NO. YES is the default which means that R2G will be set automatically. NO requires a value for R2G to be entered manually.

The sequence is as follows:

1) Set AT.R2G to NO.

2) Enter a value for R2G. See the example below.

3) Calculate and enter a value for the TUNE LOW LIMIT from 'TU.LO' = -TU.HI x R2G. See Note 2.

4) Start Auto-tune

Example - To establish a value for R2G.

One way to approximate a suitable value for R2G is to measure the heating and cooling rates around the normal operating temperature of the system.

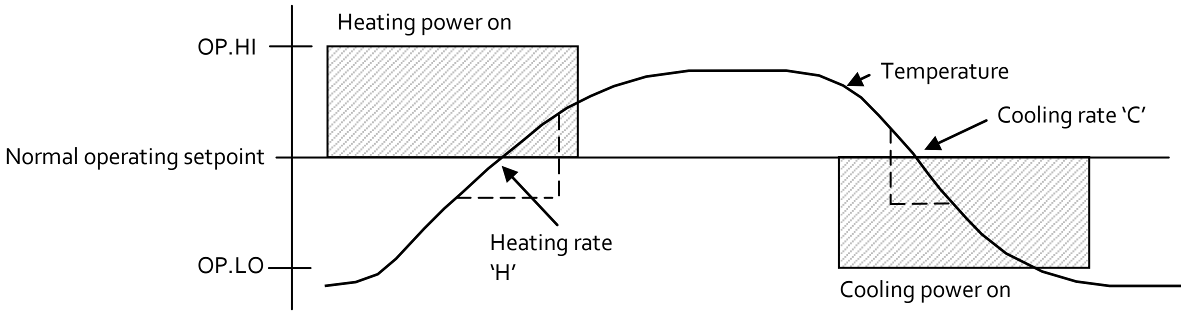
1) Measure the heating and cooling rates of the process:

a) Put the controller into Manual mode and turn heating power ON (limited by OP.HI).

b) Allow the process to heat from below normal operating setpoint and for the actual temperature to pass through the normal operating setpoint. When the actual temperature is (say 10%) above normal working temperature turn off the heat.

c) Allow the temperature to settle then turn cooling power ON (limited by OP.LO). Allow the temperature to fall below normal working setpoint.

A graphical example of the results is shown below:



2) Calculate R2G from R2G = (H/C) * (OP.LO/OP.HI)

For example Heating rate 'H' = 10°C per minute, Cooling rate 'C' = 25°C per minute, OP.HI = 80%, OP.LO = 40% then R2G = 0.2

Enter a value of 0.2 for R2G

Note 1: This calculation will compensate for the different output limits set by OP.HI and OP.LO.

Note 2: If the calculated value for TU.LO is greater than the output limit set by OP.LO, continue to enter the calculated value.

Note 3: It is envisaged that this procedure would normally be carried out by the equipment manufacturer. However, once the value of R2G has been determined and AT.R2G has been set to NO, autotuning your process from then on can be repeated by simply selecting ATUNE = On (assuming, of course, that the characteristics of the process have not changed significantly).

11.5 Example: To Configure Heating and Cooling

Enter configuration level as described. Then

Do This	The Display You Should See	Additional Notes
1. Press as many times as necessary to select 'C T R L'		
2. Press to scroll to 'C T R L H' 3. Press or to select the **Heating Type**		Heating Type choices are: Pid PID (3 term) control on.of On/Off control oFF No heating output configured
4. Press to select 'C T R L . C' 5. Press or to select the **Cooling Type**		Cooling Type choices are: oFF No cooling output configured PId PID (3 term) control on.of On/Off control
6. Press to select 'C T R L . A' 7. Press or to 'rev'		Control Action choices are: rev Reverse - heating control Dir Direct - cooling only control
8. Press to scroll to 'P B . U N T' 9. Press or to choose units		Proportional Band Units choices are: EnG Engineering units Perc Percentage
10. Continue to select parameters using for example 'O P . H I' 11. Press or to change their values		When **PID control** is selected, this places a limit on the output demand from the PID which can be applied to the heating circuit. 'OP.LO' can be set up in the same way if required. If **on/off control** is selected these parameters do not apply. They are replaced by 'HYST.H' and 'HYST.L' to set the difference between the output switching off to switching on.

11.5.1 Effect of Control Action, Hysteresis and Deadband

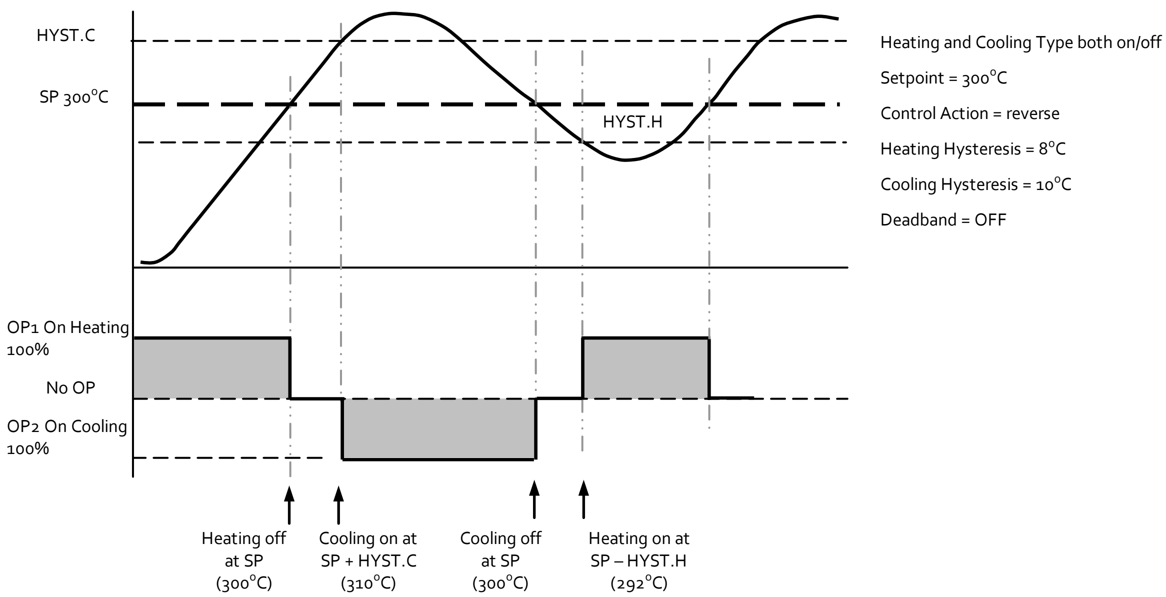
For temperature control 'CONTROL ACTION' will be set to 'rev'. For a PID controller this means that the heater power decreases as the PV increases. For an on/off controller output 1 (usually heat) will be on (100%) when PV is below the setpoint and output 2 (usually cool) will be on when PV is above the setpoint

Hysteresis applies to on/off control only. It defines the difference in temperature between the output switching off and switching back on again. The examples below shows the effect in a heat/cool controller.

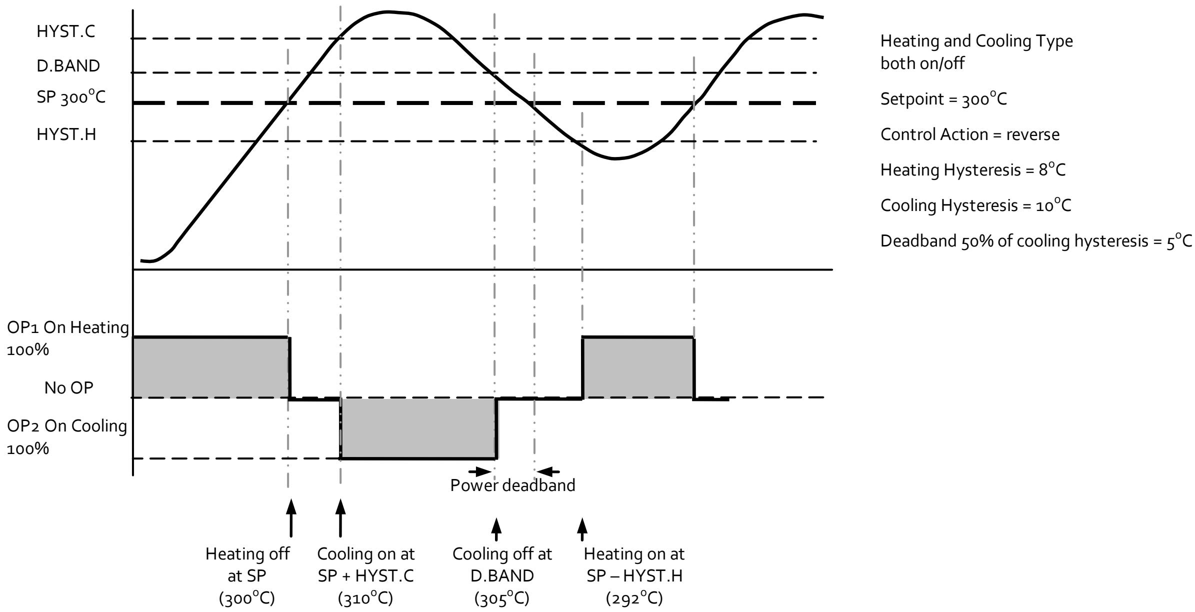
Deadband can operate on both on/off control or PID control where it has the effect of widening the period when no heating or cooling is applied. However, in PID control its effect is modified by both the integral and derivative terms. Deadband might be used in PID control, for example, where actuators take time to complete their cycle thus ensuring that heating and cooling are not being applied at the same time. Deadband is likely to be used, therefore, in on/off control only. The second example below adds a deadband of 20 to the above example.

In an on/off controller, if CONTROL ACTION = rev then OP2 will be on when PV is below SP. OP1 will be on when the PV is above SP. The outputs are, therefore, reversed in the above example.

Deadband OFF



Deadband ON



12. Alarms

Alarms are used to alert an operator when a pre-set level has been exceeded. They are indicated by a scrolling message on the display and the red ALM beacon. They may also switch an output– usually a relay to allow external devices to be operated when an alarm occurs. Alarms only operate if they have been ordered and configured.

