Powered by Possibility

3500 Series Process Controller

(Firmware version V4.0+)

User Guide

Eurotherm® a Watlow brand

Table of Contents

Associated Documents

HA033839	Installation Sheet
HA029045	Data Sheet
HA025464	EMC Booklet
HA026230	Digital Communications Handbook
HA027506	DeviceNet® Communications Handbook
HA026893	IO Expander
HA028838	iTools Help Manual

Note:

These handbooks may be downloaded from www.eurotherm.com.

Note: Whenever the symbol ☺ appears in this handbook it indicates a helpful hint.

Safety Information

Important Information

Read these instructions carefully and look at the equipment to become familiar with the device before trying to install, operate, service, or maintain it. The following special messages may appear throughout this manual or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of either symbol to a “Danger” or “Warning” safety label indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

⚠ DANGER
DANGER indicates a hazardous situation which, if not avoided, **will result in** death or serious injury.

⚠ WARNING
WARNING indicates a hazardous situation which, if not avoided, **could result in** death or serious injury.

⚠ CAUTION
CAUTION indicates a hazardous situation which, if not avoided, **could result in** minor or moderate injury.

NOTICE
NOTICE is used to address practices not related to physical injury. The safety alert symbol shall not be used with this signal word.

Notes:

1. Electrical equipment must be installed, operated, serviced and maintained only by qualified personnel. No responsibility is assumed by Eurotherm Limited or any of its affiliates or subsidiaries for any consequences arising out of the use of this material.
2. A qualified person is one who has skills and knowledge related to the construction, and operation of electrical equipment and its installation, and has received safety training to recognize and avoid the hazards involved.

Safety and EMC

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

Power down all equipment before starting the installation, removal, wiring, maintenance or inspection of the product.

For permanently connected equipment, include a disconnecting device such as an isolating switch or circuit breaker in the installation.

Use a properly rated voltage sensing device to confirm the power is off.

Power line and output circuits must be wired and fused in compliance with local and national regulatory requirements for the rated current and voltage of the particular equipment. i.e. UK, the latest IEE wiring regulations, (BS7671), and USA, NEC Class 1 wiring methods.

Failure to follow these instructions will result in death or serious injury.

Reasonable use and responsibility

The safety of any system incorporating this product is the responsibility of the assembler/installer of the system.

The disconnecting device must be in close proximity to the equipment and within easy reach of the operator, and it must be marked as the disconnecting device for the equipment.

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.

This controller is intended for industrial temperature and process control applications which meet the requirements of the European Directives on Safety and EMC.

Use in other applications, or failure to observe the installation instructions of this manual may compromize safety or EMC. The installer must ensure the safety and EMC of any particular installation.

Failure to use approved software/hardware with our hardware products may result in injury, harm, or improper operating results.

Please Note

Electrical equipment must be installed, operated, serviced, and maintained only by qualified personnel.

No responsibility is assumed by Eurotherm Limited or any of its affiliates or subsidiaries for any consequences arising out of the use of this material.

A qualified person is one who has skills and knowledge related to the construction and operation of electrical equipment and its installation, and has received safety training to recognize and avoid the hazards involved.

Qualification of Personnel

Only appropriately trained persons who are familiar with and understand the contents of this manual and all other pertinent product documentation are authorized to work on and with this product.

The qualified person must be able to detect possible hazards that may arise from parameterization, modifying parameter values and generally from mechanical, electrical, or electronic equipment.

The qualified person must be familiar with the standards, provisions, and regulations for the prevention of industrial accidents, which they must observe when designing and implementing the system.

Intended Use

The products described or affected by this document, together with software and options, are 3500 Series Controllers. They are intended for industrial use according to the instructions, directions, examples, and safety information contained in the present document and other supporting documentation.

The product must only be used in compliance with all applicable safety regulations and directives, the specified requirements, and the technical data.

Prior to using the product, a risk assessment must be performed in respect of the planned application. Based on the results, the appropriate safety-related measures must be implemented.

Since the product is used as a component within an overall machine or process, you must ensure the safety of the overall system.

Operate the product only with the specified cables and accessories. Use only genuine accessories and spare parts.

Any use other than that explicitly permitted is prohibited and can result in unanticipated hazards.

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

Electrical equipment must be installed, operated and maintained by only qualified personnel.

Turn off all power to product and all I/O circuitry (alarms, control I/O etc.) before starting the installation, removal, wiring, maintenance or inspection of the product.

Power line and output circuits must be wired and fused in compliance with local and national regulatory requirements for the rated current and voltage of the particular equipment, i.e. UK, the latest IEE wiring regulations, (BS7671), and USA, NEC class 1 wiring methods.

The unit must be installed in an enclosure or a cabinet. Failure to do this impairs the safety of the unit. An enclosure or a cabinet should provide fire enclosure and/or restriction of access to hazards.

Do not exceed the device's ratings.

This product must be installed, connected and used in compliance with prevailing standards and/or installation regulations. If this product is used in a manner not specified by the manufacturer, the protection provided by the product may be impaired.

The controller is designed to operate if a temperature sensor is connected directly to an electrical heating element. The PV Input not isolated from the logic outputs and digital inputs LA and LB, therefore, these terminals could be at line potential. 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 for use in 230Vac +15% CATII.

Do not insert anything through the case apertures.

Do not remove a fitted Ethernet communications module from a 3500 series controller if no longer required as the IP rating of the rear terminals will be compromised, with an associated increased risk of electric shock.

Tighten terminal screws in conformance with the torque specifications.

A maximum of two wires, identical in type and cross sectional size can be inserted per terminal. Strip the insulation from the cables by a minimum of 6mm (0.24") in order to ensure good contact with the terminal. Do not exceed a maximum exposed cable conductor length of 2mm (0.08").

Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E or CSA Z462.

Failure to follow these instructions will result in death or serious injury.

⚠ DANGER

FIRE HAZARD

If upon receipt, the unit or any part within is damaged, do not install but contact your supplier.

Do not allow anything to fall through the case apertures and ingress the controller.

Ensure the correct wire gauge size is used per circuit and it is rated for the current capacity of the circuit.

When using ferrules (cable ends) ensure the correct size is selected and each is securely fixed to the wire using a crimping tool.

The controller must be connected to the correct rated power supply unit or supply voltage in accordance with the supply voltage rating displayed on the controller label. or in the User guide. Use only isolating PELV or SELV power supplies to supply power to the equipment.

Failure to follow these instructions will result in death or serious injury.

⚠ WARNING

UNINTENDED EQUIPMENT OPERATION

Do not use the product for critical control or protection applications where human or equipment safety relies on the operation of the control circuit.

Observe all electrostatic discharge precautions before handling the unit.

Electrically conductive pollution must be excluded from the cabinet in which the controller is mounted for example, carbon dust. In conditions of conductive pollution in the environment, fit an air filter to the air intake of the cabinet. Where condensation is likely, for example, at low temperature, include a thermostatically controlled heater in the cabinet.

Avoid ingress of conductive materials during installation.

Use appropriate safety interlocks where personnel and/or equipment hazards exist.

Install and operate this equipment in an enclosure appropriately rated for its intended environment.

Routing of wires, to minimize the pick-up of EMI (Electromagnetic interference), the low voltage DC connections and the sensor input wiring must be routed away from high-current power cables. Where it is impractical to do this, use shielded cables with the shield grounded. In general keep cable lengths to a minimum.

Do not disassemble, repair or modify the equipment. Contact your supplier for repair.

Ensure all cables and wiring harness are secured using a relevant strain relief mechanism.

Wiring, it is important to connect the unit in accordance with the data in this User guide and use copper cables (except the thermocouple wiring).

Only connect wires to identified terminals shown on the product warning label, the wiring section of the product User guide or Installation sheet.

Safety and EMC protection can be seriously impaired if the unit is not used in the manner specified. The installer must ensure the safety and EMC of the installation.

If the output is not wired, but written to by communications, it will continue to be controlled by the communications messages. In this case take care to allow for the loss of communications.

The application of this product requires expertise in the design and programming of control systems. Only persons with such expertise must be allowed to program, install, alter and commission this product.

During commissioning ensure all operating states and potential fault conditions are carefully tested.

Do not use, or implement a controller configuration (control strategy) into service without ensuring the configuration has completed all operational tests, been commissioned and approved for service.

It is the responsibility of the person commissioning the controller to ensure the configuration is correct.

The controller must not be configured while it is connected to a live process as entering Configuration Mode pauses all outputs. The controller remains in Standby until Configuration Mode is exited.

Failure to follow these instructions can result in death, serious injury or equipment damage.

⚠ WARNING

UNINTENDED EQUIPMENT OPERATION

Actuators that are sensitive to switching pulse or cycle times should be fitted with a protective device. For example, refrigeration compressors should be fitted with a lockout timer to add additional protection against switching too quickly.

Any changes made to the controllers flash memory require the controller to enter configuration mode. The controller will not control the process when in configuration mode. Ensure that the controller is not connected to an active process when in configuration mode.

Failure to follow these instructions can result in death, serious injury or equipment damage.

⚠ CAUTION

EQUIPMENT OPERATION HAZARD

If being stored before use, store within the specified environmental conditions.

A Cold Start function erases ALL settings, removes the existing configuration and returns the controller to its original state. To minimize data loss the controller's configuration should be saved using a backup file, before committing a Cold Start.

A cold start of the controller must only be carried out under exceptional circumstances as it will erase ALL previous settings and return the controller to its original state.
"A controller must not be connected to any equipment when performing a cold start."

Cleaning. Isopropyl alcohol may be used to clean labels. A mild soap solution may be used to clean other exterior surfaces.

Ensure non-isolated modules are never installed in any 3500 Series controller. Non-isolated modules are NOT supported.

To minimize any potential loss of control or controller status when communicating across a network or being controlled via a third party client (i.e. another controller, PLC or HMI) ensure all system hardware, software, network design, configuration and cybersecurity robustness have been correctly configured, commissioned and approved for operation.

Failure to follow these instructions can result in injury or equipment damage.

Symbols

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

Risk of electric shock

Take precautions against static

Regulatory compliance mark for Australia (ACA) and New Zealand (RSM)

Complies with the 40 year Environment Friendly Usage Period

Dispose of in accordance with WEEE Directive

CE Mandatory conformity marking for certain products sold within the European Economic Area

South Korea KC Certification for Electrical and Electronic Products

Hazardous Substances

This product conforms to European **R**estriction **o**f **H**azardous **S**ubstances (RoHS) (using exemptions) and **R**egistration, **E**valuation, **A**uthorisation and Restriction of **Ch**emicals (REACH) Legislation.

RoHS Exemptions used in this product involve the use of lead. China RoHS legislation does not include exemptions and so lead is declared as present in the China RoHS Declaration.

Californian law requires the following notice:

⚠WARNING: This product can expose you to chemicals including lead and lead compounds which are known to the State of California to cause cancer and birth defects or other reproductive harm. For more information go to: https://www.P65Warnings.ca.gov

Cybersecurity

What is in this section?

This section outlines some good practice approaches to cybersecurity as they relate to use of 3500 series controllers, and draws attention to several features that could assist in implementing robust cybersecurity.

⚠ CAUTION

EQUIPMENT OPERATION HAZARD

To minimize any potential loss of control or controller status when communicating across a network or being controlled via a third party client (i.e. another controller, PLC or HMI) ensure all system hardware, software, network design, configuration and cybersecurity robustness have been correctly configured, commissioned and approved for operation.

Failure to follow these instructions can result in injury or equipment damage.

Introduction

When utilizing Eurotherm 3500 series controllers in an industrial environment, it is important to take ‘cybersecurity’ into consideration: in other words, the installation’s design should aim to prevent unauthorized and malicious access. This includes both physical access (for instance via the front panel or HMI screens), and electronic access (via network connections and digital communications).

Cybersecurity Good Practices

Overall design of a site network is outside the scope of this manual. The Cybersecurity Good Practices Guide, Part Number HA032968 provides an overview of principles to consider. This is available from www.eurotherm.com.

Typically, an industrial controller such as the 3500 controller together with any associated HMI screens and controlled devices should *not* be placed on a network with direct access to the public Internet. Rather, good practise involves locating these devices on a firewalled network segment, separated from the public Internet by a so-called ‘demilitarized zone’ (DMZ).

Security Features

The sections below draw attention to some of the cybersecurity features of 3500 series controllers.

Principle of Secure by Default

Some of the digital communication features on the 3500 series controllers can provide greater convenience and ease-of-use (particularly in regards to initial configuration), but also can potentially make the controller more vulnerable. For this reason, these features are turned off by default:

Bonjour auto-discovery disabled by default

Ethernet connectivity is available as an option on 3500 series controllers (see Ethernet Communication Parameters). Bonjour enables the controller to be automatically discovered by other devices on the network without the need for manual intervention. However, for cybersecurity reasons, it is disabled by default to prevent unauthorized access.

Port Use

The following ports are being used:

Port	Protocol
502 TCP	MODBUS (Client and Server)
5353 UDP	Zeroconf

The following should be noted about the ports:

- Ports are always closed by default and are only opened when the corresponding comms protocol is set.
- UDP Port 5353 (Auto-discovery/ZeroConf/Bonjour, open only when Comms.H.Network.AutoDiscovery parameter is ON.

HMI Access Level / Comms Config Mode

As described in section Access to Further Parameters, 3500 series controllers feature tiered, password-restricted operator levels, so that available functions and parameters can be restricted to appropriate personnel.

- Level 1 functions are the only ones that do not require password access, and are typically appropriate for routine operator use. The controller powers up in this level. All other levels are password-restricted.
- Level 2 makes an extended set of operational parameters available, typically intended for use by a supervisor.
- Level 3 parameters would typically be set when an authorized person was commissioning the device for use in a particular installation.

Config level allows access to all the controller’s parameters. Password-restricted access to these parameters is also possible over digital communications, using Eurotherm’s iTools software (See iTools integrated Online Help for further details)

At config level, it is also possible to customize the other levels from their defaults, restricting certain parameters to only be available at a higher level, or making certain parameters available at lower levels. In addition, you can configure the availability of setpoint program parameters such as Run/Reset, Program Edit and Program Mode and control parameters, such as Auto/Manual, Setpoint, and Manual Output.

HMI Passwords

When entering passwords via the HMI, the following features help protect against unauthorized access:

- Password entry is locked after three invalid attempts. The time it stays locked for (defaults to 30 minutes) is configurable. This helps protect against “brute force” attempts to guess the password.
- The controller records the number of successful and unsuccessful login attempts for each level of password. Regular auditing of these diagnostics is recommended, as a means to help detect unauthorized access to the controller.

Config Lock Password

An optional Config Lock feature is provided to give Original Equipment Manufacturers (OEMs) a layer of protection against theft of their intellectual property, and is designed to help prevent unauthorized cloning of controller configurations. This protection includes application-specific internal (soft) wiring and limited access to certain parameters via comms (by iTools or a third party comms package).

Comms Configuration Level Password

The password for Config Level access via iTools has the following features to help protect against unauthorized access (See iTools integrated Online Help for further details):

- There is no default password for comms configuration level.
- User needs to set the comms configuration password on first connect from iTools.
- If password is not set, Ethernet comms will be in Comms Lockdown mode (see below).
- Comms configuration password is encrypted before sending via comms.
- Passwords are salted and hashed before being stored.
  With password salting, a random piece of data is added to the password before it runs through the hashing algorithm, making it unique and harder to crack. When using both hashing and salting, even if two users choose the same password, salting adds random characters to each password when the users enter them.
- Number of password attempts is 5. If more than 5 unsuccessful attempts are made, the Password Lock function is triggered.
- iTools will enforce a minimum password length and complexity.
  Passwords must be at least 8 characters long and include a mix of uppercase letters, lowercase letters, numbers, and special characters. This ensures stronger security and helps protect against unauthorized access.

Comms Lockdown mode

In Comms Lockdown mode, Ethernet comms will only have read/write access to a limited set of parameters, see the following table. Config Clip, IR and Serial comms modules and HMI will not be affected.

Table 1: Comms Lockdown Limited Parameter Set

Parameter	MODBUS Address	Access	String length
CNOMO Manufacturing ID	0x0079(121)	Read-only	-
CNOMO Instrument ID	0x007A(122)	Read-only	-
Instrument firmware version	0x006B(107)	Read-only	-
CommsPasswordIsSet	0x0081(129)	Read-only	-
KeyExchange	0x53F4(21492)	Read/Write	35
CommsPassword	0x5621(22049)	Write-only	96

Ethernet security features

The following security features are specific to Ethernet:

Ethernet rate protection

One form of cyberattack is to try to make a controller process so much Ethernet traffic that it drains systems resources and useful control is compromised. For this reason, the 3500 series includes an Ethernet rate protection algorithm, which will detect excessive network activity and help to ensure the controller's resources are prioritized on the control strategy rather than servicing the Ethernet traffic. If this algorithm is running, the rate protection diagnostic parameter will be set to ON.

Broadcast Storm protection

A 'broadcast storm' is a condition which may be created by cyberattack whereby spurious network messages are sent to devices which cause them to respond with further network messages, creating a chain reaction that escalates until the network is unable to transport normal traffic. The 3500 series controllers includes a broadcast storm protection algorithm, which will automatically detect this condition, stopping the controller from responding to the spurious traffic. If this algorithm is active, the broadcast storm diagnostic parameter will be set to ON.

Communications watchdog

3500 series controllers include a 'comms watchdog' feature. This can be configured to raise an alert if any of the supported digital communications are not received for a specified period of time. See the four watchdog parameters. These provide a way to configure appropriate action if malicious action interrupts the controller's digital communications.

Configuration backup and recovery

Using Eurotherm's iTools software, you can 'clone' an 3500 series controller, saving all its configuration and parameter settings to a file. This can then be copied onto another controller, or used to restore the original controller's settings (see iTools integrated Online Help for further details).

For cybersecurity reasons, password-restricted parameters are not saved in the clone file when in operator mode (Level 1).

Clone files include a cryptographic integrity hash, meaning that if the file contents is tampered with, it will not load back into a controller.

A clone file cannot be generated or loaded if the Config Lock feature option is configured and active.

User Sessions

Communication connections only have two permission levels - an 'Operator mode' and a 'Configuration mode'. Any connection via comms (Ethernet or serial) is separated into its own unique session. A user logged in via the TCP socket will not share permissions with a different user logged in, for example, via the serial port and vice versa.

In addition, only a single user can be logged into an 3500 series controller in Configuration mode at any one time. If another user attempts to connect and select Configuration mode, the request will be denied until the other user exits the Configuration mode.

If a power cycle occurs all sessions will be in Operator Mode when connections are re-established.

Memory/Data Integrity

FLASH Integrity

When an 3500 series controller powers up, it automatically performs an integrity check on the entire contents of its internal flash memory before running it. If any integrity check detects a difference from what is expected, the controller will stop running and display a “Firmware invalid. Recovery Required” alert.

To recover the device, the Eurotherm Serial Upgrade Tool can be used to load valid firmware back onto the instrument. This tool can be obtained from Eurotherm with instructions on how to use it contained within the tool itself.

Non-volatile Data Integrity

When a 3500 series controller powers up, it automatically performs an integrity check on the contents of its internal non-volatile memory devices. Additional periodic integrity checks are performed during normal runtime and when non-volatile data is being written. If any integrity check detects a difference from what is expected, the controller enters Standby mode.

Cryptography Usage

3500 V4.0+ firmware is validated against a cryptographic signature before it will run. If for any reason the bootloader believes the firmware is invalid, then the message “Firmware invalid. Recovery Required” will be shown on the display.

To recover the device, the Eurotherm Serial Upgrade Tool can be used to load valid firmware back onto the instrument. This tool can be obtained from Eurotherm with instructions on how to use it contained within the tool itself.

Cryptography usage is employed in the following areas:

- ROM startup integrity checking
- Clone files
- Custom linearization tables
- Firmware upgrade signing

Achilles® Communications Certification

The 3500 series of controllers have been certified to Level 1 under the Achilles® Communications Robustness Test Certification scheme. This is an established industry benchmark for the deployment of robust industrial devices recognized by the major automation vendors and operators.

Decommissioning

When a 3500 series controller is at the end of its life and being decommissioned, Eurotherm advises reverting all parameters to their default settings (see the option ‘Clear Memory’ in the Instrument Security section). This can help to protect against subsequent data and intellectual property theft if the controller is then acquired by another party.

Legal Information

All pertinent state, regional, and local safety regulations must be observed when installing and using this product. For reasons of safety and to help ensure compliance with documented system data, only the manufacturer should perform repairs to components.

When devices are used for applications with technical safety requirements, the relevant instructions must be followed.

Failure to use Eurotherm Limited software or approved software with our hardware products may result in injury, harm, or improper operating results.

Failure to observe this information can result in injury or equipment damage.

Changes in 3500 V4.0+

Area	Changes
Access	Access block is no longer supported, parameters have been removed or moved to new locations Goto parameter no longer accessible IREnable, Keylock, AutoManFunction, RunHoldFunction and Key simulation parameters moved to Instrument.Access L2Passcode, L3Passcode, ConfPasscode and ClearMemory parameters moved to Instrument.Security CustomerID and AppName moved to Instrument.Info Standby (now ForceStandby) moved to Instrument.Diagnostics
Alarms	Analog and Digital Alarm blocks have been replaced with a generic alarm block capable of performing both Analog and digital functions Blocking (if enabled) is applied every time the Reference value is changed in Deviation alarms Blocking (if enabled) is applied every time the Deviation value is changed in Deviation alarms Blocking (if enabled) is applied every time the Threshold value is changed in Absolute High and Low alarms New alarm remains active in Config while in old 3500 new alarm gets cleared when entering config Alarm Summary block no longer supported – Individual Alarm status and Ack parameters now located within the alarm block itself – Alarm status parameters have been renamed and moved to Instrument.Diagnostics
Comms	The comms function blocks have been overhauled Protocols are disabled by default to support requirements of California Connected Devices Law Protocol selection is restricted based upon module fitted Parameters sorted into subclasses and hidden if not applicable to the current Protocol Native Ethernet requires use of the new Ethernet module, the old Ethernet module with flying lead is no longer supported Profibus is not supported
IO	IO.PV.Status and IO.Mod.x.Status parameter enumerations have changed Values are now consistent across the entire product - 0=Good, 1=ChannelOff, 2=OverRange, 3=UnderRange, 4=HardwareStatusInvalid, 5=Ranging, 6=Overflow, 7=Bad, 8=HWExceeded, 9=NoData
LIN16	No longer supported, replaced with new LIN32 block Parameters remapped within the SCADA region of the MODBUS address map
Mastercomms	No longer supported Replaced with ModbusMaster block
RTC	Real Time Clock block is no longer supported The product no longer contains a battery to backup the time, so the RTC functionality has been removed.
Wiring	When ordering 250 wires, device will provide 270 wires. For all other option, the expected number of wires is provided

Area	Changes
Zirconia	Total rework of the function block and underlying algorithms Parameters remapped within the SCADA region of the MODBUS address map
HMI	Comms Protocol selection added to start of quickcode settings to support requirements of the California Connected Devices Law
UsrTxt (Custom Enums)	In the old 3500 if the UsrTxt input value DOES NOT match one of the configured enum values, then the UsrTxt output parameter is NOT updated (so leaves the output text at the last known value). On the new 3500, the UsrTxt output text parameter will be forced to blank/empty text if the input value DOES NOT match any of the configurated enum values.
MODBUS	MODBUS Organization replaced Master-Slave with Client-Server and is reflected in this user guide. However, there may still be some references to outdated terminology on the instrument HMI and iTools which will be addressed in future firmware updates.

Installation and Operation

What Instrument Do I Have?

Thank you for choosing this Controller.

The 3508 controller is supplied in the standard 1/8 DIN size 48 x 96mm front panel (1.89" x 3.76"). The 3504 controller is supplied in the standard 1/4 DIN size 96 x 96mm front panel (3.76" x 3.76"). They are intended for indoor use only and for permanent installation in an electrical panel which encloses the rear housing, terminals and wiring on the back. They are designed to control industrial and laboratory processes via input sensors which measure the process variables and output actuators which adjust the process conditions.

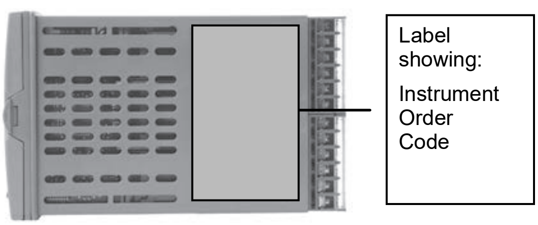
Contents of Package

When unpacking your controller please check that the following items have been included.

3508 or 3504 Controller Mounted in its Sleeve

The 3504 contains up to six plug-in hardware modules; the 3508 has up to three. Additionally digital communications modules can be fitted in two positions.

The modules provide an interface to a wide range of plant devices and those fitted are identified by an ordering code printed on a label fixed to the side of the instrument. Check this against the description of the code given in the 3500 Installation Sheet (HA033839) to ensure that you have the correct modules for your application. This code also defines the basic functionality of the instrument which may be:



- Controller only
- Programmer and controller
- Control type – Standard PID, valve positioner
- Digital communications type
- Options

Panel Retaining Clips

Two clips are required to secure the instrument sleeve in the panel. These are supplied fitted to the sleeve.

Accessories Pack

For each input a 2.49Ω resistor is supplied for mA measurement. This will need to be fitted across the respective input terminals

Installation Sheet

Installation Sheet explains:

- How to install the controller
- Physical wiring to the plant devices
- First switch on - ‘out of the box’
- Principle of operation using the front panel buttons

Orderable Accessories

Refer to 3500 Installation Sheet (HA033839) for order code details.

The following accessories may be ordered:

User Manual - This may also be downloaded from www.eurotherm.com	HA033837
2.49Ω Precision resistor	SUB35/ACCESS/249R.1
Configuration IR Clip	ITools/None/30000IR
Configuration Clip	ITools/None/30000CK
10In,10Out IO Expander	2000IO/VL/10LR/XXXX
20In,20Out IO Expander	2000IO/VL/10LR/10LR

How to Install the Controller

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

Select a location where minimum vibrations are present and the ambient temperature is within 0 and 50°C (32 and 122°F).

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

To assure IP65 and NEMA 12 front protection, use a panel with smooth surface texture.

Please read the safety information, at the end of this guide, before proceeding and refer to the EMC Booklet part number HA025464 for further information. This and other relevant manuals may be downloaded from www.eurotherm.com.

Dimensions

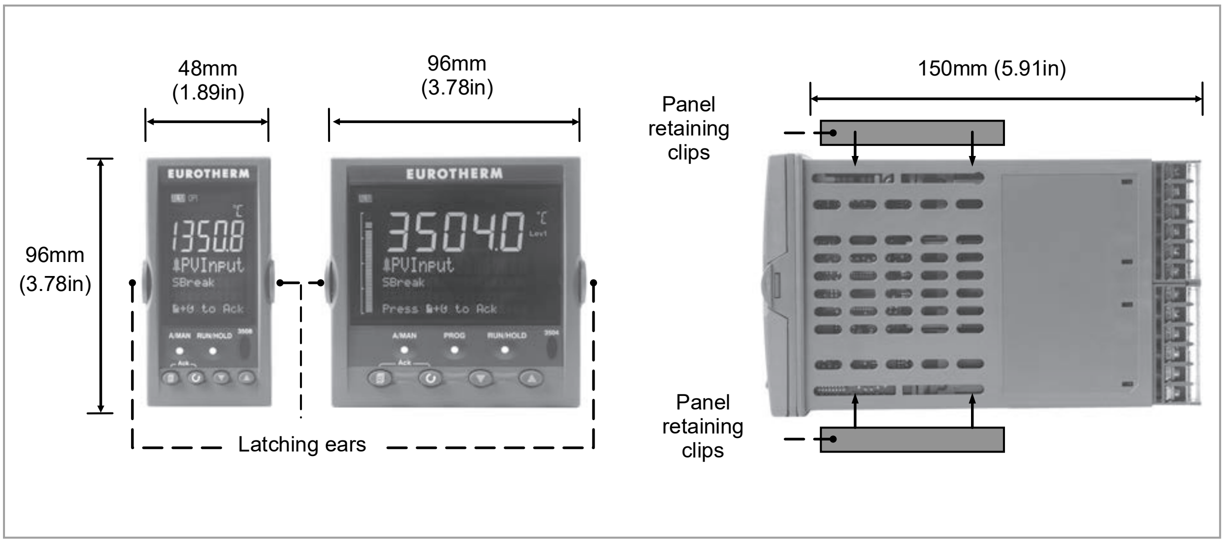


Figure 1: Controller Dimensions

To Install the Controller

Panel Cut-out

1. Prepare the panel cut-out to the size shown in the diagram
2. Insert the controller through the cut-out.
3. Spring the panel retaining clips into place. Secure the controller in position by holding it level and pushing both retaining clips forward.
4. Peel off the protective cover from the display.

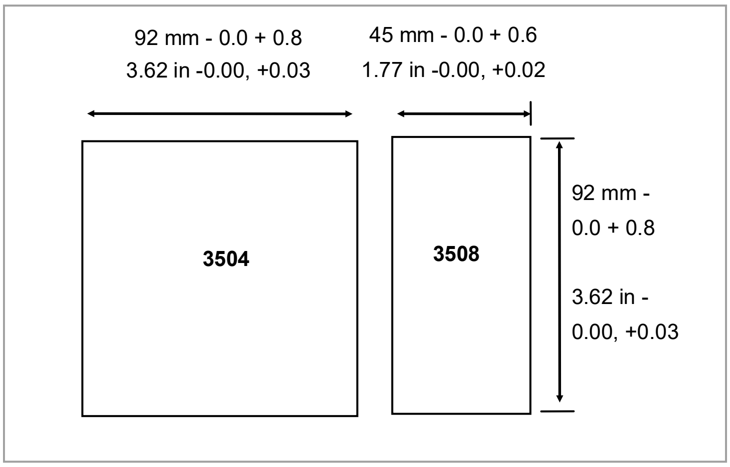


Figure 2: Panel Cut out Dimensions

Recommended Minimum Spacing

The recommended minimum spacing between controllers shown here should not be reduced to allow sufficient natural air flow.

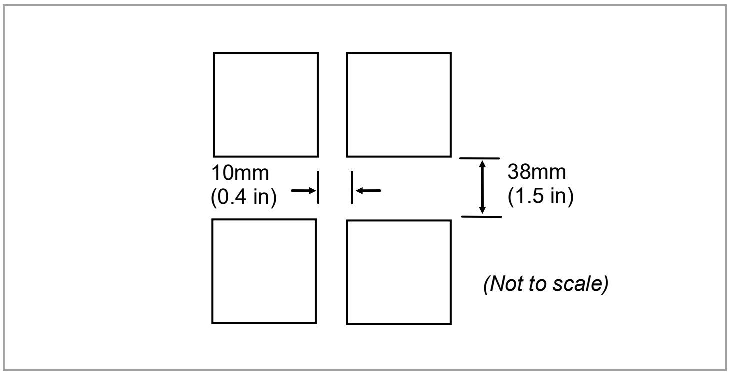


Figure 3: Minimum Spacing Between Controllers

To Remove the Controller

For Ethernet version, ensure the Ethernet cables are disconnected from the rear of the controller (isolate the power supply first).

To remove, ensure that the latching ears are eased outwards, then pull the controller forward, to remove from the sleeve. When plugging back in ensure that the latching ears click into place to maintain the IP65 sealing.

Electrical Connections

3508 Controller - Rear Terminal View

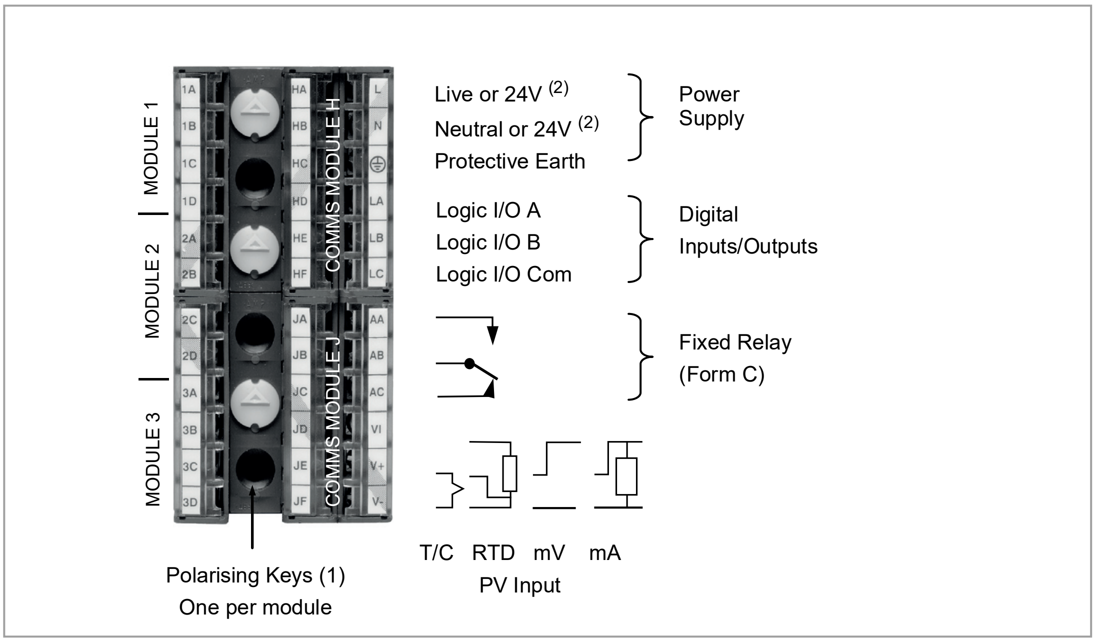


Figure 4: Rear Terminal View (with Serial or DeviceNet) – 3508 Controller

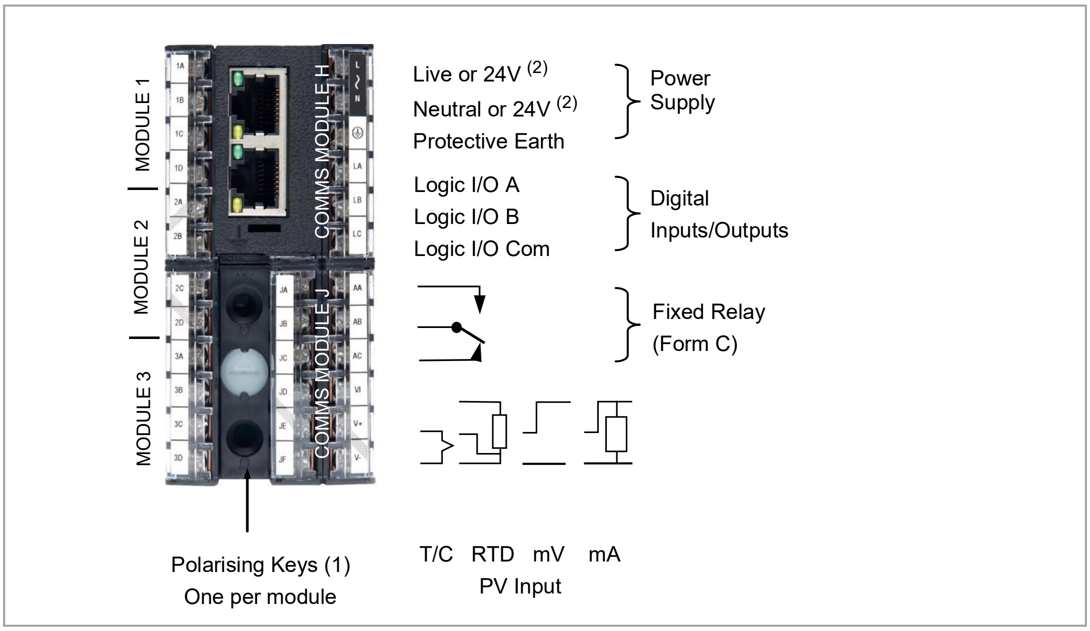


Figure 5: Rear Terminal View (with Ethernet) – 3508 Controller

3504 Controller - Rear Terminal View

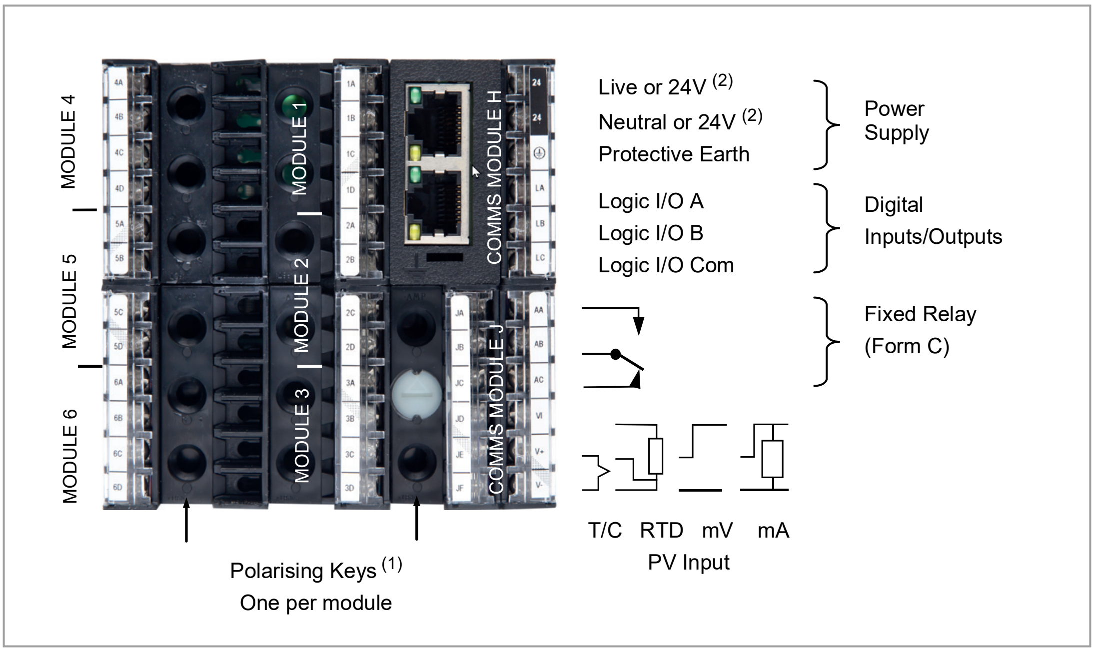


Figure 6: Rear Terminal View (with Serial or DeviceNet) – 3504 Controller

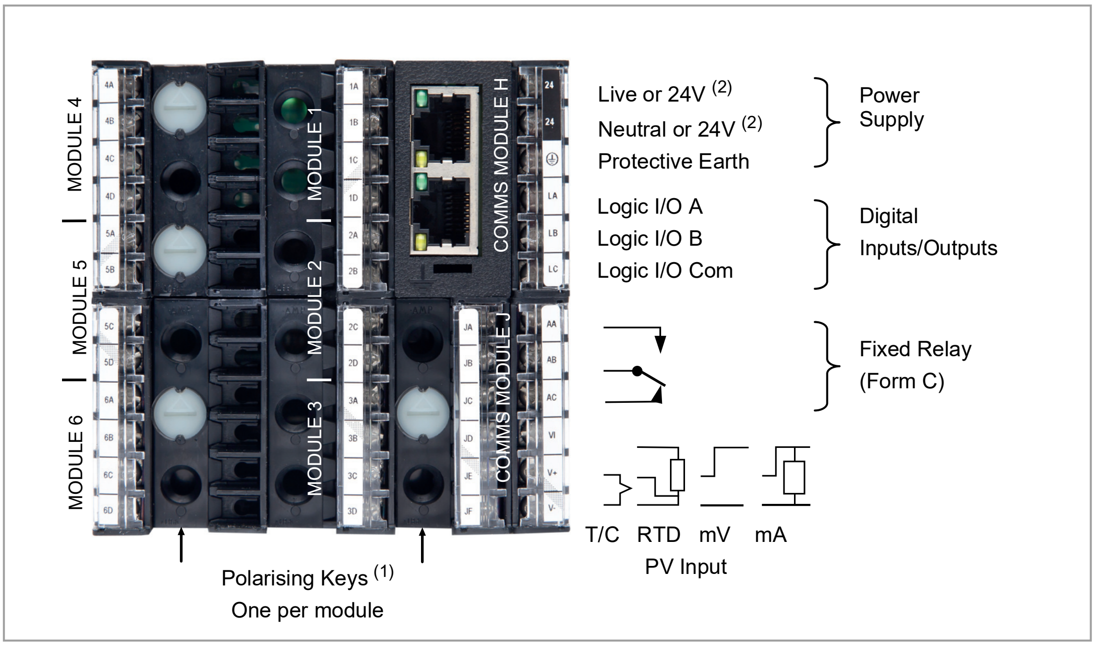


Figure 7: Rear Terminal View (with Ethernet) – 3504 Controller

(1) Polarising keys are intended to prevent modules which are not supported in this controller from being fitted into the controller. An example might be a non-isolated module (coloured red) from a 2400 controller series. When pointing towards the top, as shown, the key prevents a controller, fitted with an unsupported module, from being plugged into a sleeve which has been previously wired for isolated modules.

(2) High or low voltage versions are orderable. Ensure you have the correct version.

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

Do not remove a fitted Ethernet communications module from a 3500 series controller if no longer required as the IP rating of the rear terminals will be compromised, with an associated increased risk of electric shock.

Failure to follow these instructions will result in death or serious injury.

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).

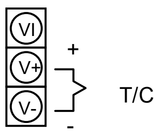
Standard Connections

These are connections which are common to all instruments in the range.

PV Input (Measuring Input)

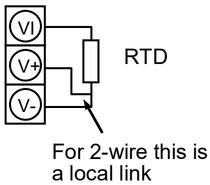
NOTICE
1. Do not run input wires together with power cables
2. When shielded cable is used, it should be grounded at one point only
3. Any external components (such as zener barriers, etc) connected between sensor and input terminals may cause errors in measurement due to excessive and/or un-balanced line resistance or possible leakage currents
4. Not isolated from logic I/O A and logic I/O B

Thermocouple or Pyrometer Input



- Use the correct type of thermocouple compensating cable, preferably shielded, to extend wiring
- It is not recommended to connect two or more instruments to one thermocouple

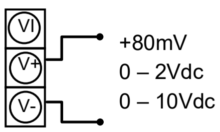
RTD Input



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

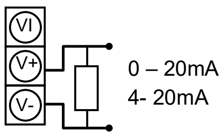
NOTICE
RTD wiring is not the same as 2400 series instruments. It is the same as 26/2700 series

Linear Input V, mV and High Impedance V



- mV range ±40mV / ±80mV
- High level range 0 – 10Vdc
- High Impedance mid level range 0 – 2Vdc
- A line resistance for voltage inputs may cause measurement errors

Linear Input mA



- Connect the supplied load resistor equal to 2.49Ω for mA input

The resistor supplied is 1% accuracy 50ppm

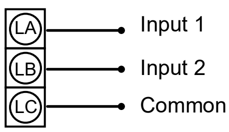
A resistor 0.1% accuracy 15ppm resistor can be ordered as a separate item

Digital I/O

These terminals may be configured as logic inputs, contact inputs or logic outputs in any combination. It is possible to have one input and one output on either channel.