Up to eight different alarms are available:

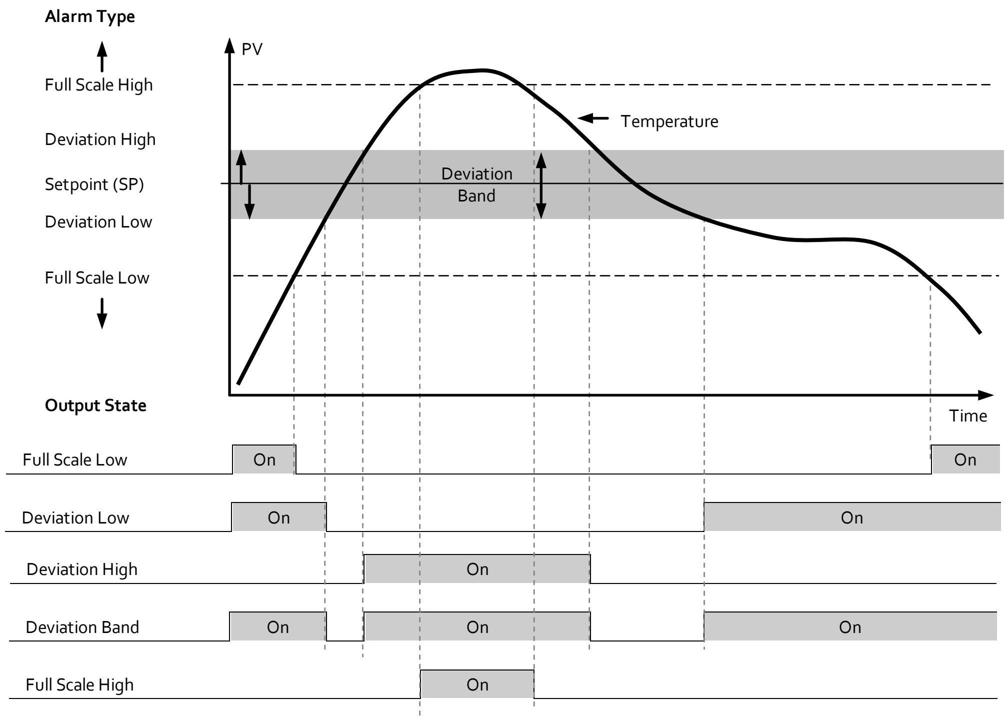
- **Alarm 1**: configurable as full scale high or low, band or deviation high or low
- **Alarm 2**: configurable as full scale high or low, band or deviation high or low
- **Alarm 3**: configurable as full scale high or low, band or deviation high or low
- **Alarm 4**: configurable as full scale high or low, band or deviation high or low
- **Sensor Fault alarm.** An alarm condition - INPUT SENSOR BROKEN (S.br) is indicated if the sensor or the wiring between sensor and controller becomes open circuit. the output level will adopt a 'SAFE' value which can be set up in Operator Level 2.
- For a PRT input, sensor break is indicated if any one of the three wires is broken.

  For mA input sensor break will not be detected due to the load resistor connected across the input terminals.

  For Volts input sensor break may not be detected due to the potential divider network connected across the input terminals.
- Loop Break alarm. Displayed as CONTROL LOOP BROKEN. This occurs if the controller does not detect a change in process value following a change in output demand after a suitable delay time.
- Current Transformer alarms – Leak, Load Fail, Overcurrent
- Remote Fail Alarm This alarm operates on the remote setpoint input. If a value is not received after a period of 5 seconds, then the Remote Fail Alarm is shown.

12.1 Types of Alarm

This section shows graphically the operation of different types of alarm used in the controller. The graphs show changes in temperature plotted against time. (Hysteresis set to zero)

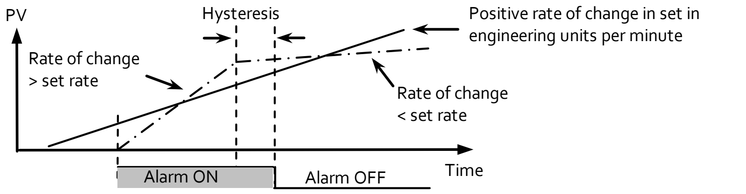


Hysteresis	Hysteresis is the difference between the point at which the alarm switches 'ON' and the point at which it switches 'OFF'. It is used to provide a definite indication of the alarm condition and to prevent alarm relay chatter.

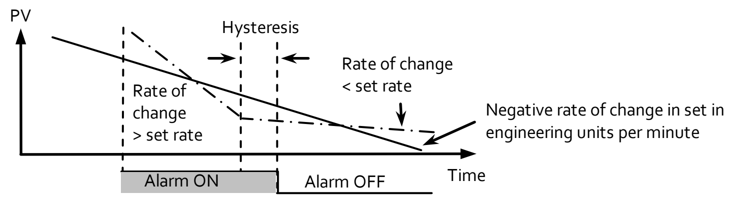
Latching Alarm	Latching is used to maintain the alarm condition once an alarm has been detected. It may be configured as:		
	none	Non latching	A non latching alarm will reset itself when the alarm condition is removed
	Auto	Automatic	An auto latching alarm requires acknowledgement before it is reset. The acknowledgement can occur **BEFORE** the condition causing the alarm is removed.
	Man	Manual	The alarm continues to be active until both the alarm condition is removed AND the alarm is acknowledged. The acknowledgement can only occur **AFTER** the condition causing the alarm is removed.
	Evt	Event	ALM beacon does not light but an output associated with this parameter will activate.
Blocking Alarms	The alarm may be masked during start up. Blocking prevents the alarm from being activated until the process has first achieved a safe state. It is used to ignore start up conditions which are not representative of running conditions. A blocking alarm is re-initiated after a setpoint change.		

From firmware version 2.11, two rate of change alarms are available. These are:

Rising rate of change (units/minute)	An alarm will be detected if the rate of change in a positive direction exceeds the alarm threshold



Falling rate of change (units/minute)	An alarm will be detected if the rate of change in a negative direction exceeds the alarm threshold



12.1.1 Alarm Relay Output

Alarms can operate a specific output (usually a relay). Any individual alarm can operate an individual output or any combination of alarms, up to four, can operate an individual output. They are either supplied pre-configured* in accordance with the ordering code or set up in configuration level.

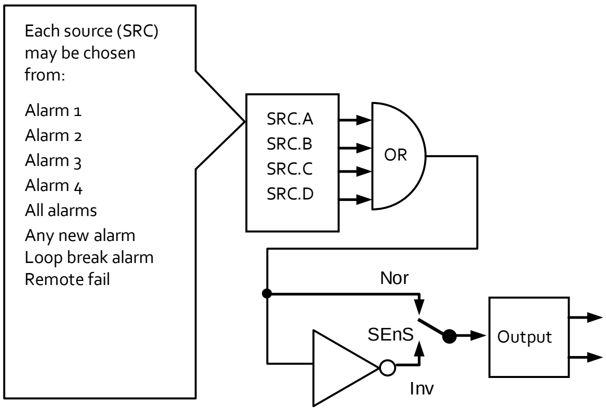
* When supplied pre-configured, the default is:

IO1 is always Heat

OP2 is always AL2

OP3 is always Heat 4-20 mA

OP4 (AA) is always AL4



12.1.2 Alarm Indication

- ALM beacon flashing red = a new alarm (unacknowledged)
- This is accompanied by a scrolling alarm message. A typical default message will show the source of the alarm followed by the type of alarm. For example, 'ALARM 1 FULL SCALE HIGH'
- If more than one alarm is present further messages are flashed in turn in the main display. The alarm indication will continue while the alarm condition is present and is not acknowledged.
- ALM beacon on continuously = alarm has been acknowledged

12.1.3 To Acknowledge An Alarm

Press and together.

The action, which now takes place, will depend on the type of latching, which has been configured

Non-Latched Alarms

Alarm condition present when the alarm is acknowledged.

- ALM beacon on continuously.
- The alarm message(s) will continue to scroll

This state will continue for as long as the alarm condition remains. When the alarm condition disappears all indication also disappears.

If a relay has been attached to the alarm output, it will de-energise when the alarm condition occurs and remain in this condition until acknowledged or the alarm is no longer present.

If the alarm condition disappears before it is acknowledged the alarm resets immediately.

Latched Alarms

See description in section 12.

12.2 Behaviour of Alarms After a Power Cycle

The response of an alarm after a power cycle depends upon the latching type, whether it has been configured to be a blocking alarm, its state and the acknowledge status of the alarm.

The response of active alarms after a power cycle is as follows:

For a non-latching alarm or an event alarm blocking will be re-instated, if configured. If blocking is not configured the active alarm will remain active. If the alarm condition has gone safe during the down time the alarm will return inactive.

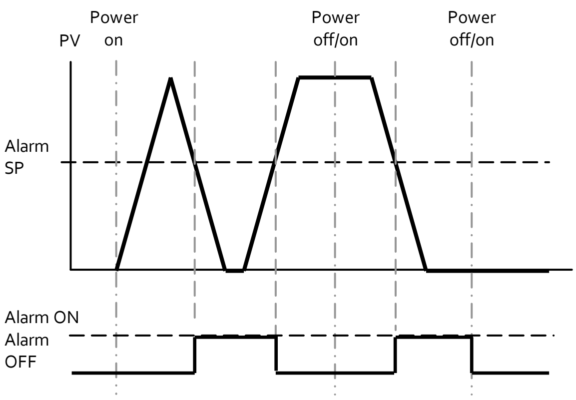
For an auto-latching alarm blocking will be re-instated, if configured, only if the alarm had been acknowledged prior to the power cycle. If blocking is not configured or the alarm had not been acknowledged the active alarm will remain active. If the alarm condition has gone safe during the downtime the alarm will return inactive if it had been acknowledged prior to the power cycle else it will return safe but not acknowledged. If the alarm was safe but not acknowledged prior to the power cycle the alarm will return safe but not acknowledged.

For a manual-latching alarm blocking will not be re-instated and the active alarm will remain active. If the alarm condition has gone safe during the downtime the alarm will return safe but not acknowledged. If the alarm was safe but not acknowledged prior to the power cycle the alarm will return safe but not acknowledged.

The following examples show graphically the behaviour under different conditions:

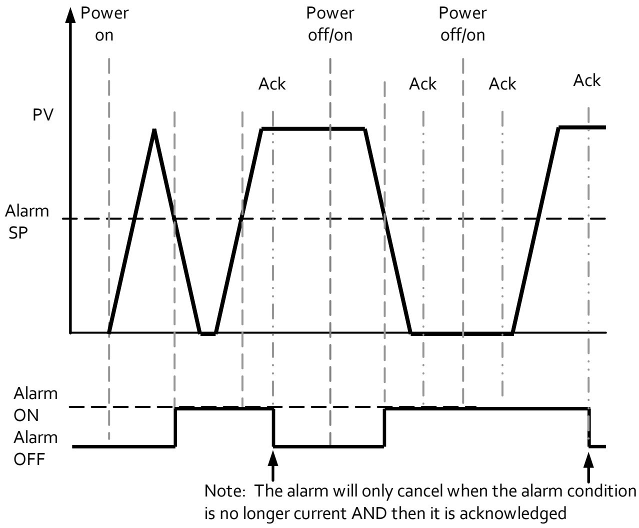
12.2.1 Example 1

Alarm configured as Absolute Low; Blocking: No Latching



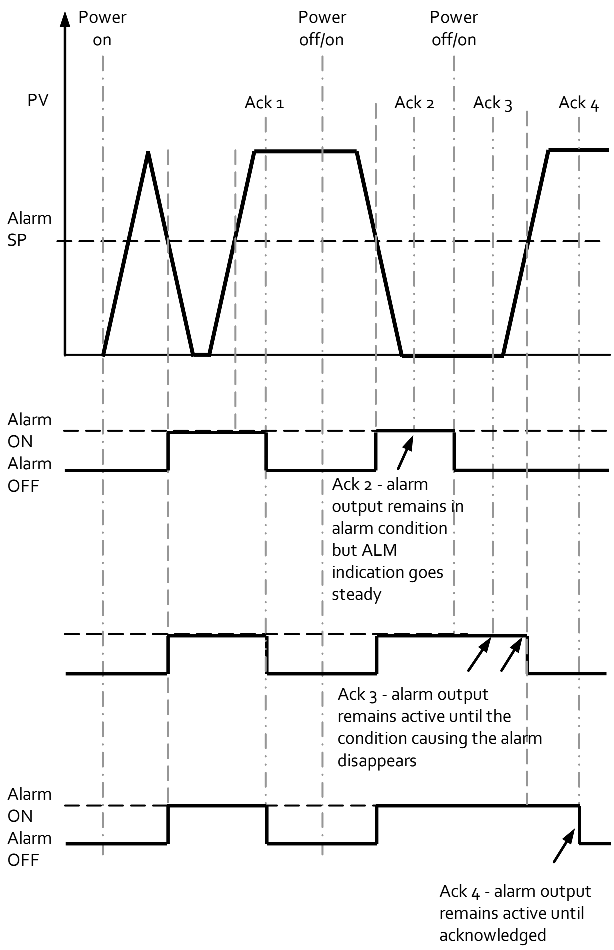
12.2.2 Example 2

Alarm configured as Absolute Low; Blocking: Manual Latching



12.2.3 Example 3

Alarm configured as Absolute Low; Blocking: Auto Latching



12.3 Alarm Parameters

Four alarms are available. Parameters do not appear if the Alarm Type = None. The following table shows the parameters to set up and configure alarms.

ALARM LIST	'ALARM'					
Name	**Scrolling Display**	**Parameter Description**	**Value**		**Default**	**Access Level**
A1.TYP	ALARM 1 TYPE	Selects the type of alarm	none	Alarm not configured		Conf
			Hi	Full Scale High		
			Lo	Full Scale Low		
			d.Hi	Deviation High		
			d.Lo	Deviation Low		
			bnd	Deviation band		
			rrc	Rising rate of change, set in 1-9999 eng units/min		
			Frc	Falling rate of change set in 1-9999 eng units/min		
A1.---	ALARM 1 SETPOINT	Alarm 1 threshold value. The last three characters show the type of alarm configured from the above list	Instrument range		0	L3
A1.sts	ALARM 1 OUTPUT	Indicates the status of the alarm	OFF	Alarm off		Read only
			On	Alarm on		
A1.HYS	ALARM 1 HYSTERESIS	See description at the beginning of this section	0 to 9999			Conf
A1.LAT	ALARM 1 LATCHING TYPE	See description at the beginning of this section	none	Non-latching		Conf
			Auto	Latching with automatic resetting		
			Man	Latching with manual resetting		
			Evt	Event (no alarm flashing beacon but messages can be displayed)		
A1.BLK	ALARM 1 BLOCKING	See description at the beginning of this section	No	No blocking	No	Conf
			yes	Blocking		
The above parameters are repeated for Alarm 2, A2; Alarm 3, A3; Alarm 4, A4						

12.3.1 Example: To Configure Alarm 1

Enter configuration level as described. Then

Do This	The Display You Should See	Additional Notes
1. Press [page] as many times as necessary to select 'ALARM'	ALARM	
2. Press [scroll] to select 'A1.TYP' 3. Press [up] or [down] to select the required alarm type	Hi a1.typ	Alarm Type choices are none Alarm not configured Hi Full Scale High Lo Full Scale Low d.Hi Deviation High d.Lo Deviation Low Bnd Deviation Band
4. Press [scroll] to select 'A1.- - -' 5. Press [up] or [down] to set the alarm trip level	215 a1.hi	This is the alarm threshold setting for. The last three characters (- - -) will show the type of alarm configured from the above list. The alarm threshold is shown in the upper display. In this example the high alarm will be detected when the measured value exceeds 215
6. Press [scroll] to select 'A1 STS'	OFF A1STS	This is a read only parameter which shows the status of the alarm output
7. Press [scroll] to select 'A1 HYS' 8. Press [up] or [down] to set the hysteresis	2 A1HYS	In this example the alarm will cancel when the measured value decreases 2 units below the trip level (at 213 units)
9. Press [scroll] to select 'A1 LAT' 10. Press [up] or [down] to select the latching type	nonE A1LAT	Latching Type choices are: none No latching Auto Automatic Man Manual Evt Event See the introduction to the alarm section for an explanation
11. Press [scroll] to select 'A1 BLK' 12. Press [up] or [down] to 'Yes' or 'No' 13. Repeat the above to configure alarms 2, 3 and 4 if required	no A1BLK	

12.4 Diagnostic Alarms

Diagnostic alarms indicate a possible fault within the controller or connected devices.

Display shows	What it means	What to do about it
E.Conf	A change made to a parameter takes a finite time to be entered. If the power to the controller is turned off before the change has been entered then this alarm will occur. Do not turn the power off to the controller while ConF is flashing	Enter configuration mode then return to the required operating mode. It may be necessary to re-enter the parameter change since it will not have been entered in the previous configuration.
E.CaL	Calibration error	Re-instate Factory calibration
E2.Er	EEPROM error	Return to Super Systems, Inc. for repair
EE.Er	Non-vol memory error	Note the error and contact Super Systems, Inc.
E.Lin	Invalid input type. This refers to custom linearisation which may not have been applied correctly or may have been corrupted.	Go to the INPUT list in configuration level and set a valid thermocouple or input type
Emod	IO1, OP2, or OP3 has been changed	If this has been field changed by the installation of a new board, enter config level, then exit back to operator level. If the message occurs at any other time return to Super Systems, Inc. for repair.

12.4.1 Out of Range Indication

If the input is too high HHHHH will be displayed

If the input is too low LLLLL will be displayed

13. Digital Communications

Digital Communications (or 'comms' for short) allows the controller to communicate with a PC or a networked computer system.

This product conforms to MODBUS RTU protocol a full description of which can be found on www.modbus.org.

Two ports are available both using MODBUS RTU communication facilities:

1. a configuration port - intended to communicate with a system to download the instrument parameters and to perform manufacturing tests and calibration
2. an EIA485 port on terminals HD, HE and HF - intended for field communications using, for example, a PC running a SCADA package.

The two interfaces cannot operate at the same time.

Each parameter has its own unique Modbus address. A list of these is given at the end of this section.

13.1 Digital Communications Wiring

13.1.1 EIA485 (2-wire)

To use EIA485, buffer the EIA232 port of the PC with a suitable EIA232/EIA485 converter. The use of a EIA485 board built into the computer is not recommended since this board may not be isolated, which may cause noise problems, and the RX terminals may not be biased correctly for this application.

To construct a cable for EIA485 operation use a screened cable with one (EIA485) twisted pair plus a separate core for common. Although common or screen connections are not necessary, their use will significantly improve noise immunity.

The terminals used for EIA485 digital communications are listed in the table below.

Standard Cable Colour	PC Function *	Instrument Terminal	Instrument Function
White	Receive, RX+	HF (B) or (B+)	Transmit, TX
Red	Transmit, TX+	HE (A) or (A+)	Receive, RX
Green	Common	HD	Common
Screen	Ground		

- These are the functions normally assigned to socket pins. Please refer to your PC manual.

13.2 Digital Communications Parameters

The following table shows the parameters available.

DIGITAL COMMUNICATIONS LIST	'comms'					
Name	**Scrolling Display**	**Parameter Description**	**Value**		**Default**	**Access Level**
I D	MODULE IDENTITY	Comms identity				Conf L3 R/O
ADDR	COMMUNICATIONS ADDRESS	Communications address of the instrument	1 to 254		1	L3
BAUD	COMMUNICATIONS BAUD RATE	Communications baud rate	1200	1200	9600	Conf L3 R/O
			2400	2400		
			4800	4800		
			9600	9600		
			19.20	19,200		
PRTY	COMMUNICATIONS PARITY	Communications parity	none	No parity	none	Conf L3 R/O
			Even	Even parity		
			Odd	Odd parity		
DELAY	RX/TX DELAY TIME	To insert a delay between Rx and Tx to ensure that drivers have sufficient time to switch over.	Off	No delay		Conf L3 R/O
			on	Fixed delay applied		
retran	COMMS RETRANSMISSION	Master comms broadcast parameter.	none	None	none	
			W.SP	Working setpoint		
			PV	Process Variable		
			OP	Output demand		
			Err	Error		
reg.ad	COMMS RETRANSMISSION ADDRESS	Parameter added in the Slave address to which the master communications value will be written	0 to 9999		0	

13.3 Example: To Set Up Instrument Address

This can be done in operator level 3

Do This	Display View	Additional Notes
1. Press as many times as necessary to select **'COMMS LIST'**		Scrolling display 'comms list'
2. Press to scroll to 'ID'		Scrolling display 'id'. This displays the type of communications board fitted
3. Press to scroll to 'ADDR' 4. Press or to select the address for this controller		Up to 254 can be chosen but note that no more than 33 instruments should be connected in series. Scrolling display 'address'

13.4 DATA ENCODING

Modbus data is normally encoded into a 16 bit signed integer representation.