⚠ WARNING
The Digital IO is not isolated from the PV input.

Logic Inputs

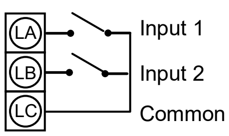


- Voltage level logic inputs, 12Vdc, 5-40mA

Active > 10.8Vdc

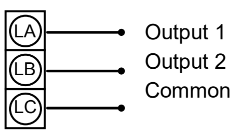
Inactive < 7.3Vdc

Contact Closure Inputs



- Contact open > 1200Ω
- Contact closed < 480Ω

Digital (Logic) Outputs



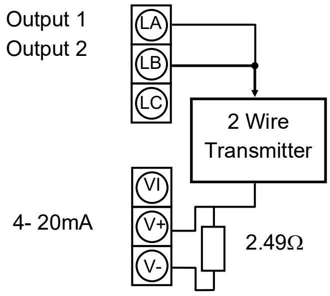
- The logic outputs are capable of driving SSR or thyristors up to 9mA, 18Vdc. It is possible to parallel the two outputs to supply 18mA, 18Vdc.

⚠ WARNING

The Digital IO terminals are not isolated from the PV.

The fixed digital logic outputs may be used to power remote 2 wire transmitters. The fixed digital I/O are, however, not isolated from the PV input circuit, so this does not allow the use of 3 or 4 wire transmitters. An isolated module must be used for the 3 and 4 wire types.

Digital (Logic) Outputs used to Power a Remote 2 wire Transmitter.

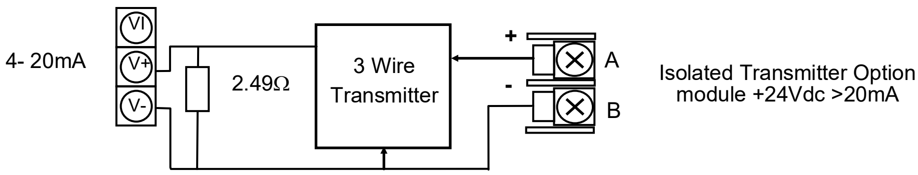


- The parallel logic outputs supply >20mA, 18Vdc.
- Connect the supplied load resistor equal to 2.49Ω for mA input

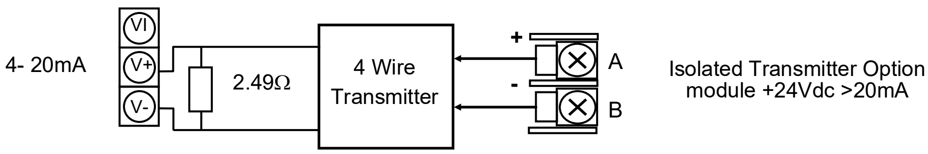
⚠ WARNING

The Digital IO terminals are not isolated from the PV.

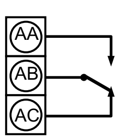
Digital (Logic) Outputs used to Power a Remote 3 wire Transmitter.



Digital (Logic) Outputs used to Power a Remote 4 wire Transmitter.



Relay Output



- Relay rating, min: 1V, 1mAdc. Max: 264Vac 2A resistive
- Relay shown in de-energised state
- Isolated output 240Vac CATII

General Note About Inductive Loads

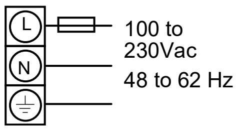
High voltage transients may occur when switching inductive loads such as some contactors or solenoid valves.

For this type of load it is recommended that a 'snubber' is connected across the contact of the relay switching the load. The snubber typically consists of a 15nF capacitor connected in series with a 100Ω resistor and will also prolong the life of the relay contacts.

⚠ WARNING

When the relay contact is open and it is connected to a load, the snubber passes a current (typically 0.6mA at 110Vac and 1.2mA at 240Vac). It is the responsibility of the installer to ensure that this current does not hold on the power to an electrical load. If the load is of this type the snubber should not be connected.
See also section Snubbers.

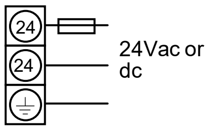
Power Supply Connections



1. Before connecting the instrument to the power line, make sure that the line voltage corresponds to the description on the identification label
2. For supply connections use 16AWG or larger wires rated for at least 75°C (167°F)
3. Use copper conductors only
4. For 24Vac/dc the polarity is not important
5. It is the Users responsibility to provide an external fuse or circuit breaker.

   For 24Vac/dc fuse type T rated 4A 250V

   For 100/240Vac fuse type T rated 1A 250V



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

NOTICE

A single switch or circuit breaker can supply more than one instrument

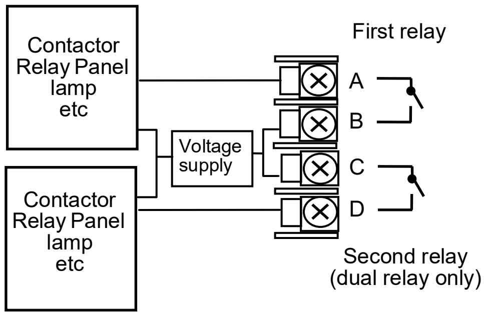
Plug in I/O Module Connections

Plug in I/O modules can be fitted in three positions in the 3508 and six positions in 3504. The positions are marked Module 1, 2, 3, 4, 5, 6. With the exception of the Analogue Input module, any other module listed in this section, can be fitted in any of these positions. To find out which modules are fitted check the ordering code printed on a label on the side of the instrument. If modules have been added, removed or changed it is recommended that this is recorded on the instrument code label.

The function of the connections varies depending on the type of module fitted in each position and this is shown below. All modules are isolated.

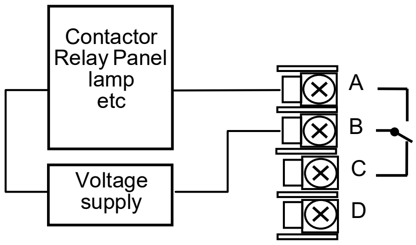
NOTICE
The order code and terminal number is pre-fixed by the module number. For example, Module 1 is connected to terminals 1A, 1B, 1C, 1D; module 2 to 2A, 2B, 2C, 2D, etc

Relay (2 pin) and Dual Relay Module



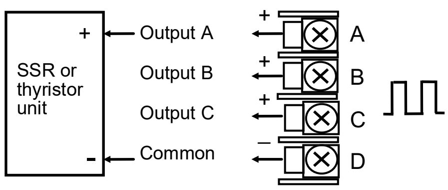
- Hardware Code: R2 and RR
- Relays Rating: 2A, 264Vac max or 10mA/12Vdc min
- Typical usage: Heating, cooling, alarm, program event, valve raise, valve lower
- Isolated output 240Vac CATII

Change Over Relay



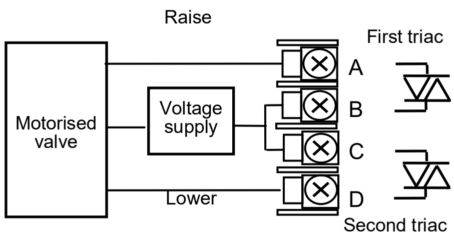
- Hardware Code: R4
- Relay Rating: 2A, 264Vac max or 10mA/12Vdc min
- Typical usage: Heating, cooling, alarm, program event, valve raise, valve lower.
- Isolated output 240Vac CATII

Triple Logic and Single Isolated Logic Output



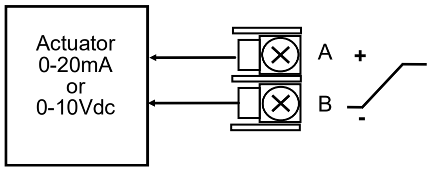
- Hardware Code: TP and LO
- Outputs Rating - Single: (12Vdc at 24mA max.)
- Outputs Rating - Triple: (12Vdc at 9mA max.)
- Typical usage: Heating, cooling, program events.
- No channel isolation. 264Vac insulation from other modules and system
- Single Logic Output connections are:
  D – Common
  A – Logic Output

Triac and Dual Triac



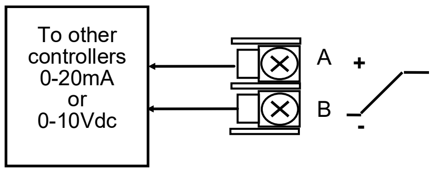
- Hardware Code: T2 and TT
- Combined Output Rating: 0.7A, 30 to 264Vac
- Typical usage: Heating, cooling, valve raise, valve lower.
- Isolated output 240Vac CATII
- Dual relay modules may be used in place of dual triac.
- **The combined current rating for the two triacs must not exceed 0.7A**

DC Control



- Hardware Code: D4
- Output Rating: (10Vdc, 20mA max)
- Typical Usage: Heating, cooling e.g. to a 4-20mA process actuator
- Isolated output 240Vac CATII

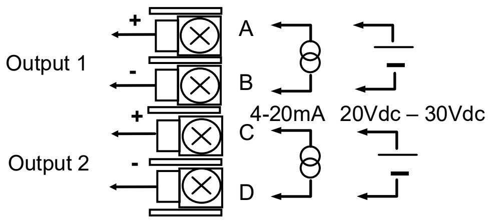
DC Retransmission



- Hardware Code: D6
- Output Rating: (10Vdc, 20mA max)
- Typical Usage: Logging of PV, SP, output power, etc., (0 to 10Vdc or 0 to 20mA)
- Isolated output 240Vac CATII

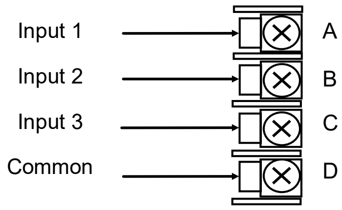
Dual DC Output

Slots 1, 2 and 4 only



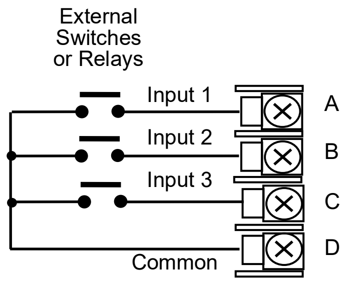
- Hardware Code: DO
- Output Rating: each channel can be 4-20mA or 24Vdc (nominal)
- Typical Usage: Control output 12 bit resolution

Triple Logic Input



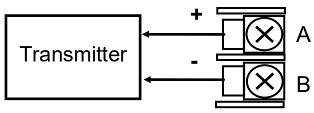
- Hardware Code: TL
- Input Ratings: Logic inputs <5Vdc OFF >10.8Vdc ON Limits: -3Vdc, +30Vdc
- Typical Usage: Events e.g. Program Run, Reset, Hold
- Isolated output 240Vac CATII

Triple Contact Input



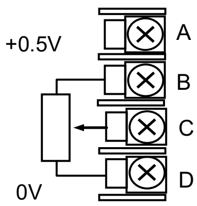
- Hardware Code: TK
- Input Ratings: Logic inputs >28KΩ OFF <100Ω ON
- Typical Usage: Events e.g. Program Run, Reset, Hold
- Isolated output 240Vac CATII

24V Transmitter Supply



- Hardware Code: MS
- Output Rating: 24Vdc 20mA
- Typical Usage: To power an external transmitter
- Isolated output 240Vac CATII

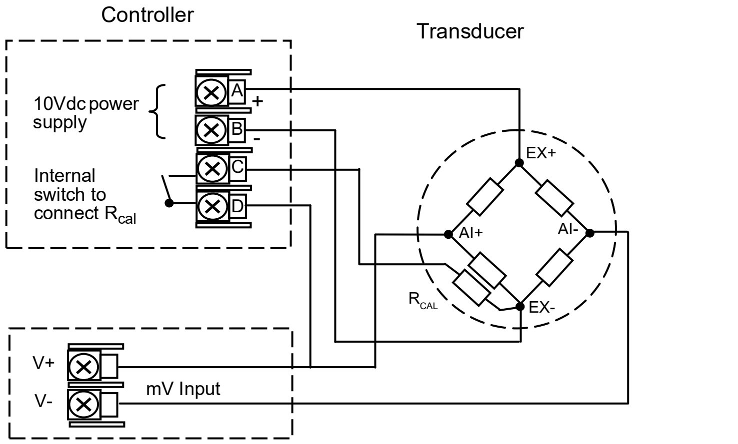
Potentiometer Input

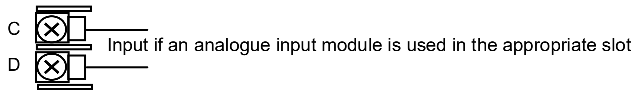


- Hardware Code: VU
- Rating: 100Ω to 15KΩ
- Typical Usage: Valve position feedback Remote setpoint
- Isolated output 240Vac CATII

Transducer Power Supply

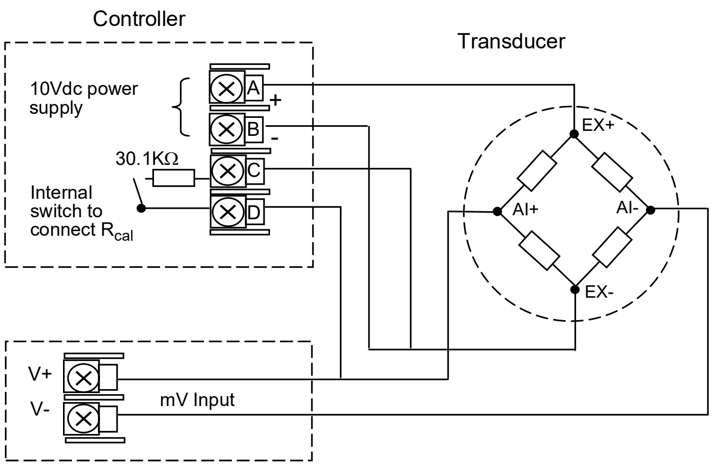
Transducer with Internal Calibration Resistor





- Hardware Code: G3
- Rating: Configurable 5Vdc or 10Vdc. Minimum load resistance 300Ω
- Typical Usage: Strain Gauge transducer power and measurement
- Isolated output 240Vac CATII

Transducer with External Calibration Resistor

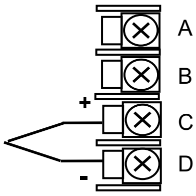


Analogue Input (T/C, RTD, V, mA, mV)

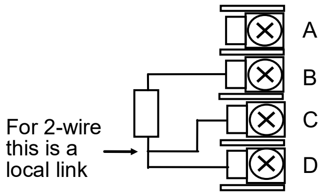
Slots 1, 3, 4 & 6 only

- Hardware Code: AM
- Typical Usage: Second PV input, Remote setpoint
- Isolated 240Vac CATII

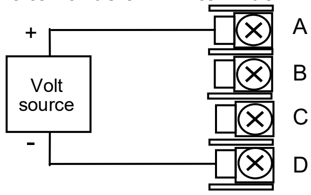
Thermocouple



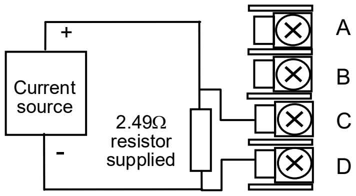
3-wire RTD



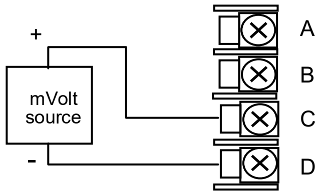
Voltage
-3 to 10Vdc or –1.4 to 2Vdc



Current
0 to 20mA or (4 to 20mA)



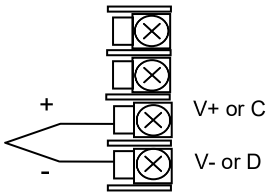
mV
±50mV



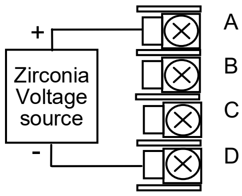
Analogue Input (Zirconia Probe)

- The temperature sensor of the zirconia probe can be connected to the Fixed PV input, terminals V+ and V-, or to an Analogue Input module, terminals C & D. The Zirconia Probe voltage source can be connected to an Analogue Input module, terminals A & D.

Fixed PV (or an Analogue Input Module)



Analogue Input Module



Zirconia Probe Construction

The zirconia sensor wires should be screened and connected to the outer shell of the probe if it is situated in an area of high interference.

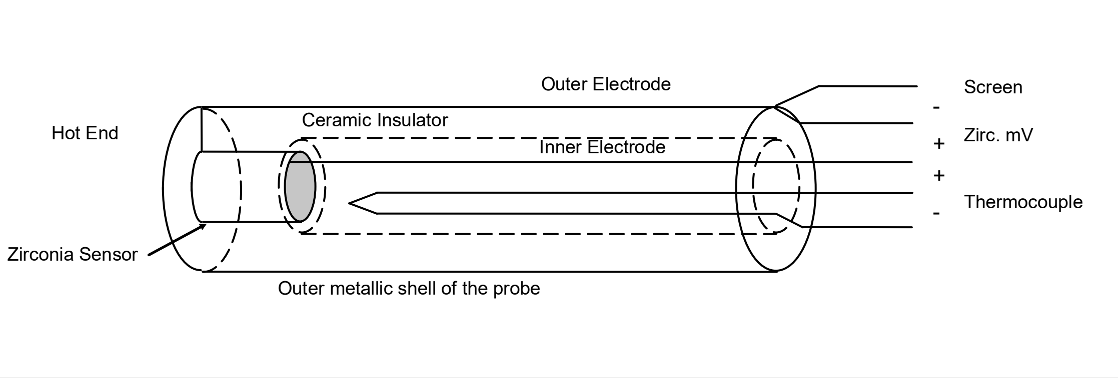


Figure 8: Zirconia Probe Wiring

Zirconia Probe Screening Connections

The zirconia sensor wires should be screened and connected to the outer shell of the probe if it is situated in an area of high interference.

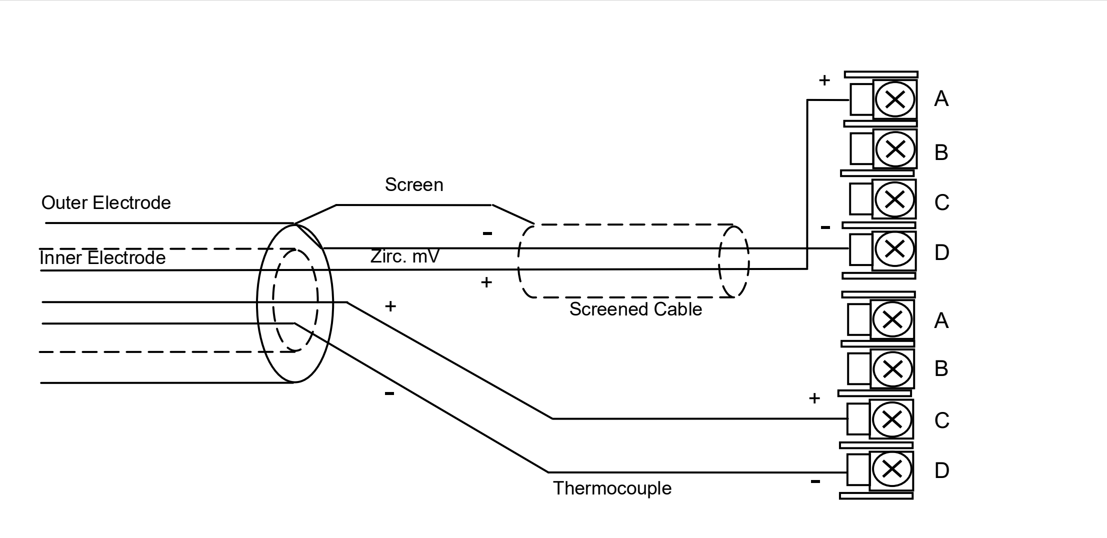


Figure 9: Zirconia Probe Wiring

Digital Communications Connections

Digital Communications modules can be fitted in two positions in both 3508 and 3504 controllers. The connections being available on HA to HF and JA to JF depending on the position in which the module is fitted. The two positions could be used, for example, to communicate with ‘iTools’ configuration package on one position, and to a PC running a supervisory package on the second position. Communications protocols may be MODBUS, EI-Bisynch, DeviceNet or MODBUS TCP.

NOTICE
1. In order to reduce the effects of RF interference the transmission line should be grounded at both ends of the screened cable. However, if such a course is taken care must be taken to ensure that differences in the earth potentials do not allow circulating currents to flow, as these can induce common mode signals in the data lines. Where doubt exists it is recommended that the Screen (shield) be grounded at only one section of the network as shown in all of the following diagrams 2. RS “Recommended Standard” (eg RS232) is sometimes referred to as EIA “Electronic Industries Alliance” (eg EIA232). 3-Wire and 5-Wire is sometimes referred to as 2-Wire and 4-Wire.

MODBUS (H or J Module), EI-BISYNCH, Broadcast and MODBUS Client

See also section Wiring Connections - Broadcast Communications for further details when wiring Broadcast and Modbus Client.

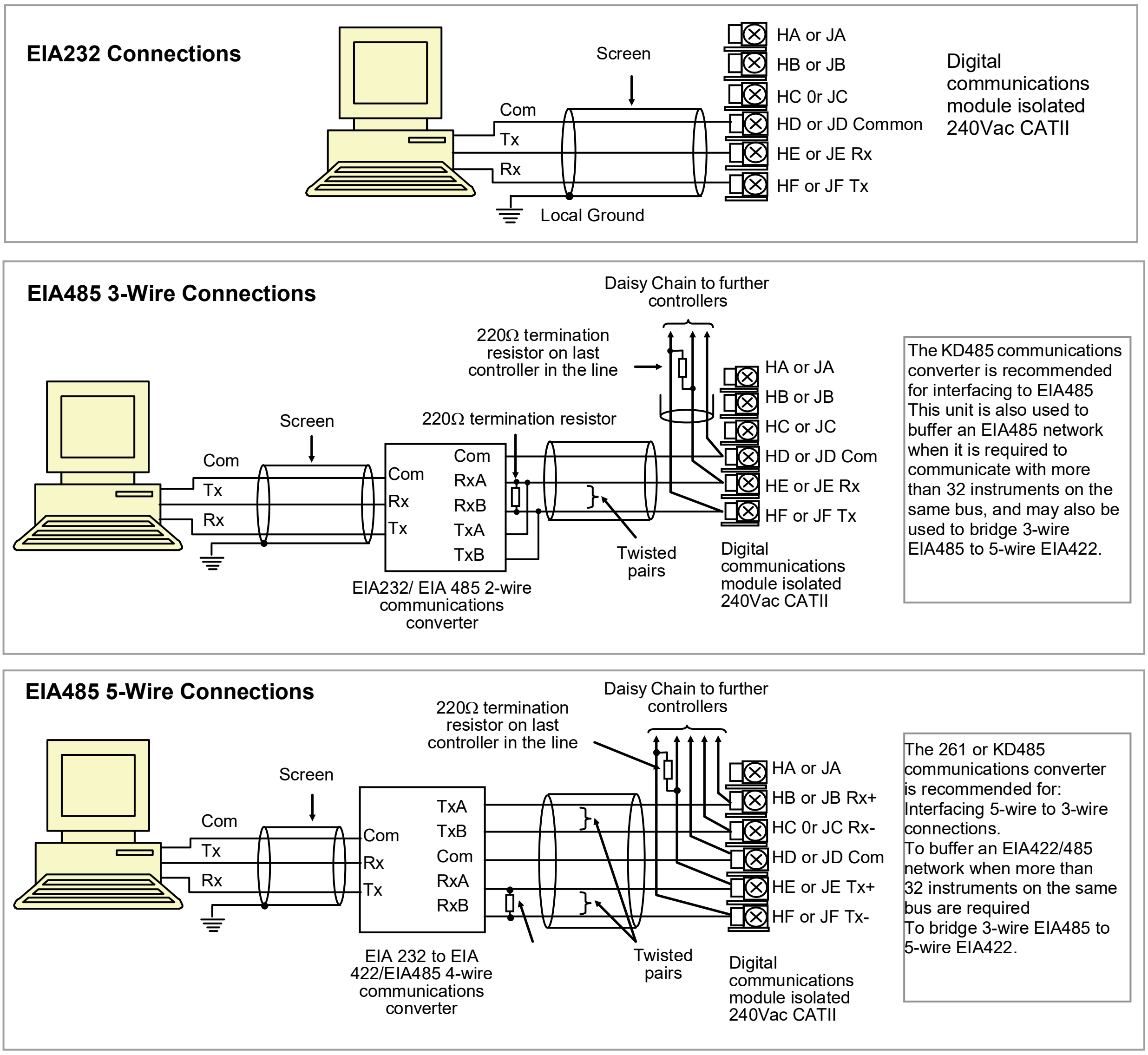


Figure 10: EIA232 and EIA485 Connections

DeviceNet Wiring

It is not within the scope of this manual to describe the DeviceNet standard. For this please refer to the DeviceNet specification which may be found at www.odva.org.

In practice it is envisaged that 3500 series controllers will be added to an existing DeviceNet network. This section, therefore, is designed to provide general guidelines to connect 3500 series controllers to this network. Further information is also available in the DeviceNet Communications Handbook Part No HA027506 which can be downloaded from www.eurotherm.com.

According to the DeviceNet standard two types of cable may be used. These are known as Thick Trunk and Thin Trunk. For long trunk lines it is normal to use Thick trunk cable. For drop lines thin trunk cable is generally more convenient being easier to install. The table below shows the relationship between cable type, length and baud rate.

Network length	Varies with speed. Up to 400m possible with repeaters		
Baud Rate Mb/s	125	250	500
Thick trunk	500m (1,640ft)	200m (656ft)	75m (246ft)
Thin trunk	100m (328ft)	100m (328ft)	100m (328ft)

Terminal Reference	CAN Label	Color Chip	Description
HA	V+	Red	DeviceNet network power positive terminal. Connect the red wire of the DeviceNet cable here. If the DeviceNet network does not supply the power, connect to the positive terminal of an external 11-25 Vdc power supply.
HB	CAN_H	White	DeviceNet CAN_H data bus terminal. Connect the white wire of the DeviceNet cable here.
HC	SHIELD	None	Shield/Drain wire connection. Connect the DeviceNet cable shield here. To prevent ground loops, the DeviceNet network should be grounded in only one location.
HD	CAN_L	Blue	DeviceNet CAN_L data bus terminal. Connect the blue wire of the DeviceNet cable here.
HE	V-	Black	DeviceNet network power negative terminal. Connect the black wire of the DeviceNet cable here. If the DeviceNet network does not supply the power, connect to the negative terminal of an external 11-25 Vdc power supply.
HF			Connect to instrument earth

Example DeviceNet Wiring Diagram

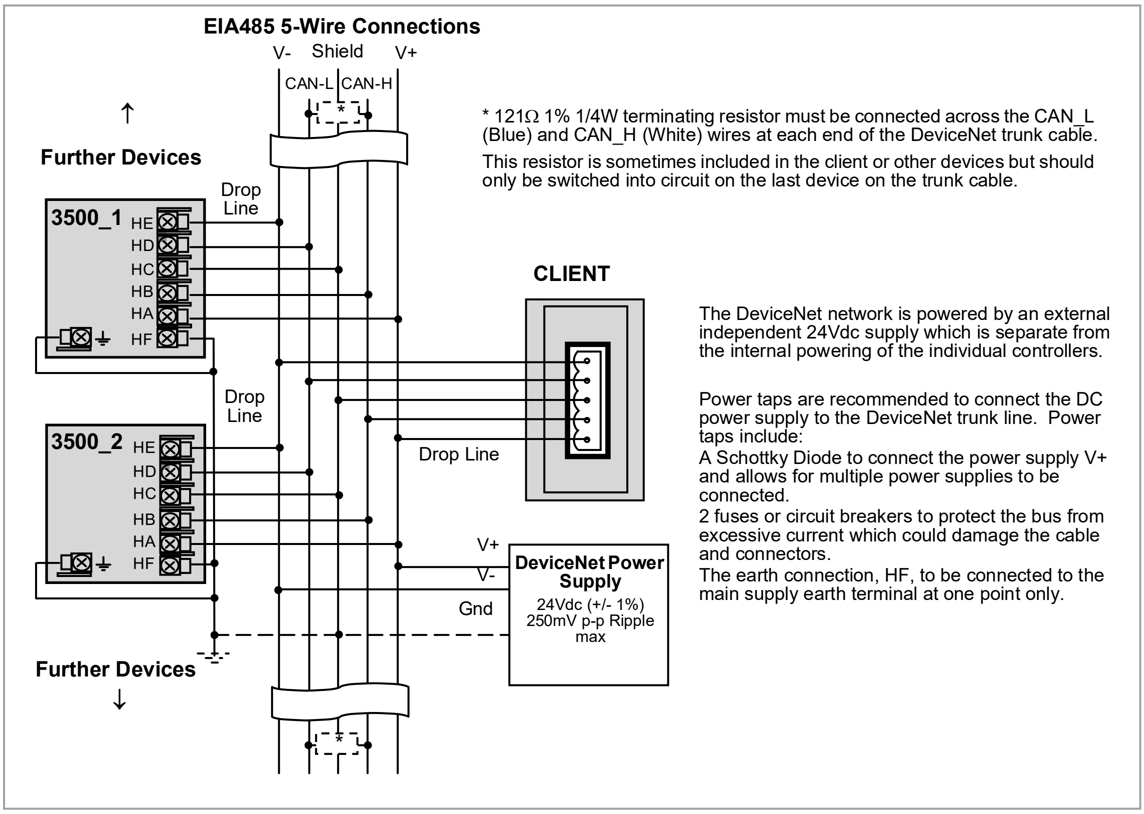


Figure 11: Example of DeviceNet Wiring

I/O Expander

An I/O expander (Model No 2000IO) can be used with 3500 series controllers to allow the number of I/O points to be increased by up to a further 10 or 20 digital inputs and 10 or 20 digital outputs. Data transfer is performed serially via a two wire interface using an optional IO Expander comms module. This module must be fitted in digital communications slot J (EX option in Order Code field 16).

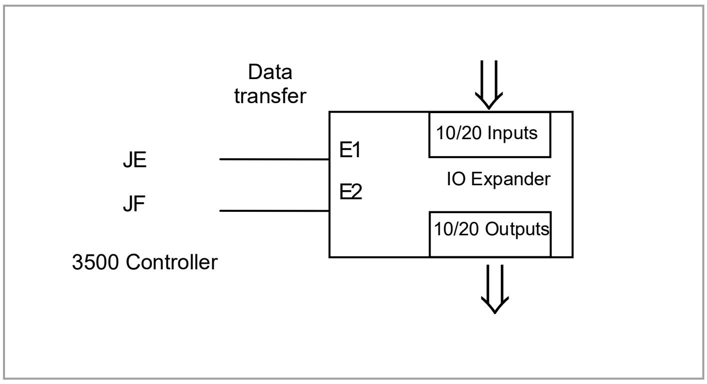


Figure 12: Data Transfer Between IO Expander and Controller

A description of the IO Expander is given in Handbook Part No HA026893 which can be downloaded from www.eurotherm.com.

The connections for this unit are reproduced below for convenience.

IO Expander Connections

The 10 Input/10 Output Expander **The 20 Input/20 Output Expander**

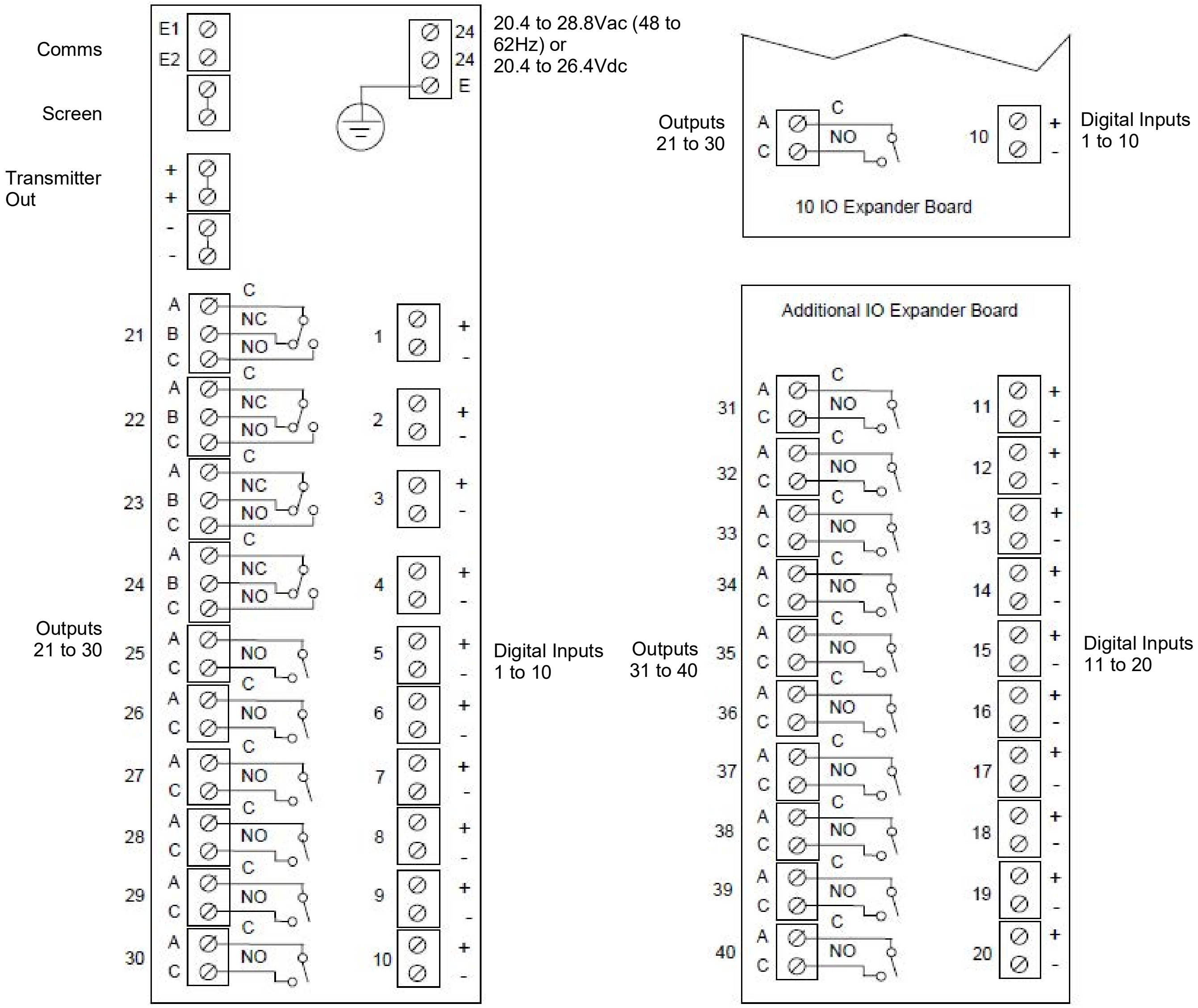


Figure 13: IO Expander Terminals

Example Wiring Diagram

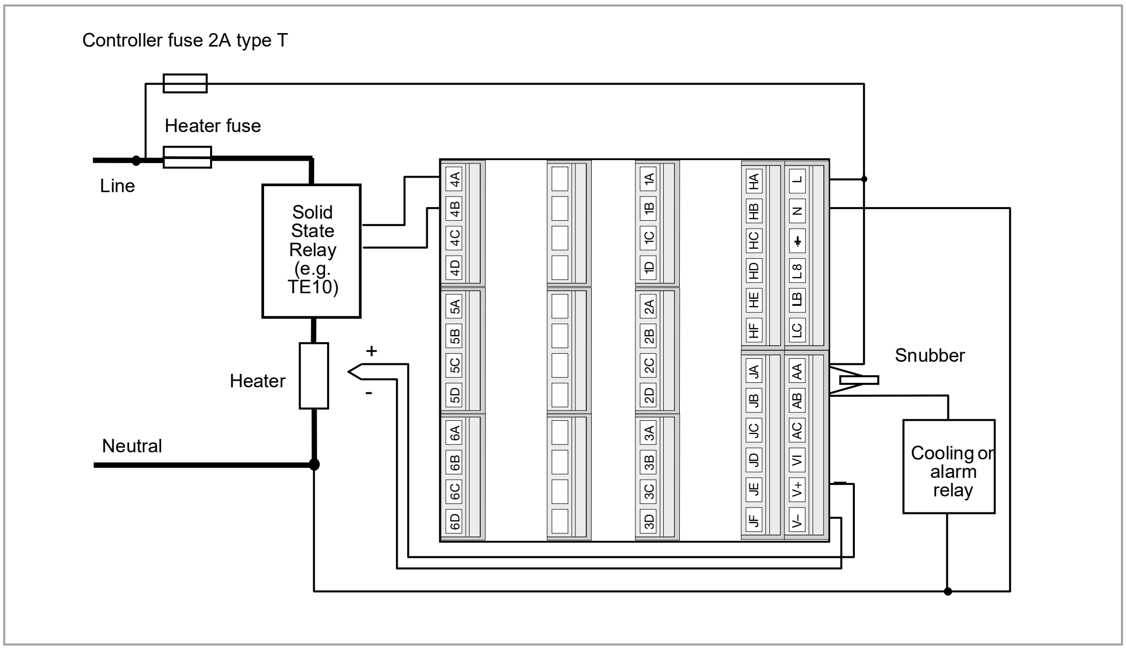


Figure 14: Example Wiring Diagram

Please refer to the EMC Electromagnetic Compatibility Handbook Part No. HA025464 for details of good wiring practice. This can be downloaded from www.eurotherm.com.

Snubbers

Snubbers are used to prolong the life of relay contacts and to reduce interference when switching inductive devices such as contactors or solenoid valves. The fixed relay (terminals AA/AB/AC) is not fitted internally with a snubber and it is recommended that a snubber be fitted externally, as shown in the example wiring diagram. If the relay is used to switch a device with a high impedance input, no snubber is necessary.

All relay modules are fitted internally with a snubber since these are generally required to switch inductive devices. However, snubbers pass 0.6mA at 110V and 1.2mA at 230Vac, which may be sufficient to hold on high impedance loads. If this type of device is used it will be necessary to remove the snubber from the circuit.

The snubber is removed from the relay module as follows:

1. Unplug the controller from its sleeve
2. Remove the relay module
3. Use a screwdriver or similar tool to snap out the track. The view below shows the tracks in a Dual Relay Output module.

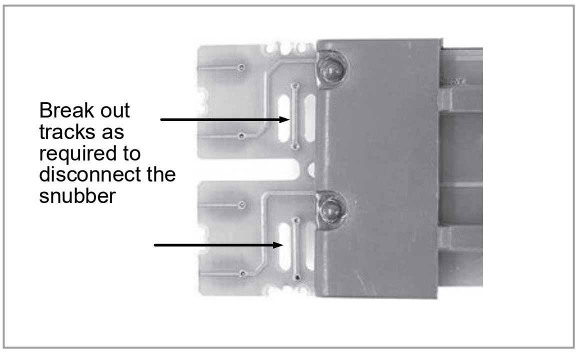


Figure 15: Snubber Removal

Getting Started

A brief start up sequence consists of a self test in which all elements of the display are illuminated and the software version is shown. What happens next depends on one of the three conditions:

1. Power up out of the box – when the controller has no preset configuration and is switched on for the very first time, it will display the 'Comms Configuration' screen to configure the following depending on the Comms options fitted to H and J:
   - Comms H protocol
   - Comms J protocol
   - Comms H Auto discovery
     (Only available for Ethernet comms)

When the controller is switched on for the very first time, it will display the 'Comms Configuration' screen shown below.

3504 Display **3508 Display**

Figure 16: Comms Configuration screens

2. 'QuickStart mode - This is an intuitive tool for configuring the controller and is described in section Quick Start - New Controller (Unconfigured) below.
3. The controller has been powered up previously and is already configured. In this case go to section Normal Operation.

Quick Start - New Controller (Unconfigured)

Quick Start is a tool which enables the controller to be matched to the most common processes without the need to go to full configuration level described later in this Manual.

When the controller is switched on using Quick Start it will display the 'Startup' screen shown below.

3504 Display

3508 Display

Figure 17: Start Up Views

Manual mode, section To Select Auto/Manual Operation, is always selected when in Quick Start mode because the controller resets to cold start when Quick Start is selected.

⚠ WARNING

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

To Configure Parameters in Quick Start Mode

With 'QckStart' selected, press ⟳ to scroll through the list of parameters

Edit the parameters using the ▲ or ▼ buttons

Each time ⟳ button is pressed a new parameter will be presented

This is illustrated by the following example: (The views shown are taken from the 3504 controller).

☺ From the Startup view, shown in the previous section, you can press ▲ or ▼ to select Configuration Mode. To fully configure the controller refer to later sections of this handbook.

☺ Backscroll – to scroll back through parameters press and hold ⟳ then press ▲ to go back through the list of parameters. You can also press and hold ⟳ + ▼ to go forward - this has the same effect as pressing ⟳ alone.

Example

Do This	Display	Additional Notes
1. From the Start view press ⟳ 2. Press ▲ or ▼ to change the 'Units' 3. A different parameter is selected each time ⟳ is pressed.		The first parameter to be configured is **'Units'**. It resides in the **'PV Input List'** because it is associated with the process variable. When the required choice is selected a brief blink of the display indicates that it has been accepted.
4. Continue setting up the parameters presented until the **'Finished'** view is displayed. 5. If all parameters are set up as required press ▲ or ▼ to **'Yes'**		If you wish to scroll around the parameters again do not select Yes but continue to press ⟳. When you are satisfied with the selections select 'Yes'. The 'HOME' display - section Normal Operation is then shown.

The following table summarises all the parameters which can be set up by the above procedure.

Quick Start Parameters

Parameters shown in **Bold** are defaults.