Integer format data, including any value without a decimal point or represented by a textual value (for example 'off', or 'on'), is sent as a simple integer value.

For floating point data, the value is represented as a 'scaled integer', in which the value is sent as an integer which gives the result of the value multiplied by 10 to the power of the decimal resolution for that value. This is easiest to understand by reference to examples:

FP Value	Integer Representation
FP Value	Integer Representation
9.	9
-1.0	10
123.5	1235
9.99	999

It may be necessary for the Modbus master to insert or remove a decimal point when using these values.

It is possible to read floating point data in a native 32 bit IEEE format.

For **time** data, for example, the length of a dwell, the integer representation depends on the resolution. For 'hours' resolution, the value returned is the number of minutes the value represents, so for example a value of 2:03 (2 hours and three minutes) would be returned as an integer value of 123. For 'minutes' resolution, the value used is the number of seconds the value represents, so that 12:09 (12 minutes and 9 seconds) would be returned as 729.

It is possible to read time data in a native 32 bit integer format, in which case it returns the number of milliseconds the variable represents regardless of the resolution.

13.5 Parameter Modbus Addresses

Parameter Mnemonic	Parameter Name	Modbus Address Decimal
PV.IN	PV (Temperature) Input Value (see also Modbus address 203 which allows writes over Modbus to this variable).	1
TG.SP	Target Setpoint. ***NB – do not write continuously changing values to this variable. The memory technology used in this product has a limited (100,000) number of write cycles. If ramped setpoints are required, consider using the internal ramp rate function or the remote comms setpoint (Modbus address 26)in preference.***	2
MAN.OP	Manual Output Value	3
WRK.OP	Working Output	4
WKG.SP	Working Setpoint (Read Only)	5
PB	Proportional Band	6

Parameter Mnemonic	Parameter Name	Modbus Address Decimal
CTRL.A	Control Action 0 = Reverse Acting 1 = Direct Acting	7
Ti	Integral Time (0 = No Integral Action)	8
Td	Derivative Time (0 = No Derivative Action)	9
RNG.LO	Input Range Low Limit	11
RNG.HI	Input Range High Limit	12
A1.---	Alarm 1 Threshold	13
A2.---	Alarm 2 Threshold	14
SP.SEL	Active Setpoint Select 0 = Setpoint 1 1 = Setpoint 2	15
D.BAND	Channel 2 Deadband	16
CB.Lo	Cutback Low	17
CB.HI	Cutback High	18
R2G	Relative Cool/Ch2 Gain	19
MTR.T	Motor Travel Time	21
SP1	Setpoint 1 ***NB – do not write continuously changing values to this variable. The memory technology used in this product has a limited (100,000) number of write cycles. If ramped setpoints are required, consider using the internal ramp rate function or the remote comms setpoint (Modbus address 26)in preference.***	24
SP2	Setpoint 2 ***NB – do not write continuously changing values to this variable. The memory technology used in this product has a limited (100,000) number of write cycles. If ramped setpoints are required, consider using the internal ramp rate function or the remote comms setpoint (Modbus address 26)in preference.***	25
Rm.SP	Remote (comms) setpoint. If selected using the remote setpoint selection (address 276 below, may also be controlled using the instrument HMI or a digital input) then this is used as a setpoint providing a value has been received within a window of about 5 seconds. If no value is received then the controller falls back to the currently selected setpoint (SP 1 or SP 2) with an error indication. The Remote Setpoint may have a local trim (SP Trim, address 27) added to it to compensate for variations in temperature in a particular zone. This parameter is not saved when the instrument is switched off. It may be written to continuously over communications without risk of damage to the instrument non-volatile memory.	26
LOC.t	Local Trim – added to the remote setpoint to compensate for local temperature variations in a control zone.	27
MR	Manual Reset	28
OP.HI	Output High Limit	30
OP.LO	Output Low Limit	31
SAFE	Safe Output Value for Sensor Break or other fault conditions.	34
SP.RAT	Setpoint Rate Limit Value (0 = no rate limit)	35
P.Err	Calculated Error (PV-SP)	39
A1.HYS	Alarm 1 Hysteresis	47
A2.HYS	Alarm 2 Hysteresis	68
A3.HYS	Alarm 3 Hysteresis	69
A4.HYS	Alarm 4 Hysteresis	71
StAt	Instrument Status. This is a bitmap: B0 – Alarm 1 Status B1 – Alarm 2 Status B2 – Alarm 3 Status B3 – Alarm 4 Status B4 – Auto/Manual Status B5 – Sensor Break Status B6 – Loop Break Status B7 – CT Low load current alarm status B8 – CT High leakage current alarm status B9 – FEATURE NOT AVAILABLE B10 – PV Over-range (by > 5% of span) B11 – CT Overcurrent alarm status B12 – New Alarm Status B13 – FEATURE NOT AVAILABLE B14 – Remote (comms) SP Fail B15 – Auto-tune Status In each case, a setting of 1 signifies 'Active', 0 signifies 'Inactive'.	75

Parameter Mnemonic	Parameter Name	Modbus Address Decimal
-	Inverted Instrument Status. This is an inverted (bitwise) version of the preceding parameter and is provided so that scrolling messages can be triggered when a condition is not active. Bit mappings are as the "Instrument Status", Modbus address 75	76
LL.AMP	Load Leakage Current	79
LD.AMP	Load ON Current	80
A3.---	Alarm 3 Threshold	81
A4.---	Alarm 4 Threshold	82
LBT	Loop Break Time	83
F.OP	Forced manual output value	84
F.MOD	Forced manual output mode 0 – None 1 - Step 2 - Last	85
HYST.H	Ch1 On/Off Hysteresis in Eng Units	86
Di.IP	Digital Inputs Status. This is a bitmap: B0 – Logic input 1A B1 – Logic input LA B2 – Logic input LB B7 – Power has failed since last alarm acknowledge A value of 1 signifies the input is closed, otherwise it is zero. Values are undefined if options are not fitted or not configured as inputs.	87
HYST.C	Ch2 On/Off Hysteresis in Eng Units	88
FILT.T	Input Filter Time	101
RC.FT	Filter time constant for the rate of change alarm.	102
RC.PV	Calculated rate of change of the temperature or process variable in engineering units per minute.	103
Home	Home Display. 0 – Standard PV and SP display 1 – PV and Output Power display 2 – PV and Time remaining display 3 – PV 4 – FEATURE NOT AVAILABLE 5 – PV and Load Current 6 – PV only 7 – PV and Composite SP/Time remaining 8 – Target setpoint 9 – No PV 10 – PV is not displayed when controller in Standby	106
-	Instrument version number. Should be read as a hexadecimal number, for example a value of 0111 hex is instrument V1.11	107
SP.HI	Setpoint High Limit	111
SP.LO	Setpoint Low Limit	112
-	Instrument type code.	122
ADDR	Instrument Comms Address	131
PV.OFS	PV Offset	141
C.Adj	Calibration Adjust	146
IM	Instrument Mode 0 – Operating mode - all algorithms and I/O are active 1 – Standby - control outputs are off 2 – Config Mode - all outputs are inactive	199
MV.IN	Input value in millivolts	202
PV.CM	Comms PV Value. This may be used to write to the Process Variable (temperature) parameter over Modbus when a linearisation type of 'Comms' is selected, allowing the instrument to control to externally derived values. If sensor break is turned on, it is necessary to write to this variable once every 5 seconds. Otherwise a sensor break alarm will be triggered as a failsafe. If this is not required, turn sensor break off.	203
CJC.IN	CJC Temperature	215
SBR	Sensor Break Status (0 = Off, 1 = Active)	258
NEW.AL	New Alarm Status (0 = Off, 1 = Active)	260
LBR	Loop Break (0 = Off, 1 = Active)	263
A.TUNE	Auto-tune Enable (0 = Off, 1 = Enabled)	270
A-M	Mode of the Loop (0 = Auto, 1 = Manual)	273
Ac.All	Acknowledge all alarms (1 = Acknowledge	274
L-R	Local Remote (Comms) Setpoint Select	276

Parameter Mnemonic	Parameter Name	Modbus Address Decimal
	Remote setpoint in percent	277
REM.HI	Remote input high scalar – sets high range for setpoint input, corresponding to 20mA or 10V depending on the input type.	278
REM.LO	Remote input low scalar – sets low range for setpoint input, corresponding to 4mA or 0V depending on the input type.	279
ROP.HI	Sets the high range limit for the retransmitted setpoint. Allows a subset of the setpoint range to be retransmitted, and also allows the setpoint range meter to display a range indication other than full scale. By default this is set to the setpoint high limit.	280
ROP.LO	Sets the low range limit for the retransmitted setpoint. Allows a subset of the setpoint range to be retransmitted, and also allows the Series 3 setpoint range meter to display a range indication other than full scale. By default this is set to the setpoint low limit.	281
A1.STS	Alarm 1 Status (0 = Off, 1 = Active)	294
A2.STS	Alarm 2 Status (0 = Off, 1 = Active)	295
A3.STS	Alarm 3 Status (0 = Off, 1 = Active)	296
A4.STS	Alarm 4 Status (0 = Off, 1 = Active)	297
LD.ALM	Low Load Current Threshold	304
LK.ALM	High Leakage Current Alarm (0 = Off, 1 = Active)	305
HC.ALM	Over Current Alarm Threshold	306
LOAD.A	Load Alarm Status (0 = Off, 1 = Active)	307
LEAK.A	Leak alarm Status.	308
HILC.A	Over Current alarm Status (0 = Off, 1 = Active)	309
REC.NO	FEATURE NOT AVAILABLE	313
StOrE	FEATURE NOT AVAILABLE	314
TM.CFG	FEATURE NOT AVAILABLE	320
TM.RES	FEATURE NOT AVAILABLE	321
SS.SP	Soft Start Setpoint	322
SS.PWR	Soft Start Power Limit	323
DWELL	FEATURE NOT AVAILABLE	324
T.ELAP	FEATURE NOT AVAILABLE	325
T.REMN	FEATURE NOT AVAILABLE	326
THRES	FEATURE NOT AVAILABLE	327
End.T	FEATURE NOT AVAILABLE	328
SERVO	FEATURE UNAVAILABLE	329
EVENT	FEATURE NOT AVAILABLE	331
P.CYCL	FEATURE NOT AVAILABLE	332
CYCLE	FEATURE NOT AVAILABLE	333
CTRL.H	Heat/Ch1 Control Type 0 – Off 1 – On/Off Control 2 – PID Control 3 – mtr Valve Position Control	512
CTRL.C	Cool/Ch2 Control Type 0 – Off 1 – On/Off Control 2 – PID Control	513
PB.UNT	Proportional Band Units 0 – Engineering Units 1 – Percent of Span	514
Lev2.P	Level 2 Code	515
UNITS	Display Units 0 – Degrees C 1 – Degrees F 2 – Kelvin 3 – None 4 – Percent	516
Lev3.P	Level 3 Code	517
Conf.P	Config Code	518
Cold	If set to 1 instrument will reset to factory defaults on next reset or power cycle.	519
PASS.C	Feature passcode C	520
PASS.2	Feature passcode 2	521
COOL.t	Cooling Algorithm Type:	524