Group	Parameter	Value	Availability
LP1 PV Input	Units Used to select the engineering units for the PV. (C, F, K options also change the displayed units)	**C**, F, K V. mV, A, mA, pH, mmHg, psi, Bar, mBar, %RH, %, mmWG, inWG, inWW, Ohms, PSIG, %O2, PPM, %CO2, %CP, %/sec, mBar/Pa/T, sec, min, hrs, None	Always
LP1 PV Input	Resolution Used to select the required decimal point position for the PV	**XXXXX**, XXXX.X, XXX.XX, XX.XXX, X.XXXX	Always
LP1 PV Input	Range Type Used to select the linearization algorithm required and the input sensor.	Thermocouple: J, **K**, L, R, B, N, T, S, PL2, C, CustC1(2&3) RTD: Pt100 Linear: 0-50mV, 0-5V, 1-5V, 0-10V, 2-10V, 0-20mA, 4-20mA	Always
LP1 PV Input	IO Type Only shown if custom curve is selected	Thermocpl, RTD, Pyrometer, mV40, mV80, mA, Volts, HIZVolts, Log10	
LP1 PV Input	Range High/Low Configures the maximum/minimum display range and SP limits	Depends on Range type selected. Default **1372/-200**	Always
LP1 Loop	Control Channel 1. Sets the control type for channel 1 (normally Heat)	**PID**, VPU, VPB, Off, OnOff	Always
LP1 Loop	Control Channel 2. Sets the control type for channel 2 (normally Cool)	PID, VPU, VPB, **Off**, OnOff	Always
LP2 PV Input	Source Defines where the PV input is wired to for Loop 2.	**None**, Fixed PV, Module1 to 6 (available only if an analogue input module is fitted).	If a dual Loop controller
The LP1 parameters listed above are repeated for LP2 if the LP2 PV Input is configured			

Group	Parameter	Value	Availability
Init LgcIO LA	Logic function (input or output) The LA Logic I/O port can be an output or an input. This parameter is used to select its function.	**Not Used**, Lp1 Ch1, Lp1 Ch2, Lp2 Ch1, Lp2 Ch2, Alarm 1 to 8, Any Alarm, New Alarm, ProgEvnt1 to 8, LP1SBrkOP, LP2SBrkOP*, LPsSBrk*, (outputs) LP1 A-M, LP1 SPsel, LP2 A-M, LP2 SPsel, AlarmAck, ProgRun, ProgReset, ProgHold (Inputs)	[Note 1] [Note 2] * LP2 and LPs (both loops) only shown if the second Loop is configured Programmer options only available if the controller is a programmer/controller

Init LgcIO LA	Min On Time This applies to both LA and LB inputs	**Auto** 0.01 to 150.00	[Note 2] [Note 3]
The above two parameters are repeated for the LB Logic I/O (LgcIO LB)			
Init RlyOP AA	Relay function This relay is always fitted.	**Not Used,** Lp1 Ch1, Lp1 Ch2, Lp2 Ch1, Lp2 Ch2, Alarm 1 to 8, Any Alarm, New Alarm, ProgEvnt1 to 8, LP1SBrkOP, LP2SBrkOP*, LPsSBrk*.	Always. [Note 4] [Note 5] Programmer options only available if the controller is a programmer/controller)
Init RlyOP AA	Min On Time	**Auto** 0.01 to 150.00	[Note 2] [Note 3]

NOTICE

1. Parameters only appear if the function has been turned on, eg If 'Control Channel 1' = 'Off', 'Chan 1' does not appear in this list. When a control channel is configured for valve positioning, LgcIO LA and LgcIO LB act as a complementary pair. If, for example, Chan 1 is connected to LgcIO LA (valve raise) then LgcIO LB is automatically set to Chan 1 (valve lower). This ensures the valve is never raised and lowered simultaneously.
2. The same complementary behaviour also applies to dual output modules and channels A and C of triple output modules
3. If any input function, for example Chan 1, is connected to another input it will not appear in this list
4. Is available if the Control Channel is not On/Off and is allocated to the LA, LB or AA output as applicable
5. For valve position control Chan 1 or Chan 2 will not appear in this list. Valve position outputs can only be dual outputs such as LA and LB or dual relay/triac output modules

Modules

The following parameters configure the plug in I/O modules. I/O Modules can be fitted in any available slot in the instrument (6 slots in 3504, 3 slots in 3508). The controller automatically displays parameters applicable to the module fitted - if no module is fitted in a slot then it does not appear in the list.

Each module can have up to three inputs or outputs. These are shown as A, B or C after the module number and this corresponds to the terminal numbers on the back of the instrument. If the I/O is single only A appears. If it is dual A and C appears if it is triple A, B and C appear.

NOTICE

1. If a Dual DC Output module is fitted, it cannot be configured using the Quick Start Code. To configure this module refer to DC Control, Dual DC Control, or DC Retransmission Output.
2. If an incorrect module is fitted the message 'Bad Ident' will be displayed.

Module type	Parameter	Value		Availability
Change over Relay (R4) 2 pin Relay (R2) Triac output (T2)	Relay (Triac) function	Not Used All parameters the same as RlyOP AA, including Min OnTime if the OP is a relay		Always (if the module is fitted)
Dual Relay (RR) Dual Triac output (TT)	Relay (Triac) function			
	Relay function			
Single Logic Output (LO)	Logic Out function	Not Used All parameters the same as RlyOP AA		Always (if the module is fitted)
Triple Logic Output (TP)				
DC Output (D4) DC Retransmission (D6)	DC Output function	Not Used	Module fitted but not configured	Always (if the module is fitted)
		LP1 Ch1OP	Loop 1 Channel 1 control output	
		LP1 Ch2OP	Loop 1 Channel 2 control output	
		LP2 Ch1OP	Loop 2 Channel 1 control output	
		LP2 Ch2OP	Loop 2 Channel 2 control output	
		LP1 SP Tx	Loop 1 setpoint retransmission	
		LP1 PV Tx	Loop 1 PV retransmission	
		LP1 ErrTx	Loop 1 error retransmission	
		LP1 PwrTx	Loop 1 output retransmission	
		LP2 SP Tx	Loop 2 setpoint retransmission	
		LP2 PV Tx	Loop 2 PV retransmission	
		LP2 ErrTx	Loop 2 error retransmission	
		LP2 PwrTx	Loop 2 output retransmission	
	Range Type	0–5V, 1-5V, 1–10V, 2–10V, 0-29mA, 4-20mA		
	Display High	100.0		
	Display Low	0		
Triple Logic Input (TL) Triple Contact Input (TK)	Logic In function	Not Used	Module fitted but not configured	A function can only be allocated to one input. eg if AlarmAck is configured on X*A it is not offered for the other inputs * is the module number. LP2 does not appear if Loop 2 is not configured.
		LP1 A-M	Loop 1 Auto/manual	
		LP1 SPsel	Loop 1 SP select	
		LP1 AltSP	Loop 1 Alternative SP select	
		LP2 A-M	Loop 2 Auto/manual	
		LP2 SPsel	Loop 2 SP select	
		LP2 AltSP	Loop 2 Alternative SP select	
		AlarmAck	Alarm acknowledge	
		ProgRun	Programmer run	
		ProgReset	Programmer reset	
		ProgHold	Programmer hold	

Module type	Parameter	Value	Availability	
Analogue Input (AM)	Analogue IP function	Not Used	Module fitted but not configured	LP1 V1Pos and LP1 V2Pos only appear if the control channel 1 or control channel 2 is set to VPB. Remote SP does not appear if the programmer option is supplied. LP2 does not appear if Loop 2 is not configured.
		LP1 AltSP	Loop 1 alternative setpoint	
		LP1 OPH	Loop 1 remote OP power max	
		LP1 OPL	Loop 1 remote OP power min	
		LP2 AltSP	Loop 2 alternative setpoint	
		LP2 OPH	Loop 2 remote OP power max	
		LP2 OPL	Loop 2 remote OP power min	
		LP1 V1Pos LP1 V2Pos	To read valve position from the feedback potentiometer Loop 1	
		LP2 V1Pos LP2 V2Pos	To read valve position from the feedback potentiometer Loop 2	
	Range Type	Thermocouple: J, K, L, R, B, N, T, S, PL2, C. RTD: Pt100 Linear: 0-50mV, 0-5V, 1-5V, 0-10V, 2-10V, 0-20mA, 4-20mA		Not shown if analogue IP function not used
	Display High	100.0		These parameters only appear for Linear Range
	Display Low	0.0		
Potentiometer Input (VU)	Pot Input function	Not Used	Module fitted but not configured	Ch1VlvPos/Ch2VlvPos only appear if the channel = VPB Remote SP does not appear if the programmer option is supplied. LP2 does not appear if Loop 2 is not configured.
		LP1 AltSP	Loop 1 Alternative setpoint	
		LP1 OPH	Loop 1 output power maximum	
		LP1 OPL	Loop 1 output power minimum	
		LP2 AltSP	Loop 2 Alternative setpoint	
		LP2 OPH	Loop 2 output power maximum	
		LP2 OPL	Loop 2 output power minimum	
		LP1 V1Pos LP1 V2Pos	To read valve position from the feedback potentiometer Loop 1	
		LP2 V1Pos LP2 V2Pos	To read valve position from the feedback potentiometer Loop 2	
Transducer Power Supply (G3)	TdcrPSU function	5 Volts 10 Volts		Always (if the module is fitted)
Transmitter power supply (MS)	No parameters. Used to show the ID of the module if fitted			

Alarms

Group	Parameter	Value		Availability
Init Alarm 1 to 8	Type	None	No alarm type configured	Always
		Abs High	Absolute high	
		Abs Low	Absolute low	
		Dev High	Deviation high	
		Dev Low	Deviation low	
		Dev Band	Deviation band	
Init Alarm 1 to 8	Source	**None**	Not connected	Always if Type ≠ None PV Input and ModX Ip do not appear if Type = Deviation
		PV Input	Connected to current process variable does not appear if Alarm Type = Deviation	
		LP1 PV	Connected to Loop 1 process variable	
		LP2 PV	Connected to Loop 2 process variable	
		Module1 to Module6	Connected to an analogue input module and only of the Alarm Type is not a deviation alarm	
Init Alarm 1 to 8	Setpoint	To adjust the alarm threshold within the range of the source.		Always if Type ≠ None

Init Alarm 1 to 8	Latch	**None**	No latching	Always if Type ≠ None
		Auto	Automatic latching, see To Acknowledge an Alarm.	
		Manual	Manual latching, see To Acknowledge an Alarm.	
		Event	Alarm beacon does not light but any output associated with the event will activate and a scrolling message will appear.	
Finished	Exit	**No**	Continue back around the quick configuration list	
		Yes	Go to normal operation. The loop(s) are set to Auto on exit from quickstart mode and the controller re-starts in Level 2.	

To Re-enter Quick Start Mode

If you have exited from Quick Start mode (by selecting 'Yes' to the 'Finished' parameter) and you need to make further changes, the Quick start mode can be entered again at any time. The action which takes place depends on one of two previous conditions as follows:-

Power up After a Quick Start Configuration

1. Ensure the instrument is fully powered off.
2. Hold ⊜ down then power up the controller. Keep this button pressed until the Quick start screen as shown in section Quick Start - New Controller (Unconfigured) is displayed.
3. Press ⊙ to enter the quick start list. You will then be asked to enter a passcode.
4. Use ⊕ or ⊖ to enter the passcode – default 4 – the same as the configuration level passcode. If an incorrect code is entered the display reverts to the 'Quick Start' view section Quick Start - New Controller (Unconfigured).

It is then possible to repeat the quick configuration as described previously.

The Quick Start view shown in section Quick Start - New Controller (Unconfigured) now contains an additional parameter - **'Cancel'**. This is now always available after a power up, and, if selected, will take you into normal operating mode, section Normal Operation.

Power up After a Full Configuration

Repeat 1,2 and 3 above.

Full configuration allows a greater number of parameters to be configured in a deeper level of access. This is described later in this manual.

If the controller has been re-configured in this level, a **'WARNING'** message, '**Delete config?'** - **'No'** or **'Yes'**, will be displayed. If 'No' is selected the display drops back to the 'GoTo' screen.

1. Use ⓐ or ⓥ to select 'Yes'
2. Press ⓞ to confirm or ⓟ to cancel. (If no button is pressed for about 10 seconds the display returns to the WARNING message).

If 'Yes' is selected the **Quick start defaults** will be re-instated. **All** the Quick start parameters must be reset.

Normal Operation

Switch on the controller. Following a brief self-test sequence, the controller will start up in AUTO mode (see AUTO/MAN section To Select Auto/Manual Operation) and Operator Level 2 (following Quick Start).

If the controller is configured as a dual Loop instrument the start up view shows a summary of the two loops. This is called the HOME display.

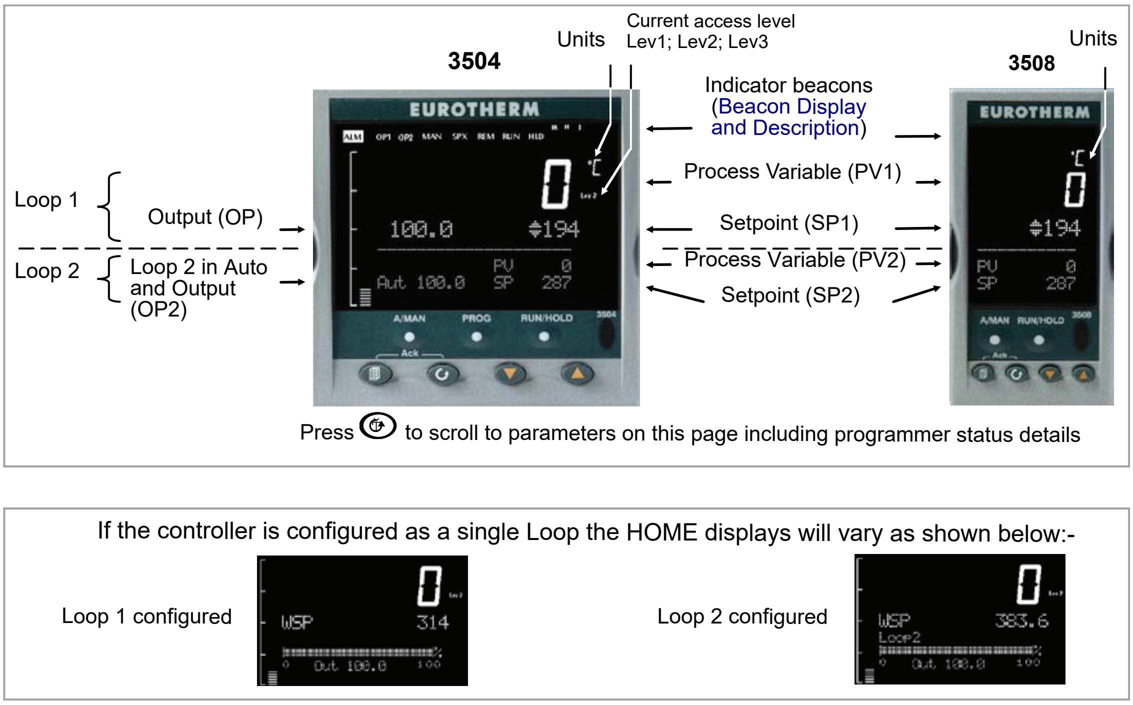


Figure 18: HOME Display

Other views may be configured as the HOME display and other summary displays can be selected using ⓟ button. See Message Centre.

Beacon Display and Description

OP1 **OP2**	In a single Loop controller OP1 and OP2 operate on channel 1 and 2 outputs respectively for the configured loop. In a dual Loop controller OP1 and OP2 operate on Loop 1 channel 1 and 2 outputs respectively when any ‘Summary Page’ (Message Centre) is displayed unless the Summary Page is Loop 2. If the Summary Page is Loop 2 then OP1 and OP2 operate on Loop 2 channel outputs. These parameters may also be soft wired, see parameters ‘OP1 Beacon’ and ‘OP2 Beacon’ in ‘Inst’ ‘Dis’ table in section Display Formatting.
MAN	Illuminates when manual mode active. If the HOME display is showing the dual Loop overview, MAN illuminates if Loop 1 is in manual. If the Loop 1 or Loop 2 overviews are being displayed MAN applies to the loop being displayed.
REM	Illuminates when remote setpoint active
SPX	Illuminates when alternative setpoint active
ALM	If an alarm occurs the red alarm beacon flashes. This is accompanied by a message showing the source of the alarm, for example ‘Boiler overheating’. To acknowledge press ⟳ and . 🗐 The message disappears. If the alarm condition is still present the beacon lights continuously. When cleared it will extinguish. Section Alarm Indication describes alarm operation.
RUN	Illuminates when programmer running – flashing indicates End
HLD	Illuminates when programmer held
J	Flashes when J Channel comms active
H	Flashes when H Channel comms active
IR	Flashes when infra red communications active

In general throughout this handbook instrument views will use the 3504. The displayed information is similar for the 3508 but in some cases is shortened due to display limitations.

The Operator Buttons

Page Scroll Lower Raise

A/MAN This button can be disabled	Toggles the selected loop between Auto and Manual operation. The action of this button is described in section To Select Auto/Manual Operation. Manual operation means that the controller output power is adjusted by the user. The input sensor is still connected and reading the PV but the control loop is open. Auto means that the controller is automatically adjusting the output to maintain control, ie the loop is closed. If the controller is in manual mode, ‘MAN’ light will be indicated. If the controller is powered down in Manual operation it will resume this mode when it is powered up again.
PROG	To select the programmer summary page
RUN/HOLD This button can be disabled	Press once to start a program. ‘RUN’ will be indicated Press again to hold a program. ‘HLD’ will be indicated Press and hold for at least two seconds to reset a program. ‘RUN’ will flash at the end of a program ‘HLD’ will flash during holdback Programmer operation is fully described in section Setpoint Programmer of the User Manual
🗐	Press to select new PAGE headings
⟳	Press to select a new parameter in the page
▼	Press to decrease an analogue value, or to change the state of a digital value
▲	Press to increase an analogue value, or to change the state of a digital value

Shortcut Key Presses	
Backpage	Press [Page] followed by ▲. With the Page key held down continue to press ▲ to scroll page headers backwards. (With [Page] still pressed you can press ▼ to page forward. This action is the same as pressing [Page] alone).
Backscroll	When in a list of parameters, press [Scroll] followed by ▲ With [Scroll] held down continue to press ▲ to scroll parameters backwards. (With [Scroll] still pressed you can press ▼ to page forward. This action is the same as pressing [Scroll] alone).
Jump to the HOME display	Press [Page] + [Scroll]
Alarm Ack/reset	Press [Scroll] and [Page] when the HOME screen is being displayed to jump to the 'Acknowledge All alarms' page. Pressing [Scroll] acknowledges all alarms if it can, see To Acknowledge an Alarm. Pressing [Page] cancels the operation.

To Set the Required Temperature (Setpoint)

A parameter value can be changed if it is preceded by ⬍. In the example shown below this is SP1, the setpoint for Loop 1.

To change the value, press ▼ or ▲. The output level shown in the HOME display will change to indicate the source of the setpoint while either of the buttons is pressed, in this example SP 1.

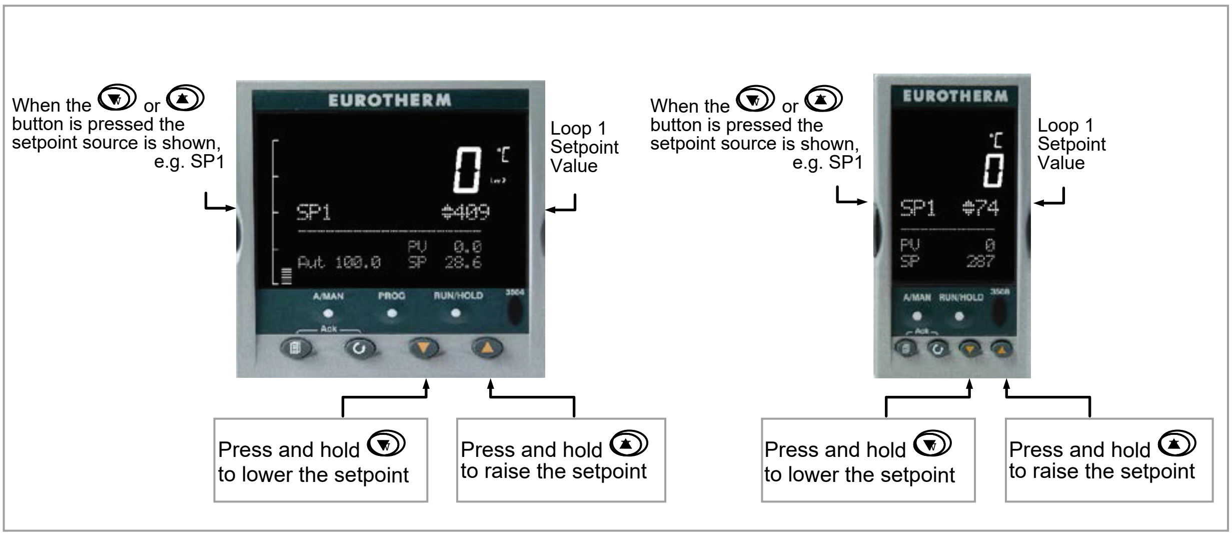


Figure 19: Temperature Setting

To change Loop 2 setpoint, press [Scroll].

Loop 2 SP value is preceded by ⬍.

Press ▼ or ▲ as above to change the value.

The action is then the same as for Loop 1.

A momentary press of either button will show the setpoint in use eg SP1.

By default, the new setpoint is accepted when the button is released and is indicated by a brief flash of the setpoint display.

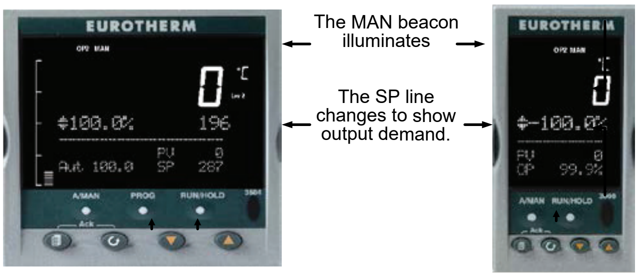
The setpoint may be made to operate continuously by enabling the parameter 'ImmSP?' (see Instrument Options).

If a single Loop is configured (or the individual loop summary is selected – see Summary Pages) pressing ▼ or ▲ will change the setpoint in the same way as described above.

To Select Auto/Manual Operation

Press  (A/MAN) button.
If two loops are enabled and the dual Loop overview is being displayed, pressing the A/MAN button will toggle Loop 1 between Auto and Manual. The beacon 'MAN' will light and the indication of output power is preceded by ⇕ .

Press and hold ⊽ or ⊼ to decrease or increase the output power.



The output power will change continuously while either ⊽ or ⊼ is pressed

To switch Loop 2 between Auto and Manual, press ⟳ to scroll into the Loop 2 section, then press A/MAN.

Figure 20: Auto/Manual Selection

If Loop 1 overview is being displayed, press the A/MAN button to toggle Loop 1 between Auto and Manual.

If Loop 2 overview is being displayed, press the A/MAN button to toggle Loop 2 between Auto and Manual.

If any other overview is being displayed, the first press of the A/MAN button will select the dual Loop overview and the action is as described above.

☺ Summary pages may be disabled - see Display Formatting.

- For a dual Loop controller, Auto/Manual cannot be selected.
- If Loop 1 is enabled and Loop 2 disabled, pressing A/MAN toggles Auto/Manual for Loop 1.
- If Loop 2 is enabled and Loop 1 disabled, pressing A/MAN toggles Auto/Manual for Loop 2.

☺ For a single Loop controller, Auto/Manual will apply regardless of whether summary pages are enabled or not.

☺ If the controller is switched off in either Auto or Manual operation it will resume the same mode when powered up again.

Bumpless Transfer

When changing from Auto to Manual, the power output will remain at the level it was prior to the change. The power output can then be ramped up or down as described above

When changing form Manual to Auto there will be no immediate change in the power output due the 'Integral De-Bump' feature (see Integral De-bump). The power output will then slowly ramp to the level demanded by the controller.

Alarm Indication

If an alarm occurs it is indicated as follows:

The red alarm (ALM) beacon in the top left of the display flashes

Alarm number is indicated together with the flashing

A default or pre-programmed message appears showing the source of the alarm

Invitation to acknowledge the new alarm

To Acknowledge an Alarm

To Acknowledge an Alarm Press and (Ack) together. The action, which now takes place, will depend on the type of latching, which has been configured

Non Latched Alarms

If the alarm condition is present when the alarm is acknowledged, the alarm beacon will be continuously lit. This state will continue for as long as the alarm condition remains. When the alarm condition disappears the indication will also disappear.

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 the alarm is acknowledged **AND** it is no longer present.

If the alarm condition disappears before it is acknowledged the alarm indication disappears as soon as the condition disappears.

Automatic Latched Alarms

The alarm continues to be active until both the alarm condition is removed **AND** the alarm is acknowledged. The acknowledgement can occur **BEFORE** the condition causing the alarm is removed.

Manual Latched Alarms

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.

Sensor Break Indication

An alarm condition (S.Br) is indicated if the sensor or the wiring between sensor and controller becomes open circuit or the input is over-range. The message ‘Sbreak’ is shown in the message centre together with the source of the sensor connection. This may be ‘PVInput’ or ‘Modx’ if an analogue module is fitted.

For a resistance thermometer 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.

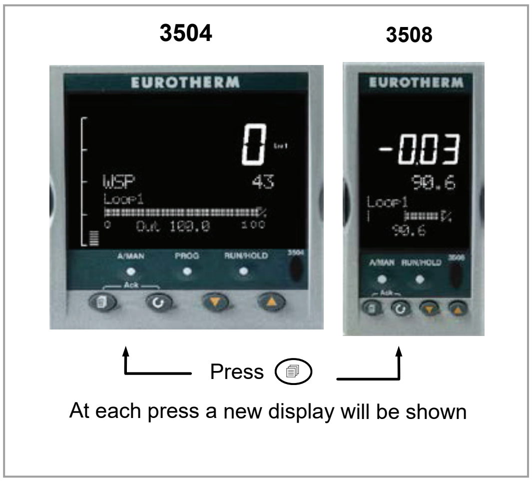
For Volts input sensor break may not be detected due to the potential divider network connected across the input terminals.

Message Centre

The lower section of the HOME display contains an alpha-numeric set of messages. These messages change between different controller types and operating modes and are grouped in summary pages. The 3504 contains more information than the 3508, and generally the parameter descriptions are longer due to the larger display.

Summary Pages

Press . A set of pre-defined summary pages are shown at each press - the following views show examples. These are typically a summary of programmer, loops and alarm operation. A further eight customised pages can be programmed off line using iTools programming software. The level in which the Summary Pages are shown may also be defined using iTools.



If Auto-tune is enabled an alternating message is shown on this display showing the loop being tuned and the stage of tuning, eg Loop1 Auto-Tune/ToSP.

Loop Summary

If two loops are configured the display shown in section Normal Operation is shown.

Press to display a summary for Loop1 and again for Loop 2.

The horizontal bar graph shows output power demand for the loop. For **heat/cool** the bar graph is bi-directional (± 100%) as shown:

For valve position control the user interface will display either heat only or heat/cool summary pages.

A timeout to the dual Loop overview may be changed in configuration level, see parameter ‘Home Timeout’ in section To Customise the Display.

Program Status

This display is only shown if the Programmer option has been enabled

SyncAll and single programmers

SyncStart programmer

Program Edit

Allows the program to be created or edited.

SyncAll and single programmers

SyncStart programmer

A full list of parameters is given in section Program Status Page.

NOTICE

For a SyncStart programmer it is possible to select between Channel 1 and Channel 2.

Alarm Summary

Press to scroll through the alarms.

A New Alarm occurs when any new alarm becomes active. This parameter may be used to activate a relay output to provide external audible or visual indication.

Alarm Settings

All configured alarms (up to eight) will be listed.

Press to scroll through the alarms.

Press or to set the threshold values

Control

To set parameters which define the operation of the loops. A full list of parameters is given in section Control Summary Page.

Transducer

This display is only shown if the Transducer option has been enabled.

For further details see section Transducer Scaling.

A further eight customised pages can be configured using iTools configuration package. See iTools integrated Online Help for further details.

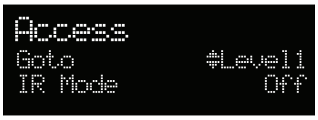
How to Edit Parameters

In the above summary pages, press to scroll to further parameters (where applicable).

Press or to change the value of the parameter selected.

Any parameter preceded by ⇕ is alterable provided the system is in a safe state to allow the parameter to be changed. For example, 'Program Number' cannot be changed if the program is running - it must be in 'Reset' or 'Hold' mode. If an attempt is made to alter the parameter its value is momentarily replaced by '---' and no value is entered.

Some parameters are protected under a higher level of security – Level 2. In these cases it will be necessary to select 'Access Level 2'. This is carried out as follows:



1. Press and hold until the display shows
2. Press to select Level 2
3. Press again to enter a security code. This is defaulted to 2. If an incorrect code is entered the display reverts to that shown in 1 above. If the default of 2 is not accepted this means that the code has been changed on your particular controller.
4. 'Pass' is displayed momentarily. You are now in Level 2.

Program Status Page

Provided it has been ordered and enabled the 3500 series controllers can program the rate of change of setpoint. Two program channels are available which can be run as two separate programmers or as a pair. Up to 50 programs and up to a maximum of 500 segments can be stored and run. Setpoint programming is explained in more detail in section Setpoint Programmer.

To Select a Parameter

Press to scroll through a list of parameters. On the 'Programmer Summary' shown here, the list of parameters which can be selected are:

Parameter Name	Parameter Description	Value	Default	Available in Level
Program	Program number (and name if this has been configured)	1 to max number of programs	1	L1 Alterable when prog in reset
Segment	Segment number (and type on 3504) Only appears when the programmer is running	1 to max number of segments	1	L1
Seg Time Left	Segment Time Left Only appears when the programmer is running	hrs:mins:secs	Read only	L1
Delayed Start	Program will run after a set time has elapsed	0:00 to 499:99	0:00	L1 if configured
Status	Program Status	End Prog ended Run Prog running Hold Prog held Holdback In holdback See note below		L1
Ch1 PSP (or PSP)	Profile setpoint value channel 1	Can be changed in Hold		L1
Ch2 PSP	Profile setpoint value channel 2	Can be changed in Hold		L1
Fast Run	This allows the program to be run at a fast rate and may be used for testing the program. It can only be selected before the program is run.	No/Yes	No	
Rst UsrVal	User value to be used in reset state. Defines the value for 'UsrValOP'. In segments that specify 'PVEvent', 'UsrValOP' is set to this value Only appears when the program is in reset mode.			
Ch1 Seg Target (or Segment Target)	Requested setpoint at end of segment			
Ch2 Seg Target				
Seg. Duration (or Segment Rate)	Segment time – Time to Target programmer Rate of change of SP – Ramp Rate programmer			
Cur. Seg Type	Single programmer only			
Cycles Left	Number of repeat cycles left to run Can only be changed in Hold or Reset	1 to maximum number of cycles set		L1 R/O in Run
Events or Rst Events	State of the event outputs when the program is running or when in reset	□ Event inactive ■ Event active		L1
PrgTimeLeft	Time remaining to end of selected program	hrs:mins:secs		L1
GoBackCyclesLeft	The number of cycles left if Go Back is configured and active	1 to maximum number of cycles set		

NOTICE
Holdback freezes the program if the process value (PV) does not track the setpoint (SP) by more than a user defined amount. The instrument will remain in HOLDBACK until the PV returns to within the requested deviation from setpoint. The display will flash the HOLD beacon. In a Ramp it indicates that the PV is lagging the SP by more than the set amount and that the program is waiting for the process to catch up. In a Dwell it freezes the dwell time if the difference between the SP and PV exceeds the set limits. In both cases it maintains the correct soak period for the product, see also section Holdback. In addition to the usual PV Holdback, Holdback is also the state when synchronisation is taking place. For a SyncAll programmer, this occurs if Holdback has caused one PSP to be held back while the other has progressed to completion. For a SyncStart programmer, this occurs when Ch1/2 is waiting for the other channel. In both models, it occurs when a Wait segment has been configured and is active. When one channel has reached the end of the first cycle and is waiting fro the other channel to complete its first cycle. Both channels will start cycle 2 only when they have both completed. (Implied Sync point at the end of each cycle).

To Select and Run a Program

In this example it is assumed that the program to be run has already been entered. Setpoint programming is described in detail in section Setpoint Programmer.

Do This	The Display You Should See	Additional Notes
1. Press RUN/HOLD 2. Press ▲ or ▼ to choose the program number to be run		In this example Program Number 1. It may also have a user defined name. In the 3504 Program names can be entered using the off-line programming package 'iTools'
3. Press RUN/HOLD again		If a delayed start has been configured the program will start to run after the delay period set. The 'RUN' beacon is illuminated at the top of the display. The view shown here shows program being run, segment number and type and time left to complete this segment.
4. Repeated pressing of ⟳ will scroll through parameters associated with the running program. The parameters are listed in the above table		These show current value of channel 1 setpoint and current value of channel 2 setpoint. The target value of channel 1 is also shown.
5. To Hold a program press RUN/HOLD		Press RUN/HOLD again to continue the program. When the program is complete 'RUN' will flash
6. To Reset a program press and hold RUN/HOLD for at least 3 seconds		'RUN' will extinguish and the controller will return to the HOME display shown in section Normal Operation.

Alternatively, run, hold or reset a program by scrolling to 'Program Status' using ⟳ and select 'Run', 'Hold' or 'Reset' using ▲ or ▼.

The RUN/HOLD button (3504 only) provides a short cut to the Program Status page from any view.

When the programmer is running, the controller overview may be displayed by pressing the page button and the scroll button together.

WSP is the Working Setpoint and is the current setpoint derived from the programmer. To change the value of WSP the programmer must be put into Hold, then it can be adjusted using the buttons ▲ or ▼. By default the new value is entered after the button is released and is indicated by a brief flash of the value.

However, it is possible to select an option where the value is entered continuously as the raise or lower button is depressed. This option (ImmSP) is selected in configuration level as described in section Instrument Options.

Program Edit Page

A program can be edited in any level. A summary of the Edit Page is given here but for a full description refer to section Setpoint Programmer. A program may be only edited when it is in Reset or Hold. Press the page button until the Program Edit page is shown. Then press the scroll button to scroll through a list of parameters shown in the following table – parameters only appear in this table if the relevant option has been configured:

Para Name	Parameter Description	Value	
Program	Program number (and name if this has been configured)	1 to max number of programs	
Segments Used	Displays the number of segments in the program. This value automatically increments each time a new segment is added	1 to max number of segments	
Cycles	Number of times the whole program repeats	Cont 1 to 999	Continuous Repeats 1 to 999 times
Segment	To select the segment number	1 to 50	
Segment Type	Defines the type of segment. The type of segment varies depending on whether the program is Single, SyncAll or SyncStart. Call only available in single programmer Rate, Dwell, Step not available in SyncAll programmer	Rate	Rate of change of SP
		Time	Time to target
		Dwell	Soak at constant SP
		Step	Step change to new SP
		Wait	Wait for condition
		GoBack	Repeat previous segs
		Call	Insert new program
		End	Final segment
Target SP	Value of SP required at the end of the segment	Range of controller	
Ramp Rate	Rate of change of SP	Units/sec, min or hour	
Holdback Type	Deviation between SP and PV at which the program is put into a hold condition to wait for the PV to catch up. Only appears if configured	Off	No holdback
		Low	PV<SP
		High	PV>SP
		Band	PV<>SP
PV Event	To set the analogue PV event in the selected segment. If PV Event ≠ None it is followed by 'PV Threshold' which sets the level at which the event becomes active. Only appears if configured	None	No PV Event
		Abs Hi	Absolute high
		Abs Lo	Absolute low
		Dev Hi	Deviation high
		Dev Lo	Deviation low
		Dev Band	Deviation band

Para Name	Parameter Description	Value	
Time Event	To allow an On Time and an Off Time to be set in the first program event output. If set to 'Event1' an On time parameter and an Off Time parameter follow. Only appears if configured	Off Event1	
UsrVal	Sets the value of an analogue signal which can be used in the segment. Only appears if configured. Using iTools configuration package, it is possible to give this parameter an 8 character name.	Range	
PID Set	To select the PID set most relevant to the segment. Only appears if configured	Set1, Set2, Set3	
Event Outs	Defines the state of up to eight digital outputs. 1 to 8 can be configured	□□□□□□□□ to ■■■■■■■■ or T□□□□□□□□ to ■■■■■■■■ T = Time event: □ = event off; ■ = event on	
Duration	Time for a Dwell or Time segment	0:00:00 to 500.00 secs, mins or hours	
GSoak Type	Applies a guaranteed soak in a Dwell segment. See also sections Guaranteed Soak, To Edit a Syncstart Programmer and To Edit a Single Channel Programmer If configured this parar is followed by a G.Soak Value	Off	
		Low	
		High	
		Band	
End Type	Defines the action to be taken at the end of the program	Dwell	Continue at current SP
		SafeOP	Go to a defined level
		Reset	Reset to start of prog
Wait For	Only appears if the segment is set as Wait. Defines the condition that the program should wait for.	Prgln1	The first four parameters are digital values which can be wired to suitable sources
		Prgln2	
		Prgln1n2	
		Prgln1or2	
		PVWaitIP	Analogue wait value
		Ch2Sync	A Ch2 segment input
PV Wait	Only appears if 'PVWaitIP' is configured and defines the type of alarm which can be applied. If this parameter is configured it is followed by 'Wait Val' which allows the trip level to be set for the condition to become true	None	No wait
		Abs Hi	Absolute high
		Abs Lo	Absolute low
		Dev Hi	Deviation high
		Dev Lo	Deviation low
		Dev Band	Deviation band
GoBack Seg	Only appears if the segment type is 'GoBack'. It defines the segment to return to to repeat that part of the program	1 to the number of segments defined	
GoBack Cycles	Sets the number of times the chosen section of the program is repeated	1 to 999	
Call Program	Only applies to single program and only if the segment is 'Call'. Enter the program number to be inserted in the segment	Up to 50 (current program number excluded	
Call Cycles	Defines the number of times the called program repeats	Cont 1 to 999	Continuous Once to 999 times

Control Summary Page

On the Control Summary page the following parameters are available:

Para Name	Parameter Description	Value	Default	Availability
SP Select	To select SP1 or SP2	Between range limits set in higher levels of access	As order code	Lev1
SP1	To set the value of SP1			Lev1
SP2	To set the value of SP2			Lev1
SP Rate	To set the rate at which the setpoints change			Lev 1 alterable in Lev2 * Parameter does not appear if control is configured for On/Off
Tune*	To start self tuning	Off, On	Off	
PB*	To set proportional band	0 to 99999		
Ti*	To set integral time	Off to 99999		
Td*	To set derivative time	Off to 99999		
R2G*	To set relative cool gain	0.1 to 10.0		
CBH*	To set cut back high	Auto to 99999		
CBL*	To set cut back low	Auto to 99999		
Output Hi	To set a high limit on the control output	-100.0 to 100.0%	100.0	
Output Lo	To set a low limit on the control output	-100.0 to 100.0%	0.0	
Ch1 OnOff Hyst	Channel 1 hysteresis (Only if configured and for On/Off control)	0.0 to 200.0		Lev 1- alterable in Lev2
Ch2 OnOff Hyst	Channel 2 hysteresis (Only if configured and for On/Off control)	0.0 to 200.0		
Ch2 DeadB	Channel 2 deadband. To set the period in which there is no output from either channel. (This does not appear if channel 2 is not configured)	Off to 100.0		
Ch1 TravelT	Motor travel time if valve control output on channel 1	0.0 to 1000.0 sec		
Ch1 TravelT	Motor travel time if valve control output on channel 1	0.0 to 1000.0 sec		
Safe OP	To set an output level under sensor break conditions	-100.0 to 100.0%	0.0	

Access to Further Parameters

Parameters are available under different levels of security defined as Level 1, Level 2, Level 3 and Configuration Level. Level 1 has no security password since it contains a minimal set of parameters generally sufficient to run the process on a daily basis. Level 2 allows parameters, such as those used in commissioning a controller, to be adjusted. Level 3 and Configuration level parameters are also available as follows:

Level 3

Level 3 makes all operating parameters available and alterable (if not read only)

Examples are:

Range limits, setting alarm levels, communications address.

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

Configuration Level

This level makes available all parameters including the operating 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 are:

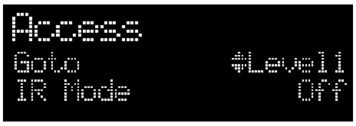
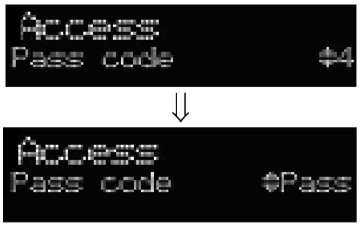
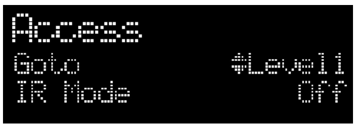
Input (thermocouple type); Alarm type; communications type.

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 will not necessarily be 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
Configuration	✓	✓	✓	No

To Select Different Levels of Access

Do This	The Display You Should See	Additional Notes
1. From any display press and hold ⊜		After a few seconds the display will show Goto ⇕ Level 1. If no button is pressed for about 2 minutes the display returns to the HOME display. This is a view for the 3504, and shows additional parameters in the list. The 3508 shows these parameters one at a time In either controller, press ⟳ to scroll through the list of parameters
2. Press ▲ or ▼ to choose different levels of access		The choices are: Level 1 Level 2 Level 3 Configuration
3. Press ▲ or ▼ to enter the correct code for the level chosen		The default codes are: Level 1 None Level 2 2 Level 3 3 Configuration 4 If an incorrect code is entered the display reverts to the previous view.
4. The controller is now in configuration level in this example		Press ⊜ to scroll through the list headers in the chosen level starting with Access List. The full list of headers is shown in the Navigation Diagram, section Navigation Diagram.
5. To return to a lower level, press and hold (if necessary) ⊜ to return to the Access Page 6. Press ▲ or ▼ to select the level		It is not necessary to enter a code when going from a higher level to a lower level. When Level 1 is selected the display reverts to the HOME display Do not power down while the controller is changing levels. If a power down does occur an error message will appear.

NOTICE

1. 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.
2. When the controller is in configuration level the ACCESS list header can be selected from any view by pressing ⊜ and ⟳ together.
3. An alternative way to access configuration level is to power up the instrument with ▲ and ▼ buttons pressed. You will then be asked to enter the security code to take you to configuration level.

Access Parameter List

The following table summarises the parameters available under the Access list header

List Header – Access		Sub-headers: None			
Name to select	**Parameter Description**	**Value** Press (▲) or (▼) to change values		**Default**	**Access Level**
Goto	To select different levels of access. Passcodes prevent accidental edit	Lev.1 Lev.2 Lev.3 Config	Operator mode level 1 Operator mode level 2 Operator mode level 3 Configuration level	Lev.1	L1
Level2 Code *	To customise the passcode to access level 2	0 to 9999		2	Conf
Level3 Code *	To customise the passcode to access level 3	0 to 9999		3	Conf
Config Code *	To customise the passcode to access configuration level	0 to 9999		4	Conf
IR Mode	To activate/de-activate the front panel InfraRed port. This is normally deactivated. The IR port is used to link the instrument to a PC and may be used for configuring the instrument using iTools when a digital comms link is not available. It requires an IR clip, available from Eurotherm, to link your Instrument to a PC.	Off On	Inactive Active	Off	Conf
Customer ID	To set an identification number for the controller	0 to 9999		0	Conf
A/Man Func	This enables or disables the front panel A/MAN button	On Off	Enabled Disabled	On	Conf
Run/Hold Func	This enables or disables the front panel RUN/HOLD button	On Off	Enabled Disabled	On	Conf
Keylock	When set to 'All' no front panel key is active. This protects the instrument from accidental edits during normal operation. To restore access to the keyboard from operator levels, power up the instrument with the (▲) and (▼) buttons pressed. This will take you directly to the configuration level password entry.	None All	Front panel keys active All Edits and Navigation are prevented.	None	Conf
Standby	Set to 'Yes' to select standby mode. In standby all control outputs are set to zero. The controller automatically enters standby mode when it is in Configuration level or during the first few seconds after switch on.	No Yes		No	Conf

CAUTION

* When changing passwords please make a record the new password

List Header – Access		Sub-headers: None			
Name (Scroll) **to select**	**Parameter Description**	**Value** (Raise) **or** (Lower) **to change**		**Default**	**Access Level**
Clear Memory	This parameter only appears if Config Code = 0. See Warning below.	No	Disabled	No	Conf
		AllMemory	Initialises all memory except linearization tables after firmware upgrade		
		Programs	Clears all programs		
Raise Key	These parameters allow keys to be wired, for example, to digital inputs so that the function can be controlled externally	Off	Shows the current state of the function		Conf
Lower Key		On			
Page Key					
Scroll Key					
Auto/Man Key					
Run/Hold Key					
Prog Key					

⚠ WARNING

Clear Memory must be used with care.
When selected it initialises the controller to default values.

The format of this table is used throughout this manual to summarise all parameters in a list.

The title of each table is the list header.

Column 1 shows the mnemonic (Name) of the parameter as it appears on the display

Column 2 describes the meaning or purpose of the parameter

Column 3 the value of the parameter

Column 4 a description of the enumeration

Column 5 the default value set when the controller is first delivered

Column 6 the access level for the parameter. If the controller is in a lower access level the parameter will not be shown

Function Blocks

The controller software is constructed from a number of 'function blocks'. A function block is a software device which performs a particular duty within the controller. It may be represented as a 'box' which takes data in at one side (as inputs), manipulates the data internally (using parameter settings) and 'outputs' the data. 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.

A representation of a function block is shown below.

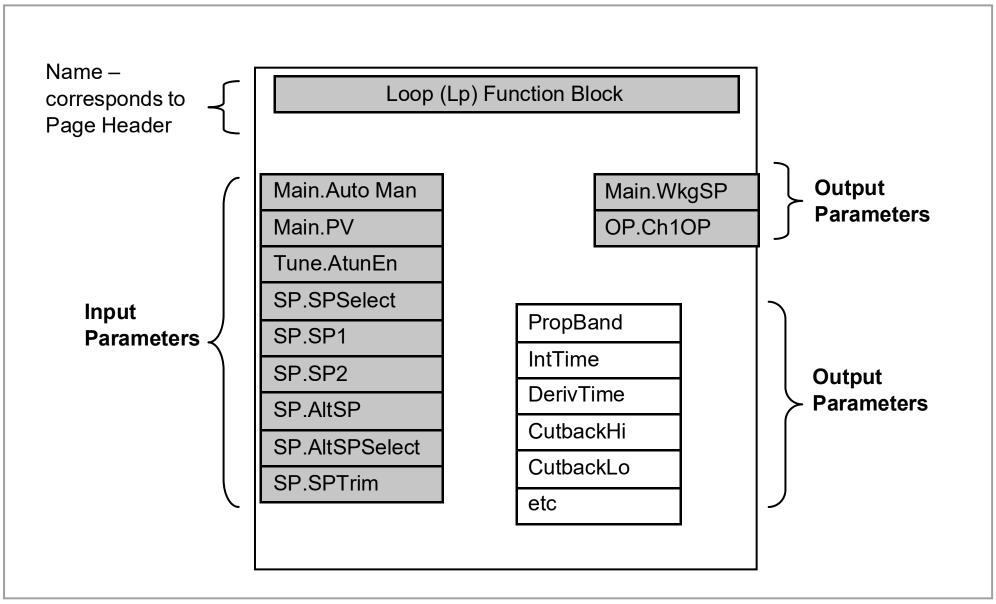


Figure 21: Example of a Function Block

In the controller, parameters are organised in simple lists. The top of the list shows the list header. This corresponds to the name of the function block and is generally presented in alphabetical order. This name 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.

In this manual the parameters are listed in tables similar to that shown in section Access Parameter List. The tables include all possible parameters available in the selected block but in the controller only those available for a particular configuration are shown.

To Access a Function Block

Press the Page button until the name of the function block is shown in the page header.

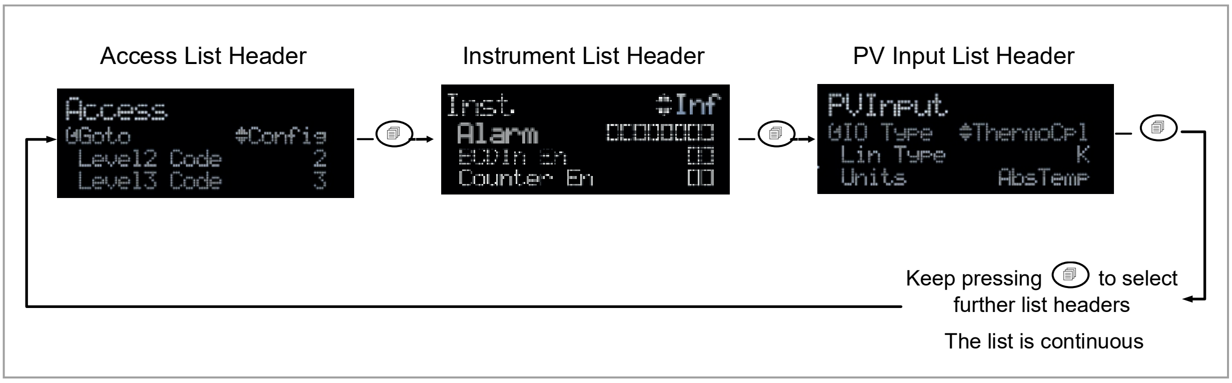


Figure 22: Parameter List Headings

Sub-Lists or Instances

In some cases the list is broken down into a number of sub-headers to provide a more comprehensive list of parameters. An example of this is shown above for the Instrument List. The sub-header is shown in the top right hand corner (as ⬍ Inf in the diagram). To select a different sub-header press ▲ or ▼.

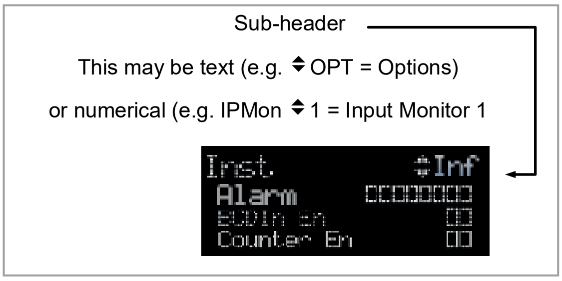
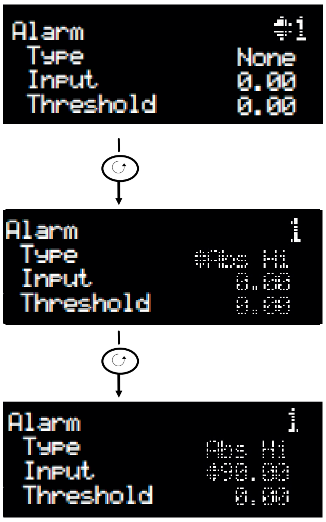


Figure 23: Sub-Header

To Access a Parameters in a Function Block

Press the scroll button until the required parameter is located.

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 format.



List Header - Alarm Number (1)

Alarm Type (in this example, Absolute or Full scale High)

Alarm Input level

Press for further parameters. This list is continuous and will scroll back to the top of the list

OR

Press to jump back to the top of the list.

Figure 24: Parameters

To Change the Value of a Parameter

Press or to raise or lower the value of an analogue (numeric) parameter or to change the selection of enumerated parameter options.

Any parameter preceded by ⬍ is alterable provided the system is in a safe state to allow the parameter to be changed. For example, 'Program Number' cannot be changed if the program is running - it must be in 'Reset' mode. If an attempt is made to alter the parameter its value is momentarily replaced by '---' and no value is entered.

Analogue Parameters

When the raise or lower button is first depressed there is a single increment or decrement of the least significant digit. Either button can be held down to give a repeating action at an accelerating rate.

Enumerated Parameters

Each press of the raise or lower button changes the state of the parameter. Either button can be held down to give a repeating action but not at an accelerating rate. Enumerated parameters are allowed to wrap around.

Time Parameters

Time parameters start with a resolution of 0.1 second mm:ss.s 0:00.0 to 59:59.9

When 59:59.9 is reached the resolution becomes 1 second hh:mm:ss 1:00:00 to 99:59:59

When this limit is reached the resolution becomes 1 minute hhh:mm 100:00 to 500:00

Boolean Parameters

These are similar to enumerated parameters but there are only two states. Pressing either the raise or lower button causes the parameter to toggle between states.

Digital Representation Characters

Parameters whose values are used digitally (i.e. bitfields) are represented by:

█ - On State or

▯ - Off State

A parameter may be represented by using any number of bits between 1 and 16 inclusive. Scrolling on to the parameter selects the leftmost bit, and subsequent scroll operations move the selected bit right by one. Backscroll may be used to move the selected bit towards the left. Raise and lower buttons are used to turn the selected bit on or off respectively.

Navigation Diagram

The diagram below shows all the function blocks available in the 3500 series controllers as list headings in configuration level. A function block will not be shown if it has not been enabled or ordered, if it is a chargeable option. Select in turn using :

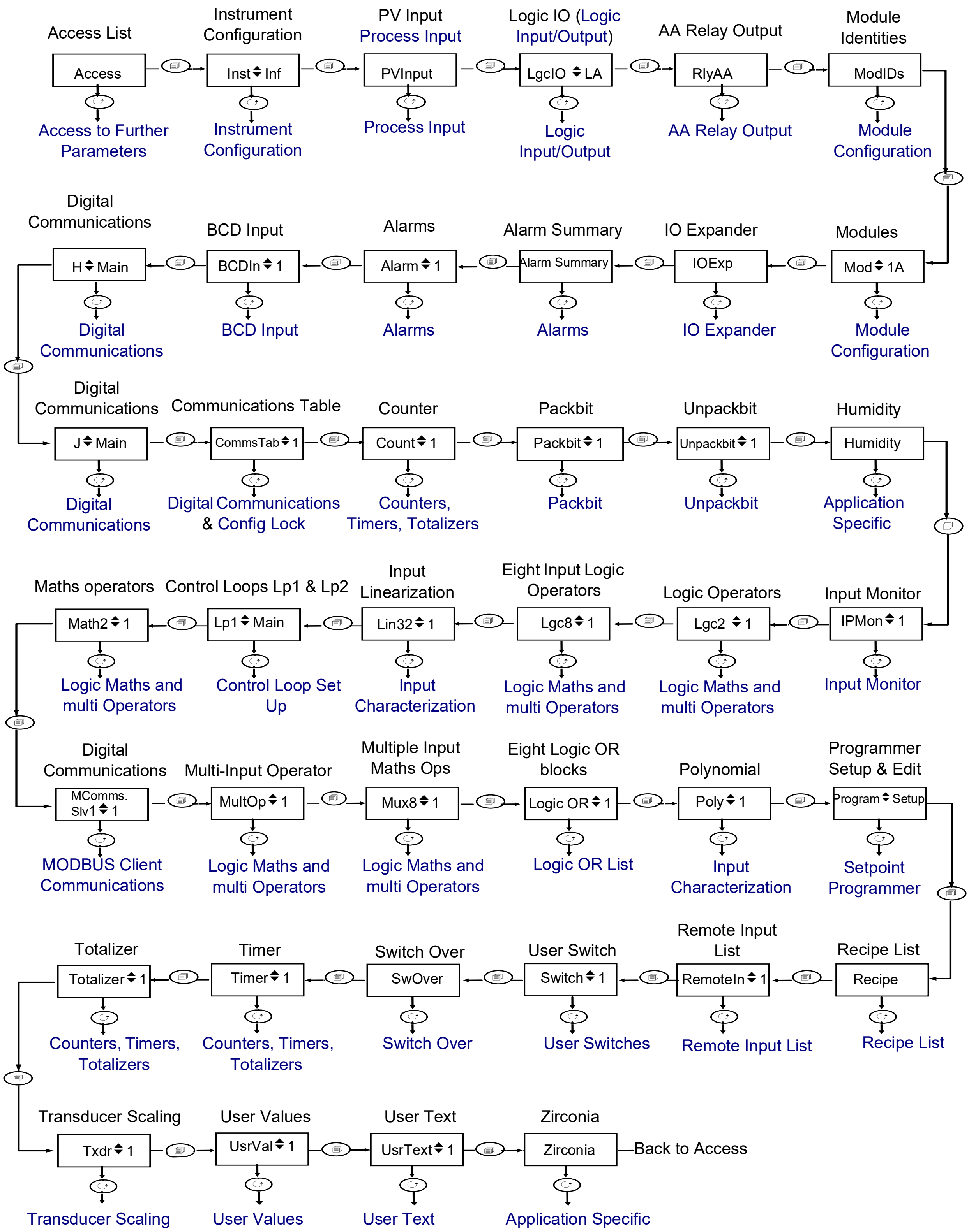


Figure 25: Navigation Diagram

Function Block Wiring

Input and output parameters of function blocks are wired together in software to form a particular instrument or function within the instrument. A simplified overview of how these may be interconnected to produce a single control loop is shown below.

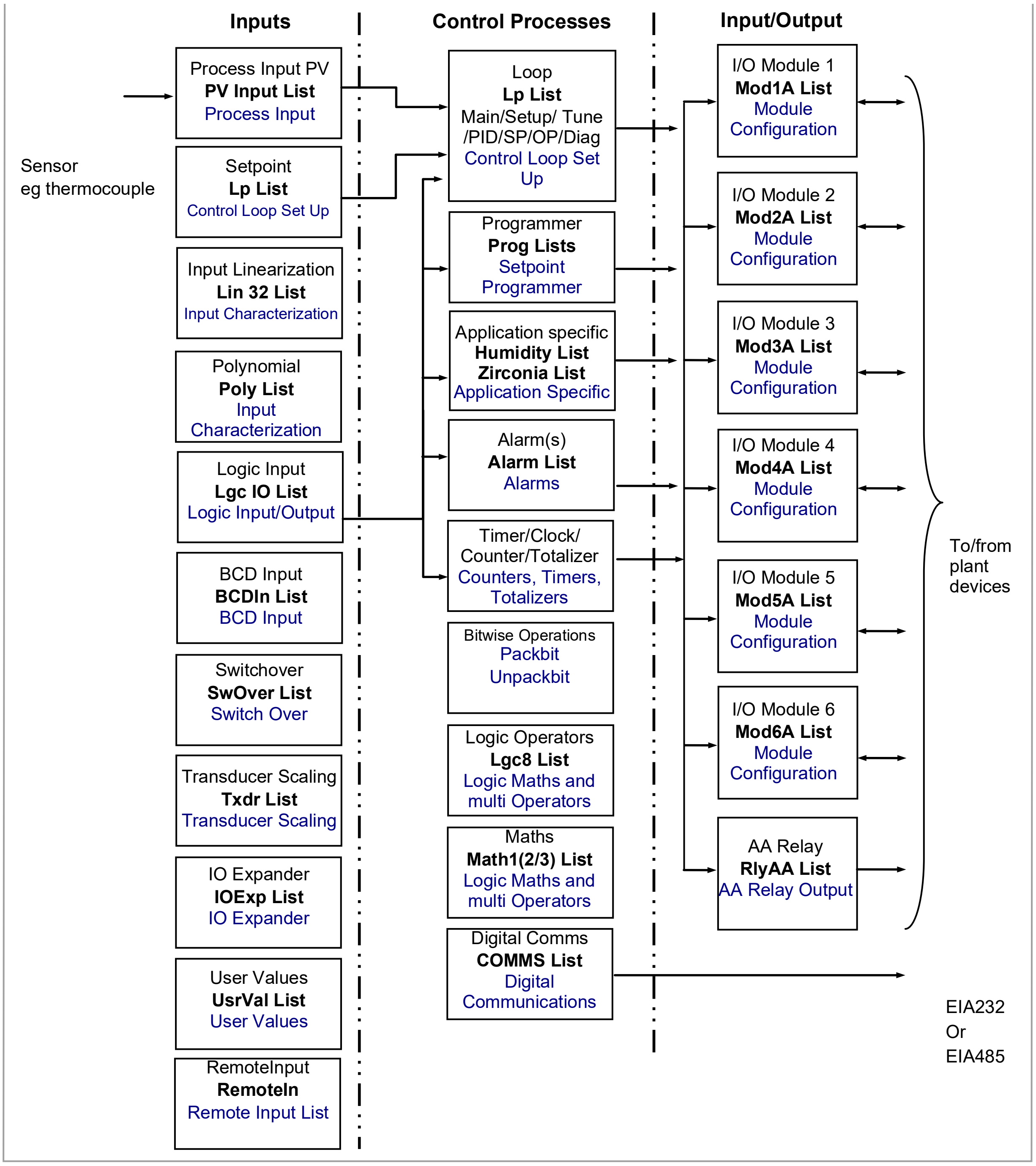


Figure 26: Controller Example

Function blocks are wired (in software) using the Quick Start mode and/or full configuration mode. In the controller example here, the Process Variable (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, programmer and alarms 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 controller can be customised to suit a particular process by 'soft wiring' between function blocks. The procedure is described in the following sections.

Soft Wiring

Soft Wiring (sometimes known as User Wiring) refers to the connections which are made in software between function blocks. Soft wiring, which will generally be referred to as 'Wiring' from now on, is possible through the operator interface of the instrument. This is described in the next section but it is recommended that this method is only used if small changes are required, for example, when the instrument is being commissioned.

The preferred method of wiring uses the iTools configuration package since it is quicker and easier. See iTools integrated Online Help for further details.

Wiring Example

In general every function block has at least one input and one output. Input parameters are used to specify where a function block reads its incoming data (the 'Input Source'). The input source is usually wired to the output from a preceding function block. Output parameters are usually wired to the input source of subsequent function blocks.

The value of a parameter which is not wired can be adjusted through the front panel of the controller provided it is not Read Only (R/O) and the correct access level is selected.

All parameters shown in the function block diagrams are also shown in the parameter tables, in the relevant sections, in the order in which they appear on the instrument display (alphabetical).

Figure 27 shows an example of how the channel 1 (heat) output from the PID block might be wired to the logic output connected to terminals LA/LC.

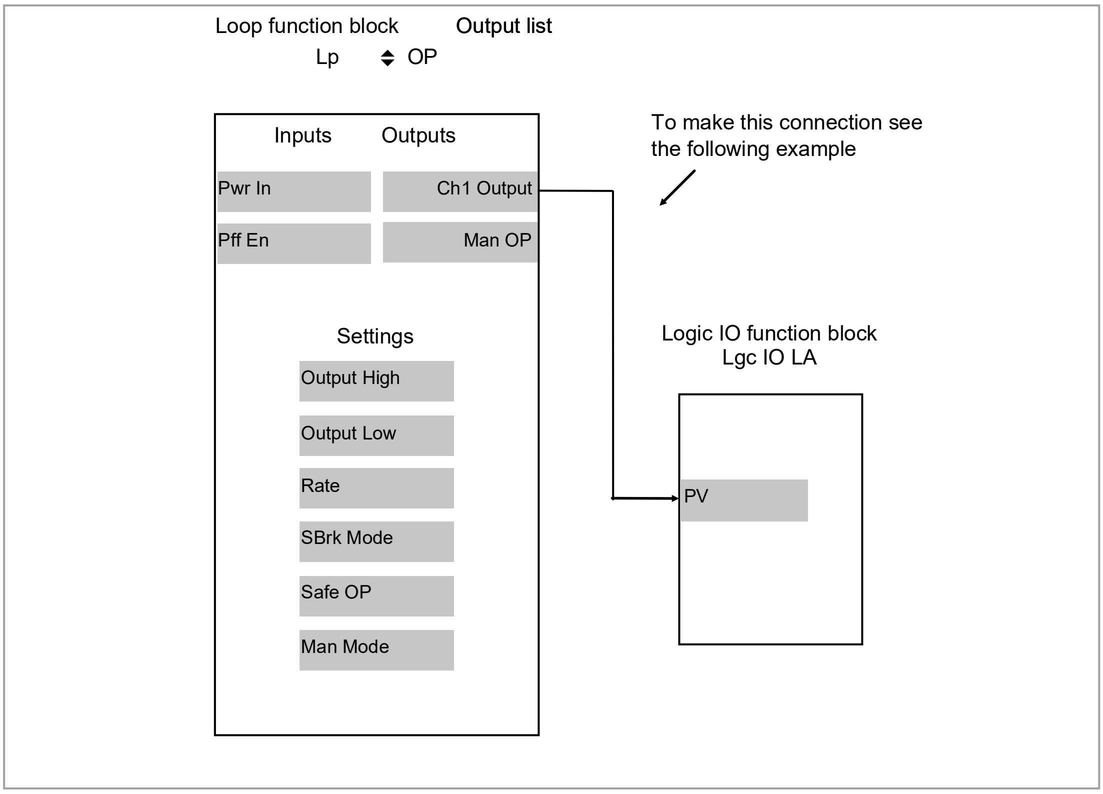


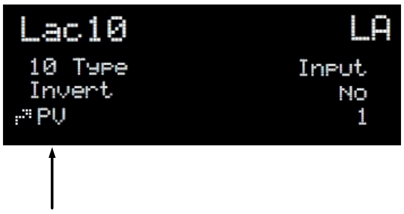
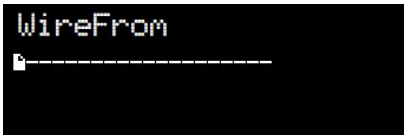
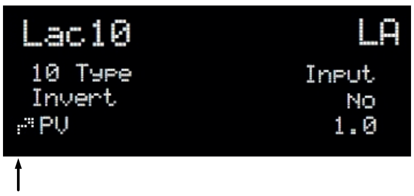
Figure 27: Function Block Wiring

Wiring Through the Operator Interface

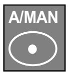
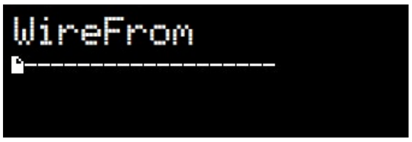
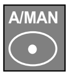
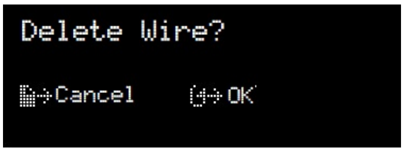
The example shown in the previous section will be used.

Select configuration level as described in section To Select Different Levels of Access.

Then:

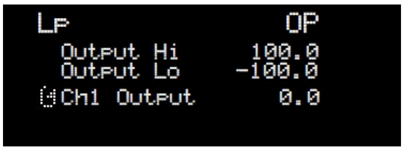
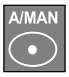
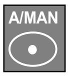
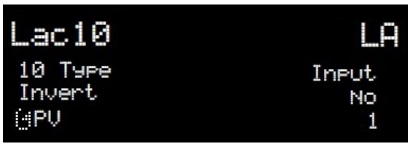
Do This	The Display You Should See	Additional Notes
1. From any display press to locate the page in which the parameter is to be found. (In this example **'LgcIO'** page) 2. Press or if necessary to select a sub-header. (In this example **'LA'**) 3. Press to scroll to the parameter to be wired **TO**. (In this example **'PV'**)	 Indicates parameter selected	This locates the parameter you want to wire TO
4. Press A/MAN to display **'WireFrom'**		In configuration mode the A/MAN button is the Wire button.
5. Press (as instructed) to navigate to the list header which contains parameter you want to wire **FROM**.		You will also need to use or to select a sub-header, if appropriate, and to scroll to the parameter - in this example **'Ch1 Output'** in the **'Lp OP'** page
6. Press A/MAN		This 'copies' the parameter to be wired FROM
7. Press as instructed to confirm	 Indicates that the parameter is wired. If you want to inspect this press A/MAN. Press A/MAN again to go back to the display above.	This 'pastes' the parameter to 'PV'

To Remove a Wire

Do This	The Display You Should See	Additional Notes
1. Select the wired parameter eg LgcIO PV in the above example,		
2. Press 		This locates the parameter you want to wire TO
3. Press Ack to clear the **'WireFrom'** display		This is the quick way to select no wire. You can also select this by pressing repeatedly
4. Press 		
5. Press to OK		

Wiring a Parameter to Multiple Inputs

You can repeat the procedure given in section Wiring Through the Operator Interface. but it is also possible to 'Copy' and 'Paste' a parameter. In configuration level the RUN/HOLD button becomes a copy function. The following example wires Ch1 Output to both LA and LB PV inputs.

Do This	The Display You Should See	Additional Notes
1. Select Ch1 Output		
2. Press RUN/HOLD		This copies channel 1 output
3. Select the parameter to wire to. In this case LgcIO LA PV		
4. Press 		
5. Press RUN/HOLD		
6. Press 		
7. Press  to OK		
8. Now repeat 3 to 8 but for LgcIO LB		

Wiring Floats with Status Information

There is a subset of float values which may be derived from an input which may become faulty for some reason, e.g. sensor break, over range, etc. These values have been provided with an associated status which is automatically inherited through the wiring. The list of parameters which have associated status is as follows:

Block	Input Parameters	Output Parameters
Loop.Main	PV	PV
Loop.SP		TrackPV
Loop.OP	CH1PotPosition	
	CH2PotPosition	
Math2	In1	
	In2	
		Out
Programmer.Setup	PVIn	
Poly	In	
		Out
Lin32	In	
		Out
Txdr	InVal	
		OutVal
IPMonitor	In	
SwitchOver	In1	
	In2	
		Out
Total	In	
Mux8	In1..8	
		Out
Lgc2	In1	
	In2	
UsrVal	Val	Val
Humidity		RelHumid
		DewPoint
	WetTemp	
	DryTemp	
	PsychroConst	
	Pressure	
IO.MOD	A.PV, B.PV, C.PV	A.PV, B.PV, C.PV
IO.PV	PV	PV
MultiOper	CascIn	SumOut
	In1 to 8	MaxOut
		MinOut
		AvOut
Alarm	Input, Threshold, Reference, Rate, ThresholdLow	
MODBUS Master	ValueToWrite	PV
RemoteInput		Output
Zirconia	ProbeIn, TemperatureIn, SaturationLimit.	CarbonPotential, DewPoint, Oxygen
Packbit	In1-16	Output
Unpackbit	Input	

Parameters appear in both lists where they can be used as inputs or outputs depending on configuration. The action of the block on detection of a ‘Bad’ input is dependent upon the block. For example, the loop treats a ‘Bad’ input as a sensor break and takes appropriate action; the Mux8 simply passes on the status from the selected input to the output, etc.

The Poly, Lin32, SwitchOver, Mux8, Multi-Operator, IO.Mod, and IO.PV blocks can be configured to act on bad status in varying ways. The options available are as follows:

0: Clip Bad

The measurement is clipped to the limit it has exceeded and its status is set to ‘BAD’, such that any function block using this measurement can operate its own fallback strategy. For example, control loop may hold its output to the current value.

1: Clip Good

The measurement is clipped to the limit it has exceeded and its status is set to ‘GOOD’, such that any function block using this measurement may continue to calculate and not employ its own fallback strategy.

2: Fallback Bad

The measurement will adopt the configured fallback value which has been set by the user. In addition the status of the measured value will be set to ‘BAD’, such that any function block using this measurement can operate its own fallback strategy. For example, control loop may hold its output to the current value.

3: Fallback Good

The measurement will adopt the configured fallback value which has been set by the user. In addition the status of the measured value will be set to ‘GOOD’, such that any function block using this measurement may continue to calculate and not employ its own fallback strategy.

4: Up Scale

The measurement will be forced to adopt its high limit. This is like having a resistive pull up on an input circuit. In addition the status of the measured value will be set to ‘BAD’, such that any function block using this measurement can operate its own fallback strategy. For example, the control loop may hold its output to the current value.

5: Down Scale

The measurement will be forced to adopt its low limit. This is like having a resistive pull down on an input circuit. In addition the status of the measured value will be set to ‘BAD’, such that any function block using this measurement can operate its own fallback strategy. For example, the control loop may hold its output to the current value.

Edge Wires

If the Loop.Main.AutoMan parameter was wired from a logic input in the conventional manner it would be impossible to put the instrument into manual from the front panel of the instrument. Other parameters need to be controlled by wiring but also need to be able to change under other circumstances, e.g. Alarm Acknowledgements. for this reason some Boolean parameters are wired in an alternative way. These are listed as follows:

SET DOMINANT

When the wired in value is 1 the parameter is always updated. This will have the effect of overriding any changes through the front panel or through digital communications. When the wired in value changes to 0 the parameter is initially changed to 0 but is not continuously updated. This permits the value to be changed through the front panel or through digital communications.

Loop.Main.AutoMan
Programmer.Setup.ProgHold
Instrument.Diagnostics.ForceStandby
Zirconia.Clean.Start
Zirconia.Clean.Abort

RISING EDGE

When the wired in value changes from 0 to 1, a 1 is written to the parameter. At all other times the parameter is not updated by the wire. This type of wiring is used for parameters which start an action and when once completed the block clears the parameter. When wired to, these parameters can still be operated from the front panel or through digital communications.

Programmer.Setup.ProgRun
Programmer.Run.AdvSeg
Programmer.Run.SkipSeg
Alarm.Ack
Instrument.Diagnostics.GlobalAck
ModbusMaster.Data1-100.Send
Zirconia.Clean.MsgReset
Txdr.ClearCal
Txdr.StartCal
Txdr.StartHighCal
Txdr.StartTare
IPMonitor.Reset

BOTH EDGE

This type of edge is used for parameters which may need to be controlled by wiring or but should also be able to be controlled from the front panel or through digital communications. If the wired in value changes then the new value is written to the parameter by the wire. At all other times the parameter is free to be edited from the front panel or through digital communications.

Loop.SP.RateDisable
Loop.OP.RateDisable
Loop.Tune.AutotuneEnable
Programmer.Setup.RunHold
Programmer.Setup.RunReset

Operation of Booleans and Rounding

Mixed Type Wiring

Parameters of function blocks are one of the following types shown below. Wires which connect one type to another cause a type conversion to occur. The values wired may also be rejected or clipped depending on type and limits.

BOOLEANS (including Edges)

Any value greater than or equal to 0.5 wired to a boolean (or edge) is considered true. When wired to other values booleans will be considered as 0 or 1.

INTEGER

Values outside the limits of the integer will be clipped to the limits.

ENUMERATED INTEGER

Values which are outside the limits of an enumerated parameter or do not have a defined enumeration will not be written.

BINARY INTEGER (PIANO KEYS)

A value which exceeds the number of bits used by the parameter will be rejected.

FLOAT

Values outside the limits of a float parameter will be clipped to the limits. Wiring from a float to any other type will be rounded to the nearest integer. Where the value falls half way between two integers it will be rounded towards the higher absolute value. I.e. -3.5 rounds to -4 and +3.5 rounds to +4.

TIME

Times can only be wired to or from other times or floats. When wired to or from floats the float value is in seconds.

STRING

String values can not be wired.

Logic OR List

The Logic OR function block allows multiple parameters to be wired to a single Boolean parameter without the need to enable toolkit blocks for the LGC2 or LGC8 'OR' functionality. There are 8 Logic OR blocks available.

Each block consists of 8 inputs which are OR'd together into one output. It may be used, for example, to take the outputs from a number of alarm blocks and OR them together to operate a single general alarm output.

Parameter Name Press ⟳ to select in turn	**Value** Press ▼ or ▲ to change values (if read/write, R/W)		**Description**	**Access**
INPUT 1	OFF	0	Input 1 to the OR block	R/O
	On	1		
INPUT 2	OFF	0	Input 2 to the OR block	
	On	1		
INPUT 3	OFF	0	Input 3 to the OR block	
	On	1		
INPUT 4	OFF	0	Input 4 to the OR block	
	On	1		
INPUT 5	OFF	0	Input 5 to the OR block	
	On	1		
INPUT 6	OFF	0	Input 6 to the OR block	
	On	1		
INPUT 7	OFF	0	Input 7 to the OR block	
	On	1		
INPUT 8	OFF	0	Input 8 to the OR block	
	On	1		
OUTPUT	OFF	0	Output result	
	On	1		

Recipe List

A recipe is a list of parameters whose values can be captured and stored in a dataset. This dataset can then be loaded into the controller at any time to restore the recipe parameters, thus providing a means of altering the configuration of an instrument in a single operation even in operator mode.

A maximum of 8 datasets are supported, referenced by its name, defaulted to be the dataset number i.e. 1…8.

Parameter Name Press ⟳ to select in turn	Value Press ▼ or ▲ to change values (if read/write, R/W)		Description	Access
dataset to load	NONE	0	Selects which recipe dataset to load. Once selected, the values stored in the dataset will be copied back over the active parameters. **Default: None**	
	1 to 8		Dataset 1 to 8	
	DONE	101	Load completed successfully	
	u.suc	102	Dataset selection unsuccessful	
dataset to save	NONE	0	Selects which of the 5 recipe datasets in which to store the current active parameters. When selected, this parameter initiates a snapshot of the current parameter set into the selected recipe dataset.	
	1 to 8		Dataset 1 to 8	
	DONE	101	Save completed successfully	
	u.suc	102	Unsuccessful will be displayed if the values were not saved successfully. If it completes OK, then the display does not change.	
Enable alterability checks	YES	1	Enabled. Set to 'Yes' to check all parameters can be written in the current mode before loading a recipe dataset. **Default: Yes**	
	No	0	Disabled. Set to 'No' to write all parameters regardless of their 'config-only' status. See Note below	

Note: Changing configurations and certain parameters whilst in Operator mode can cause disturbances in the process and, therefore, by default, a dataset will not be loaded (no parameters written to) if a parameter contained in the recipe is not writeable in operator mode. To cater for users who require the loading to operate in a similar manner to the 3200 controller (no parameter checking), this functionality can be disabled. However, to reduce disturbances in the process, whilst loading a dataset which contains configuration parameters the Instrument will be forced into standby whilst the loading is in progress.

If the recipe load cannot be completed for any reason (values are invalid or out of range), the instrument will be half configured. The instrument will put itself into Standby and display the "REC.S - INCOMPLETE RECIPE LOAD" message. This will continue after a power cycle, but can be cleared by entering and exiting config mode.

There is no default list of parameters for the 3500 series controllers. The parameters required to be held in recipe are defined using iTools.

To Save Recipes

1. Add your required parameters to the Recipe Definition list.
2. In the controller, adjust any of the parameters in the above list (or in your customized list) as required for a particular process or batch.
3. Scroll to the Recipe List, and select ’dataset to save’.
4. Select a recipe number (1 to 8) in which to store the current parameter values. When the current values have been successfully saved the display will show **dONE**.
5. Repeat the above for a second or subsequent process or batch and save under a different recipe number.

To Load a Recipe

To recall a saved recipe:

1. Scroll to the Recipe List, and select ‘dataset to load’.
2. Select the required Recipe number. The display will flicker once to show that the selected recipe has been loaded.

Notes:

1. Recipes may be saved and recalled in Operator Levels 2, 3 and Configuration by default. It is also possible to Promote the Recipe parameters to Level 1 if required. This is done using iTools.
2. Recipes can also be saved and recalled using iTools.

Remote Input List

This list configures the remote input as shown in the following table.

Parameter Name Press (key) to select in turn	Value Press (down) or (up) to change values (if read/write, R/W)		Description	Access
remote input			This parameter can be written to via a remote client	Conf R/W L3 R/W
range high			Maximum value of the input **Default: 100**	Conf R/W L3 R/O
range low			Minimum value of the input **Default: 0**	Conf R/W L3 R/O
scale high			The maximum value of the scaled output PV **Default: 100**	Conf R/W L3 R/O
Scale lo			The minimum value of the scaled output PV **Default: 0**	Conf R/W L3 R/O
timeout			This is the period in which the input has to be written to (in seconds). If this period is exceeded the output PV status will be set to Bad. If this period is set to 0, the timeout strategy is disabled. **Default: 1s**	Conf R/W L3 R/O
resolution	nnnnn	0	Resolution of the input /output. No decimal places	Conf R/W L3 R/O
	nnnn.n	1	One decimal place **Default: nnnn.n**	
	nnn.nn	2	Two decimal places	
	nn.nnn	3	Three decimal places	
	n.nnnn	4	Four decimal places	
units			This list configures the remote input as shown in the following table. See Display Units for a list of units used throughout **Default: AbsTemp**	
pv			The output PV that has been linearly scaled Range High to Scale High and Range Low to Scale Low	Conf R/O
status			Status of the output PV	Conf R/O

Instrument Configuration

What Is Instrument Configuration?

Instrument configuration allows you to:

1. Customise the display
2. Read information about the controller
3. Read internal diagnostics

To Select Instrument Configuration

Select Configuration level as described in section Access to Further Parameters.

Press ⊜ from the Access list. The first view displayed is the header '**Inst**' plus the sub-header '⇕ **Inf**'.

This allows you to read and configure settings specific to this individual instrument. The '⇕' symbol indicates further sub-headers are available. To select these press ⊙ or ⊙.

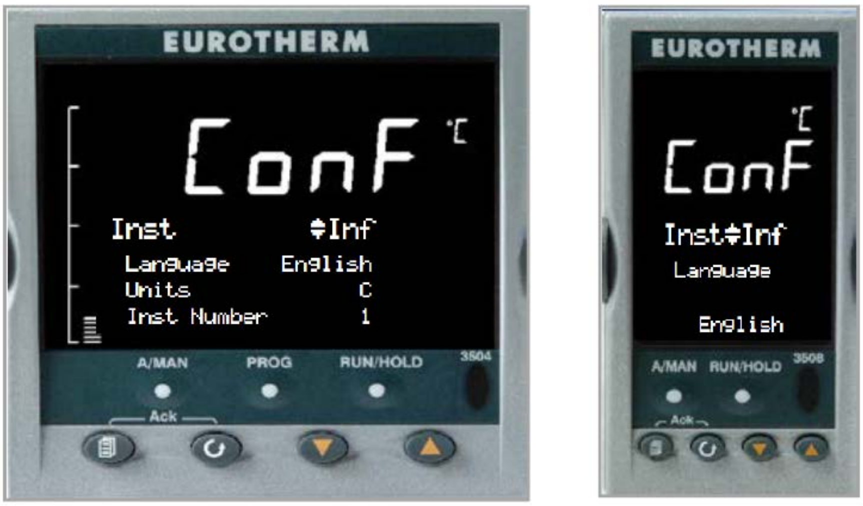


Figure 28: Instrument Configuration Displays

Function Block Options

See, Function Blocks. All function blocks are enabled by default. Refer to Navigation Diagram to see all the function blocks as list headings in configuration level.

Function blocks that are protected by feature passcodes will be hidden, but will appear once the relevant feature has been purchased, see Instrument Feature Passcodes below.

Instrument Feature Passcodes

Feature passcodes are required to enable chargeable features. These can be added after the instrument has been purchased. Examples of chargeable features include Number of Loops, Number of programs, Number of wires, Toolkit Blocks, Digital Communications protocols and Configuration Lock, etc. These passcodes can only be added through iTools, see the iTools User Guide for more information.

Instrument Information

This list provides information about the controller as follows:

List Header: Inst		Sub-header: Inf			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Language	The language used by the Instrument HMI	0	English	English	Config RW
		1	French		
		2	German		
		4	Spanish		
Units	Sets the temperature units of the instrument. When temperature units is changed, those parameters which are flagged as having a temperature type (Absolute or relative) will have their values converted to reflect the new temperature units.	0	C (° Celsius)	C	Config RW
		1	F (° Fahrenheit)		
		2	K (° Kelvin)		
Inst Number	The unique serial number of the instrument. This is set at the factory and cannot be changed.				RO
Inst Type	The type of instrument e.g., 3504, can be used over comms to identify the instrument being communicated with		3504		RO
			3508		
PSU Type	The type of power supply in use. Note this will display LV PSU if powered by CPI clip.		LV		RO
			HV		
Version Num	The version of instrument software. Can be used to identify the build of software being used and hence what features are available.				RO
Company ID	A MODBUS code allocated to Eurotherm			1280	RO
Customer ID	A non-volatile value for customer use: it has no effect on instrument functionality			0	Config RW

Instrument Options

This page allows you to set up options as listed in the following table:

List Header: Inst		Sub-header: Opt (Options)			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
ProgMode	To select the type of programmer. ☺ Ensure that two programmers are enabled (see previous section) otherwise only 'SingleChn' can be selected).	SingleChn	Single channel (two independent channels)	SyncAll	Conf
		SyncAll	All segments of two programmer blocks are synchronised		
		SyncStart	Two programmers syncronised at start of run		
PVStart?	To enable PV Start. See Programmer section PV Start.	No Yes	Disabled Enabled	Disabled	Conf

List Header: Inst		Sub-header: Opt (Options)			
Name ⊙ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
ImmSP?	When enabled, changes to the working setpoint (WSP) take effect immediately when adjusted using the front panel ▲ or ▼ buttons. (Note, when adjusted over comms the change always takes place immediately). The working setpoint may be derived from SP1, SP2 or a programmer setpoint - PSP*. Edits to the active setpoint usually take effect after the raise/lower button is released. It may be desirable, in some applications such as crystal growing, to eliminate this delay. The effect is seen on Summary Pages, User Pages (when WSP is promoted) and in Program Status Page (when changing PSP in Hold). * If the working setpoint is derived from the programmer then the parameter 'ImmPSP' is shown in the programmer Run list in iTools only. This parameter can be hidden by disabling the parameter 'EnableImmPSP' which is shown in the programmer Setup list in iTools. These parameters are not shown in the user interface of 3500.	No	Disabled - In operator level the new setpoint is entered after the raise/lower button is released and is indicated by a brief flash in the display	Disabled	Conf
		Yes	Enabled - In operator level the new setpoint is entered continuously and no flash of the display is shown.		

Display Formatting

The display which will be shown in Operator levels 1 to 3 may be customised.

This is achieved in the 'Inst' configuration list using the sub-header 'Dis'.

To Customise the Display

The controller must be in Configuration level.