Parameter Mnemonic	Parameter Name	Modbus Address Decimal
	0 – Linear 1 – Oil 2 – Water 3 – Fan	
DEC.P	Decimal Point Position 0 – XXXX. 1 – XXX.X 2 – XX.XX	525
STBY.T	Standby Type 0 – Absolute Alarm Outputs Active – others off 1 – All outputs inactive	530
RAMP UNITS	0 – Ramp per Minute 1 – Ramp per Hour 2 – Ramp per Second	531
Meter	Ammeter configuration 0 – No ammeter 1 – Heat Output (0-100%) 2 – Cool Output (0-100% cooling) 3 – Working Setpoint (scaled within SP limits) 4 – PV (scaled within range) 5 – Output Power (scaled within Op Low and OP High limits) 6 – Output centered between –100% and 100% 7 – Error (PV-SP) (scaled between +/- 10 degrees) 8 – Instantaneous Amps (scaled 0 to CT Span) 9 – Load Current (scaled 0 to CT Span)	532
uCAL	User Calibration Enable	533
A1.TYP	Alarm 1 Type 0 – Off 1 –Absolute High 2 – Absolute Low 3 – Deviation High 4 – Deviation Low 5 – Deviation Band	536
A2.TYP	Alarm 2 Type (as Alarm 1 Type)	537
A3.TYP	Alarm 3 Type (as Alarm 1 Type)	538
A4.TYP	Alarm 4 Type (as Alarm 1 Type)	539
A1.LAT	Alarm 1 Latching Mode 0 – No latching 1 – Latch - Automatic Reset 2 – Latch – Manual Reset	540
A2.LAT	Alarm 2 Latching Mode (as Alarm 1 Latching Mode)	541
A3.LAT	Alarm 3 Latching Mode (as Alarm 1 Latching Mode)	542
A4.LAT	Alarm 4 Latching Mode (as Alarm 1 Latching Mode)	543
A1.BLK	Alarm Blocking Mode Enable (0 = OFF, 1 = BLOCK)	544
A2.BLK	Alarm Blocking Mode Enable (0 = OFF, 1 = BLOCK)	545
A3.BLK	Alarm Blocking Mode Enable (0 = OFF, 1 = BLOCK)	546
A4.BLK	Alarm Blocking Mode Enable (0 = OFF, 1 = BLOCK)	547
Di.OP	Digital Outputs Status. This is a bitmap: B0 – Output 1A B1 – Output 2A B3 – Output 4/AA It is possible to write to this status word to use the digital outputs in a telemetry output mode. Only outputs whose function is set to 'none' are affected, and the setting of any bits in the Digital Output Status word will not affect outputs used for heat (for example) or other functions. Thus it is not necessary to mask in the settings of these bits when writing to this variable.	551
OFS.HI	Adjust High Offset	560
OFS.LO	Adjust Low Offset	561
PNT.HI	Adjust High Point	562

Parameter Mnemonic	Parameter Name	Modbus Address Decimal
PNT.LO	Adjust Low Point	563
CT.RNG	CT Range	572
Sb.tyP	Sensor Break Type 0 – No Sensor Break 1 – Non-Latching Sensor Break 2 – Latching Sensor Break	578
Id	Customer ID – May be set to any value between 0-9999 for identification of instruments in applications. Not used by the instrument itself.	629
PHASE	Calibration Phase 0 – None 1 – 0 mv 2 – 50 mv 3 – 150 Ohm 4 – 400 Ohm 5 – CJC 6 – CT 0 mA 7 – CT 70 mA 8 – Factory Defaults 9 – Output 1 mA low cal 10 – Output 1 mA high cal 11 – Output 2 mA low cal 12 – Output 2 mA high cal 13 – Output 3 ma low cal 14 – Output 3 ma high cal 15 – Remote setpoint input low volts 16 - Remote setpoint input high volts 17 - Remote setpoint input low current 18 - Remote setpoint input high current	768
GO	Calibration Start 0 – No 1 – Yes (start cal) 2 – Cal Busy 3 – Cal Pass 4 – Cal Fail Note values 2-4 cannot be written but are status returns only	769
-	Analogue Output Calibration Value	775
K.LOC	Allows instrument to be locked via a key/digital input 0 - unlocked, 1 – all keys locked 2 – Edit keys (raise and lower) disabled 3 – Mode key disabled 4 – Manual mode disabled 5 – Enter standby mode when Mode combination pressed	1104
Dwel.1	FEATURE NOT AVAILABLE	1280
TSP.1	FEATURE NOT AVAILABLE 1	1281
RMP.1	FEATURE NOT AVAILABLE	1282
Dwel.2	FEATURE NOT AVAILABLE	1283
TSP.2	FEATURE NOT AVAILABLE	1284
RMP.2	FEATURE NOT AVAILABLE	1285
Dwel.3	FEATURE NOT AVAILABLE	1286
TSP.3	FEATURE NOT AVAILABLE 3	1287
RMP.3	FEATURE NOT AVAILABLE 3	1288
Dwel.4	FEATURE NOT AVAILABLE	1289
TSP.4	FEATURE NOT AVAILABLE 4	1290
RMP.4	FEATURE NOT AVAILABLE	1291
AT.R2G	Auto-tune Configures R2G 0 - YES 1 - No	4176
IN.TYP	Input Sensor Type 0 – J Type Thermocouple 1 – K Type Thermocouple 2 – L Type Thermocouple 3 – R Type Thermocouple	12290

Parameter Mnemonic	Parameter Name	Modbus Address Decimal
	4 – B Type Thermocouple 5 – N Type Thermocouple 6 – T Type Thermocouple 7 – S Type Thermocouple 8 – RTD 9 – millivolt 10 – Comms Input (see Modbus address 203) 11 – Custom Input (Downloadable)	
CJ.tyP	CJC Type 0 – Auto 1 – 0 Degrees C 2- 50 Degrees C	12291
mV.HI	Linear Input High	12306
mV.LO	Linear Input Low	12307
L.TYPE	Logic Input A channel hardware type 0 – None 1 – Logic Inputs	12352
L.D.IN	Logic input A function 40 – None 41 – Acknowledge all alarms 42 – Select SP1/2 43 – Lock All Keys 44 – FEATURE UNAVAILABLE 45 – FEATURE UNAVAILABLE 46 – FEATURE UNAVAILABLE 47 – FEATURE UNAVAILABLE 48 – Auto/Manual Select 49 – Standby Select 50 – Remote setpoint 51 – Recipe select through IO1 52 – Remote key UP 53 – Remote key DOWN	12353
L.SENS	Configures the polarity of the logic input channel A (0 = Normal, 1 = Inverted)	12361
L.TYPE (LB)	Logic Input B channel hardware type 0 – None 1 – Logic Inputs	12368
L.D.IN (LB)	Logic input B function 40 – None 41 – Acknowledge all alarms 42 – Select SP1/2 43 – Lock All Keys 44 – FEATURE UNAVAILABLE 45 – FEATURE UNAVAILABLE 46 – FEATURE UNAVAILABLE 47 – FEATURE UNAVAILABLE 48 – Auto/Manual Select 49 – Standby Select 50 – Remote setpoint 51 – Recipe select through IO1 52 – Remote key UP 53 – Remote key DOWN	12369
L.SENS (LB)	Configures the polarity of the logic input channel B (0 = Normal, 1 = Inverted)	12377
BAUD	Baud Rate 0 – 9600 1 – 19200 2 – 4800 3 – 2400 4 – 1200	12548
PRTY	Parity setting 0 – None 1 – Even 2 – Odd	12549
DELAY	RX/TX Delay – (0 = no delay, 1 = delay) Select if a delay is required between received and transmitted comms messages. Sometimes required when intelligent EIA232 adaptors are used.	12550
RETRN	Comms Retransmission Variable selection: 0 – Off	12551