Then:

Do This	The Display You Should See	Additional Notes
1. Press ▣ as many times as necessary until **'Inst'** is displayed 2. Press ▲ or ▼ to select **'Dis'**		If a parameter from, say, the previous display is being shown, then it will be necessary to press to return to the top of the list
3. Press ⊙ to scroll to the first parameter - **'Home Page'** 4. Press ▲ or ▼ to change the selection		In operator level the instrument, by default, shows 'Loop' parameters in the HOME display. The HOME display may also show: Program Programmer parameters Custx Up to 8 views may be customised Cust1 will select the first Access Access parameters
		The following table shows the full list of parameters available to customise the display ⇓

List Header: Inst		Sub-header: Dis (Display)			
Name ⊙ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Home Page	Configures which set of parameters are shown in the message display of the HOME view when the controller is in operator level.	Loop Program Custom 1 to 8 Access	Loop summary Program summary Customised Access	Loop	Conf
Home Timeout	In operator level the controller can be made to revert to the HOME display after a fixed time following selection of other pages	Off to 0:01 to 1:00 hr	Off = the controller will not revert to the HOME display	0:01 (1 min)	Conf
Loop Summary	A summary of the Loop parameters are displayed in the message centre (section Summary Pages) in the selected operating level	On Off	Enabled Disabled	On	Conf
Loop 1 Summary	A summary of Loop 1 parameters	On Off	Enabled Disabled	On	Conf
Loop 2 Summary	A summary of Loop 2 parameters	On Off	Enabled Disabled	On	Conf
Prog Edit	Defines the level in which a program may be edited	Level1 Level2 Level3		Level1	Conf
Prog Status	A summary of the Program Status parameters are displayed in the message centre (section Summary Pages) in the selected operating level	Level1 Level2 Level3 Off		Level1	Conf
Bar Scale Max	Upper limit of the vertical bar graph scale	-99999 to 99999		1372	Conf
Bar Scale Min	Lower limit of the vertical bar graph scale	-99999 to 99999		-200	Conf
Main Bar Val	Main bar graph value	This can be wired to any parameter. See also section Bar Graph (3504 Only).			L3
Aux1 Bar Val	First auxiliary bar graph value				L3
Aux2 Bar Val	Second auxiliary bar graph value				L3
Control1 Page	Defines the level in which the control page 1 is shown	Off Level1 Level2		Level1	Conf
Control2 Page	Defines the level in which the control page 2 is shown				
Alarm Page	Defines the level in which the alarm page is shown				
Alarm Summary	Enables/disables the alarm summary page in operator levels	On Off	Enabled Disabled	On	Conf
OP1 Beacon	By default the output beacons are wired to operate when channel 1 or channel 2 outputs from the selected loop are active. They can, however, be wired to operate on any parameter.	Off	Beacon off		R/O
		On	Beacon on		
OP2 Beacon		Off	Beacon off		R/O
		On	Beacon on		
Txdr1 Page	Defines the level in which the Transducer 1 Scaling page is visible	Level 1 Level 2 Level 3		Level 1	Conf
Txdr2 Page	Defines the level in which the Transducer 2 Scaling page is visible	Level 1 Level 2 Level 3		Level 1	Conf

Bar Graph (3504 Only)

The bar graph shown on the left hand side of the display can be wired to any analogue parameter.

Markers can also be placed on the bar graph which can be used to indicate minimum and maximum points. These points are defined by the parameters ‘Aux1 Bar Val’ and ‘Aux2 Bar Val’ respectively. The markers may be fixed in position by leaving these two parameters unwired and entering an analogue value. Alternatively, they may be wired – in the following example they are wired to low and high alarm points.

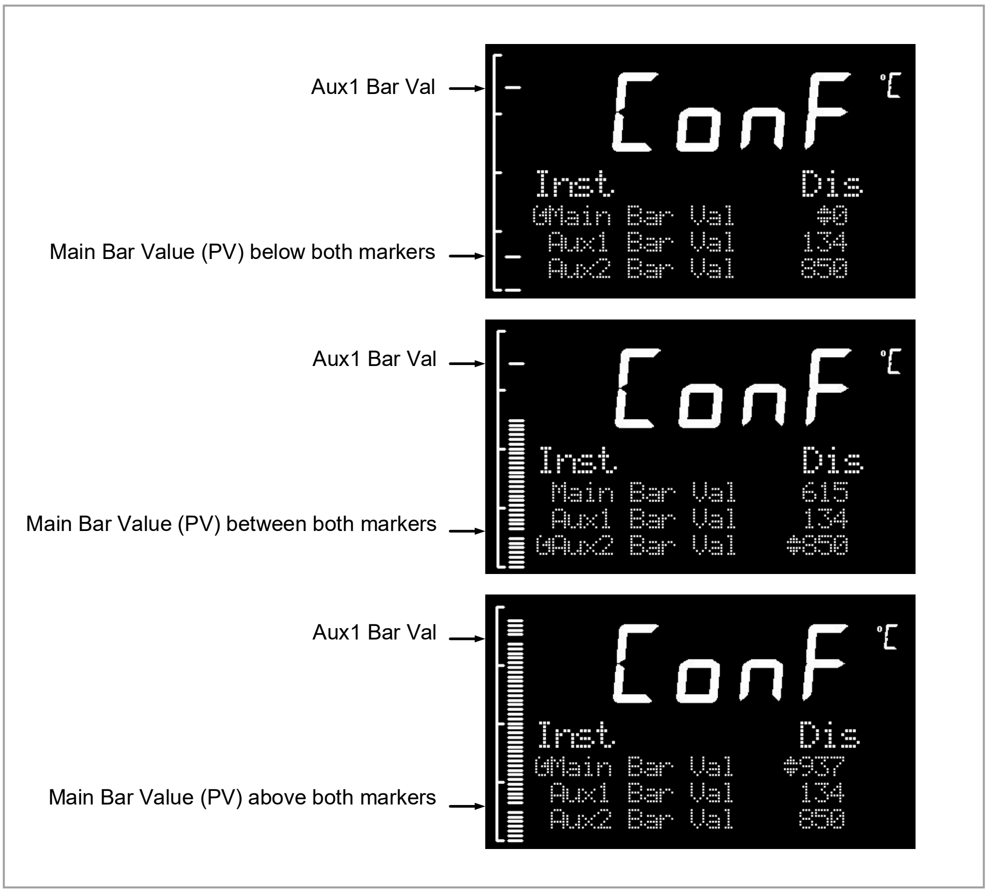


Figure 29: Bar Graph Markers

Instrument Security

This list provides security information as follows:

List Header: Inst	Sub-header: Security
Name to select	**Parameter Description**
Level2 Code	The HMI passcodes used to enter the HMI access levels
Level3 Code	
Config Code	
Comms Expiry	Number of days after to wait after comms password is set before raising the "Comms Password Expired" notification. Set to 0 to disable this notification.
Password Lock Time	After entering maximum invalid attempts to login, the password entry mechanism will be locked out for this period. This lockout time affects all access level passcodes and the comms config password. Note: A value of 0 will disable the lockout mechanism.
Clear Memory	Used to clear instrument to Factory defaults. Can also be used to default programs and segments only.
Comms Security	When this parameter is set, a string parameter becomes available via comms for entering plain text passwords to enter configuration mode.
Clear Comms Password	When set, the comms configuration password will be cleared
Http Enable	Set by EFMT to perform firmware upgrade
Upgrade Mode	Set by EFMT to perform firmware upgrade

Instrument Diagnostics

This list provides fault finding diagnostic information as follows:

List Header: Inst	Sub-header: Diag	
Name to select	**Parameter Description**	
Notification Status	Provides bit-mapped instrument status information	
	Bit No	Description
	0	Comms password not set
	1	Password has expired
	2	HMI level 2 access locked out
	3	HMI level 3 access locked out
	4	HMI config access locked out
	5	Comms config access locked out
	6	Not Used
	7	Not Used
	8	Comms in config mode
	9	Not Used
	10	Config Lock Password locked out
	11	Not used
	12	Not used
	13	Not used
	14	Not used
	15	Not used
Standby Condition Status	Provides bit-mapped instrument standby condition information	
	Bit No	Description
	0	Invalid RAM image of NVOL
	1	NVOL parameter database load/store was unsuccessful
	2	NVOL region load/store was unsuccessful
	3	Option NVOL load/store was unsuccessful
	4	Factory Calibration not detected
	5	Unexpected CPU condition
	6	Hardware Ident Unknown
	7	Fitted hardware differs from expected hardware
	8	Unexpected Keyboard condition during startup
	9	Powered down in config mode
	10	Recipe load unsuccessful
	11	Not Used
	12	Not Used
	13	Not Used
	14	Not Used
	15	Not Used
Alarm Status 1	A summary of the alarms represented by bits in a word	
Alarm Status 2		
SBreak Alarm	A summary of the sensor break alarms represented by bits in a word	
New Alarm	Notification flag for a new active alarm	
Any Alarm	Notification flag for any active alarm	
Global Ack	Used to acknowledge all instrument alarms	
Sample Time	Execution period	

List Header: Inst	Sub-header: Diag
Name to select	**Parameter Description**
Line Voltage	The measurement of the instrument line voltage. Power feedforward can be enabled by setting the parameter 'Pff En' in the Loop Output list (section Loop Parameters - Output) to 'Yes'. This sets the control loop PFF Value parameter such that the control algorithm can compensate for mains voltage fluctuations when the instrument is connected to the same phase as the heater.
L2 Pass Unsuccess	Count of the number of successful or unsuccessful attempts to log in to the HMI or comms access levels
L2 Pass Success	
L3 Pass Unsuccess	
L3 Pass Success	
Config Pass Unsuccess	
Config Pass Success	
Comms Pass Unsuccess	
Comms Pass Success	
Time Format	Time format used by CPI and IR comms connections (ms, s, min, hour)
Time DP	Scaling factor for scaled time parameters used by CPI and IR comms connections
Force Standby	Force the instrument into standby to halt IO operations
Exec Status	Indicates the status of the execution engine (Running, Standby, Startup)
PowerFail Count	Indicates the number of times the instrument has reset (power cycle, exit from config or unexpected software reset). Clear the count by writing 0 or performing coldstart.
Error Count	The number of errors logged since the last Clear Log **Note**: However, if an error occurs multiple times only the first occurrence will be logged, but each event will increment the count.
Error 1 to Error 8	The first 8 errors to occur | See Note below for options
Clear Log	Used to clear Error 1 to Error 8 and Error Count
A/Man Key	The purpose of these parameters is to allow the functions to be wired to, for example, a digital input so that the function can be controlled from an external source.
Prog Key	
Run/Hold Key	
Page Key	
Scroll Key	
Lower Key	
Raise Key	
Max Segments	Displays the maximum number of program segments - 500 (read only)
Max Segs per Prog	Displays the maximum number of segments available in any program - 50 (read only)
Segments Left	Number of Available Program Segments - Gives the number of unused program segments. Each time a segment is allocated to a program, this value is reduced by one.

NOTICE
Error 1 to Error 8 parameters may be set to one of the following values: 0: There is no error 1: Bad or unrecognised module ident. A module has been inserted and has a bad or unrecognised ident, either the module is damaged or the module is unsupported. 3: Factory calibration data bad. The factory calibration data has been read from an I/O module and has not passed the checksum test. Either the module is damaged or has not been initialised. 4: Module changed for one of a different type. The configuration may now be incorrect 5: I/O Chip DFC1 communication failure. The onboard generic I/O Chip DFC1 will not communicate. This could indicate a build fault in the instrument. 6: I/O Chip DFC2 communication failure. The onboard generic I/O Chip DFC2 will not communicate. This could indicate a build fault in the instrument. 7: I/O Chip DFC3 communication failure. The onboard generic I/O Chip DFC3 will not communicate. This could indicate a build fault in the instrument. 10: Calibration data write error. An error has occured when attempting to write calibration data back to an I/O module's EE. 11: Calibration data write error. An error occured when trying to read calibration data back from the EE on an I/O module. 13: Fixed PV input error. An error occured whilst reading data from the fixed PV Input EE. 18: Checksum error. The checksum of the NVol RAM has failed. The NVol is considered currupt and the instrument configuration may be incorrect. 20: Resistive identifier error. An error occured when reading the identifier from an I/O module. The module may be damaged. 21: Fixed PV ident has been changed. This may be due to installation of new Power Supply Board. 22: Module 1 changed for one of a different type. The configuration may now be incorrect 23: Module 2 changed for one of a different type. The configuration may now be incorrect 24: Module 3 changed for one of a different type. The configuration may now be incorrect 25: Module 4 changed for one of a different type. The configuration may now be incorrect 26: Module 5 changed for one of a different type. The configuration may now be incorrect 27: Module 6 changed for one of a different type. The configuration may now be incorrect 28: H Module changed for one of a different type. The configuration may now be incorrect 29: J Module changed for one of a different type. The configuration may now be incorrect 43: Invalid custom linearization table. One of the custom linearization tables is invalid. Either it has failed checksum tests or the table downloaded to the instrument is invalid. 55: Instrument wiring invalid or corrupt. 56: Non Vol write to volatile. An attempt was made to perform a checksummed Non Vol write to a non checksummed address. 58: Recipe load failure. The selected recipe failed to load. 62: Max Wire Limit reached. Using Quick Start the maximum number of wires has been reached 78: Corrupted User Page. A corruption of one or more configured user pages has been detected

Instrument Modules

This list provides module information as follows:

List Header: Inst	Sub-header: Modules
Name to select	**Parameter Description**
IO1 to IO6 Fitted	The module currently fitted in the IO slot, as per IO.ModIDs parameters
IO1 to IO6 Expected	The module that is expected to be fitted based on the current configuration. If this does not match the respective Fitted parameter, the Instrument will be held in standby until this parameter is changed and the configuration is updated.
H/J Comms Fitted	The comms module currently fitted in the comms slots, as per Comms.Ident parameters
H/J Comms Expected	The comms module that is expected to be fitted based on the current configuration. If this does not match the respective Fitted parameter, the Instrument will be held in standby and the comss will not operate until this parameter is changed and the configuration is updated.

Configuration Lock Parameters

Config Parameter List

- When the Instrument has been locked down by Configuration Lock Password, which has been configured to restrict parameter alterability, only configuration parameters included in this list will be alterable when instrument is in the Configuration access level. It should be noted that parameters that are alterable in Operator access level will remain alterable in the Operator access level.

Operator Parameter List

- When the Instrument has been locked down by Configuration Lock Password, which has been configured to restrict parameter alterability, the parameters included in this list which would normally be alterable in Operator will become read only in both Operator and Configuration access levels.

Process Input

The process input list characterises and ranges the signal from the input sensor. The Process Input parameters provide the following features:

Input Type and linearization	Thermocouple (TC) and 3-wire resistance thermometer (RTD) temperature detectors Volts, mV or mA input through external shunt or voltage divider, available with linear, square root or custom linearization See the table in section Input Types and Ranges for the list of input types available
Display units and resolution	The change of display units and resolution will apply to 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 PV Input Scaling for further details.
Over/Under range	When the input signal exceeds the input span by more than 5% the PV is shown as 'HHHHH' or 'LLLLL'. The check is executed twice: before and after user calibration and offset adjustments. The same indications apply when the display is not able to show the PV, for example, when the input is greater than 9999.9°C with one decimal point.

To select PV Input

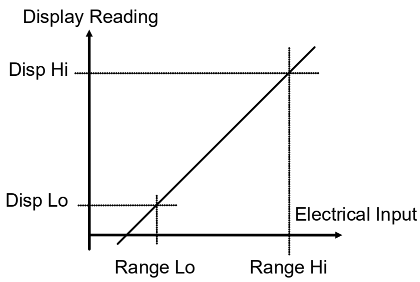
Select Level 3 or Configuration level as described in section Access to Further Parameters.

Then press ⊜ as many times as necessary until the header 'PVInput' is displayed

Process Input Parameters

List Header - PV Input		**Sub-headers: None**			
Name ⊙ to select	**Parameter Description**	**Value** **Press ⊽ or ⊼ to change values**		**Default**	**Access Level**
IO Type	PV input type. Selects input linearization and range	ThermoCpl	Thermocouple		Conf R/O L3
		RTD	Platinum resistance thermometer		
		Log10	Logarithmic		
		HZ Volts	High impedance voltage input (typically used for zirconia probes)		
		Volts	Voltage		
		mA	milli amps		
		80mV	80 millivolts		
		40mV	40 millivolts		
		Pyrometer	Pyrometer		
Lin Type	Input linearization	see section Input Types and Ranges.			Conf R/O L3
Units	Display units used for units conversion	see section Display Units.			Conf

List Header - PV Input		Sub-headers: None			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
Res'n	Resolution	XXXXX to X.XXXX			Conf
CJC Type	To select the cold junction compensation method Only appears if IO Type = Thermocouple	Internal 0°C 45°C 50°C External Off	See description in section CJC Type for further details	Internal	Conf
AlarmAck	Sensor Break Alarm Acknowledge	No			L1
		Yes			
SBrk Type	Sensor break type	Low	Sensor break will be detected when its impedance is greater than a 'low' value		Conf
		High	Sensor break will be detected when its impedance is greater than a 'high' value		
		Off	No sensor break		
SBrk Alarm	Sets the alarm action when a sensor break condition is detected	ManLatch	Manual latching — see also Alarms		L3
		NonLatch	No latching		
		Off	No sensor break alarm		
SBrk Out	Sensor break alarm status	Off or On			L3 R/O
Disp Hi	Configures the maximum displayable reading.	see also section PV Input Scaling These parameters only appear for V, mV, mA input types			L3
Disp Lo	Configures the minimum displayable reading.				L3
Range Hi	Configures the maximum (electrical) input level.				L3
Range Lo	Configures the minimum (electrical) input level				L3
Fallback	Fallback Strategy See also section Fallback.	Downscale	Meas Value = Input range lo - 5% of the mV signal received from the PV input.		Conf
		Upscale	Meas Value = Input range Hi + 5% of the mV signal received from the PV input.		
		Fall Good	Meas Value = Fallback PV		
		Fall Bad	Meas Value = Fallback PV		
		Clip Good	Meas Value = Input range Hi/lo +/- 5%		
		Clip Bad	Meas Value = Input range Hi/lo +/- 5%		
Fallback PV	Fallback value. See also section Fallback.		Instrument range		Conf
Filter Time	Input filter time. An input filter provides damping of the input signal. This may be necessary to prevent the effects of excessive noise on the PV input.		Off to 500:00 (hhh:mm) m:ss.s to hh:mm:ss to hhh:mm	0:01.6	L3
Emiss	Emissivity. Used for Pyrometer input only to compensate for the different reflectivity produced by different type of surface		Off 0.1 to 1.0	1.0	L3
Meas Value	The current electrical value of the PV input				R/O
PV	The current value of the PV input after linearization		Instrument range		R/O
Offset	Used to add a constant offset to the PV, see section PV Offset.		Instrument range		L3
Lo Point	Allows a two point offset to be applied to the controller to compensate for sensor or connection errors between sensor and the input to the controller. See section Two Point Offset for further details		Instrument range		L3
Lo Offset					
Hi Point					
Hi Offset					
CJC Temp	Reads the temperature of the rear terminals at the thermocouple connection Only appears if IO Type = Thermocouple				L3 R/O



List Header - PV Input		Sub-headers: None			
Name (scroll button) to select	**Parameter Description**	**Value** **Press (down) or (up) to change values**		**Default**	**Access Level**
SBrk Value	Sensor break Value Used for diagnostics only, and displays the sensor break trip value				R/O
Lead Res	The measured lead resistance on the RTD Only appears if IO Type = RTD				R/O
Cal State	Calibration state Calibration of the PV Input is described in section Calibration.	**Idle**			Conf L3 R/O
Status	PV Status The current status of the PV	Good (0)	Normal Operation		R/O
		Channel Off (1)	Channel is configured to be off		
		Over Range (2)	Input signal is greater than configured high limit		
		Under Range (3)	Input signal is less than configured low limit		
		Hardware Status Invalid (4)	Input hardware status invalid		
		Ranging (5)	Input hardware is being ranged i.e. being set-up as required by the range configuration		
		Overflow (6)	Process variable overflow, possibly due to calculation attempting to add a small number to a relatively large number		
		Bad (7)	The process variable is not ok and cannot be relied upon		
		Hardware exceeded (8)	The hardware capabilities have been exceeded at the point of configuration, for example configuration set to 0 to 40V when input hardware is capable of up to 12V		
		No Data (9)	Insufficient input samples to perform calculation		
		No Calibration (13)	Calibration data is corrupt or missing		
		Saturated input (14)	Input hardware is in saturation. This can occur if PV input, CJC input or RTD lead compensation input is outside the working range of the hardware		

Input Types and Ranges

Used to select the linearization algorithm required by the input sensor.

A selection of default sensor linearizations are provided for thermocouples/RTD's and Pyrometers.

If linearization type is linear a y=mx+c relationship is applied between DisplayHigh/DisplayLow and RangeHigh/RangeLow.

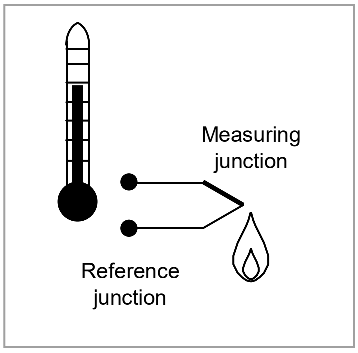
Three custom tables may be configured by downloading an appropriate table from an extensive library

Input Type		Min Range	Max Range	Units	Min Range	Max Range	Units
J	Thermocouple type J	-210	1200	°C	-346	2192	°F
K	Thermocouple type K	-200	1372	°C	-328	2502	°F
L	Thermocouple type L	-200	900	°C	-328	1652	°F
R	Thermocouple type R	-50	1768	°C	-58	3214	°F
B	Thermocouple type B	0	1820	°C	32	3308	°F
N	Thermocouple type N	-200	1300	°C	-328	2372	°F

Input Type		Min Range	Max Range	Units	Min Range	Max Range	Units
T	Thermocouple type T	-200	400	°C	-328	752	°F
S	Thermocouple type S	-50	1768	°C	-58	3214	°F
PL2	Platinell	0	1369	°C	32	2496	°F
C	Thermocouple type C	1650	2315	°C	3000	4200	°F
PT100	Pt100 resistance thermometer	-200	850	°C	-328	1562	°F
Linear	mV or mA linear input	-10.00	80.00				
SqRoot	Square root						
Tbl 1	Customised linearization table 1						
Tbl 2	Customised linearization table 2						
Tbl 3	Customised linearization table 3						

CJC Type

A thermocouple measures the temperature difference between the measuring junction and the reference junction. The reference junction, therefore, must either be held at a fixed known temperature or accurate compensation be used for any temperature variations of the junction.



Internal Compensation

The controller is provided with a temperature sensing device which senses the temperature at the point where the thermocouple is joined to the copper wiring of the instrument and applies a corrective signal.

Where very high accuracy is needed and to accommodate multi-thermocouple installations, larger reference units are used which can achieve an accuracy of ±0.1°C or better. These units also allow the cables to the instrumentation to be run in copper. The reference units are contained basically under three techniques. Ice-Point, Hot Box and Isothermal

The Ice-Point

There are usually two methods of feeding the EMF from the thermocouple to the measuring instrumentation via the ice-point reference. The bellows type and the temperature sensor type.

The bellows type utilises the precise volumetric increase which occurs when a known quantity of ultra pure water changes state from liquid to solid. A precision cylinder actuates expansion bellows which control power to a thermoelectric cooling device. The temperature sensor type uses a metal block of high thermal conductance and mass, which is thermally insulated from ambient temperatures. The block temperature is lowered to 0°C by a cooling element, and maintained there by a temperature sensing device.

Special thermometers are obtainable for checking the 0°C reference units and alarm circuits that detect any movement from the zero position can be fitted.

The Hot Box

Thermocouples are calibrated in terms of EMF generated by the measuring junctions relative to the reference junction at 0°C (32°F). Different reference points can produce different characteristics of thermocouples, therefore referencing at another temperature does present problems. However, the ability of the hot box to work at very high ambient temperatures, plus a good reliability factor has led to an increase in its usage. The unit can consist of a thermally insulated solid aluminium block in which the reference junctions are embedded.

The block temperature is controlled by a closed loop system, and a heater is used as a booster when initially switching on. This booster drops out before the reference temperature, usually between 55°C (131°F) and 65°C (149°F), is reached, but the stability of the hot box temperature is now important. Measurements cannot be taken until the hot box reaches the correct temperature.

Isothermal Systems

The thermocouple junctions being referenced are contained in a block which is heavily thermally insulated. The junctions are allowed to follow the mean ambient temperature, which varies slowly. This variation is accurately sensed by electronic means, and a signal is produced for the associated instrumentation. The high reliability factor of this method has favoured its use for long term monitoring.

CJC Options in 3500 Series

0: CJC measurement at instrument terminals

1: CJC based on external junctions kept at 0°C/32°F (Ice Point)

2: CJC based on external junctions kept at 45°C/113°F (Hot Box)

3: CJC based on external junctions kept at 50°C/122°F (Hot Box)

4: CJC based on independent external measurement

5: CJC switched off

Display Units

None

Abs Temp °C/°F/°K,

V, mV, A, mA,

PH, mmHg, psi, Bar, mBar, %RH, %, mmWG, inWG, inWW, Ohms, PSIG, %O2, PPM, %CO2, %CP, %/sec,

RelTemp °C/°F/°K(rel)*,

Vacuum

sec, min, hrs,

* RelTemp (Relative Temperature) may be used when measuring differential temperatures. It informs the controller not to add or subtract 32 when changing between °C and °F.

Sensor Break Value

The controller continuously monitors the impedance of a transducer or sensor connected to any analogue input (including plug in modules). This impedance, expressed as a percentage of the impedance which causes the sensor break flag to trip, is a parameter called 'SBrk Trip Imp' and is available in the parameter lists associated with both Standard and Module inputs of an analogue nature.

The table below shows the typical impedance which causes sensor break to trip for various types of input and high and low 'SBrk Impedance parameter settings. The impedance values are only approximate (+25%) as they are not factory calibrated.

PV Input (Also applies to the Analogue Input module)			
mV input (±40mV or ±80mV)		**Volts (±10V)**	
SBrk Impedance – High SBrk Impedance - Low	~ 12KΩ ~ 3KΩ		
Volts input (-3V to +10V) and HZ Volts input (-1.5 to 2V)			
SBrk Impedance – High SBrk Impedance - Low		~ 20KΩ ~ 5KΩ	

Fallback

A Fallback strategy may be used to configure the default value for the PV in case of an error condition. The error may be due an out of range value, a sensor break, lack of calibration or a saturated input.

The Status parameter would indicate the error condition and could be used to diagnose the problem.

Fallback has several modes and may be associated with the Fallback PV parameter

The Fallback PV may be used to configure the value assigned to the PV in case of an error condition. The Fallback parameter should be configured accordingly.

The fallback parameter may be configured so as to force a Good or Bad status when in operation. This in turn allows the user to choose to override or allow error conditions to affect the process.

PV Input Scaling

PV input scaling applies to the linear mV input range only. This is set by configuring the 'IO Type' parameter to 40mV, 80mV, mA, Volts or HZVolts. Using an external burden resistor of 2.49Ω, the controller can be made to accept 4-20mA from a current source. Scaling of the PV 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, pyrometer or RTD inputs.

The graph below shows an example of input scaling, where it is required to display 75.0 when the input is 4mV and 500.0 when the input is 20mV.

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

For mA inputs

4-20mA = 9.96-49.8mV with 2.49Ω load resistor

0-20mA = 0-49.8mV with 2.49Ω load resistor

mA input will detect sensor break if mA < 3mA

Use a current source to remove shunt resistor errors

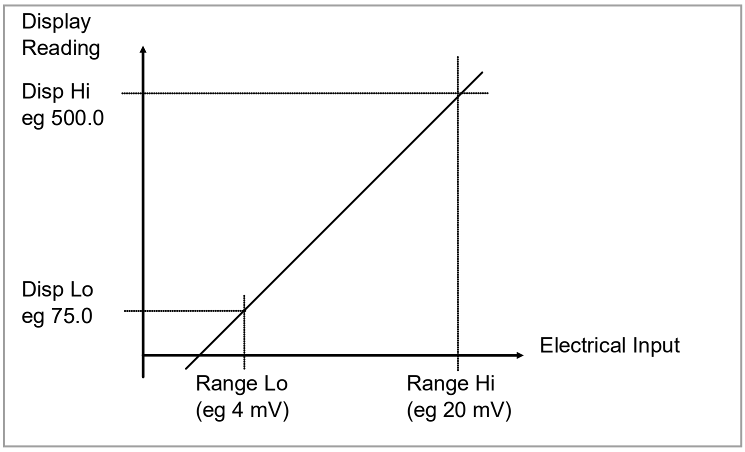


Figure 30: PV Input Scaling

Example: To Scale a Linear Input:

Do This	The Display You Should See	Additional Notes
1. Select Conf as described in section Access to Further Parameters. Then press to select **'PVInput'**		
2. Press to scroll to **'IO Type'** 3. Press or to **'mA'**, 'Volts' or mV		Linearization type and resolution should also be set as appropriate.
4. Press to scroll to **'Disp Hi'** 5. Press or to **'500.00'**		Resolution set to XXXX.X in this example
6. Press to scroll to **'Disp Lo'** 7. Press or to **'75.00'**		
8. Press to scroll to **'Range Hi'** 9. Press or to **'20.000'**		The controller will read 500.0 for a mA input of 20.00
10.Press to scroll to **'Range Lo'** 11.Press or to **'4.000'**		The controller will read 75.0 for a mA input of 4.00

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 calibration, but to apply a user defined offset.

It is also possible to apply a two point offset and this is described in the next section.

PV Offset applies a single offset 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:

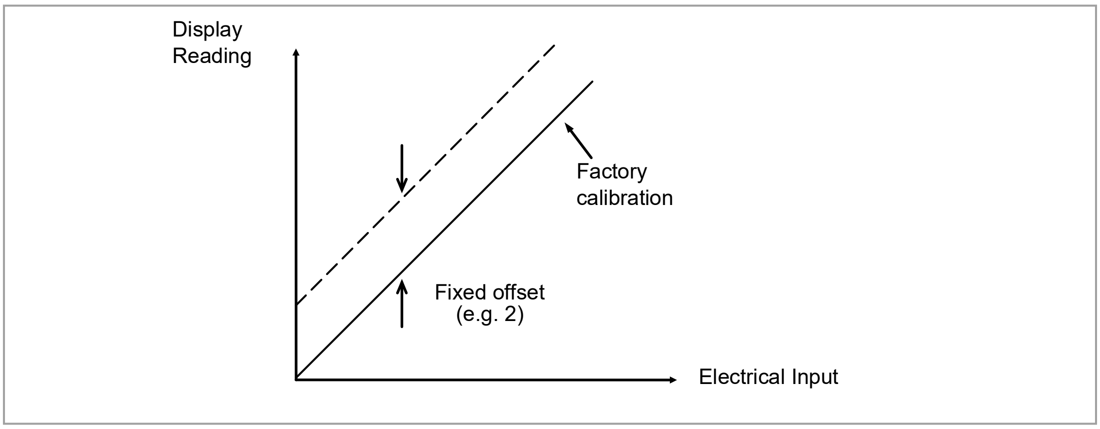


Figure 31: PV Offset

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	The Display You Should See	Additional Notes
1. Select Level 3 or Conf as described in section Access to Further Parameters. Then press ⊜ to select **'PVInput'**		
2. Press ⟳ to scroll to **'Offset'** 3. Press ▲ or ▼ to adjust the offset to the reading you require		In this case an offset of 2.0 units is applied

Two Point Offset

A two point offset enables the controller display to be offset by different amounts at the low end of the scale and at the high end of the scale. The basic calibration of the controller is unaffected but the two point offset provides a compensation for sensor or inter-connection errors. The diagrams below show that a line is drawn between the low and high offsets values. Any readings above and below the calibration points will be an extension of this line. For this reason it is best to calibrate with the two points as far apart as possible.

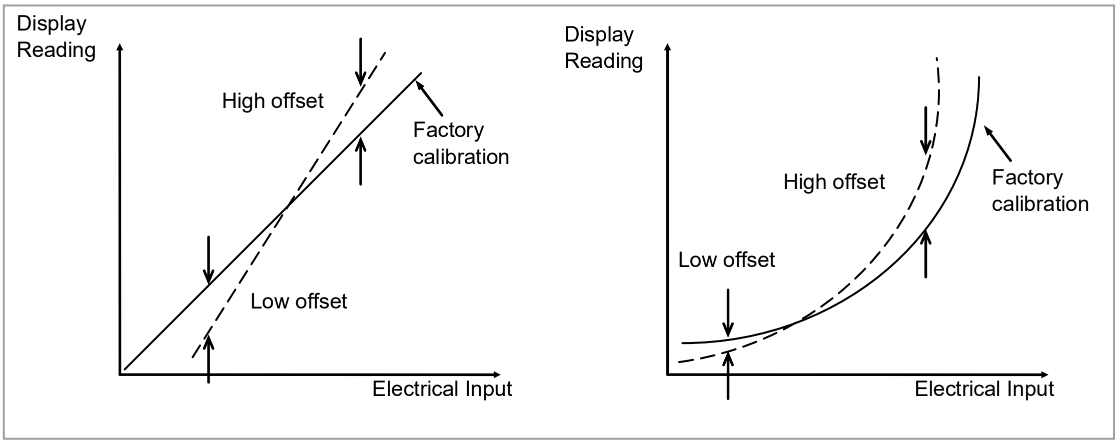


Figure 32: Two Point Offsets

Example: To Apply a Two Point Offset:

For this example it is assumed that an input of 0.0 mV produces a reading of 0.0 and an input of 80.0mV produces a reading of 1000.0.

- Connect the input of the controller to the source device which you wish to calibrate to
- With the source set to its low output set the ‘Lo Point’ to 0. This defines the low point at which you wish to calibrate the sensor to the controller. Set ‘Lo Offset’ until the display reads as required.
- With the source set to its high output set the ‘Hi Point’ to 1000. This defines the high point at which you wish to calibrate the sensor to the controller. Set ‘Hi Offset’ until the display reads as required.

Logic Input/Output

There are two logic IO channels, standard on all controllers, which may be configured independently as inputs or outputs. Connections are made to terminals LA and LB, with LC as the common for both. Parameters in the **'LgcIO'** lists allow each IO to be configured independently under the sub-headers LA and LB.

WARNING

The two IO are not isolated from each other since they share a common return.

The logic IO channels can also be used as a transmitter power supply as described in section Digital I/O.

To select Logic IO list

Select Level 3 or Configuration level as described in section Access to Further Parameters.

Then press as many times as necessary until the header **'LgcIO'** is displayed.

Logic IO Parameters

List Header - LgcIO		**Sub-header - LA and LB**			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
IO Type	To configure the type of input or output	Input	Logic input	Input	Conf R/O L3
		ContactCl	Contact closure input		
		OnOff	On off output		
		Time Prop	Time proportioning output		
		ValvRais See Note	Motorised valve position output – raise on LA only		

NOTICE

LA and LB work in a complementary manner in Valve Positioning (VP) applications. When LA is set to ValvRais LB is automatically set to ValvLowr. IOType for LB is NOT alterable in VP applications. Configuration settings applied to LA will be applied to LB automatically.

Summary of parameters which follow 'IO Type' for different configurations of Input or Output:

Input	**ContactCl**	**OnOff**	**Time Prop**	**ValvRais**
Invert	Invert	Invert	Cycle Time	
PV	PV	SbyAct	Min OnTime	Min OnTime
		Meas Val	Res'n	SbyAct
		PV	Disp Hi	Meas Val
			Disp Lo	PV
			Range Hi	Inertia
			Range Lo	Backlash
			SbyAct	Cal State
			Meas Val	
			PV	

Explanation of Logic IO Parameters:

List Header - LgcIO		**Sub-header - LA and LB**			
Name Ⓢ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
PV	When configured as an output, this is the desired output value	0 to 100			L3
	When configured as an input the current state of the digital input is displayed	0 to 1 (OnOff)			
Invert	Sets the sense of the logic input or on/off output. Does not apply if the IO Type is Time Prop or ValvRais.	No	Non inverted. Output off (logic 0) when PID demand off. For control this is when PV>SP. Output on (logic 1) when PID demand off. For control this is when PV<SP. This is the normal setting for control.	No	Conf
		Yes	Inverted Output off (logic 0). For an alarm this is when the alarm is active. Output on (logic 1). For an alarm this is when the alarm is in-active. This is the normal setting for alarms.		
The next six parameters are only shown when 'IO Type' = 'Time Prop' outputs					
Cycle Time See also section Cycle Time and Minimum OnTime Algorithms.	Allows the output to be switched on and off within the set time period. Applies only to an output type configured as Time Proportioning.	Off or 0.01 to 60.00 seconds	When Off is selected the Min OnTime algorithm will run. When set to any other value the CycleTime algorithm will run.	Off	L3
Min OnTime See also section Cycle Time and Minimum OnTime Algorithms.	The minimum time (in seconds) that the relay is on or off. Applies only to an output type configured as Time Proportioning or ValvRais and is only available when 'Cycle Time' = Off	Auto 0.01 to 150.00 seconds	If set to Auto the minimum on time will be 110mS. If the logic is used to control an external relay, Min OnTime should be set to a minimum of (say) 10 seconds to prevent the relay from switching too rapidly.	Auto	L3
Res'n	Display resolution. This sets the number of decimal places displayed by Disp Hi and Disp Lo parameters	XXXXX XXXX.X XXX.XX XX.XXX X.XXXX	No decimal points One decimal point Two decimal points Three decimal points Four decimal points	XXXXX	Conf
Disp Hi	The maximum displayable reading	0.000 to 100.000	These parameters allow high and low limits to be applied to the output against a set limit of the output demand signal from the PID loop. See also section Relay, Logic or Triac Outputs for further information	100.00	L3
Disp Lo	The minimum displayable reading	0.000 to 100.000		0.00	L3
Range Hi	The maximum (electrical) input/output level	0.00 to 100.00			L3
Range Lo	The minimum (electrical) input/output level	0.00 to 100.00			L3
SbyAct See also section Output State When the Controller is in Standby.	Standby action. Determines the action of an output when the instrument is in Standby Mode.	Off	The output will drive to 'electrical low' value regardless of the 'Invert' parameter.	Off	Conf R/O L3
		On	The output will drive to 'electrical high' value regardless of the 'Invert' parameter.		
		Cont	The output will assume a status according to how it is driven		
		For motor valve outputs the options are:			
		Frz	Freeze – only shown if the output is configured for valve position control		
		Cont	Continue - only shown if the output is configured for valve position control		
Meas Val	The current value of the output demand signal	0 1	On (unless Invert = Yes) Off (unless Invert = Yes)		L3 R/O
The following parameters are additional if 'IO Type' = 'ValvRais'					
Inertia	Set this parameter to match the inertia (if any) of the motor		0.0 to 9999.9 secs	0.0	L3
Backlash	Compensates for any backlash which may be present in the linkages		0.0 to 9999.9 secs	0.0	L3

List Header - LgcIO		Sub-header - LA and LB		
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values	**Default**	**Access Level**
Cal State See also section Example: To Calibrate a VP Output.	Calibration status This is only applicable to valve position outputs	Idle Raise Lower		L3

PV can be wired to the output of a function block. For example if it is used for control it may be wired to the control loop output (Ch1 Output) as shown in the example in section Wiring Example.

Output State When the Controller is in Standby

The output strategy of **all digital outputs** may be defined using ‘SbyAct’. The strategy depends on the use to which the output is configured, for example, if it is an alarm it may be required to turn the output on or to continue normal operation when the controller is in standby. For a control output the strategy may be to turn the output off when in standby.

There are three possible states:

Off - The output will drive to 'electrical low' value regardless of the 'Invert' parameter.

On - The output will drive to 'electrical high' value regardless of the 'Invert' parameter.

Continue - The output will assume a status according to how it is driven:

- If locally wired, the output will continue to be driven by the wire.
- If not wired or driven by communications, the output will maintain the last state written to it.
- If not wired but written to by communications, the output will continue to be controlled by the communications messages. In this case care should be taken to allow for the loss of communications.

For motor valve outputs the options are:

Freeze - The valve outputs will both stop driving in standby.

Continue - The valve outputs will assume a status according to how they are driven:

- If locally wired, the output will continue to be driven by the wire.
- If not wired or driven by communications, the output will maintain the last state written to it
- If not wired but written to by communications, the output will continue to be controlled by the communications messages. In this case care should be taken to allow for the loss of communications.

Cycle Time and Minimum OnTime Algorithms

The ‘Cycle Time’ algorithm and the ‘Min OnTime’ algorithm are mutually exclusive and provide compatibility with existing controller systems. Both algorithms apply to time proportioning outputs only and are not shown for on/off control. The ‘Min OnTime’ parameter is only displayed when the ‘Cycle Time’ is set to Off.

A fixed cycle time allows the output to switch on and off within the time period set by the parameter. For example, for a cycle time of 20 seconds, 25% power demand would turn the output on for 5 seconds and off for 15 seconds, 50% power demand would turn the output on and off for 10 seconds, for 75% power demand the output is on for 15 seconds and off for 5 seconds.

Fixed cycle time may be preferred when driving mechanical devices such as refrigeration compressors.

The ‘Min OnTime’ algorithm allows a limit to be applied to the switching device so that it remains on (or off) for a set minimum time. When set to Auto, the minimum pulse time that can be set is 110ms. A very low power demand is represented by a short on pulse of 110ms duration followed by a correspondingly long off time. As the power demand increases the on pulse becomes longer and the off pulse becomes correspondingly shorter. For a 50% power demand the on and off pulse lengths are the same (at 220ms on and 220ms off). Setting to Auto is suitable for triac or logic outputs, not driving a mechanical device.

If the control device is a relay or contactor the minimum on time should be set greater than 10 seconds (for example) to prolong relay life. By way of illustration, for a setting of 10 seconds the relay will switch (approximately) as shown in the table below:

Power demand	Relay ON time (seconds)	Relay OFF time (seconds)
10%	10	100
25%	13	39
50%	20	20
75%	39	13
90%	100	10

The Minimum OnTime algorithm is often preferred for control of switching devices using triac, logic or relay outputs in a temperature control application. It also applies to valve position outputs - see also section Nudge Raise/Lower.

Example: To Configure a Time Proportioning Logic Output

Select configuration level as described in section To Select Different Levels of Access.

Then:

Do This	The Display You Should See	Additional Notes
1. From any display press ⊟ until the **'LgcIO'** page is reached 2. Press ⊕▲ or ▼ as necessary to select **'LA'** or **'LB'** 3. Press ⊟ to scroll to **'IO Type'** 4. Press ▲ or ▼ to **'Time Prop'**		

Example: To Calibrate a VP Output

The 'Cal State' parameter in this list allows you to fully open or fully close the valve when it is required to calibrate a feedback potentiometer used with a bounded VP control.

Do This	The Display You Should See	Additional Notes
1. From the **'LgcIO' 'LA'** page, press ⊟ to scroll to **'Cal State'** 2. Press ▲ or ▼ to select **'Raise'**	  	The loop is temporarily disconnected to allow the valve to drive fully open.
3. Now select the page header which contains the Potentiometer Input module		
4. Press ⊟ to scroll to **'Cal State'** in the **Potentiometer list** - section Potentiometer Input.		
5. Press ▲ or ▼ to select **'Hi'**. Then **'Confirm'**. The controller will automatically calibrate to the potentiometer position. The messages **'Go'** and **'Busy'** will be displayed during this time. If successful the message **'Passed'** will be displayed and if unsuccessful **'Failed'** will be displayed. A fail could be due to the potentiometer value being out of range. See also section Potentiometer Input Scaling.		
6. Drive the valve fully closed using **'Lower'** in the **'LgcIO'** page. Then repeat 3, 4 and 5 for the **'Lo'** calibration point		

Logic Output Scaling

If the output is configured for time proportioning control, it can be scaled such that a lower and upper level of PID demand signal can limit the operation of the output value.

By default, the output will be fully off for 0% power demand, fully on for 100% power demand and equal on/off times at 50% power demand. You can change these limits to suit the process. It is important to note, however, that these limits are set to safe values for the process. For example, for a heating process it may be required to maintain a minimum level of temperature. This can be achieved by applying an offset at 0% power demand which will maintain the output on for a period of time. Care must be taken to ensure that this minimum on period does not cause the process to overheat.