Parameter Mnemonic	Parameter Name	Modbus Address Decimal
	1 – Working Setpoint 2 – PV 3 – Output Power 4 – Error	
REG.AD	Modbus register address to broadcast retransmission to. For example if you wish to retransmit the working setpoint from one Series 3 to a group of slaves, and receive the master working setpoint into the slaves' remote setpoint, set this variable to 26 (the address of the remote setpoint in the slave units).	12552
Ct.Id	Current Transformer	12608
CT.SRC	CT Source 0 – None 1 – IO1 2 – OP2 8 – AA (OP4)	12609
CT.LAT	CT Alarm Latch Type 0 – No latching 1 – Latch – Automatic Reset 2 – Latch – Manual Reset	12610
1.ID	IO channel 1 hardware type 0 – None 1 – Relay 2 – Logic I/O 3 – DC OP 4 – Triac (SSR)	12672
1.D.IN	IO1 Digital input function Logic input function 40 – None 41 – Acknowledge all alarms 42 – Select SP1/2 43 – Lock All Keys 44 – FEATURE NOT AVAILABLE 45 – FEATURE NOT AVAILABLE 46 – FEATURE NOT AVAILABLE 47 – FEATURE NOT AVAILABLE 48 – Auto/Manual Select 49 – Standby Select 50 – Remote setpoint 51 – Recipe select through IO1 52 – Remote key UP 53 – Remote key DOWN	12673
1.Func	I/O Channel Function 0 – None (or Telemetry Output) 1 – Digital Output 2 – Heat or UP if valve position 3 – Cool or DOWN if valve position 4 – Digital Input 10 – DC Output no function 11 – DC Output Heat 12 – DC Output Cool 13 – DC Output WSP retransmission 14 – DC Output PV retransmission 15 – DC Output OP retransmission	12675
1.RNG	IO Channel 1 DC Output Range 0 – 0-20mA 1 – 4-20mA	12676
1.SRC.A	IO Channel 1 Source A 0 – None 1 – Alarm 1 2 – Alarm 2 3 – Alarm 3 4 – Alarm 4 5 – All Alarms (1-4) 6 – New Alarm 7 – CT Alarm (Load, Leak or Overcurrent) 8 – Loop Break Alarm 9 – Sensor Break Alarm 10 – FEATURE NOT AVAILABLE 11 – FEATURE UNAVAILABLE	12678

Parameter Mnemonic	Parameter Name	Modbus Address Decimal
	12 – Auto/Manual 13 – Remote fail 14 – Power fail 15 – FEATURE UNAVAILABLE	
1.SRC.B	IO Channel 1 Source B As IO Channel 1 Source A (Modbus address 12678)	12679
1.SRC.C	IO Channel 1 Source C As IO Channel 1 Source A (Modbus address 12678)	12680
1.SRC.D	IO Channel 1 Source D As IO Channel 1 Source A (Modbus address 12678)	12681
1.SENS	Configures the polarity of the input or output channel (0 = Normal, 1 = Inverted)	12682
1.PLS	IO1 Time proportioning Output minimum pulse time	12706
2.ID	Output 2 Type 0 – None 1 – Relay 2 – Logic Output 3 – DC OP 4 – Triac (SSR)	12736
2.FUNC	Output 2 Channel function 0 – None (or Telemetry Output) 1 – Digital Output 2 – Heat or UP if valve position 3 – Cool or DOWN if valve position 10 – DC Output no function 11 – DC Output Heat 12 – DC Output Cool 13 – DC Output WSP retransmission 14 – DC Output PV retransmission 15 – DC Output OP retransmission	12739
2.RNG	IO Channel 2 DC Output Range 0 – 0-20mA 1 – 4-20mA	12740
2.SRC.A	Output 2 source A As IO Channel 1 Source A (Modbus address 12678)	12742
2.SRC.B	Output 2 source B As IO Channel 1 Source A (Modbus address 12678)	12743
2.SRC.C	Output 2 source C As IO Channel 1 Source A (Modbus address 12678)	12744
2.SRC.D	Output 2 source D As IO Channel 1 Source A (Modbus address 12678)	12745
2.SENS	Output 2 Polarity (0 = Normal, 1 = Inverted)	12746
2.PLS	Output 2 Time proportioning Output minimum pulse time	12770
3.ID	Output 3 Type 0 – None 1 – Relay 2 - 3 – DC OP	12800
3.FUNC	Output 3 Channel function 0 – None (or Telemetry Output) 1 – Digital Output 2 – Heat or UP if valve position 3 – Cool or DOWN if valve position 10 – DC Output no function 11 – DC Output Heat 12 – DC Output Cool 13 – DC Output WSP retransmission 14 – DC Output PV retransmission 15 – DC Output OP retransmission	12803
3.RNG	IO Channel 3 DC Output Range 0 – 0-20mA 1 – 4-20mA	12804
3.SRC.A	Output 3 source A As IO Channel 1 Source A (Modbus address 12678)	12806
3.SRC.B	Output 3 source B As IO Channel 1 Source A (Modbus address 12678)	12807

Parameter Mnemonic	Parameter Name	Modbus Address Decimal
3.SRC.C	Output 3 source C As IO Channel 1 Source A (Modbus address 12678)	12808
3.SRC.D	Output 3 source D As IO Channel 1 Source A (Modbus address 12678)	12809
3.SENS	Output 3 Polarity (0 = Normal, 1 = Inverted)	12810
3.PLS	Output 3 Time proportioning Output minimum pulse time	12834
4.TYPE	Output AA Type 0 – None 1 – Relay	13056
4.FUNC	Output 4 Channel function 0 – None (or Telemetry Output) 1 – Digital Output 2 – Heat or UP if valve position 3 – Cool or DOWN if valve position	13059
4.SRC.A	Output AA source A As IO Channel 1 Source A (Modbus address 12678)	13062
4.SRC.B	Output AA source B As IO Channel 1 Source A (Modbus address 12678)	13063
4.SRC.C	Output AA source C As IO Channel 1 Source A (Modbus address 12678)	13064
4.SRC.D	Output AA source D As IO Channel 1 Source A (Modbus address 12678)	13065
4.SENS	Output Polarity (0 = Normal, 1 = Inverted)	13066
4.PLS	Output AA Time proportioning Output minimum pulse time	13090

14. Calibration

The controller is calibrated during manufacture using traceable standards for every input range. It is, therefore, not necessary to calibrate the controller when changing ranges. Furthermore, the use of a continuous automatic zero correction of the input ensures that the calibration of the instrument is optimised during normal operation.

To comply with statutory procedures such as the Heat Treatment Specification AMS2750, the calibration of the instrument can be verified and re-calibrated if considered necessary in accordance with the instructions given in this chapter.

For example AMS2750 states: "Instructions for calibration and recalibration of "field test instrumentation" and "control monitoring and recording instrumentation" as defined by the NADCAP Aerospace Material Specification for pyrometry AMS2750D clause 3.2.5 (3.2.5.3 and sub clauses), including Instruction for the application and removal of offsets defined in clause 3.2.4."

14.1 To Check Input Calibration

The PV Input may be configured as mV, mA, thermocouple or platinum resistance thermometer.

14.1.1 Precautions

Before checking or starting any calibration procedure the following precautions should be taken:

1. When calibrating mV inputs make sure that the calibrating source output is set to less than 250mV before connecting it to the mV terminals. If accidentally a large potential is applied (even for less than 1 second), then at least one hour should elapse before commencing the calibration.
2. RTD and CJC calibration must not be carried out without prior mV calibration.
3. A pre-wired jig built using a spare instrument sleeve may help to speed up the calibration procedure especially if a number of instruments are to be calibrated.
4. Power should be turned on only after the controller has been inserted in the sleeve of the pre-wired circuit. Power should also be turned off before removing the controller from its sleeve.
5. Allow at least 10 minutes for the controller to warm up after switch on.

14.1.2 To Check mV Input Calibration

The input may have been configured for a process input of mV, Volts or mA and scaled in Level 3. The example described in section 8.3.1 assumes that the display is set up to read 2.0 for an input of 4.000mV and 500.0 for an input of 20.000mV.

To check this scaling, connect a milli-volt source, traceable to national standards, to terminals V+ and V- using copper cable as shown in the diagram below.

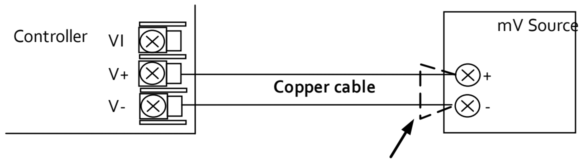


Figure 1: Connections for mV Input Calibration

☺ Ensure that no offsets have been set in the controller.

Set the mV source to 4.000mV. Check the display reads 2.0 ±0.25% ± 1LSD (least significant digit).

Set the mV source to 20.000mV. Check the display reads 500.0 ±0.25% ± 1LSD.

14.1.3 To Check Thermocouple Input Calibration

Connect a milli-volt source, traceable to national standards, to terminals V+ and V- as shown in the diagram below. The mV source must be capable of simulating the thermocouple cold junction temperature. It must be connected to the instrument using the correct type of thermocouple compensating cable for the thermocouple in use.

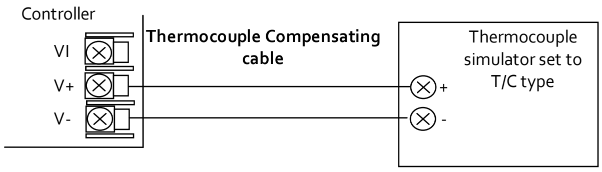


Figure -2: Connections for Thermocouple Calibration

Set the mV source to the same thermocouple type as that configured in the controller.

Adjust the mV source for to the minimum range. For a type J thermocouple, for example, the minimum range is -210°C. However, if it has been restricted using the Range Low parameter then set the mV source to this limit. Check that the reading on the display is within ±0.25% of reading ± 1LSD.

Adjust the mV source for to the maximum range. For a type J thermocouple, for example, the minimum range is 1200°C. However, if it has been restricted using the Range High parameter then set the mV source to this limit. Check that the reading on the display is within ±0.25% of reading ± 1LSD.

Intermediate points may be similarly checked if required.

14.1.4 To Check RTD Input Calibration

Connect a decade box with total resistance lower than 1K and resolution to two decimal places in place of the RTD as indicated on the connection diagram below **before the instrument is powered up**. If at any instant the instrument was powered up without this connection then at least 10 minutes must elapse from the time of restoring this connection before RTD calibration check can take place.

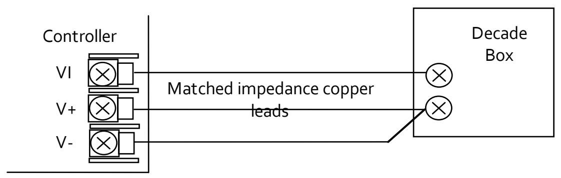


Figure -3: Connections for RTD Calibration

The RTD range of the instrument is -200 to 850°C. It is, however, unlikely that it will be necessary to check the instrument over this full range.

Set the resistance of the decade box to the minimum range. For example 0°C = 100.00Ω. Check the calibration is within ±0.25% of reading ± 1LSD.

Set the resistance of the decade box to the maximum range. For example 200°C = 175.86Ω. Check the calibration is within ±0.25% of reading ± 1LSD.