If Range Hi is set to a value <100% the time proportioning output will switch at a rate depending on the value - it will not switch fully on.

Similarly, if Range Lo is set to a value >0% it will not switch fully off.

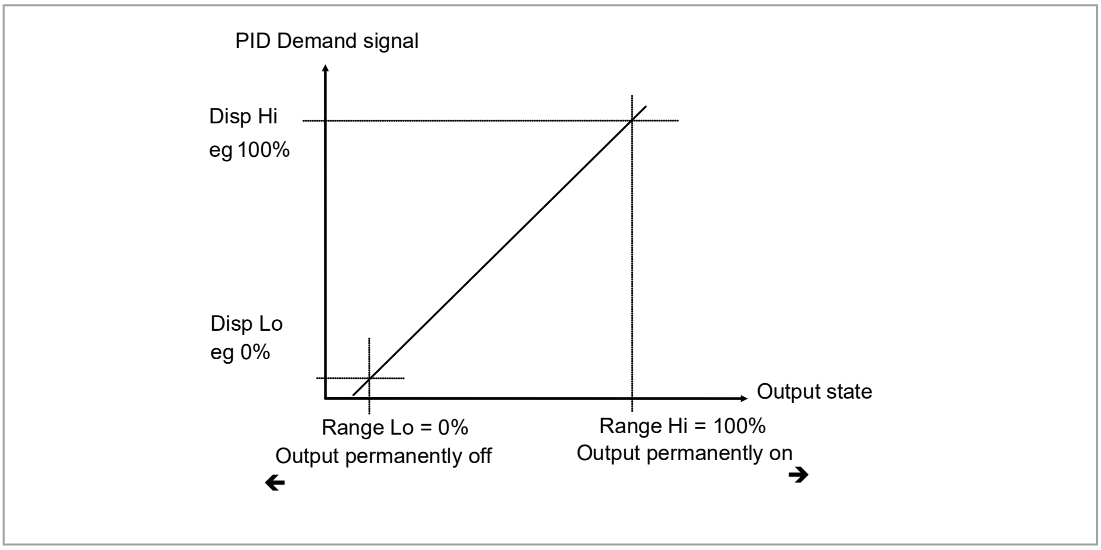


Figure 33: Scaling a Logic Output

Example: To Scale a Proportioning Logic Output

Select level 3 or configuration level as described in section Access to Further Parameters.

Then:

Do This	The Display You Should See	Additional Notes
1. From the **'LgcIO'** page, press ⊡ to scroll to **'Disp Hi'** 2. Press ▲ or ▼ to set the PID demand limit. This will normally be 100% 3. Repeat the above for **'Disp Lo'**. This will normally be set to zero		
4. Press ⊡ to scroll to **'Range Hi'** 5. Press ▲ or ▼ to set the upper output limit. 6. Repeat the above for **'Range Lo'** to set the lower switching limit		In this example the output will switch on for 8% of the time when the PID demand signal is at 0%. Similarly, it will remain on for 90% of the time when the demand signal is at 100%

AA Relay Output

A changeover relay is standard on all 3500 series controllers and is connected to terminals AA (normally open), AB (common) and AC (normally closed).

Parameters in the **'RlyAA'** list allow the relay functions to be set up.

To Select AA Relay List

Select Level 3 or Configuration level as described in section Access to Further Parameters.

Then press as many times as necessary until the header 'RlyAA' is displayed

AA Relay Parameters

List Header - RlyAA		No Sub-headers			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
IO Type	To configure the function for the relay	OnOff	On off output		Conf R/O L3
		Time Prop	Time proportioning output		

Parameters available if IO Type is configured as Time Proportioning

List Header - RlyAA		No Sub-headers				
Name to select	**Parameter Description**	**Value** Press or to change values			**Default**	**Access Level**
Cycle Time See also section Cycle Time and Minimum OnTime Algorithms.	Allows the output to be switched on and off within the set time period.	Off or 0.01 to 60.00 seconds	When Off is selected the Min OnTime algorithm will run. When set to any other value the CycleTime algorithm will run.		Off	L3
Min OnTime Only available when 'Cycle Time' = Off See also section Cycle Time and Minimum OnTime Algorithms.	The minimum time (in seconds) that the relay is on or off.	Auto 0.01 to 150.00 seconds	If set to 0 - Auto the minimum on time will be 110mS. For a relay output this should be set greater than, say, 10 seconds to prevent the relay from switching too rapidly.		Auto	L3
Res'n	Display resolution. This sets the number of decimal places displayed by Disp Hi and Disp Lo parameters		XXXXX XXXX.X XXX.XX XX.XXX X.XXXX	No decimal points One decimal point Two decimal points Three decimal points Four decimal points	XXXXX	Conf
Disp Hi	The maximum displayable reading		0.000 to 100.000	These parameters allow high and low limits to be applied to the output against a set limit of the output demand signal from the PID loop. See also section Relay, Logic or Triac Output Scaling for further information	100.00	L3
Disp Lo	The minimum displayable reading		0.000 to 100.000		0.00	L3
Range Hi	The maximum (electrical) input/output level		0.00 to 100.00			L3
Range Lo	The minimum (electrical) input/output level		0.00 to 100.00			L3

List Header - RlyAA		No Sub-headers			
Name to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
SbyAct	Standby action. Determines the output action when the instrument is in Standby Mode. See Section Output State When the Controller is in Standby.	Off	The output will drive to 'electrical low' value regardless of the 'Invert' parameter.	Off	Conf R/O L3
		On	The output will drive to 'electrical high' value regardless of the 'Invert' parameter.		
		Cont	The output will assume a status according to how it is driven		
Meas Val	Status of the digital output.	0 1	On (unless Invert = Yes) Off (unless Invert = Yes)		L3 R/O
PV	The current (analogue) value of the output	0 to 100			L3 R/O L3

Parameters available if IO Type is configured as OnOff

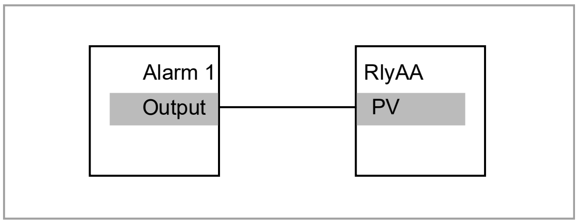
List Header - RlyAA		No Sub-headers			
Name to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Invert	To change the normal operating state of the relay.	No	Relay de-energised when the output demand is off Relay energised when the output demand is on (normal setting if the relay is used for control)		Conf R/O L3
		Yes	Relay energised when the output demand is off Relay de-energised when the output demand is on (normal setting if the relay is used for alarm)		
SbyAct	Standby action. Determines the output action when the instrument is in Standby Mode. See Section Output State When the Controller is in Standby.	Off	The output will drive to 'electrical low' value regardless of the 'Invert' parameter.	Off	Conf R/O L3
		On	The output will drive to 'electrical high' value regardless of the 'Invert' parameter.		
		Cont	The output will assume a status according to how it is driven		
Meas Val	The current value of the output demand signal	0 1	On (unless Invert = Yes) Off (unless Invert = Yes)		L3 R/O
PV	The current (digital) value of the output	0 1	On Off		L3 R/O L3

PV can be wired to the output of a function block. For example if it is used for control it may be wired to the control loop output (Ch1 Output) as shown in the example in section Wiring Example.

If it is used for an alarm it may be wired to the ‘Output’ parameter in an alarm list.

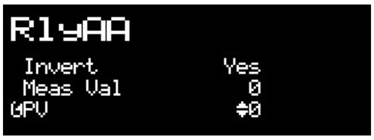
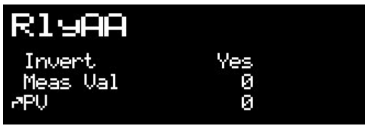
Example: To Wire the AA Relay to an Alarm

In this example the relay will be made to operate when analogue alarm 1 occurs.



Select configuration level as described in section To Select Different Levels of Access.

Then:

Do This	The Display You Should See	Additional Notes
1. From any display press ▤ until the **'RlyAA'** page is reached 2. Press ⊙ to scroll to **'PV'**		Set 'IO Typ' to 'OnOff' Set 'Invert' to 'Yes' This locates the parameter to be wired to
3. Press **A/MAN** to display **'WireFrom'**		If the parameter is already wired the display shown below is shown
4. Press ▤ (as instructed) as many times as necessary to select the **'Alarm'** page 5. Press ▲ or ▼ to select **'1'** 6. Press ⊙ to scroll to **'Output'**		This selects Alarm 1. The relay can also be wired to operate on one or more alarms. This 'copies' the parameter to be wired from
7. Press **A/MAN**		This 'pastes' the parameter to 'PV'
8. Press ⊙ as instructed to confirm		The arrow shown next to the parameter indicates that it has been wired

NOTICE

To remove a wire see section To Remove a Wire

Relay Output Scaling

If the output is configured for time proportioning control, it can be scaled such that a lower and upper level of PID demand signal can limit the operation of the output value.

The procedure for this is the same as logic outputs described in section Logic Output Scaling.

Module Configuration

Plug in IO modules provide additional analogue and digital IO. These modules can be fitted in any of six slots. The terminal connections for these are given in section Installation and Operation.

The type and position of any modules fitted in the controller is shown in the order code printed on the label on the side of the controller. This can be checked against the order code in section Installation and Operation.

The module part number is printed on the side of the plastic case of the module.

Spare modules can be ordered by contacting Eurotherm support/service where they can be supplied using a 'SUB' number. For reference this is shown in the final column of the table below.

All modules fitted are identified in the controller under the page heading 'ModIDs' and 'Instrument.Modules'.

Modules are available as single channel, two channel or three channel IO as listed below:

Module	Instrument Order Code	Idents Displayed As	Number of Channels	Module Part No.	SUB part number
No module fitted	XX	No Module			
Change over relay 2 pin relay Dual relay	R4 R2 RR	COvrRelay Form A Relay DualRelay	1 1 2	AH025408U002 AH025245U002 AH025246U002	SUB35/R4 SUB35/R2 SUB35/RR
Triple logic output	TP	TriLogic	3	AH025735U002	SUB35/TP
Isolated single logic output	LO	SinLogic	1	AH025735U003	SUB35/LO
Triac Dual triac	T2 TT	Triac DualTriac	1 2	AH025253U002 AH025409U002	SUB35/T2 SUB35/TT
DC control	D4	DC Output	1	AH025728U003	SUB35/D4
DC retransmission	D6	DCRetran	1	AH025728U002	SUB35/D6
Analogue input module	AM	DCInput	1	AH025686U004	SUB35/AM
Triple logic input Triple contact input	TL TK	TriLogIP TriConIP	3 3	AH025317U002 AH025861U002	SUB35/TL SUB35/TK
Potentiometer input	VU	PotIP	1	AH025864U002	SUB35/VU
24Vdc transmitter supply	MS	TXPSU	1	AH025862U002	SUB35/MS
5Vdc or 10Vdc Transducer power supply	G3	TransPSU	1	AH026306U002	SUB35/G3
Dual DC control output	DO	DualDCOut	2	AH027249U002	SUB35/DO

Table 10: I/O Modules

NOTICE

If an incorrect module is fitted (for example, from a 2000 series controller), 'Bad Ident' will be displayed.

Parameters for the above modules, such as input/output limits, filter times and scaling of the IO, can be adjusted in the Module IO pages

To Fit a New Module

IO modules can be fitted in any of six slots in the 3504 and any of three slots in 3508 controllers. Communications modules can be fitted in any of two slots. A list of available IO modules is given in Table 10: I/O Modules. These modules are fitted simply by sliding them into the relevant position as shown below.

When a module has been changed, the controller will power up with the message '!:Error **M(X) Changed'** where (X) is the module number. This must be acknowledged by pressing and together, then logging into configuration level to ensure the Instrument.Modules Fitted and Expected parameters are matching.

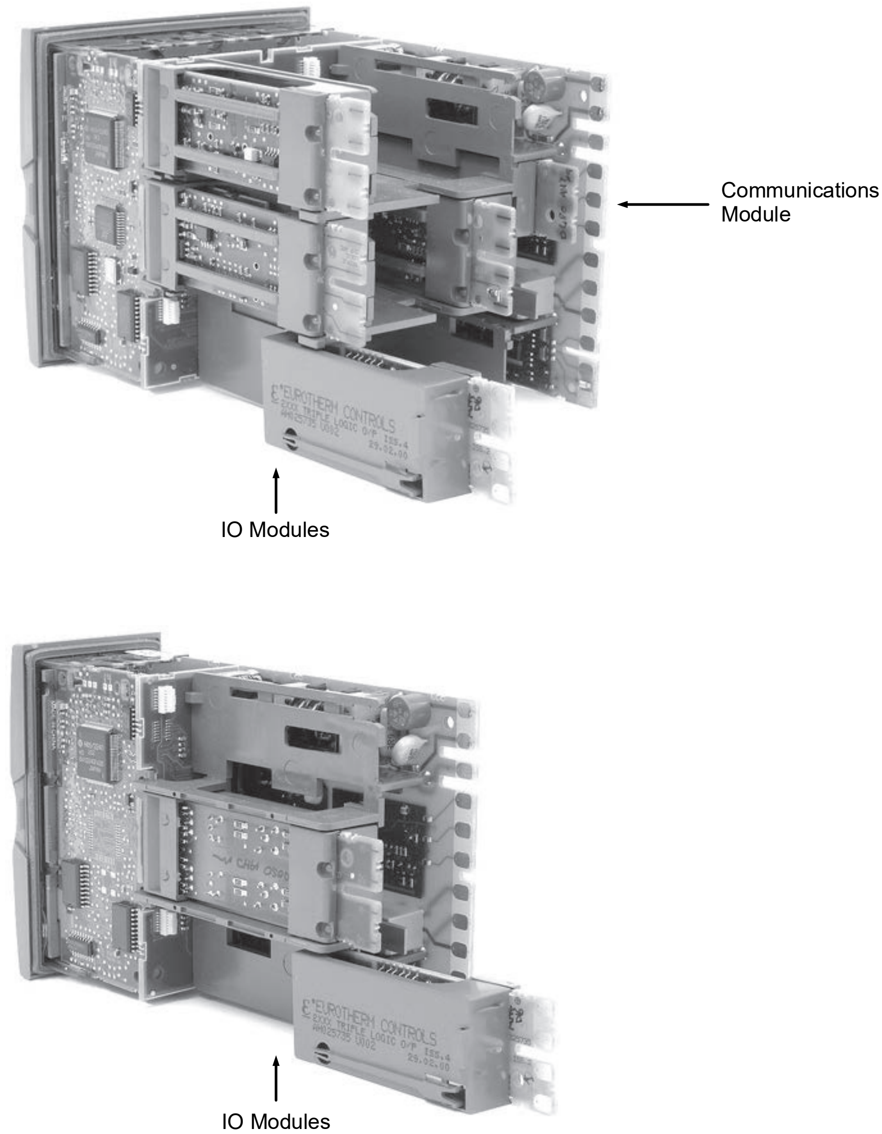


Figure 34: View of the Plug-in Modules

Module Identification

Press until the list header 'ModIDs' is displayed. The type of IO module fitted in any of the six slots (three if 3508) is shown. The identification of the module fitted is shown in Table 10: I/O Modules.

Module Types

The tables in the following pages list the parameters available for the different modules.

Relay, Logic or Triac Outputs

These modules are used to provide an output to a two state output device such as a contactor, SSR, motorized valve driver, etc.

List Header - Mod		Sub-headers: xA (triac, changeover or 2-pin relay); xA and xC (dual relay, dual triac); xA, xB, xC (triple logic) x = the number of the slot in which the module is fitted			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Ident	Channel type	Relay Logic Out Triac	Any relay output Logic output Triac or dual triac output		L3 R/O
IO Type	To configure the function of the relay	OnOff	On off output		Conf R/O L3
		Time Prop	Time proportioning output		
		ValvRais	Motor valve position raise. See note below:		

NOTICE

A triple logic output, a dual relay output or a dual triac output module may be used for a valve position output. If Valve Raise is configured on channel output A then Valve Lower is automatically allocated to channel output C. Channel output B (triple logic output) is only available as an on/off or time proportioning output. Valve raise/lower is not available on a single isolated logic output.

The following shows a summary of parameters which follow ‘IO Type’ for different configurations of the Output:

OnOff	Time Prop	ValvRais
Invert	Cycle Time	Min OnTime
SbyAct	Min OnTime	
Meas Val	Res’n	SbyAct
PV	Disp Hi	Meas Val
	Disp Lo	PV
	Range Hi	Inertia
	Range Lo	Backlash
	SbyAct	Cal State
	Meas Val	
	PV	

Explanation of Relay, Logic, Triac Output Module Parameters

List Header - Mod		Sub-headers: xA (triac, changeover or 2-pin relay); xA and xC (dual relay, dual triac); xA, xB, xC (triple logic) x = the number of the slot in which the module is fitted			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Invert	To change the normal operating state of the relay. This only applies if the output is configured as OnOff	No	Relay de-energised when output demand off and energised when output demand on Normal setting if the relay is used for control		Conf R/O L3
		Yes	Relay energised when output demand off and de-energised when output demand on Normal setting if the relay is used for an alarm		

List Header - Mod		**Sub-headers: xA (triac, changeover or 2-pin relay); xA and xC (dual relay, dual triac); xA, xB, xC (triple logic)** x = the number of the slot in which the module is fitted			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
SbyAct See also Output State When the Controller is in Standby.	Standby action. Determines the output action when the instrument is in Standby Mode.	Off	The output will drive to 'electrical low' value regardless of the 'Invert' parameter.	Off	Conf R/O L3
		On	The output will drive to 'electrical high' value regardless of the 'Invert' parameter.		
		Cont	The output will assume a status according to how it is driven		
		For motor valve outputs the options are:			
		Frz	Freeze – only shown if the output is configured for valve position control		
		Cont	Continue - only shown if the output is configured for valve position control		
Meas Value	Current state of the output	0 1	Off (if ‘Invert’ = ‘No’) On (if ‘Invert’ = ‘No’)		L3 R/O
PV	Normally wired to the output of a function block such as PID output to control a plant actuator	0	Demand for output to be off (if ‘Invert’ = ‘No’)		Conf R/O L3 Alterable if not wired
		1	Demand for output to be on (if ‘Invert’ = ‘No’)		
The next seven parameters are only shown when ‘IO Type’ = ‘Time Prop’ outputs					
Cycle Time See also Cycle Time and Minimum OnTime Algorithms.	Allows the output to be switched on and off within the set time period. Applies only if the output type is Time Proportioning.	Off or 0.01 to 60.00 seconds	When Off is selected the Min OnTime algorithm will run. When set to any other value the CycleTime algorithm will run.	Off	L3
Min OnTime See also Cycle Time and Minimum OnTime Algorithms.	The minimum time (in seconds) that the relay is on or off. Applies only to an output type configured as Time Proportioning and is only available when ‘Cycle Time’ = Off	Auto 0.01 to 150.00 seconds	If set to 0 - Auto the minimum on time will be 110mS. For a relay output this should be set greater than, say, 10 seconds to prevent the relay from switching too rapidly.	Auto	L3
Res’n	Display resolution. This sets the number of decimal places displayed by Disp Hi and Disp Lo parameters	XXXXX XXXX.X XXX.XX XX.XXX X.XXXX	No decimal points One decimal point Two decimal points Three decimal points Four decimal points	XXXXX	Conf
Disp Hi	The maximum displayable reading	0.000 to 100.000	These parameters allow high and low limits to be applied to the output against a set limit of the output demand signal from the PID loop. See also Relay, Logic or Triac Output Scaling for further information	100.00	L3
Disp Lo	The minimum displayable reading	0.000 to 100.000		0.00	L3
Range Hi	The maximum (electrical) input/output level	0.00 to 100.00			L3
Range Lo	The minimum (electrical) input/output level	0.00 to 100.00			L3
The following parameters are additional if ‘IO Type’ = ‘ValvRais’					
Inertia	Set this parameter to match the inertia (if any) of the motor	0.0 to 9999.9 secs		0.0	L3
Backlash	This parameter compensates for any backlash which may be present in the linkages	0.0 to 9999.9 secs		0.0	L3
Cal State	Calibration state	Idle Raise lower	See also Calibration Parameters for further details.		L3

List Header - Mod		Sub-headers: xA (triac, changeover or 2-pin relay); xA and xC (dual relay, dual triac); xA, xB, xC (triple logic) x = the number of the slot in which the module is fitted		
Name to select	**Parameter Description**	**Value** Press or to change values	**Default**	**Access Level**
Status	Module status	Good (0) - Normal Operation Channel Off (1) - Channel is configured to be off Over Range (2) - Input signal is greater than configured high limit Under Range (3) - Input signal is less than configured low limit Hardware Status Invalid (4) - Input hardware status invalid Ranging (5) - Input hardware is being ranged i.e. being set-up as required by the range configuration Overflow (6) - Process variable overflow, possibly due to calculation attempting to add a small number to a relatively large number Bad (7) - The process variable is not ok and cannot be relied upon Hardware exceeded (8) - The hardware capabilities have been exceeded at the point of configuration, for example configuration set to 0 to 40V when input hardware is capable of up to 12V No Data (9) - Insufficient input samples to perform calculation No Calibration (13) - Calibration data is corrupt or missing Saturated input (14) - Input hardware is in saturation. This can occur if PV input, CJC input or RTD lead compensation input is outside the working range of the hardware		R/O

Single Isolated Logic Output

This provides isolation from other IO and should be used, for example, in applications where the sensor and the output device may be at supply potential. It is only available as a time proportioning or on/off output.

List Header - Mod		Sub-headers: xA			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
Ident	Channel type	Logic Out	Logic output		L3 R/O
IO Type	To configure the function of the relay	OnOff	On off output		Conf R/O L3
		Time Prop	Time proportioning output		
Invert	Sets the sense of the logic output. This only applies if the output is configured as OnOff	No	Non inverted. Output off (logic 0) when PID demand off. For control this is when PV>SP. Output on (logic 1) when PID demand off. For control this is when PV<SP. This is the normal setting for control.		Conf R/O L3
		Yes	Inverted. Output off (logic 0). For an alarm this is when the alarm is active. Output on (logic 1). For an alarm this is when the alarm is in-active. This is the normal setting for alarms.		
SbyAct See also Output State When the Controller is in Standby.	Standby action. Determines the output action when the instrument is in Standby Mode.	Off	The output will drive to 'electrical low' value regardless of the 'Invert' parameter.	Off	Conf R/O L3
		On	The output will drive to 'electrical high' value regardless of the 'Invert' parameter.		
		Cont	The output will assume a status according to how it is driven		
Meas Value	Current state of the output	0 1	Off (if 'Invert' = 'No') On (if 'Invert' = 'No')		L3 R/O
PV	Normally wired to the output of a function block such as PID output to control a plant actuator	0 1	Output off (if 'Invert' = 'No') Output on (if 'Invert' = 'No') Alterable if not wired		Conf R/O L3

Status	Module status	Good (0) - Normal Operation Channel Off (1) - Channel is configured to be off Over Range (2) - Input signal is greater than configured high limit Under Range (3) - Input signal is less than configured low limit Hardware Status Invalid (4) - Input hardware status invalid Ranging (5) - Input hardware is being ranged i.e. being set-up as required by the range configuration Overflow (6) - Process variable overflow, possibly due to calculation attempting to add a small number to a relatively large number Bad (7) - The process variable is not ok and cannot be relied upon Hardware exceeded (8) - The hardware capabilities have been exceeded at the point of configuration, for example configuration set to 0 to 40V when input hardware is capable of up to 12V No Data (9) - Insufficient input samples to perform calculation No Calibration (13) - Calibration data is corrupt or missing Saturated input (14) - Input hardware is in saturation. This can occur if PV input, CJC input or RTD lead compensation input is outside the working range of the hardware			R/O
The next six parameters are only shown when 'IO Type' = 'Time Prop' outputs					
CycleTime See also Cycle Time and Minimum OnTime Algorithms.	To switch the output on and off within the set time period. Applies only to Time Proportioning outputs.	Off or 0.01 to 60.00 seconds	When Off is selected the Min OnTime algorithm will run. When set to any value the CycleTime algorithm will run.	Off	L3
Min OnTime See also Cycle Time and Minimum OnTime Algorithms.	The minimum time (in seconds) that the logic output is on or off. Applies only to Time Proportioning outputs and is only available when 'Cycle Time' = Off	Auto 0.01 to 150.00 seconds	If set to Auto the minimum on time will be 110mS. If the logic is used to control an external relay, Min OnTime should be set to a minimum of (say) 10 seconds to prevent the relay from switching too rapidly.	Auto	L3
Res'n	Display resolution. This sets the number of decimal places displayed by Disp Hi and Disp Lo parameters	XXXXX XXXX.X XXX.XX XX.XXX X.XXXX	No decimal points One decimal point Two decimal points Three decimal points Four decimal points	XXXXX	Conf
Disp Hi/Lo	Maximum/minimum output demand signal	0.00 to 100.00	These parameters allow high and low limits to be applied to the output against a set limit of the output demand signal from the PID loop. See also Relay, Logic or Triac Output Scaling.	100.00	L3
Range Hi/Lo	Electrical output high/low	0.00 to 100.00			L3
Meas Value	The current status of the digital output.	0 1	On (unless Invert = Yes) Off (unless Invert = Yes)		L3 R/O L3

DC Control, Dual DC Control, or DC Retransmission Output

The DC output module is used as a control output to interface with an analogue actuator such as valve driver or thyristor unit. The dual DC control output uses two channels xA and xC.

The DC retransmission module is used to provide an analogue output signal proportional to the value which is being measured. It may be used for chart recording or retransmit a signal to another controller. This function is often performed through digital communications where greater accuracy is required.

List Header - Mod		**Sub-headers: xA (DC Control and DC Retransmission)** **xA and xC (Dual DC Control)** x = the number of the slot in which the module is fitted			
Name (select key) to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Ident	Channel type	DC Out DCRetran	DC Output (single or dual output) DC retransmission		L3 R/O
IO Type	To configure the output drive signal	Volts	Volts dc Set the IO Type to 'Volts' to use the Dual DC Output as a transducer power supply.	As order code	Conf L3 R/O
		mA	milli-amps dc		
Res'n	Display resolution	XXXXX to X.XXXX	No decimal points to four decimal points		Conf
Disp Hi	Display high reading	-99999 to 99999 decimal points depend on resolution HHHHH = out of high range LLLLL = out of low range		100	L3
Disp Lo	Display low reading			0	L3
Range Hi	Electrical high input level	0 to 10		10	L3
Range Lo	Electrical low input level			0	L3
Meas Value	The current output value				R/O
PV					L3
Cal State	Calibration state	Idle Lo Hi Confirm Go Abort Busy Passed Failed Accept	Non calibrating state Select calibration of the low position Select calibration of the high position Confirm the position to calibrate Start calibration Abort calibration Controller automatically calibrating Calibration OK Calibration bad To store the new values	Idle	Conf
The above 8 parameters are not available on Dual DC Output module when IO Type is set to Volts.					
Status	Working condition of the module	Good (0) - Normal Operation Channel Off (1) - Channel is configured to be off Over Range (2) - Input signal is greater than configured high limit Under Range (3) - Input signal is less than configured low limit Hardware Status Invalid (4) - Input hardware status invalid Ranging (5) - Input hardware is being ranged i.e. being set-up as required by the range configuration Overflow (6) - Process variable overflow, possibly due to calculation attempting to add a small number to a relatively large number Bad (7) - The process variable is not ok and cannot be relied upon Hardware exceeded (8) - The hardware capabilities have been exceeded at the point of configuration, for example configuration set to 0 to 40V when input hardware is capable of up to 12V No Data (9) - Insufficient input samples to perform calculation No Calibration (13) - Calibration data is corrupt or missing Saturated input (14) - Input hardware is in saturation. This can occur if PV input, CJC input or RTD lead compensation input is outside the working range of the hardware			R/O

Analogue Input

The analogue input module provides additional analogue inputs for multi-loop controllers or other multi input measurements.

List Header - Mod		Sub-headers: xA x = the number of the slot in which the module is fitted			
Name ↻ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Ident	Channel type	Analog IP			L3 R/O
IO Type	PV input type Selects input linearization and range	ThermoCpl	Thermocouple		Conf L3 R/O
		RTD	Platinum resistance thermometer		
		Log10	Logarithmic		
		HiZV	High impedance voltage input (typically used for zirconia probe)		
		V	Voltage		
		mA	milli amps		
		80mV	80 milli volts		
		40mV	40 milli volts		
		Pyrometer	Pyrometer		
Lin Type	Input linearization	See Input Types and Ranges			L3 R/O
Units	Controller units	See Display Units			Conf
Res'n	Resolution	XXXXX to X.XXXX	No decimal points to four decimal points		Conf
CJC Type	To select the cold junction compensation method	Internal 0°C 45°C 50°C External Off	See description in section CJC Type. for further details	Internal	Conf
SBrk Type	Sensor break type	Low	Sensor break will be detected when its impedance is greater than a 'low' value		Conf
		High	Sensor break will be detected when its impedance is greater than a 'high' value		
		Off	No sensor break		
SBrk Alarm	Sets the alarm action when a sensor break condition is detected	ManLatch	Manual latching — See also Alarms		L3
		NonLatch	No latching		
		Off	No sensor break alarm		
SBrk Out	Status of the sensor break alarm	Off or On			L3
AlarmAck	Sensor Break Alarm Acknowledge	No			L1
		Yes			
Disp Hi	Display reading high	See Analogue Input Scaling and Offset			L3
Disp Lo	Display reading low				L3
Range Hi	Input high value				L3
Range Lo	Input low value				L3
Fallback	Configures the default value in case of an erroneous condition. The error may be due an out of range value, a sensor break, lack of calibration or a saturated input. The Status parameter would indicate the error condition and could be used to diagnose the problem. Fallback has several modes and may be associated with the Fallback PV parameter.	Downscale	Same as PV input		Conf
		Upscale			
		Fall Good			
		Fall Bad			
		Clip Good			
		Clip Bad			
Fallback PV	To set the value of PV during a sensor break		Instrument range		Conf

List Header - Mod		Sub-headers: xA x = the number of the slot in which the module is fitted			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Filter Time	Input filter time. An input filter provides damping of the input signal. This may be necessary to prevent the effects of excessive noise on the PV input.	Off to 500:00 (m:ss.s) (hh:mm:ss) or (hh:mm)		0:00.4	L3
Emiss	Emissivity. This parameter only appears if the input is configured for Pyrometer. It is used to compensate for the different reflectivity produced by different type of surface	Off 0.1 to 1.0		1.0	L3
Meas Value	The current electrical value of the PV input				L3 R/O
PV	The current value of the PV input in engineering units	Instrument range			L3 R/O
Offset	Single offset value applied to the input	Instrument range			L3
Lo Point	Allows a two point offset to be applied to the controller to compensate for sensor or connection errors between sensor and the input to the controller. See Two Point Offset for further details	Instrument range			L3
Lo Offset					
Hi Point					
Hi Offset					
CJC Temp	Reads the temperature of the rear terminals at the thermocouple connection				Conf R/O
SBrk Value	Used for diagnostics only, and displays the sensor break trip value.				L3 R/O
Lead Res	The measured lead resistance on the RTD				L3 R/O
Cal State	Calibration state	Idle	Non calibrating state		Conf
		Lo	Select low point calibration		
		Hi	Select high point calibration		
		Confirm	Confirm the position to calibrate		
		Go	Start calibration		
		Abort	Abort calibration		
		Busy	Automatically calibrating		
		Passed	Calibration OK		
		Failed	Calibration bad		
		Accept	To store the new values		
Status	The current status for the channel.	Good (0) - Normal Operation Channel Off (1) - Channel is configured to be off Over Range (2) - Input signal is greater than configured high limit Under Range (3) - Input signal is less than configured low limit Hardware Status Invalid (4) - Input hardware status invalid Ranging (5) - Input hardware is being ranged i.e. being set-up as required by the range configuration Overflow (6) - Process variable overflow, possibly due to calculation attempting to add a small number to a relatively large number Bad (7) - The process variable is not ok and cannot be relied upon Hardware exceeded (8) - The hardware capabilities have been exceeded at the point of configuration, for example configuration set to 0 to 40V when input hardware is capable of up to 12V No Data (9) - Insufficient input samples to perform calculation No Calibration (13) - Calibration data is corrupt or missing Saturated input (14) - Input hardware is in saturation. This can occur if PV input, CJC input or RTD lead compensation input is outside the working range of the hardware			L3 R/O

Input Types and Ranges

Input Type		Min Range	Max Range	Units	Min Range	Max Range	Units
J	Thermocouple type J	-210	1200	°C	-346	2192	°F
K	Thermocouple type K	-200	1372	°C	-328	2502	°F
L	Thermocouple type L	-200	900	°C	-328	1652	°F
R	Thermocouple type R	-50	1700	°C	-58	3092	°F
B	Thermocouple type B	0	1820	°C	32	3308	°F
N	Thermocouple type N	-200	1300	°C	-328	2372	°F
T	Thermocouple type T	-200	400	°C	-328	752	°F
S	Thermocouple type S	-50	1768	°C	-58	3214	°F
PL2	Thermocouple Platinel II	0	1369	°C	32	2496	°F
C	Thermocouple type C	1650	2315	°C	3000	4200	°F
PT100	Pt100 resistance thermometer	-200	850	°C	-328	1562	°F
Linear	mV or mA linear input	-10.00	80.00				
SqRoot	Square root						
Custom	Customised linearization tables						

Display Units

None

Abs Temp oC/oF/oK,

V, mV, A, mA,

PH, mmHg, psi, Bar, mBar, %RH, %, mmWG, inWG, inWW, Ohms, PSIG, %O2, PPM, %CO2, %CP, %/sec,

RelTemp oC/oF/oK(rel),

Custom 1, Custom 2, Custom 3

sec, min, hrs,

Triple Logic Input and Triple Contact Input

This module may be used to provide additional logic inputs.

List Header - Mod		Sub-headers: xA, xB, xC x = the number of the slot in which the module is fitted			
Name to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Ident	Channel type	Logic In	Logic input or contact input		L3 R/O
IO Type	Function of the module	Input			L3 R/O
PV	State of the measured input	0 1	Demand for output to be off Demand for output to be on		Conf R/O L3
Status See Relay, Logic or Triac Outputs	Module status	OK	Normal operation		R/O

Potentiometer Input

This module may be connected to a feedback potentiometer fitted to a motorized valve driver, or to provide a measured value from any other potentiometer input between 100Ω and 15KΩ. The excitation voltage is 0.5Vdc.

List Header - Mod		Sub-headers: xA x = the number of the slot in which the module is fitted			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
Ident	Channel type	Pot Input	Potentiometer input		L3 R/O
Units	Engineering units.	None			Conf
Res'n	Display resolution	XXXXX to X.XXXX	No decimal points to four decimal points		Conf
SBrk type	Allows one of three strategies to be configured if potentiometer break is indicated. Same as analogue input	Low	Sensor break will be detected when its impedance is greater than a 'low' value		Conf
		High	Sensor break will be detected when its impedance is greater than a 'high' value		Conf
		Off	No sensor break		Conf
SBrk Alarm	To configure the alarm action should the potentiometer become disconnected	Off NonLatch ManLatch	No sensor break alarm Non latching sensor break alarm Manual latching sensor break alarm		L3
Fallback	Condition to be adopted if the 'Status' parameter ≠ OK	Clip Bad Clip Good Fall Bad Fall Good Upscale DownScale			Conf
Fallback PV		-99999 to 99999			Conf
Filter Time	To adjust the input filter time constant to reduce the effect of noise on the input signal	Off or 0:00.1 to 500:00		0:00:04	L3
Meas Value	The current value in engineering units				L3 R/O
PV	Requested output/current input signal level (after linearization where applicable).				L3 R/O
SBrk Value	Used for diagnostics only, and displays the sensor break trip value.				L3 R/O
Cal State	This parameter allows the controller to be calibrated against the maximum and minimum positions of the potentiometer. Adjust the pot to minimum position, select 'Lo' followed by 'Confirm'. The controller will automatically calibrate to this position. Repeat for the maximum position and selecting 'Hi'. If the potentiometer is part of the valve positioning motor it may be difficult to adjust the pot position. In this case refer back to section Example: To Calibrate a VP Output.	Idle	Non calibrating state	Idle	Conf L3 R/O
		Lo	Select calibration of the low position		
		Hi	Select calibration of the high position		
		Confirm	Confirm the position to calibrate		
		Go	Start calibration		
		Abort	Calibration stopped		
		Busy	Controller automatically calibrating		
		Passed	Calibration OK		
		Failed	Calibration bad		
		Accept	To start using the new values		
		Save User	To store the new values to EE memory (For User calibration)		
		Save Fact	To store the new values to EE memory (For Factory calibration: password protected)		
		Load Fact	Load factory calibration (Save User required for permanent use of Factory calibration).		
Status See Relay, Logic or Triac Outputs	Working condition of the module	OK Sbreak	Potentiometer input broken		R/O

Transmitter Power Supply

This module may be used to provide 24Vdc to power an external transmitter.

List Header - Mod		**Sub-headers: xA, xB, xC** x = the number of the slot in which the module is fitted			
Name ⟲ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Ident	Channel type	TxPSU	Transducer power supply		L3 R/O
Status See Relay, Logic or Triac Outputs	Module status	OK	Normal operation		R/O

Transducer Power Supply

The transducer power supply may be used to power an external transducer which requires an excitation voltage of 5Vdc or 10Vdc. It contains an internal shunt resistor for use when calibrating the transducer. The value of this resistor is 30.1KΩ ±0.25% when calibrating a 350Ω bridge.

List Header - PV Input		**Sub-headers: xA** x = the number of the slot in which the module is fitted			
Name ⟲ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Ident	Channel type	TransPSU	Transducer power supply		R/O
Meas Value	The current output value				R/O
PV	Requested output/current input signal level (after linearization where applicable). Normally wired				
Status See Relay, Logic or Triac Outputs	The current status for the channel.	OK	Normal operation		R/O
Shunt		External Internal	Select external calibration resistor Select internal calibration resistor 30.1KΩ	External	Conf
Voltage	To select the output voltage	10 Volts 5 Volts	10 Volts 5 Volts		Conf

Module Scaling

The controller is calibrated for life against known reference standards during manufacture, but user scaling allows you to offset the 'permanent' factory calibration to either:

1. Scale the controller to your reference standards
2. Match the calibration of the controller to an individual transducer or sensor
3. To compensate for known offsets in process measurements

Analogue Input Scaling and Offset

Scaling of the analogue input uses the same procedure as described for the PV Input (Process Input) and applies to linear process inputs only, eg linearised transducers, where it is necessary to match the displayed reading to the electrical input levels from the transducer. PV input scaling is not provided for direct thermocouple or RTD inputs.

Figure 35 shows an example of input scaling. where an electrical input of 4-20mA requires the display to read 2.5 to 200.0 units.

Offset has the effect of moving the whole curve, shown in Figure 10-2, up or down about a central point. The 'Offset' parameter is found in the 'Mod' page under the number of the slot position in which the Analogue Input module is fitted.

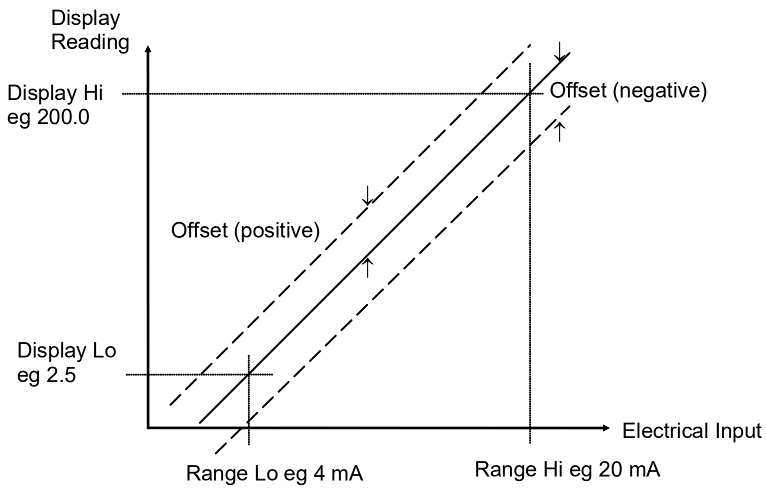


Figure 35: Input Scaling (Standard IO)

To scale a mA analogue input as shown in the above example (also applies to V or mV input types):

1. Select Conf as described in section Access to Further Parameters. Then press to select the page header in which the analogue input module is fitted
2. Press to scroll to **'Disp Hi'**. Then press or to **'200.0'**
3. Press to scroll to **'Disp Lo'**. Then press or to **'2.5'**
4. Press to scroll to **'Range Hi'**. Then press or to **'20.0'**
5. Press to scroll to **'Range Lo'**. Then Press or to **'4.00'**
6. Press to scroll to **'Offset'**. Then Press or to adjust the offset in a positive or negative direction as required

Two Point Offset

A two point offset applies to Analogue Input Modules in the same way as the PV Input. The procedure is described in section Two Point Offset.

Relay, Logic or Triac Output Scaling

If the output is configured for time proportioning control, it can be scaled such that a lower and upper level of PID demand signal can limit the operation of the output value.

By default, the output will be fully off for 0% power demand, fully on for 100% power demand and equal on/off times at 50% power demand. You can change these limits to suit the process. It is important to note, however, that these limits are set to safe values for the process. For example, for a heating process it may be required to maintain a minimum level of temperature. This can be achieved by applying an offset at 0% power demand which will maintain the output on for a period of time. Care must be taken to ensure that this minimum on period does not cause the process to overheat.

If Range Hi is set to a value <100% the time proportioning output will switch at a rate depending on the value - it will not switch fully on.

Similarly, if Range Lo is set to a value >0% it will not switch fully off.

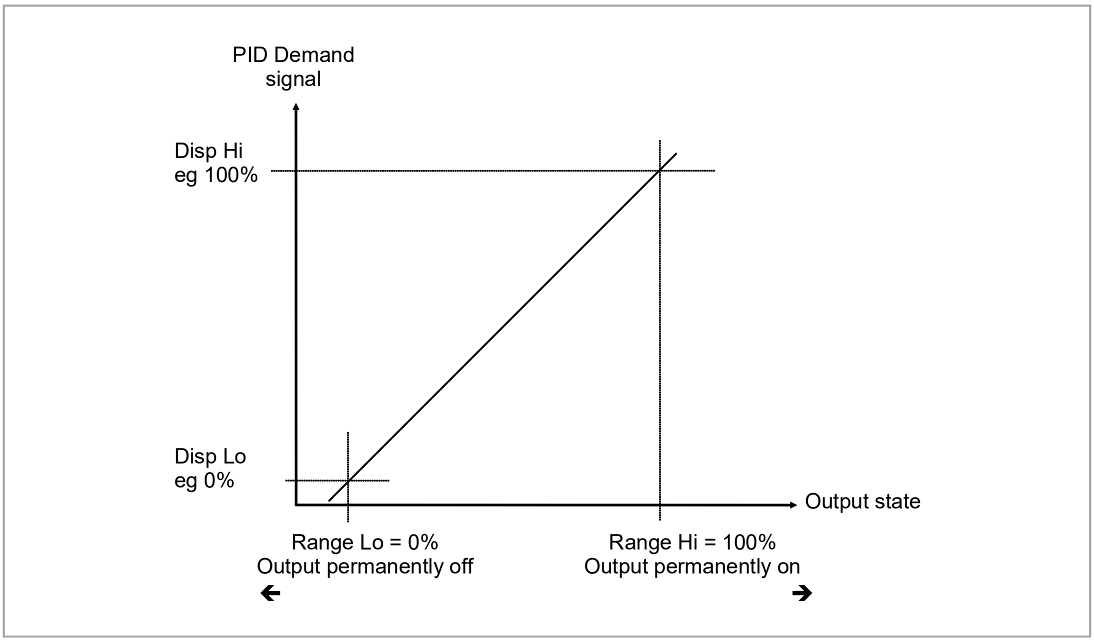


Figure 36: Time Proportioning Output

The procedure for adjusting these parameters is the same as that given in the previous section.