14.2 Offsets

The process value can be offset to take into account known errors within the process. The offset can be applied to any Input Type (mV, V, mA, thermocouple or RTD).

A single offset can be applied - the procedure is carried out in the **INPUT** list..

It is also possible to adjust the low and high points as a two point offset. This can only be done in **Level 3** in the '**Cal**' list and is described below.

14.2.1 Two Point Offset

A two point offset adjusts both a low point and a high point and applies a straight line between them. Any readings above and below the calibration points will be an extension of this straight line. For this reason it is best to calibrate with the two points as far apart as possible as shown in the example below:

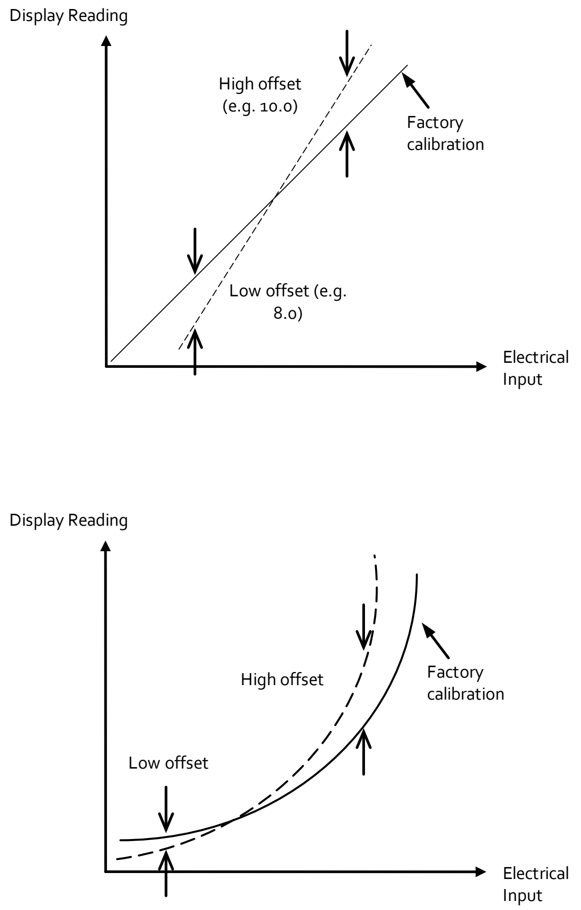


Figure 4 Two Point Offset Applied to Linear and Non-linear Inputs

14.2.2 To Apply a Two Point Offset

Assume the instrument is set up to display 0.0 for an input of 4.00mV and 500.0 for an input of 20.00mV. Assume that a particular sensor in use has known errors such that the instrument is required to read 8.0 for an input of 4.00mV and 490.0 for an input of 20.00mV. To compensate for these errors in the process a low point offset of 8.0 and a high point offset of 10.0 can be set as follows

Operation	Do This	Display View	Additional Notes
Select Calibration list header	**1.** Select **Level 3**. Then press to select 'CAL'	cal	Two pint offset can only be carried out in Level 3
Set mV input to 4.00mV			
Select User Calibration	2. Press to scroll to 'U.CAL'	IdLe ucal	Scrolling 2message user calibration
Select Low calibration point	3. Press or to 'LO'	Lo ucal	
Set the low offset value	4. Press to scroll to 'C.ADJ' 5. Press or to set the low offset value eg 8.0	8.0 c.adj	This applies an offset over the whole range in the same way as a simple offset.
	6. The controller then reverts to the CAL list header	CAL	This is the same as 1 above
Set mV input to 20.00mV			
Select User Calibration	7. Press to scroll to 'U.CAL'	IdLe ucal	This is the same as 2 above
Select the high calibration point	8. Press or to 'HI'	Hi ucal	
Select the high calibration offset parameter	9. Press to scroll to 'C.ADJ'	508.0 c.adj	The reading will show 508.0
Set the high offset value	10. Press or to set the high offset value to read 490.0	490.0 c.adj	

Under normal operating conditions the controller will now read 8.0 for an input of 4.000mV and 490.0 for an input of 20.000mV.

14.2.3 To Remove the Two Point Offset

Operation	Do This	Display View	Additional Notes
In level 3 select the Calibration list header	**1.** In **Level 3,** press to select 'CAL'	cal	Two point offset can only be carried out in Level 3
Select User Calibration	2. Press to scroll to 'U.CAL'	IdLe ucal	Scrolling message user calibration
Reset to no offset	3. Press or to select 'R.set'	rset ucal	

The display will revert to 2 above and the two point offsets will be removed.

14.3 Input Calibration

If the calibration is not within the specified accuracy follow the procedures in this section

In Series 3 series instruments, inputs which can be calibrated are

- **mV Input.** This is a linear 80mV range calibrated at two fixed points. This should always be done before calibrating either thermocouple or resistance thermometer inputs. mA range calibration is included in the mV range.
- **Thermocouple** calibration involves calibrating the temperature offset of the CJC sensor only. Other aspects of thermocouple calibration are also included in mV calibration.
- **Resistance Thermometer**. This is also carried out at two fixed points - 150Ω and 400Ω.

14.3.1 To Calibrate mV Input

Calibration can only be carried out in configuration level.

Calibration of the mV range is carried out using a 50 milli-volt source. mA calibration is included in this procedure.

For best results 0mV should be calibrated by disconnecting the copper wires from the mV source and short circuiting the input to the controller

To calibrate the mV Input, select **Conf Level,** set the controller input to mV range, then:

Operation	Do This	Display View	Additional Notes
Select the Calibration List header	1. From any display press as many times as necessary until the 'CAL' page header is displayed.		Scrolling display 'C A L I B R A T I O N L I S T'
Select the Calibration Phase	2. Press to select 'P H A S E'		Scrolling display 'C A L I B R A T I O N p h a s e'
Set mV source for 0mV			
Select the low calibration point	3. Press or to choose '0'		
Calibrate the instrument to the low calibration point (0mV)	4. Press to select 'G O' 5. Press or to choose 'YES'		Scrolling display 'C A L I B R A T I O N s t a r t' The controller automatically calibrates to the injected input mV. The display will show busy then PASS, (if calibration is successful.) or 'FAIL' if not. Fail may be due to incorrect input mV
Set mV source for 50mV			
Select the high calibration point	6. Press to select 'P H A S E' 7. Press or to choose '50' 8. Repeat 5 and 6 above to calibrate the high point		The controller will again automatically calibrate to the injected input mV. If it is not successful then 'FAIL' will be displayed

14.3.2 To Calibrate Thermocouple Input

Thermocouples are calibrated, firstly, by following the previous procedure for the mV ranges, then calibrating the CJC.

Connect a mV source. Set the mV source to **'internal compensation'** for the thermocouple in use and set the output for **omV**. Then

Operation	Do This	Display View	Additional Notes
Select the Calibration List header	1. From any display press as many times as necessary until the 'C A L ' page header is displayed.	CAL	
Select the calibration phase	2. Press to select 'P H A S E '	none phase	Scrolling display 'C A L I B R A T I O N phase '
Select CJC calibration	3. Press or to select 'CJC'	CJC PHASE	
Calibrate CJC	4. Press to select 'GO' 5. Press or to choose 'YES'	YES GO bUSY GO PASS GO	The controller automatically calibrates to the CJC input at omV. The display will show busy then pass, (if calibration is successful) or 'FAIL' if not. Fail may be due to an incorrect input mV

14.3.3 To Calibrate RTD Input

The two points at which the RTD range is calibrated are 150.00Ω and 400.00Ω.

Before starting RTD calibration:

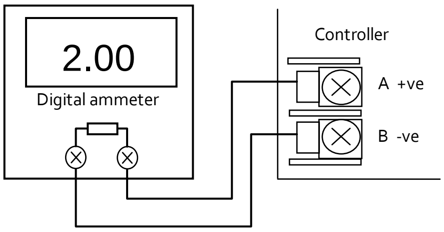
- A decade box with total resistance lower than 1K must be connected in place of the RTD as indicated on the connection diagram in section 15.1.4 **before the instrument is powered up**. If at any time the instrument was powered up without this connection then at least 10 minutes must elapse from the time of restoring this connection before RTD calibration can take place.
- The instrument should be powered up for at least 10 minutes.
- Before calibrating the RTD input the mV range must be calibrated first

Operation	Do This	Display View	Additional Notes
Select the Calibration List header	1. From any display press [page button] as many times as necessary until the 'C A L ' page header is displayed.		Scrolling display 'C A L I B R A T I O N L I S T'
Select the calibration phase	2. Press [scroll button] to select 'P H A S E '		Scrolling display 'C A L I B R A T I O N p h a s e'
Set the decade box for 150.00Ω			
Select the low calibration point (150Ω)	3. Press [up] or [down] to choose '150r		
Calibrate the low point	4. Press [scroll button] to select 'GO' 5. Press [up] or [down] to choose 'YES'	  	Scrolling display 'C A L I B R A T I O N s t a r t'
The controller automatically calibrates to the injected 150.00Ω input. The display will show busy then pass (if calibration is successful) or 'FAIL' if not. Fail may be due to an incorrect input resistance			
Set the decade box for 400.00Ω			
Select the high calibration point (400Ω)	7. Press [up] or [down] to choose '400r		
Calibrate the high point	8. Repeat 5 and 6 above to calibrate the high point		
The controller will again automatically calibrate to the injected 400.00Ω input. If it is not successful then 'FAIL' will be displayed			

14.3.4 To Calibrate mA Outputs

Output 3 is supplied as mA outputs. The output may be adjusted as follows

Connect an ammeter to the output – terminals 3A/3B as appropriate.

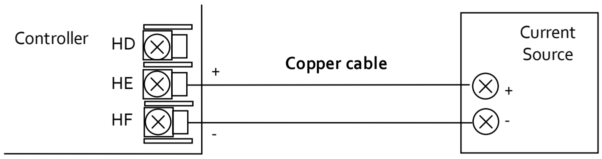


Then, in configuration level

Operation	Do This	Display View	Additional Notes
Select low point calibration phase for the mA output to be calibrated (eg OP3)	1. From the 'CAL' list header press to select 'PHASE' 2. Press or to choose '1ma.L'		Scrolling message 'calibration phase'
Set the low point output	3. Press to select 'V A L U E ' 4. Press or to adjust this value so that it reads the same value as shown on the ammeter. For example if the meter reads 2.06 then set the controller reading for 206. The decimal point is not displayed on the controller so that 200 represents 2.00.		Scrolling message 'dc output reading'
Select high point calibration phase for the mA output to be calibrated (eg OP3)	5. Press to go back to 'PHASE' 6. Press or to choose '1ma.H'		Scrolling message 'calibration phase'
Set the high point output	7. Press to select 'V A L U E ' 8. Press or to adjust this value so that it reads the same value as shown on the ammeter. The value represents 18.00mA		Scrolling message 'dc output reading'

14.3.5 To Calibrate Remote Setpoint Input

Connect a milli amp source to terminals HD and HE as shown.



Select **Conf Level**, then:

Operation	Do This	Display View	Additional Notes
Select the Calibration List header	1. From any display press [page button] as many times as necessary until the 'CAL' page header is displayed.	CAL	Scrolling display 'C A L I B R A T I O N L I S T'
Select the Calibration Phase	2. Press [scroll button] to select 'P H A S E'	none phase	Scrolling display 'C A L I B R A T I O N phase'
Set mA source for 4mA			
Select the low calibration point	3. Press [up] or [down] to choose 'rm.CL'	r m.CL phase	
Calibrate the instrument to the low calibration point (4mA)	4. Press [scroll button] to select 'G O' 5. Press [up] or [down] to choose 'YES'	YES GO bUSY GO PASS GO	Scrolling display 'C A L I B R A T I O N start' The controller automatically calibrates to the injected input. The display will show busy then pass, (if calibration is successful.) or 'FAIL' if not. Fail may be due to incorrect input. mA
Set mV source for 20mA			
Select the high calibration point	9. Press [scroll button] to select 'P H A S E' 10. Press [up] or [down] to choose 'rm.CH' 11. Repeat 4 and 5 above to calibrate the high point	r m.CH phase	The controller will again automatically calibrate to the injected input mV. If it is not successful then 'FAIL' will be displayed

To calibrate the voltage input, connect a volts source to terminals HD (negative) and HF (positive). The procedure is the same as described above but the calibration points are

Parameter	Calibration Voltage
rm.VL	0 Volts
rm.VH	10 Volts

14.3.6 To Return to Factory Calibration

It is always possible to revert to the factory calibration as follows

Operation	Do This	Display View	Additional Notes
Select the calibration phase	1. From the 'CAL' list header press to select 'PHASE'		
Select factory calibration values	2. Press or to choose 'FAct'		
Confirm	3. Press to select 'GO' 4. Press or to choose 'yes'	 	The controller automatically returns to the factory values stored during manufacture

14.4 Calibration Parameters

The following table gives the parameters available in the Calibration List.

The User Calibration is available in Level 3 only and is used to calibrate 'Offset'

CALIBRATION PARAMETER LIST			'cAL'			
Name	**Scrolling Display**	**Parameter Description**	**Value**		**Default**	**Access Level**
ucal	USER CALIBRATION	To select low and high offset state or reset to no offsets.	IdLe	Normal operating state	IdLE	L3 only
			Lo	Low offset		
			Hi	High offset		
			rEST	Remove high and low offsets		
The following parameters appear when calibrating the controller ie UCAL = Lo or Hi						
c.adj	CALIBRATION ADJUST	To set an offset value.	-1999 to 9999			L3 only

Input and Output calibration can only be done in Conf level.

CALIBRATION PARAMETER LIST			'cAL'			
Name	**Scrolling Display**	**Parameter Description**	**Value**	**Default**	**Access Level**	
phase	CAL PHASE	To calibrate low and high offset	none	Not selected	none	Conf only
			0	Select mV low calibration point		
			50	Select mV high calibration point		
			150r	Select PRT low cal point		
			400r	Select PRT high cal point		
			CJC	Select CJC calibration		
			Ct 0	Select CT low cal point		
			Ct 70	Select CT high cal point		
			Fact	Return to factory settings		
			Ima.L	Low mA output from I/O 1		
			Ima.H	High mA output from I/O 1		
			2ma.L	Low mA output from output 2		
			2ma.H	High mA output from output 2		
			3ma.L	Low mA output from output 3		
			3ma.H	High mA output from output 3		
GO		To start the calibration sequence	NO		NO	Conf only
			Yes	Start		
			Busy	Calibrating		
			Pass	Calibration successful		
			faiL	Calibration unsuccessful		

15. Appendix A TECHNICAL SPECIFICATION

General	
Temperature limits	Operation: 0 to 55°C (32 to 131°F), Storage: -10 to 70°C (14 to 158°F)
Humidity limits	Operation: RH: 5 to 90% non-condensing Storage: RH: 5 to 90% non-condensing
Panel sealing	IP 65, Nema 4X
Shock	BS EN61010
Vibration	2g peak, 10 to 150Hz
Altitude	<2000 metres
Atmospheres	Not suitable for use above 2000m or in explosive or corrosive atmospheres.
Electromagnetic compatibility (EMC)	EN61326-1 Suitable for domestic, commercial and light industrial as well as heavy industrial environments. (Class B emissions, Industrial Environment immunity). Low supply voltage versions are suitable for industrial environments only.
Installation category II	The rated impulse voltage for equipment on nominal 230V supply is 2500V
Pollution degree 2	Normally only non conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation shall be expected.
Physical	Series 3
Panel mounting	1/4 DIN
Weight grams	420

Operator interface	
Type	LCD TN with backlight
Main PV display	4 digits green
Lower display	Series 3 5 character starburst green
Staus beacon	Units, outputs, alarms, active setpoint

Power requirements	
Series 3	100 to 240Vac, -15%, +10% 48 to 62Hz, max 8W

Approvals	
	CE, cUL listed (file ES7766)
	Suitable for use in Nadcap and AMS2750D applications under Systems Accuracy Test calibration conditions

Transmitter PSU	
Isolation	264Vac double insulated
Output Voltage	24Vdc, >28mA, <33mA

Communications: serial communications option	
Protocol	Modbus RTU slave
Isolation	264Vac double insulated
Transmission	EIA485 2-wire standard

Process Variable Input	
Calibration accuracy	<±0.25% of reading ±1LSD (1)
Sample rate	4Hz (250mS)
Isolation	264Vac double insulated from the PSU and communications
Resolution (µV)	< 0.5µV when using a 1.6 second filter
Resolution (effective bits)	>17 bits
Linearisation accuracy	<0.1% of reading
Drift with temperature	<50ppm (typical) <100ppm (worst case)
Common mode rejection	48 - 62 Hz, >-120db
Series mode rejection	48 - 62 Hz, >-93db
Input impedance	100MΩ
Cold junction compensation	>30 to 1 rejection of ambient temperature
External cold junction	Reference of 0°C
Cold junction accuracy	<±1°C at 25°C ambient
Process Linear	-10 to 80mV, 0 to 10V with external potential divider module 100KΩ/806Ω
Thermocouple Types	K, J, N, R, S, B, L, T, C
RTD/PT100 Type	3-wire, Pt100 DIN43760
Bulb current	0.2mA
Lead compensation	No error for 22 ohms in all 3 leads
Input filter	Off to 59.9 seconds
Zero offset	User adjustable over the full display range
User calibration	2-point gain & offset

Notes

(1) Calibration accuracy quoted over full ambient operating range and for all input linearisation types.

AA relay	
Type	Form C changeover
Rating	Min: 12V, 100mA dc Max: 2A, 264Vac resistive
Functions	Control, alarms or events

Digital input (DigIn A/B)	
Contact closure	Contact open >600Ω Contact closed <300Ω
Input current	<13mA
Isolation	None from PV or system
	264Vac double insulated from PSU and communications
Functions	Include alarm acknowledge, SP2 select, manual keylock, standby select, RSP select

Logic I/O module Output	
Rating	On/High 12Vdc at <44mA
	Off/Low <300mV at 100µA
Isolation	None from PV or system
	264Vac double insulated from PSU and communications
Functions	Control, alarms or events

Logic I/O module Digital input	
Contact closure	Contact open >500Ω Contact closed <150Ω
Isolation	None from PV or system
	264Vac double insulated from PSU and communications
Functions	Include alarm acknowledge, SP2 select, manual keylock, standby select, RSP select

Relay output channels	
Type	Form A (normally open)
Rating	Min: 12V, 100mA dc Max: 2A, 264Vac resistive
Functions	Control, alarms or events

Triac output	
Rating	0.75A rms 30 to 264V rms (resistive load)
Isolation	264Vac double insulated
Functions	Control, alarms or events

Analogue output (3) OP1, OP2 and OP3	
Rating	0-20mA into <500Ω
Accuracy	± (<1% of reading + <100µA) [<50µA for OP3]
Resolution	13.5 bits [13.6 bits for OP3]
Isolation	264Vac double insulated from PSU and communications.
	Module code C and OP3 provides full 264V double insulated
Functions	Control, retransmission

Note (3) Voltage output can be achieved by external adaptor

Remote SP input	
Calibration Accuracy	<± 0.25% of reading ± 1LSD
Sample Rate	4Hz (250mS)
Isolation	264Vac double insulated from instrument
Resolution	<0.5mV for 0-10V input, or <2µA for 4-20mA
Resolution (effective bits)	>14 bits
Drift with temperature	<50ppm typical, <150ppm worst case
Common mode rejection	48 - 62 Hz, >-120db
Series mode rejection	48 - 62 Hz, >-90db
Input Impedance	>222Kohm (Volts) 2.49R (Current)
Normal input range	0 – 10V and 4 – 20mA
Max input range	-1V to 11V and 3.36mA to 20.96mA

Software features	
Control	
Number of loops	1
Loop update	250mS
Control types	PID, ON/OFF, VP
Cooling types	Linear, fan, oil, water
Modes	Auto, manual, standby, forced manual
Overshoot inhibition	High, low
Alarms	
Number	3
Type	Absolute high and low, deviation high, low or band, rate of change
Latching	Auto or manual latching, non-latching, event only
Output assignment	Up to four conditions can be assigned to one output
Custom messages	
Number	15 scrolling text messages
No. of characters	127 characters per message max
Languages	English
Selection	Active on any parameter status using conditional command