Analogue Output Scaling

Analogue control or retransmission outputs are scaled in exactly the same way as above except that Range Lo and Hi corresponds to the electrical output (0 to 10V, 4 to 20mA, etc). For an analogue retransmission output Disp Lo and Hi correspond to the reading on the display and for an analogue control output Disp Lo and Hi corresponds to the PID demand output signal from the control block.

Potentiometer Input Scaling

When using the controller in bounded valve position mode, it is necessary to calibrate the feedback potentiometer to correctly read the position of the valve. The minimum position of the potentiometer corresponds to a measured value reading of 0 and the maximum position corresponds to 100. This may be carried out in Access level 3:

1. Adjust the potentiometer for the minimum required position. This may not necessarily be on the end stop.
2. Press to scroll to **'Cal State'**. Then press or to **'Lo'** and **'Confirm'**. The display will show **'Go'** followed by **'Busy'** while the controller automatically calibrates to the minimum position. When complete **'Passed'** should be displayed. If **'Failed'** is displayed this may indicate that the potentiometer is outside the range of the input.
3. Adjust the potentiometer for the maximum required position. This may not necessarily be on the end stop.
4. Repeat 2 above for the 'Hi' position.
5. The controller will now use these values until it is powered down. If it required to store these values, which is the usual case, press or to '**Accept'**. The controller will store these values for future use.

IO Expander

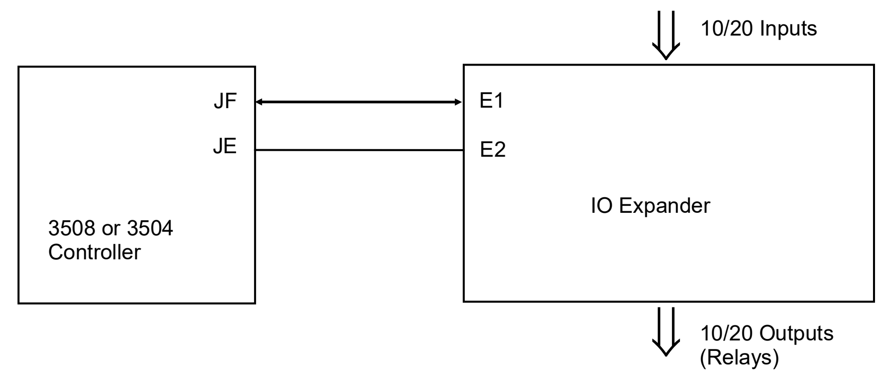
The IO Expander is an external unit which can be used in conjunction with the 3500 series controllers to allow the number of digital IO points to be increased. There are two versions:-

10 Inputs and 10 Outputs

20 Inputs and 20 Outputs

Each input is fully isolated and voltage or current driven. Each output is also fully isolated consisting of four changeover contacts and six normally open contacts in the 10 IO version and four changeover and sixteen normally open contacts in the 20 IO version.

Data transfer is performed serially via an IO Expander module which is fitted in the J serial communications slot. This module is identified as 'IOExp' in the 'Comms' 'J' parameter list (see section Digital Communications). It should be noted that, when this module is fitted in the J comms slot the remaining parameters in the 'Comms' 'J' list are not used.



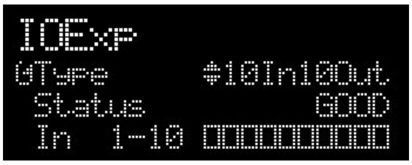
It is recommended that a cable length of 10 metres is not exceeded, however, no shielding or twisted pair cable is required.

Figure 37: IO Expander Data Transfer

Wiring connections and further details of the IO Expander are given in the IO Expander Handbook, Part No. HA026893.

When this unit is connected to the controller it is necessary to set up parameters to determine its operation. These parameters can be set up in Level 3 or configuration level.

To Configure the IO Expander

Do This	The Display You Should See	Additional Notes
1. From any display press until the **'IOExp'** page is reached		
2. Press to scroll to **'Type'** 3. Press or to select **'10In10Out'**		This configured an IO Expander for 10 inputs and 10 outputs. A further choice is 20In20Out

Remaining parameters in the Analogue Operators list are accessed and adjusted in the same way.

The list of parameters available is shown in the following table ⇓

IO Expander Parameters

List Header: IOExp	Sub-headers: None			
Parameter Name	**Parameter Description**	**Value**	**Default**	**Access Level**
Expander Type	Expander type	None 10In 10Out 20In 20Out	None 10 inputs 10 outputs 20 inputs 20 outputs	Conf
Status	IO Expander status	Good COMM FAIL	OK No communications	L3 R/O
In 1-10	Status of the first 10 digital inputs □□□□□□□□□□ to ■■■■■■■■■■	□ = Off ■ = On		L3 R/O
In 11-20	Status of the second 10 digital inputs □□□□□□□□□□ to ■■■■■■■■■■	□ = Off ■ = On		L3 R/O
Out21-30	Status of the first 10 digital outputs. Press to select outputs in turn. The flashing underlined output can be changed using buttons. □□□□□□□□□□ to ■■■■■■■■■■	□ = Off ■ = On		L3
Out31-40	Status of the second 10 digital outputs. Press to select outputs in turn. The flashing underlined output can be changed using buttons. □□□□□□□□□□ to ■■■■■■■■■■	□ = Off ■ = On		L3
Inv21-30	To change the sense of the first 10 outputs.	□ = direct ■ = Inverted		L3
Inv31-40	To change the sense of the second 10 outputs.	□ = direct ■ = Inverted		L3
In1 to In 20	State of each configured input	0 or 1	These are normally wired to a digital source. If not wired they can be changed here	L3
Out21 to Out 40	State of each configured output	0 or 1	Off or On	L3

Alarms

Alarms are used to alert an operator when a pre-set level has been exceeded. They are indicated by a message in the message centre and the red ALM beacon as described in section Alarm Indication. They may also switch an output– usually a relay (see section Alarm Relay Output) – to allow external devices to be operated when an alarm occurs.

Alarms can be divided into three main types. These are:

- Analog alarms - operate by monitoring an analog variable such as the process variable and comparing it with a set threshold.
- Digital alarms – operate when the state of a boolean variable changes, for example, sensor break.
- Rate of Change alarms - operate when the rate at which the input increases (Rising Rate of Change) or decreases (Falling Rate of Change) at a rate that exceeds the maximum rate of change (per change time). The alarms remain active until the rising or falling rate of the input is below the configured rate of change.

Number of Alarms - up to 16 alarms may be configured.

Further Alarm Definitions

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 minimize alarm relay chatter.

Latch used to hold 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.

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.

Event
Alarm output will activate.

Block The alarm may be masked during start up. Blocking inhibits the alarm from being activated until the process has first achieved a steady state. It is used, for example, to ignore start up conditions which are not representative of running conditions. A blocking alarm is not re-initiated after a setpoint change.

Delay A short time can be set for each alarm before the output goes into the alarm state. The alarm is still detected as soon as it occurs, but if it cancels before the end of the delay period then no output is triggered. The timer for the delay is then reset. It is also reset if an alarm is changed from being inhibited to uninhibited.

Note: Setting a new alarm threshold causes an action depending on the latching setting:

- If no latching then the alarm condition is re-evaluated and may change
- If latching then the alarm condition persists until acknowledged
- Blocking starts after acknowledgement for latching alarms and after setpoint write for non latching

Analog Alarms

Analog alarms operate on variables such as PV, output levels, and so on. They can be soft wired to these variables to suit the process.

Analog Alarm Types

Absolute High	an alarm occurs when the PV exceeds a set high threshold.
Absolute Low	an alarm occurs when the PV exceeds a set low threshold.
Deviation High	an alarm occurs when the PV is higher than the setpoint by a set threshold.
Deviation Low	an alarm occurs when the PV is lower than the setpoint by a set threshold.
Deviation Band	an alarm occurs when the PV is higher or lower than the setpoint by a set threshold.

These are shown graphically below for changes in PV plotted against time. (Hysteresis set to zero).

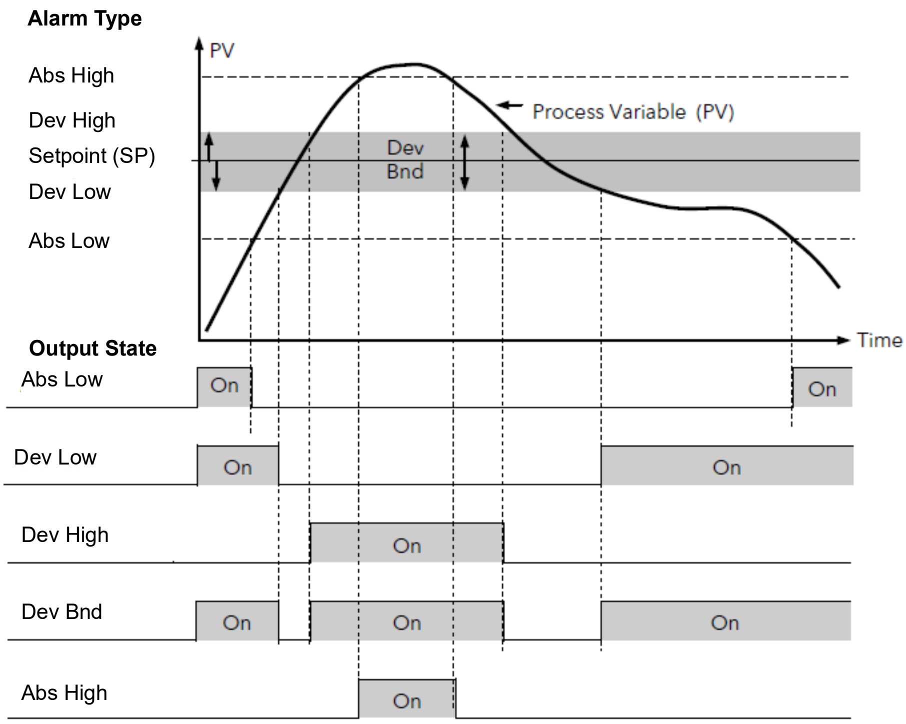


Figure 38 Analog Alarm Types

Digital Alarms

Digital alarms operate on Boolean variables. They can be soft wired to any suitable Boolean parameter such as digital inputs or outputs.

Digital Alarm Types

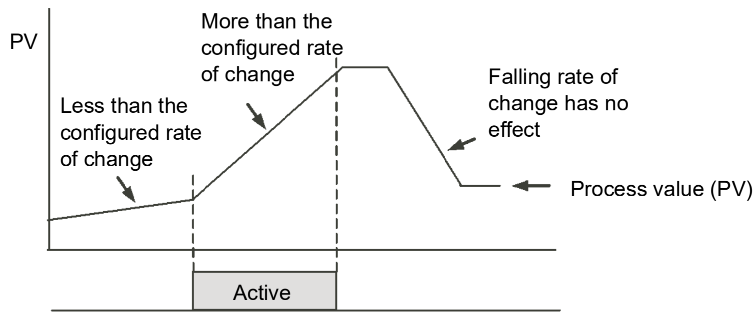
Pos Edge	The alarm will trigger when the input changes from a low to high condition.
Neg Edge	The alarm will trigger when the input changes from a high to low condition.
Edge	The alarm will trigger on any change of state of the input signal.
High	The alarm will trigger when the input signal is high.
Low	The alarm will trigger when the input signal is low.

Rate of Change Alarms

Rate of Change alarms operate on the rate at which the input increases or decreases with respect to the configured maximum rate of change (per change time). They are either rising or Falling Rate of Change alarms.

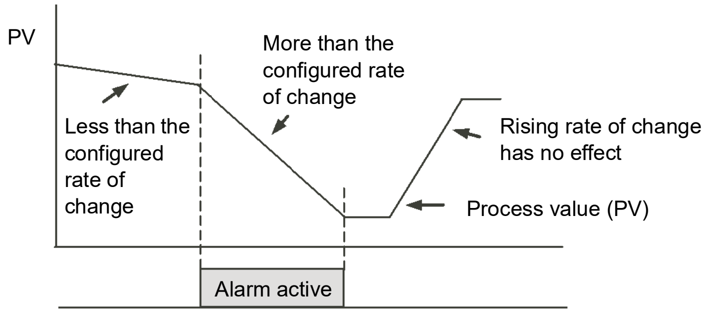
Rising Rate of Change

The Rising Rate of Change alarm sets the alarm active when the rate at which the input increases exceeds the configured maximum rate of change (per change time). It will remain active until the rising rate of the input falls below the configured rate of change.



Falling Rate of Change

The Falling Rate of Change alarm sets the alarm active when the rate at which the input decreases exceeds the configured maximum rate of change (per change time). It will remain active until the falling rate of the input falls below the configured rate of change.



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.

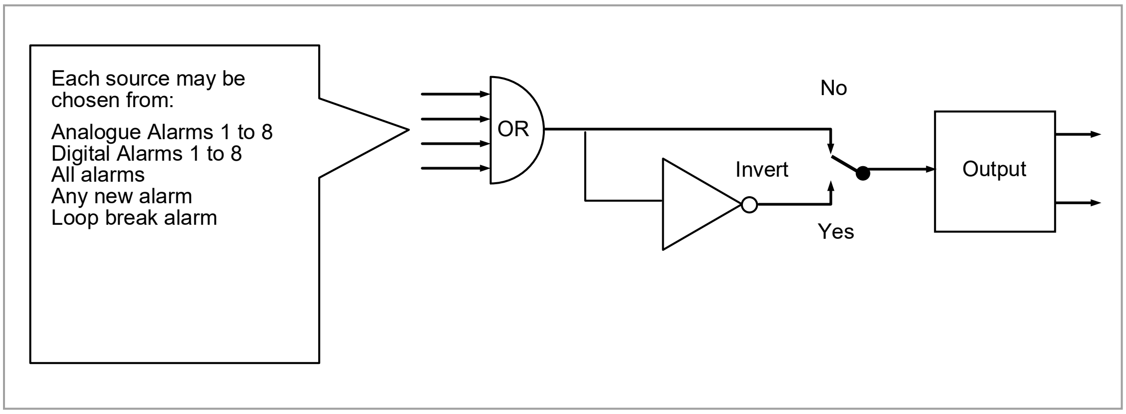


Figure 39 Attaching an Alarm to Operate an Output

How Alarms are Indicated

- ALM beacon flashing red = a new alarm (unacknowledged)
- This is accompanied by an alarm message. A typical default message will show the source of the alarm followed by the type of alarm. For example, 'AnAlm 1' is the default message for analogue alarm 1.
- Using Eurotherm iTools configuration package, it is also possible to download customised alarm messages. An example might be, 'Process Too Hot' for an analogue alarm or 'Vent open' for a digital alarm (see See iTools integrated Online Help for further details).
- If more than one alarm is present they are listed in the AlmSmry' (Alarm Summary) page.

ALM beacon on continuously = alarm has been acknowledged

Further details of alarm indication are shown in section Alarm Indication.

To Acknowledge an Alarm

Press and **(Ack)** together as instructed on the display.

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

Non Latched Alarms

As stated above, when an alarm condition occurs a red flashing alarm beacon is displayed accompanied by an alarm message. If a relay has been configured to operate when this alarm occurs (as shown in section Alarm Relay Output) the relay will relax to the alarm condition (this is the default state for alarm relay outputs). This state will continue for as long as the alarm condition remains.

If the alarm condition disappears before it has been acknowledged all indication will be cancelled and the alarm output relay will reset to the energised non-alarm state.

If the alarm condition is present when the alarm is acknowledged, the red alarm beacon will continuously light, the alarm message will disappear and the output relay will remain in the alarm condition. If the alarm condition is then removed both the red beacon and the relay output will reset.

NOTICE
If the 'Invert' parameter found in the Output List is set to 'No' the relay will energise in alarm and be in the de-energised state when no alarm is present. The default setting is 'Yes'.

Automatic Latched Alarms

The alarm continues to be active until both the alarm condition is removed **AND** the alarm is acknowledged. The acknowledgement can occur **BEFORE** the condition causing the alarm is removed.

Manual Latched Alarms

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.

Alarm Parameters

Four groups of eight alarms are available. The following table shows the parameters to set up and configure alarms.

Block: Alarm Sub-blocks: 1 to 16					
Name	**Parameter Description**	**Value**		**Default**	**Access Level**
Type	Selects the type of alarm	0 Off	Alarm not configured	Off (0)	Conf
		1 Abs Hi	Full Scale High		
		2 Abs Lo	Full Scale Low		
		3 Dev Hi	Deviation High		
		4 Dev Lo	Deviation Low		
		5 DevBnd	Deviation Band		
		6 RRoC	Rising Rate of Change		
		7 FRoC	Falling Rate of Change		
		8 DigHi	Digital High (1)		
		9 DigLo	Digital Low (0)		
		10 DigPosEdge	On rising edge		
		11 DigNegEdge	On falling edge		
		12 DigEdge	On change		
		13 AbsHiLo	Full Scale High or Low		
In	This is the parameter that will be monitored and checked according to the AlarmType to see if an alarm condition has occurred.	0 to 1			Oper
Out	The output indicates whether the alarm is on or off depending on the alarm condition, latching and acknowledge, inhibiting and blocking.	Off	Alarm output deactivated		Read Only
		On	Alarm output activated		
Inhibit	Inhibit is an input to the Alarm function. It allows the alarm to be switched OFF. Typically the Inhibit is connected to a digital input or event so that during a phase of the process alarms do not activate. For Example, if the door to a furnace is opened the alarms may be inhibited until the door is closed again.	No Yes	Alarm not inhibited Inhibit function active		Oper
Latch	Determine the type of latching the alarm will use, if any. Auto latching allows acknowledgement while the alarm condition is still active, whereas manual latching needs the condition to leave the alarm state before the alarm can be acknowledged. See also the description at the beginning of this chapter.	None	No latching is used		Oper
		Auto	Automatic		
		Manual	Manual		
		Event	Event		
Ack	Used in conjunction with the latching parameter. It is set when the user responds to an alarm.	No Yes	Not acknowledged Acknowledged		Oper
Block	Alarm Blocking is used to inhibit alarms from activating during start-up. In some applications, the measurement at start-up is in an alarm condition until the system has come under control. Blocking causes the alarms to be ignored until the system is under control, after this any deviations trigger the alarm.	No Yes	No blocking Blocking		Oper
Delay	This is a small delay between sensing the alarm condition and displaying it. If in the time between the two, the cause of the alarm is removed, then no alarm is shown and the delay timer is reset. It can be used on systems that are prone to electrical noise.	0:00.0 to 500 mm:ss.s hh:mm:ss hhh:mm		0:00.0	Oper

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'**		Up to 8 alarms can be selected using ▲ or ▼
2. Press ↻ to select **'Type'** 3. Press ▲ or ▼ to select the required alarm type		Alarm Type choices are:- None Alarm not configured Abs Hi Full Scale High Abs Lo Full Scale Low Dev Hi Deviation High Dev Lo Deviation Low Dv Bnd Deviation Band
4. Press ↻ to select **'Threshold'** 5. Press ▲ or ▼ to set the alarm trip level		This is the alarm threshold setting for. In this example, the high alarm will be detected when the measured value exceeds 100.00. The current measured value is 50.00 as measured by the 'Input' parameter. This parameter will normally be wired to an internal source such as the PV.
6. Press ↻ to select **'Hyst'** 7. Press ▲ or ▼ to set the hysteresis		In this example, the alarm will cancel when the measured value decreases 2 units below the trip level (at 98 units)
Continue to select parameters using ↻ and setting their values using ▲ or ▼		

BCD Input

The Binary Coded Decimal (BCD) input function block uses a number of digital inputs and combines them to make a numeric value. A very common use for this feature is to select a setpoint program number from panel mounted BCD decade switches.

The block uses 4 bits to generate a single digit.

Two groups of four bits are used to generate a two digit value (0 to 99)

The block outputs four results

1. Units Value: The BCD value taken from the first four bits (range 0 – 9)
2. Tens Value: The BCD value taken from the second four bits (range 0 – 9)
3. BCD Value: The combined BCD value taken from all 8 bits (range 0 – 99)

The following table shows how the input bits combine to make the output values.

Input 1	Units value (0 – 9)	BCD value (0 – 99)
Input 2		
Input 3		
Input 4		
Input 5	Tens value (0 – 9)	
Input 6		
Input 7		
Input 8		

Since the inputs cannot all be guaranteed to change simultaneously, the output will only update after the specified Settle Time has elapsed.

BCD Parameters

List Header - BCDIn		**Sub-headers: 1 and 2**			
Name ⟳ **to select**	**Parameter Description**	**Value** **Press ▼ or ▲ to change values**		**Default**	**Access Level**
In 1	Digital Input 1	On or Off	Alterable from the operator interface if not wired	Off	L3
In 2	Digital Input 2	On or Off		Off	L3
In 3	Digital Input 3	On or Off		Off	L3
In 4	Digital Input 4	On or Off		Off	L3
In 5	Digital Input 5	On or Off		Off	L3
In 6	Digital Input 6	On or Off		Off	L3
In 7	Digital Input 7	On or Off		Off	L3
In 8	Digital Input 8	On or Off		Off	L3
BCD Value	Reads the value (in BCD) of the switch as it appears on the digital inputs	0 – 99	See examples below		
BcdSettleTime	Time to wait between inputs changing and updating the BCD Value parameter	0.0 – 10.0		1.0	Conf

In 1	**In 2**	**In 3**	**In 4**	**In 5**	**In 6**	**In 7**	**In 8**	**BCD**
1	0	0	0	0	0	0	0	1
1	1	1	1	0	0	0	0	9
0	0	0	0	1	1	1	1	90
1	1	1	1	1	1	1	1	99

Example: To wire a BCD Input

The BCD digital input parameters may be wired to digital input terminals of the controller.

There are two standard digital input terminals which may be used (LA and LB), but it may also be necessary to use a triple digital input module in addition. The wiring procedure is the same and the example given below wires BCD input 1 to LA.

Do This	The Display You Should See	Additional Notes
1. From any display press until the **'BCDIn'** page is reached 2. Press or to select **'1'** or **'2'** as required		In this example BCD block 1 is used.
3. Press to scroll to **'In1'**		
4. Press to display '**WireFrom'**		
5. Using and select the parameter which is to be wired from. In this example Logic input LA		PV is the parameter required and this procedure 'copies' the parameter to be wired from
6. Press		
7. Press to confirm		This 'pastes' the parameter to 'In1' The arrow next to the parameter indicates that it has been wired

Digital Communications

Digital Communications (or 'comms' for short) allows the controller to communicate with a PC or a networked computer system or any type of communications client using the protocols supplied. A data communication protocol defines the rules and structure of messages used by all devices on a network for data exchange. Communications can be used for many purposes – SCADA packages; plcs; data logging for archiving and plant diagnostic purposes; cloning for saving instrument set ups for future expansion of the plant or to allow you to recover a set-up after a fault.

This product supports the following protocols:

Protocol	For a full description of these protocols please refer to the relevant published standards but further details may be found in:
MODBUS RTU ®	Series Communications Handbook part no. HA026230: A full description can be found on www.modbus.org.
DeviceNet	DeviceNet Communications Handbook part no. HA027506; Section Protocol of this handbook
MODBUS TCP	Section Ethernet Communication Parameters of this handbook. A full description of the MODBUS TCP protocol can be found on www.modbus.org.

There are two communications ports available within the instrument; these are defined as the 'H' and 'J' ports and act as a communications server. Various communications modules each supporting a different protocol may be fitted to each port as follows:

Port	MODBUS	DeviceNet	Ethernet
H	✓	✓	✓
J	✓	X	X

Wiring connections for each of these protocols is given in Digital Communications Connections.

Serial Communications

MODBUS RTU uses EIA232, EIA485 2 wire and EIA422 4 wire serial communications. The wiring connections for these and the other protocols are given in section Digital Communications Connections.

EIA232

EIA232 uses a three wire cable (Tx, Rx, Gnd). The signals are single ended, i.e. there is a single wire for transmit and another for receive. This makes EIA232 less immune to noise in industrial applications. EIA232 can only be used with one instrument. To use EIA232 the PC will be equipped with an EIA232 port, usually referred to as COM 1.

To construct a cable for EIA232 operation use a three core screened cable.

The terminals used for EIA232 digital communications are listed in the table below. Some PC's use a 25 way connector although the 9 way is more common.

Standard Cable Colour	**PC socket pin no.**		**PC Function ***	**Instrument Terminal**	**Instrument Function**
	9 way	**25 way**			
White	2	3	Receive (RX)	HF or JF	Transmit (TX)
Black	3	2	Transmit (TX)	HE or JE	Receive (RX)
Red	5	7	Common	HD or JD	Common
Link together	1 4 6	6 8 11	Rec'd line sig. detect Data terminal ready Data set ready		
Link together	7 8	4 5	Request to send Clear to send		
Screen		1	Ground		

✶ These are the functions normally assigned to socket pins. Please check your PC manual to confirm.

EIA485

The EIA485 standard allows one or more instruments to be connected (multi dropped) using a two wire connection, with cable length of less than 1200M. 31 instruments and one client may be connected. The balanced differential signal transmission is less prone to interference and should be used in preference to EIA232 in noisy environments. EIA485 may be used with Half Duplex Communications such as MODBUS RTU.

To use EIA485, buffer the EIA232 port of the PC with a suitable EIA232/EIA485 converter. The Eurotherm KD485 Communications Adapter unit is recommended for this purpose. 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 or damage to the computer, 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 or JF (B) or (B+)	Transmit (TX)
Red	Transmit (TX+)	HE or JE (A) or (A+)	Receive (RX)
Green	Common	HD or JD	Common
Screen	Ground		

✶ These are the functions normally assigned to socket pins. Please check your PC manual to confirm.

Configuration Ports

In addition to the above communications, the 3500 series also supports infrared (IR Clip) and configuration (CFG Clip) communications. These interfaces always adhere to the following fixed settings:

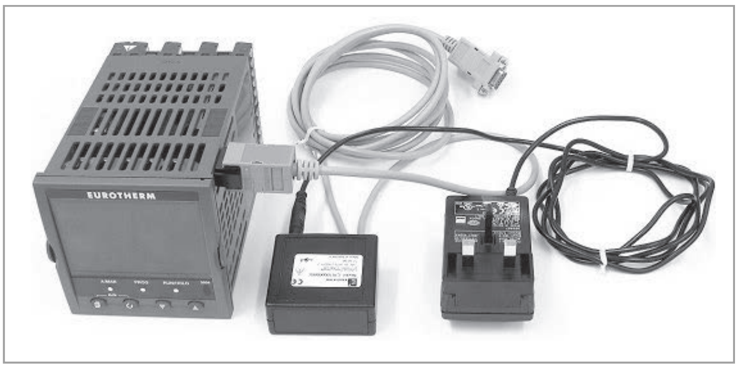
- MODBUS protocol
- Instrument address 255
- Baud rate 19K2
- No parity

IR Clip

An IR Clip, available from Eurotherm, clips to the front of the controller as shown. It is enabled/disabled via the "IR Mode" parameter within the "Access" page of the instrument.

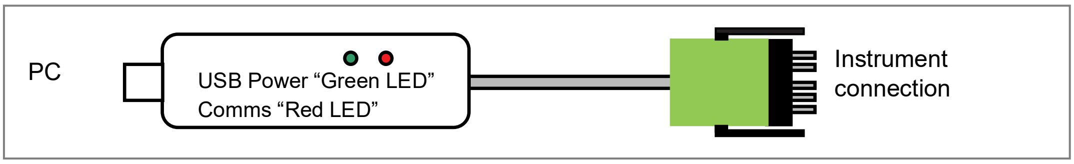
CFG Clip

A configuration clip is also available from Eurotherm which interfaces directly with the main printed circuit board in the controller. It can be clipped into position with the controller in or out of its sleeve.



USB CPI Clip

From May 2013 the above clip has been replaced by a USB clip. It is designed to clip into the side of the controller in the same way as the previous item and can be used with the instrument powered or un-powered and with the instrument mounted or un-mounted in its sleeve. The clip is intended to be used with the Eurotherm configuration package, iTools. It may be ordered as ITOOLS/NONE/USB.



Cloning of Configuration Port Settings

Full instrument cloning is supported via the CFG clip without the need for instrument power although errors may be reported with I/O module settings. This is because the modules are not powered so confirmation of downloaded settings is not possible.
If the IR comms port is used during cloning then parameters associated with both J and H ports are cloned.

If the H or J port is used, then none of the H and J port settings are cloned.

Serial Communications Parameters

Serial communications parameters may be found in the ‘Comms’ page. Communications modules may be fitted in the ‘H’ slot or ‘J’slot. The following table shows the parameters available in each position.

List Header - Comms.H and Comms.J		**Sub-headers: Main**			
Name **to select**	**Parameter Description**	**Value** **Press ▼ or ▲ to change values**		**Default**	**Access Level**
Interface	Identifies that the comms module is fitted in the H slot	None	No Module fitted		RO
		IOExp	IO expander (J slot only)		
		Comms	Serial Communications module fitted		
		Ethernet	Ethernet Communications module fitted (Ethernet Communication Parameters)		
Protocol	Digital communications protocol	None	No comms protocol selected	None	Config RW
		ModbusRTU	MODBUS RTU		
		EI-Bisynch	Available in firmware V4.15+		
		Modbus Master	MODBUS RTU Client (Master)		
		DeviceNet	DeviceNet protocol		
Status	Status of the network - DeviceNet Only	Running	DeviceNet network is connected and actively communicating		RO
		Init	DeviceNet network is initializing		
		Ready	DeviceNet network is connected		
		Offline	DeviceNet network is offline		
WDTimeout	Network Watchdog Timeout If the Network communications stop addressing the instrument for longer than this value, the Watchdog Flag will become active.	0.0 to 60.0 seconds	A value of 0 disables the watchdog	0.0	Config RW
WDAction	Network Watchdog Action The Watchdog Flag may be cleared automatically upon reception of valid messages or manually by a parameter write or a wired value.	Manual	Manual Recovery The Watchdog Flag must be cleared manually - either by a parameter write or a wired value.	Manual	Level 3 RW
		Auto	Automatic Recovery The Watchdog Flag will be automatically cleared when the Network Communcations resume - according to the value in the Recovery Timer.		
WDRecovery	Network Watchdog Recovery This is only shown when the Watchdog Action is set to Auto. This timer determines the delay after resumption of communications before the Watchdog Flag is cleared.	0.0 to 60.0 seconds	A value of 0 will reset the Watchdog flag upon the first valid message received. Other values will wait for at least 2 valid messages to be received within the set time before clearing the Watchdog flag.	0.0	Config RW
WDFlag	Network Watchdog Flag This flag is ON when the Network communications have stopped addressing the instrument for longer than the Timeout time. It will be set by the Watchdog process and may be cleared Automatically or Manually according to the value of the Watchdog Action parameter.	Off			RO
		On			
Delay	This inserts a delay between Rx and Tx to ensure that the drivers used by intelligent EIA232/EIA485 converters have sufficient time to switch over.	Off	No Delay	No	Config RW
		On	Delay Enabled		

List Header - Comms.H and Comms.J		Sub-headers: Main			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
TimeFormat	Sets the resolution of time parameters on this comms channel when read/written via scaled integer comms	ms	milliseconds	ms	Config RW
		sec	seconds		
		min	minutes		
		hour	hours		

List Header - Comms.H and Comms.J		Sub-headers: Network			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
Baud	Communications baud rate	4800	EI-Bisynch Only		
		9600	MODBUS and EI-Bisynch Only	MODBUS: 19200 EI-Bisynch: 9600	Conf RW
		19200	MODBUS and EI-Bisynch Only		
		125K	DeviceNet Only	DeviceNet: 125K	
		250K	DeviceNet Only		
		500K	DeviceNet Only		
Parity	MODBUS parity setting - used by MODBUS RTU only	None	No parity used	None	Conf RW
		Even	Even parity		
		Odd	Odd parity		
Address	Instrument address	ModbusRTU: 1 - 254		1	Conf RW
		DeviceNet: 0 - 63			
		EI-Bisynch: 0 - 99			

Communications Identity

The identity ‘id’ shows that a communications board is fitted or not.

Protocol

MODBUS (Jbus) Protocol

MODBUS defines a digital communication network to have only one CLIENT and one or more SERVER devices. Either a single or multi-drop network is possible.
All message transactions are initiated by the CLIENT. Eurotherm instruments communicate using the MODBUS RTU binary protocol.

The JBUS protocol is identical in all respects but ‘1’ is added to the MODBUS protocol parameter or register address. Both use a numeric index but the JBUS index starts at '0' while the MODBUS index starts at '1'.

MODBUS is available in the 'H' or the 'J' port modules. 3500 series instruments have a fixed table of addresses referred to as the SCADA table which are designed for use with SCADA or PLC packages. Every parameter may be addressed from the iTools OPC server using the OPC name.

DeviceNet Protocol

DeviceNet is a cost-effective communications link designed to replace hardwired I/O interconnection between industrial devices.

DeviceNet is simple to use through the application of automated software configuration tools and simple wiring layouts. Engineering cost and time to design, configure and commission a DeviceNet installation is significantly less than other comparable networks. DeviceNet is an Open Standard and is now used by a wide range of vendors. Common definition of simple devices allows interchangeability while making interconnectivity of more complex devices possible. In addition to reading the state of discrete devices, DeviceNet allows easy access to operating node variables such as process temperatures, alarm status as well as system diagnostic status.

The DeviceNet communication link is based on a broadcast- oriented, communications protocol the Controller Area Network (CAN).

The minimum revision for DeviceNet communications module software used with the 3500 instruments is revision 1.6. This is identified by the module part no. AH027179U003.

EI-Bisynch Protocol

EI-Bisynch is a proprietary Eurotherm protocol based on the ANSI X3.28-2.5 A4 standard for message framing. Despite its name, it is an ASCII based asynchronous protocol. Data is transferred using 7 data bits, even parity, 1 stop bit.

EI-Bisynch identifies parameters within an instrument using what are known as ‘mnemonics’. These are usually two letter abbreviations for a given parameter, for example, PV for Process Variable, OP for Output, SP for Setpoint, and so on.

EI-Bisynch communications within the 3500 series instruments allows for the reading/writing of a number of parameters over EIA232 or EIA485 communications using the parameter’s mnemonic as a reference and the 818 & 902/3/4 style EI-Bisynch communications protocol. This does not include 900EPC controllers.

EI-Bisynch is available in the 'H' or the 'J' port modules and has been included in this instrument for backward compatibility. Where mnemonic conflicts occur, the 818 mnemonic takes priority. The mnemonics are the same as the 818 & 902/3/4 controllers.

Ethernet (MODBUS TCP)

See section Ethernet Communication Parameters.

MODBUS Client (MBUS_M)

See section MODBUS Client Communications.

Baud Rate

The baud rate of a communications network specifies the speed that data is transferred between instrument and client. A baud rate of 9600 equates to 9600 Bits per second. Since a single character requires 8 bits of data plus start, stop, and optional parity, up to 11 bits per byte may be transmitted. 9600 baud equates approximately to 1000 Bytes per second. 4800 baud is half the speed – approx. 500 Bytes per second.

In calculating the speed of communications in your system it is often the Latency between a message being sent and a reply being started that dominates the speed of the network.

For example, if a message consists of 10 characters (10msec at 9600 Baud) and the reply consists of 10 characters, then the transmission time would be 20 msec. However, if the Latency is 20msec, then the transmission time has become 40msec.

Parity

Parity is a method of ensuring that the data transferred between devices has not been corrupted. Parity is the lowest form of integrity in the message. It ensures that a single byte contains either an even or an odd number of ones or zero in the data.

In industrial protocols, there are usually layers of checking to ensure that the first byte transmitted is good. MODBUS applies a CRC (Cyclic Redundancy Check) to the data to ensure that the package is correct.

Communication Address

On a network of instruments an address is used to specify a particular instrument. Each instrument on a network should have a unique address. Address 255 is reserved for factory use.

Example: To Set Up Instrument Address

This can be done in operator level 3:

Do This	The Display You Should See	Additional Notes
1. Press as many times as necessary to select 'Comms'		
2. Press to scroll to 'Address' 3. Press or to select the address for the particular controller		Up to 254 can be chosen but note that no more than 31 instruments should be connected to a single EIA485 link. For further information see 2000 Series Communications Handbook Part No. HA026230 available on www.eurotherm.com

Comms Delay

In some systems it is necessary to introduce a delay between the instrument receiving a message and its reply. This is sometimes caused by communications converter boxes which require a period of silence on the transmission to switch over the direction of their drivers.

Ethernet Communication Parameters

If ‘Protocol’ is set to ‘Ethernet’ the following parameters are available.

List Header - Comms.H Only		**Sub-header: Main**			
Name to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Interface	Identifies that the comms module is fitted in the H or J slot	None	No Module fitted		RO
		Ethernet	Ethernet Communications module fitted		
Protocol	Digital communications protocol	None	No comms protocol selected	None	Config RO
		ModbusSlave	MODBUS TCP Client (Server)		
		EtherNetIPAndModbus	Available in a future firmware release		
		ModMstAndModSlv	MODBUS TCP Client/Server		
Status					
WDTimeout	Network Watchdog Timeout If the Network communications stop addressing the instrument for longer than this value, the Watchdog Flag will become active. NOTE: This functionality can be unreliable with Ethernet comms depending on the type of connection in use. For MODBUS TCP, if the socket doesnt get disconnected, the watchdog will not be triggered. In this case, it is highly recommended to ensure that critical parameter writes are instead directed into a RemoteInput Function Block, then use graphical wiring to link the RemoteInput timeout into the control strategy instead of WDFlag.	0.0 to 60.0 seconds	A value of 0 disables the watchdog	0.0	Config RO
WDAction	Network Watchdog Action The Watchdog Flag may be cleared automatically upon reception of valid messages or manually by a parameter write or a wired value.	Manual	Manual Recovery The Watchdog Flag must be cleared manually - either by a parameter write or a wired value.	Manual	Level 3 RW
		Auto	Automatic Recovery The Watchdog Flag will be automatically cleared when the Network Communcations resume - according to the value in the Recovery Timer.		
WDRecovery	Network Watchdog Recovery This is only shown when the Watchdog Action is set to Auto. This timer determines the delay after resumption of communications before the Watchdog Flag is cleared.	0.0 to 60.0 seconds	A value of 0 will reset the Watchdog flag upon the first valid message received. Other values will wait for at least 2 valid messages to be received within the set time before clearing the Watchdog flag.	0.0	Config RW
WDFlag	Network Watchdog Flag This flag is ON when the Network communications have stopped addressing the instrument for longer than the Timeout time. It will be set by the Watchdog process and may be cleared Automatically or Manually according to the value of the Watchdog Action parameter.	Off		Off	Config RW
		On			

TimeFormat	Sets the resolution of time parameters on this comms channel when read/written via scaled integer comms	ms	milliseconds	ms	Config RW
		sec	seconds		
		min	minutes		
		hour	hours		

List Header - Comms.H Only		**Sub-header: Network**			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
AutoDiscovery	Both 3500 controllers and iTools software support automatic discovery of MODBUS TCP enabled instruments, to enable this feature set this parameter to ON.	None	No Module fitted		Config RW
		Ethernet	Ethernet Communications module fitted		
IPMode	Select whether the IP address, subnet mask, etc., are as configured (Static) or supplied from a DHCP server (Dynamic). Consult with your network administrator to determine if the IP Addresses for the instruments should be fixed or Dynamically allocated by a DHCP server. If the IP Addresses are to be dynamically allocated then all MAC addresses must be supplied to the network administrator. For fixed IP Addresses the Network Administrator will provide the IP address as well as a SubNet Mask. These must be configured into the instrument during set-up through the "COMMS" page. Remember to note the allocated addresses.	Static	IP address and Subnet mask configured manually	Static	Config RW
		DHCP	IP Address and Subnet mask obtained automatically		
IPAddress1 to IPAddress4	Used to set the IP address of this instrument if IPMode has been set to Static. If IPMode is set to DHCP, the IP address parameters will be updated to reflect the IP address obtained from the DHCP server. This can take up to 30 seconds. Note, if the DHCP lease expires and is not renewed, the IPAddress will revert to 0.0.0.0.	0.0.0.0 to 255.255.255.255		192.168.111.222	Config RW
SubnetMask1 to SubnetMask4	Used to set the Subnet Mask of this instrument if IPMode has been set to Static. If IPMode is set to DHCP, the Subnet Mask parameters will be updated to reflect the Subnet Mask obtained from the DHCP server. This can take up to 30 seconds.	0.0.0.0 to 255.255.255.255		255.255.255.0	Config RW
DefaultGateway1 to DefaultGateway4	Used to set the Default Gateway to allow this instrument to communicate outside of the local subnet. If IPMode is set to DHCP, the Default Gateway parameters will be updated to reflect the Default Gateway obtained from the DHCP server. This can take up to 30 seconds.	0.0.0.0 to 255.255.255.255			Config RW
MAC1 to MAC6	Unique MAC address assigned to this Ethernet Comms Module. In the 3500 controllers, the MAC address is represented by 6 separate hexadecimal values in the format aa-bb-cc-dd-ee-ff.				RO
BroadcastStormActive	Broadcast Storm Protection discards all broadcast packets if the broadcast rate climbs too high. Broadcast Storm and Ethernet Rate Protection are intended to favour maintaining the control strategy in certain high traffic network environments. If the instrument has detected a Broadcast Storm, this parameter will be set to Yes.	No	No Broadcast Storm detected		RO
		Yes	Broadcast packets are being discarded		

RateProtectionActive	Certain excessive network loads on embedded products have the potential to impact processor availability to the point that useful control is compromised and the product restarts as there is no longer CPU to service the device watchdog. The 3500 controllers incorporate an Ethernet Rate Protection algorithm which will de-prioritize Ethernet comms in very heavy traffic environments so that the control strategy continues and the instrument does not watchdog reset. If Ethernet Rate Protection is active, this parameter will be set to Yes.	No	Ethernet packets handled normally		RO
		Yes	Priority of Ethernet packet handling has been reduced		
PrefMasterIP1 to PrefMasterIP4	3500 Ethernet supports a limited number of simultaneous connections, so to reserve a connection for a specific IP address, you may enter it here. Typical use cases include a PLC that is sending a Setpoint to the 3500, or a recording device such as Eurotherm Nanodac or 6000.	0.0.0.0 to 255.255.255.255		192.168.111.111	Config RW

Instrument Setup

NOTICE

1. It is recommended that you setup the communications settings for each instrument before connecting it to any Ethernet network. This is not essential but network conflicts may occur if the default settings interfere with equipment already on the network. By default the instruments are set to a fixed IP address of 192.168.111.222 with a default SubNet Mask setting of 255.255.255.0.
2. IP Addresses are usually presented in the form "xxx.xxx.xxx.xxx". Within the instrument each element of the IP Address is shown and configured separately

"IP address 1" relates to the first set of three digits, IP address 2 to the second set of three digits and so on. This also applies to the SubNet Mask, Default Gateway and Preferred client IP Address.

DeviceNet Protocol

DeviceNet has been designed as a low level network for communication between Programmable Logic Controllers (PLCs) and devices such as switches and IO devices. Each device and/or controller is a node on the network. 3500 series controllers can be included in a DeviceNet installation using the DeviceNet interface module plugged into communications slot H. For further information regarding configuration of 3500 series controllers for a DeviceNet network, refer to the DeviceNet Communications Handbook HA027506 which may be downloaded from www.eurotherm.com.

It is not within the scope of this manual to describe the DeviceNet standard and for this you should refer to the DeviceNet specification which may be found at www.odva.org.

Comms Indirection Table

3500 series controllers make a fixed set of parameters available over digital communications using MODBUS addresses. This is know as the SCADA Table. The SCADA MODBUS address area is 0 to 16064 3EC0 (HEX). There are three addresses reserved to allow iTools to detect the instrument: 107, 121 and 122 - these cannot be set as a Destination value.

The following MODBUS addresses have been reserved for use via the Comms Indirection Table. By default the addresses have no associated parameters:

MODBUS Range (Decimal)	MODBUS Range (Hex)
15360 to 15615	3C00 to 3CFF

The programmer area 8192 (2000 Hex) to 10175 (27BF (hex) within the SCADA table is not supported.

When accessed here, the parameter may be presented as scaled integer, minutes or Native format and may be flagged as read-only.

The Comms Table is used to make additional parameters which are not in the SCADA table available for specific applications. It is recommended that iTools is used to set up the required table as shown in section Modbus Scada Table.

The following parameters are available in the Comms Table:

List Header - Commstab		Sub-headers: 1 to 250		
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values	**Default**	**Access Level**
Dest	MODBUS destination	The MODBUS address where the selected parameter will appear in the SCADA table area. Range is 0 to 16111. A value of -1 indicates not used.	Not Used	Conf
Source	Source parameter	The parameter that will be mapped into the Destination MODBUS address. It should be noted that setting this parameter via iTools will allow sources that are unavailable to the HMI. If such a setting is subsequently examined using the front panel it cannot be edited, only deleted.		Conf
Native	Native data format	The data format in which the source parameter will be presented at the destination address. 0 Integer - causes a scaled integer representation of the value to appear at the MODBUS address. 1 Native - causes the native format of the value to appear at the MODBUS address. It should be noted that if a 32 bit value is returned, it will use two adjacent 16 bit MODBUS addresses.	Integer	Conf
ReadOnly	Read only Read/write only if source is R/W	This parameter may be used to override the normal alterability rule for the parameter and force it to be Read Only. Setting this value to 'ReadWrite' enables the normal alterability rule(s). 0 ReadWrite - Allow the value's normal alterability rule to be applied at the selected MODBUS address 1 Read-Only- Overrides the parameter's normal alterability rule to present it as read only at the selected MODBUS address		Conf
Minutes	Time parameter resolution.	This allows for Time parameters to be presented in alternate resolutions, for example 1/10th of minutes or 1/10th of seconds. 0 Seconds- the Time parameter will be presented as sss.s 1 Minutes - the Time parameter will be presented as mmm.m	Seconds	Conf

Broadcast Communications

Broadcast communications allows 3500 series controllers to send a single value from a client to a number of server instruments using the broadcast address 0 with MODBUS broadcast function code 6 (Write single value). This allows the 3500 to link through digital communications with other products without the need for a supervisory PC to create a small system solution.

Example applications include multi-zone profiling applications or cascade control using a second controller. The facility provides a simple and precise alternative to analogue retransmission.

WARNING

When using broadcast communications, bear in mind that updated values are sent many times a second. Before using this facility, check that the instrument to which you wish to send values can accept continuous writes. It should be noted that in common with many third party lower cost units, the Eurotherm 2200 series and the 3200 series prior to version V1.10 do not accept continuous writes to the temperature setpoint. Damage to the internal non-volatile memory could result from the use of this function. If in any doubt, contact the manufacturer of the device in question for advice.
When using the 3200 series fitted with software version 1.10 and greater, use the Remote Setpoint variable at MODBUS address 26 if you need to write to a temperature setpoint. This has no write restrictions and may also have a local trim value applied. There is no restriction on writing to the 2400 or 3500 series.

Broadcast Parameters

Tthe following parameters are available:

List Header - Commstab		Sub-headers: 1 to 250		
Name to select	**Parameter Description**	**Value** Press or to change values	**Default**	**Access Level**
Enable	Enables the MODBUS Single Value Broadcast. This is only available if Serial Comms module is fitted and protocol is set to ModbusRTU	No - Broadcast Disabled Yes - Broadcast Enabled	No	Conf RW
Destination	This address will be used as the destination register for the value to be sent to	0 - 32767	0	Conf RW
Broadcast Value	This value will be sent to the server devices, after being transformed into a 'scaled integer' 16 bit value. To use the feature, enable broadcast using BroadcastEnable, and wire any instrument value to this parameter.		0.0	Level3 RW

3500 Broadcast Client

The 3500 broadcast client can be connected to up to 31 servers if no segment repeaters are used. If repeaters are used to provide additional segments, 32 servers are permitted in each new segment. The client is configured by selecting a MODBUS register address to which a value is to be sent. The value to send is selected by wiring it to the Broadcast Value. Once the function has been enabled, the instrument will send this value out over the communications link every control cycle (110ms).

NOTICE

1. The parameter being broadcast must be set to the same decimal point resolution in both client and server instruments.
2. iTools, or any other MODBUS client, may be connected to the same port on which the broadcast client is enabled. In this case the broadcast is temporarily inhibited. It will restart approximately 30 seconds after iTools is removed. This is to allow reconfiguration of the instrument using iTools even when broadcast communications is operating.

A typical example might be a multi zone oven where the setpoint of each zone is required to follow, with digital accuracy, the setpoint of a client controller.

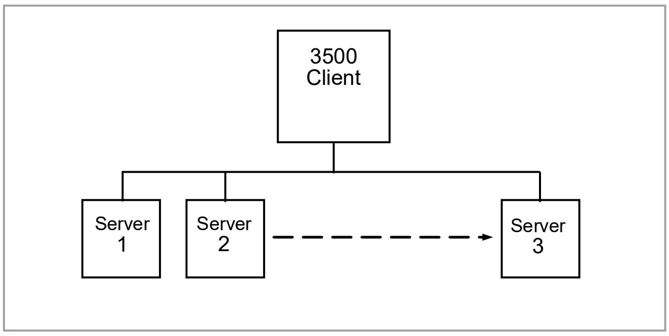


Figure 40: Broadcast Comms

Wiring Connections - Broadcast Communications

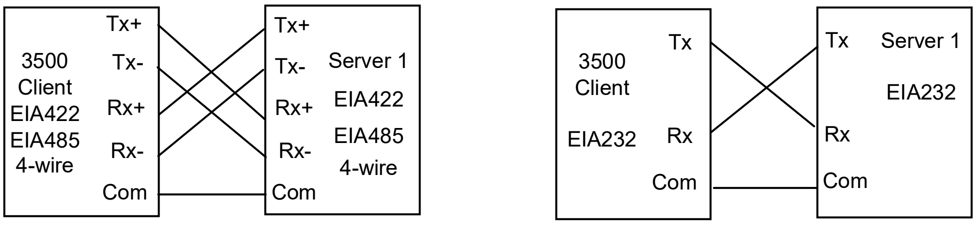
The Digital Communications module for the client can be fitted in either Communications Module slot H or J and uses terminals HA to HF or JA to JF respectively.

The Digital Communications module for the server is fitted in either slot J or slot H.

The wiring connections and the precautions shown in section Digital Communications Connections apply.

CAUTION

EIA422, EIA485 4-wire or EIA232
Rx connections in the client are wired to Tx connections of the server
Tx connections in the client are wired to Rx connections of the server



Terminal Function	Terminal number
Tx+ (TxA)	HE or JE
Tx- (TxB)	HF or JF
Rx+ (RxA)	HB or JB
Rx- (RxB)	HC or JC
Common	HD or JD

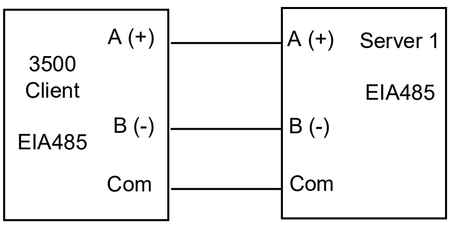
Terminal Function	Terminal number
Tx	HE or JE
Rx	HF or JF
Common	HD or JD

Figure 41: Rx/Tx Connections for EIA422, EIA485 5-wire, EIA232

CAUTION

EIA485 2-wire
Connect A (+) in the client to A (+) of the server
Connect B (-) in the client to B (-) of the server

This is shown diagrammatically below



Terminal Function	Terminal number
B (-) (Tx)	HE or JE
A (+) (Rx)	HF or JF
Common	HD or JD

Figure 42: : Rx/Tx Connections EIA485 3-wire

Example: To Send SP from the Client to SP in a Server

Wire the setpoint in the client to **'Bcast Val'**. The procedure for this is shown in section Soft Wiring or using iTools.

Set **'Dest Addr'** in the client to '2'. 2 is the MODBUS value for **'Target SP'**. The value of the client setpoint will be shown in the lower display on the server (assuming the server has been configured for SP in the lower display).

MODBUS Client Communications

Overview

MODBUS Client feature is available over serial (MODBUS RTU) and over Ethernet (MODBUS TCP). MODBUS TCP Client is protected by feature security.

Server profiles for Eurotherm products EPC3000 series, EPC2000, ePack, 3200 series, and ePower, ePack, 3200, and ePower devices are supported for ease of configuration.

A maximum of three MODBUS server devices can be configured with timeouts and retries configurable per server. The servers can be 3x MODBUS TCP servers, 3x RTU servers or any combination of RTU and TCP MODBUS servers.

A maximum of 32 data points are supported to be shared among the three server devices. These data points can be configured for writing to or reading from a configured MODBUS server.

MODBUS Client Configuration

MODBUS Client can be configured using the 3500 HMI or via a PC using iTools software.

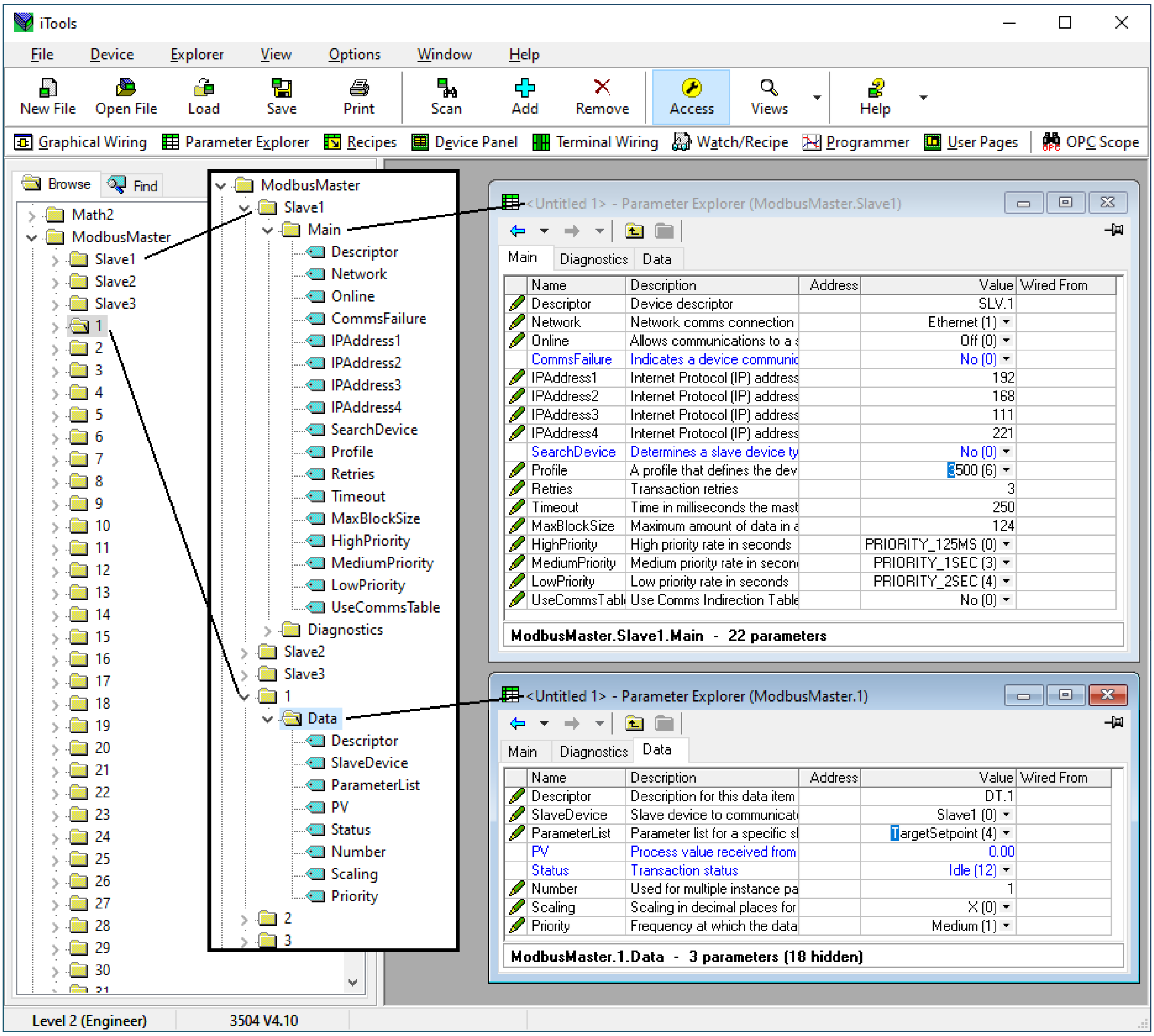
Once the MODBUS Client feature is enabled via Feature Security, Comms.Option.Main.Protocol must be set to ModMstAndSlv(15) and/or Comms.Fixed.Main.Protocol set to ModbusMaster(3). The instrument must then be restarted to reinitialise comms settings and make the ModbusMaster function block available.

MODBUS Client configuration is divided into two parts:

- Setting up the MODBUS Client server(s)
- Defining the required server data that will be read from or written to the configured server(s)

Notes:

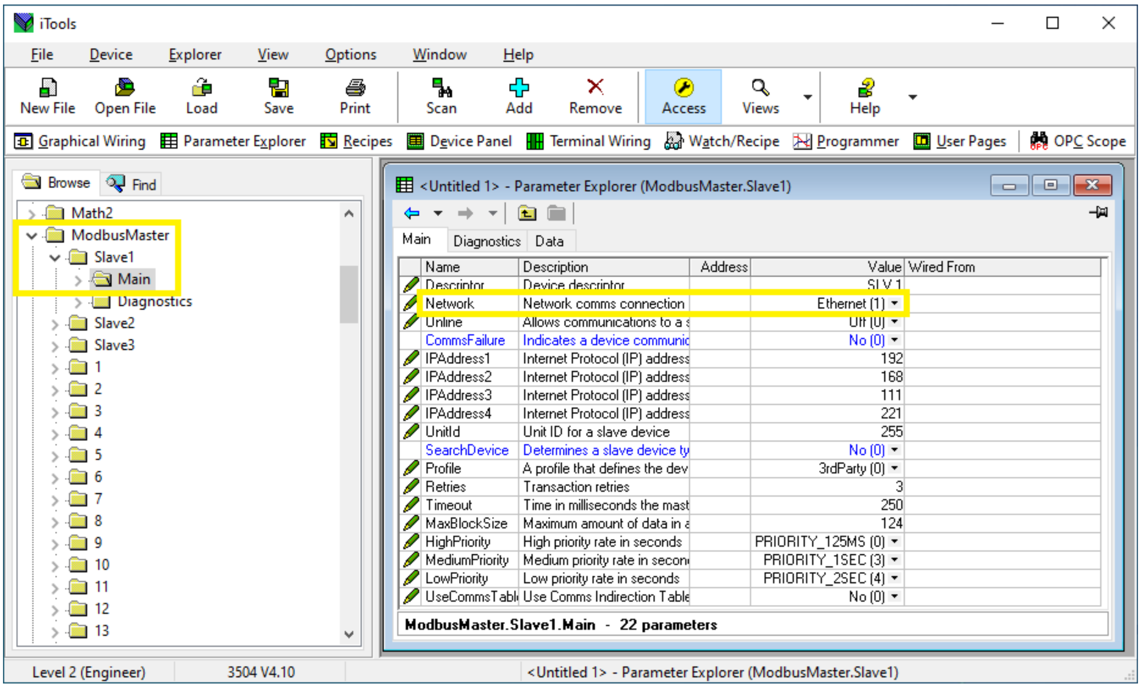
1. Server profiles are supported for some Eurotherm controllers. This simplifies the configuration and minimizes the need to know detailed data information, for example the MODBUS address, data type and resolution for frequently used parameters.
2. The Network configuration of the MODBUS TCP Client is the same as the MODBUS TCP Server and can be found in Comms.Option.Network. Confirm that the IP address and subnet mask are configured correctly to be able to communicate with MODBUS Server devices within the subnet. If the Server device is outside the subnet then the Comms.Option.Network.DefaultGateway must be configured correctly.



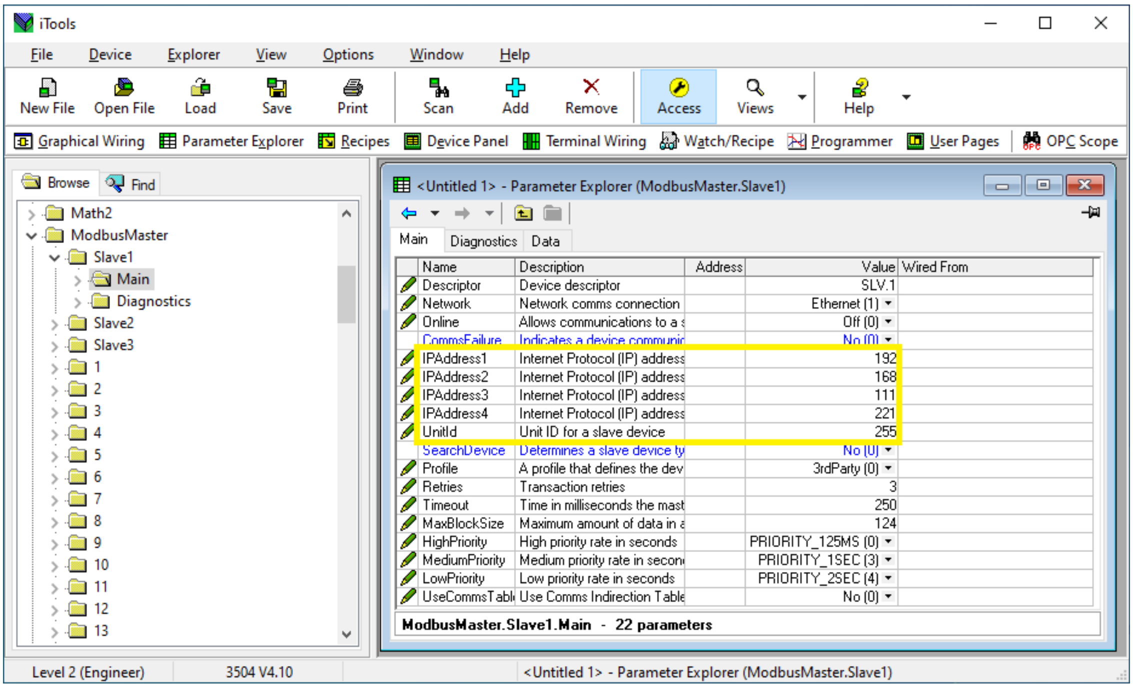
Configuring MODBUS Servers

To configure communications to MODBUS Servers, proceed as follows:

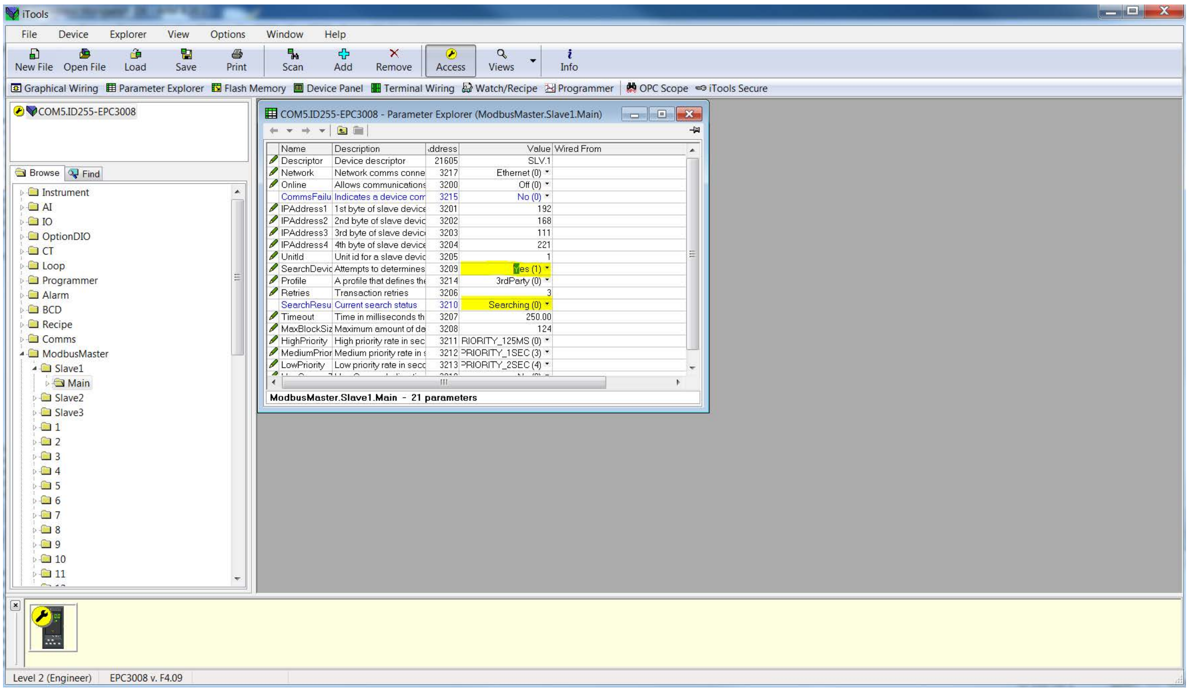
1. From iTools, place the instrument in Config mode and open ModbusMaster>Slave1>Main to configure the first server. Make sure that the Network parameter is set to Ethernet(1) because we want to communicate to the server using the Option Comms Ethernet interface. It can also be Serial(2) if we want to communicate with a server through a serial interface.



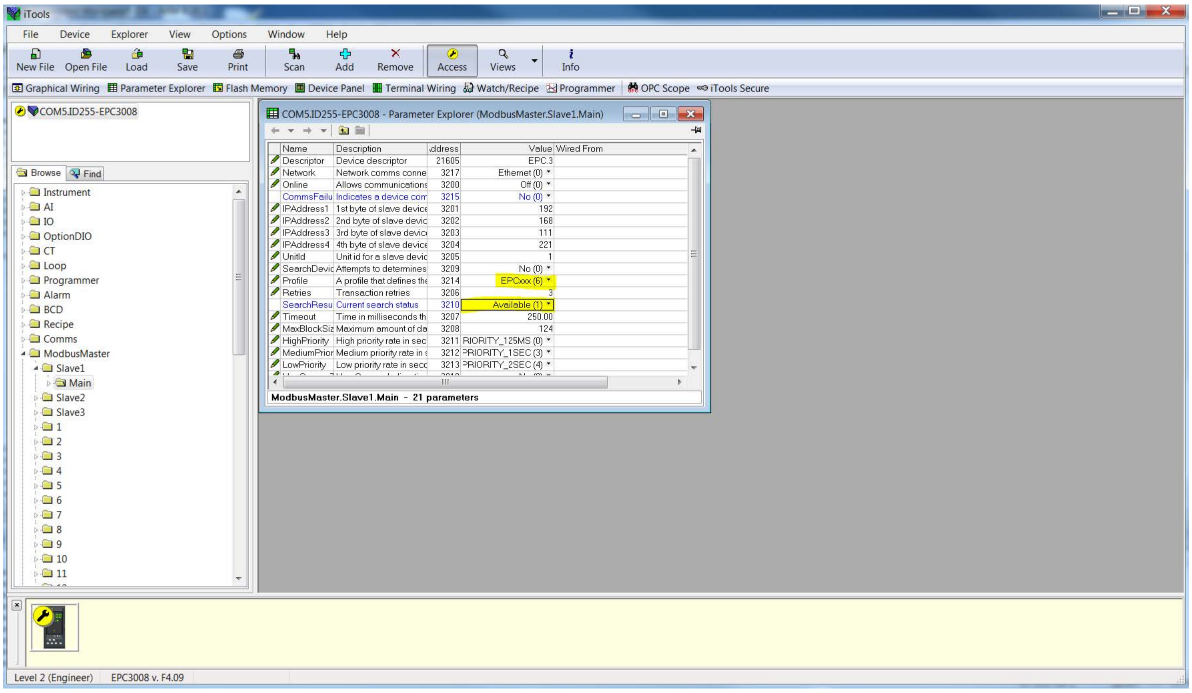
2. Configure the IP Address and unit ID.



3. You can now check if the device is online via the "Search device" parameter by setting its value to "Yes". The search status should change to "Searching(0)".

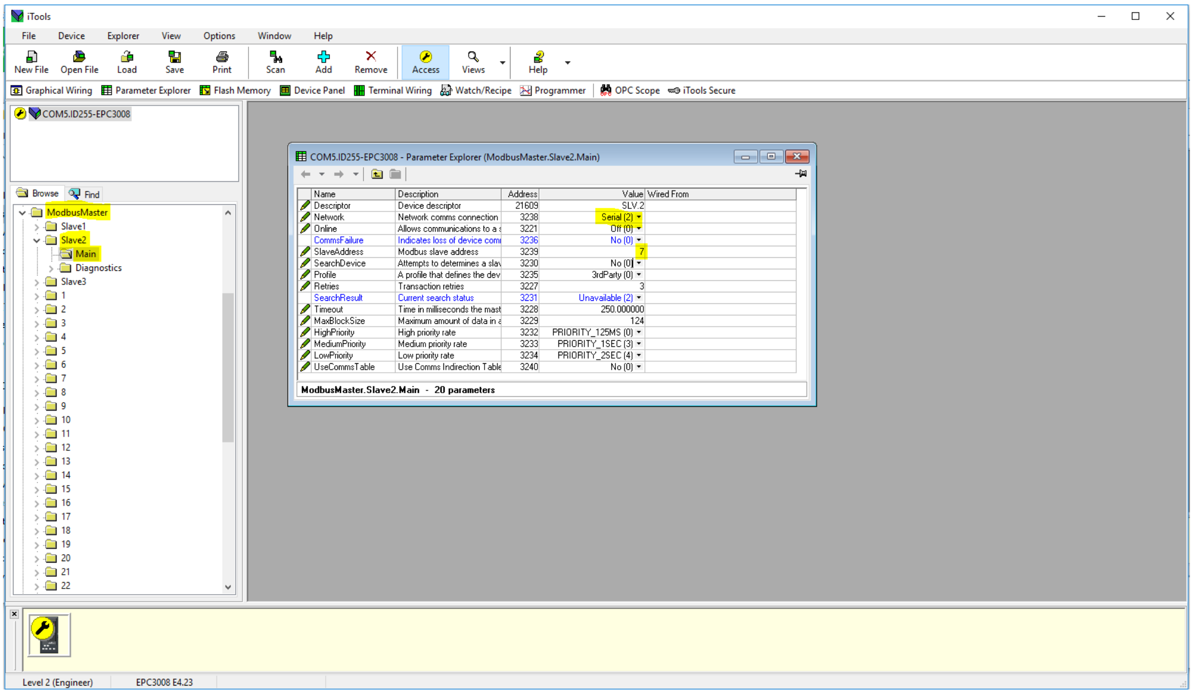


4. If the MODBUS server is online then the search result will be "Available(1)" otherwise the result will be "Unreachable(3). If it is a Eurotherm instrument with a supported profile, the "Profile" parameter will display the MODBUS server's profile otherwise it will display "3rdParty(0)".

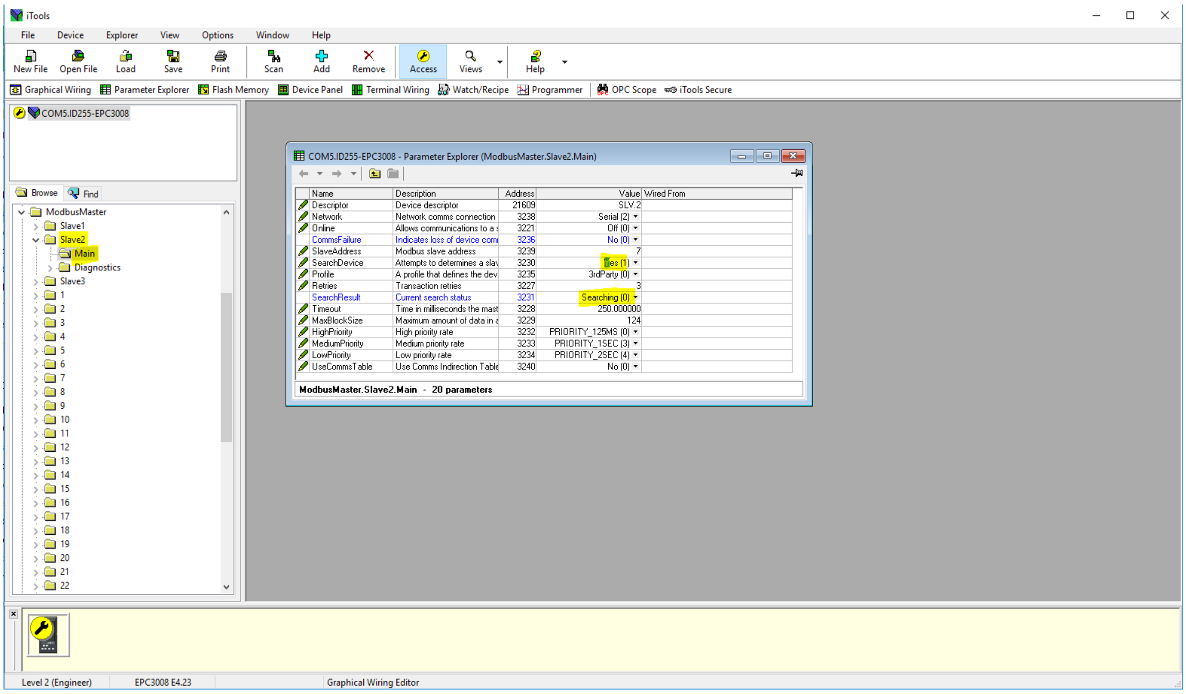


5. We will now configure a second server but this time using the Fixed comms serial interface making sure that we select “Serial(2)” enumeration for the Network parameter and set the correct MODBUS server address.

Note: Serial(2) can only be selected if Comms.Fixed.Main.Protocol is set to ModbusMaster(3).

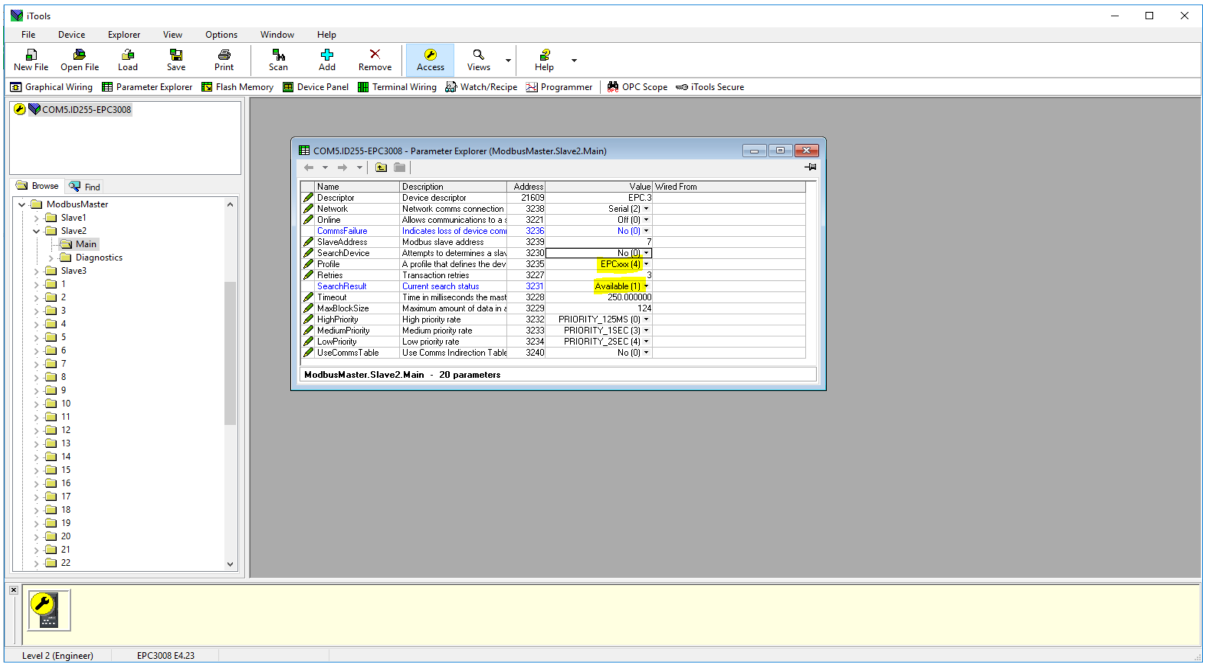


6. You can now check if the device is online via the “Search device” parameter by setting its value to “Yes”. The search status should change to “Searching(0)”.

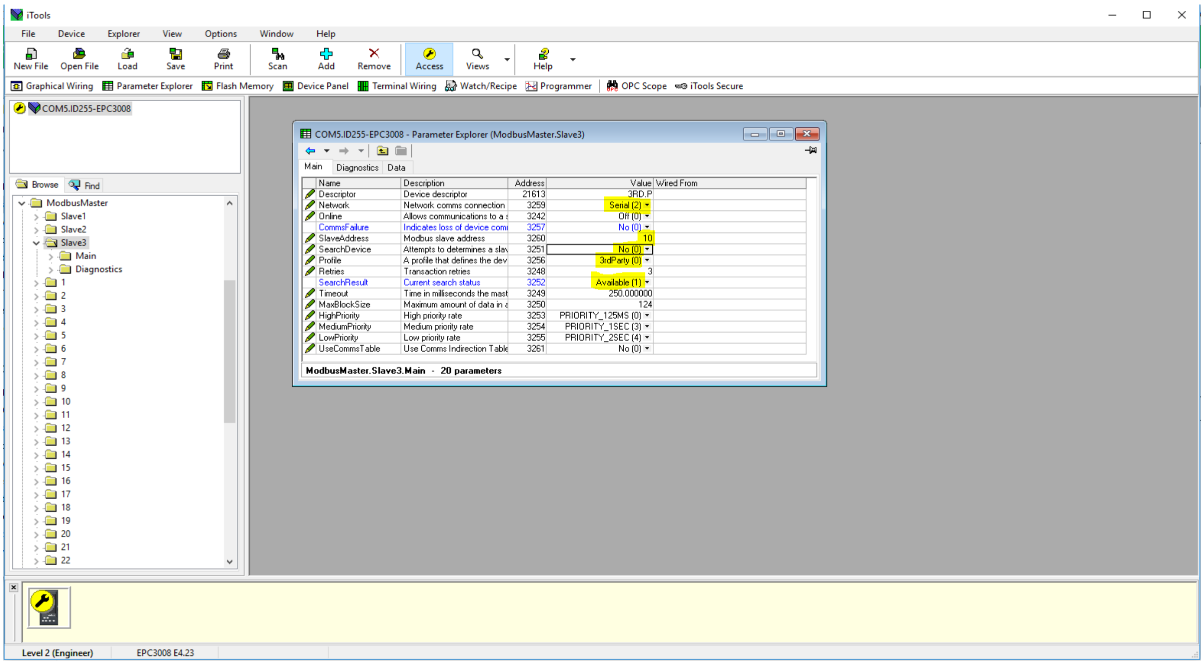


7. If the MODBUS server is online then the search result will be “Available(1)” otherwise the result will be “Unreachable(3). If it is a Eurotherm instrument with a supported profile, the “Profile” parameter will display the MODBUS server’s profile otherwise it will display “3rdParty(0)”.

Note: Changes to the server profile will default previous data configured to be read from or written to the server.



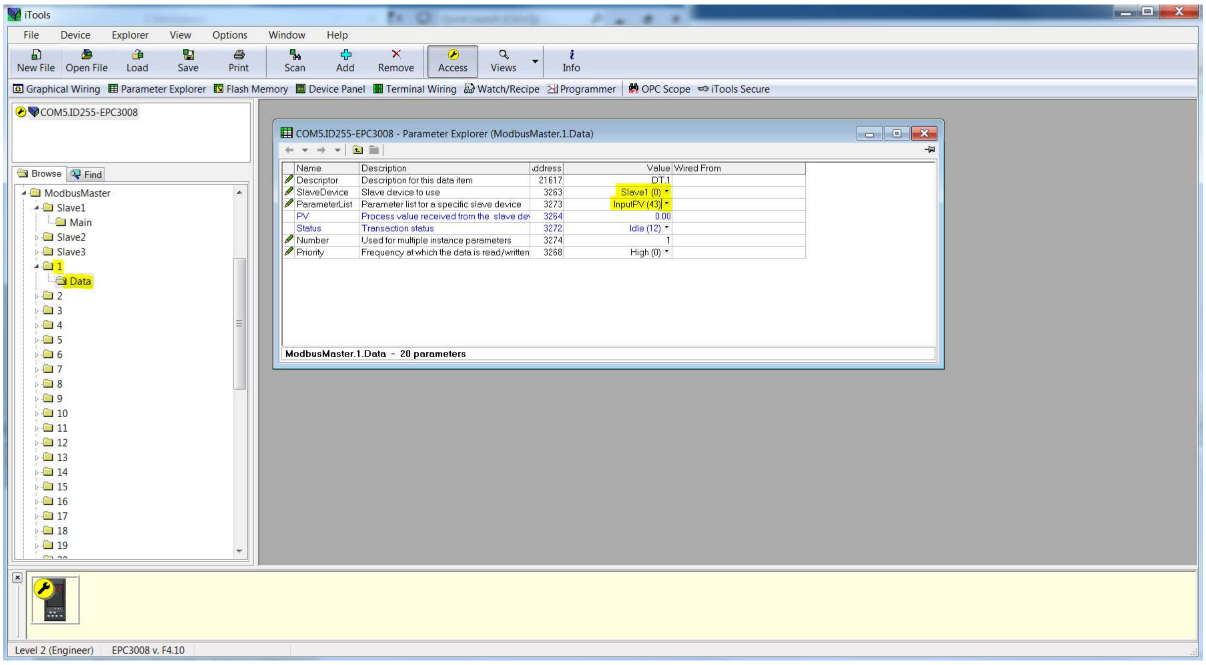
8. For the third server (ModbusMaster>Slave3>Main), we can configure a serial server with an unsupported profile by configuring the MODBUS server address and then starting “SearchDevice”.



Data Configuration for Cyclic Read/Writes

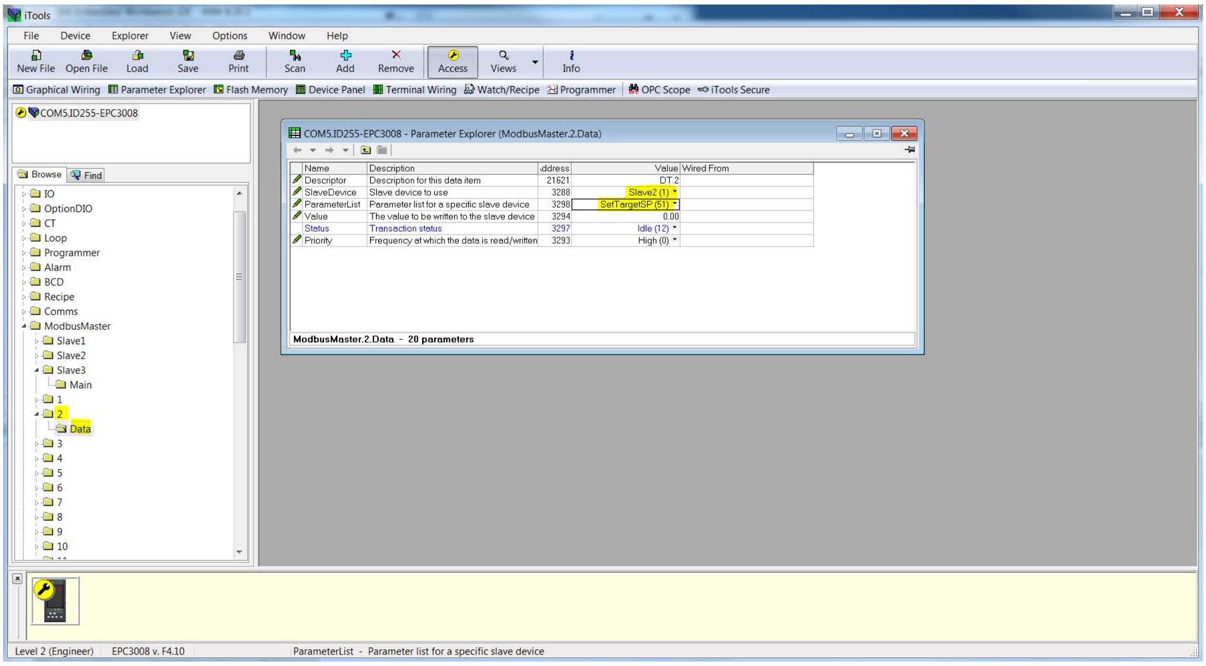
To configure data for cyclic read/writes:

1. A maximum of 32 data points can be configured. These data points can be shared among all three servers or it can be used for a single server.
2. For a server with a known profile, a data read can be configured by selecting the server and then select the required parameter from the Parameter list drop-down box. The register address, function code, data type and priority for the parameter will be automatically configured. You still have the option to change the recommended priority.

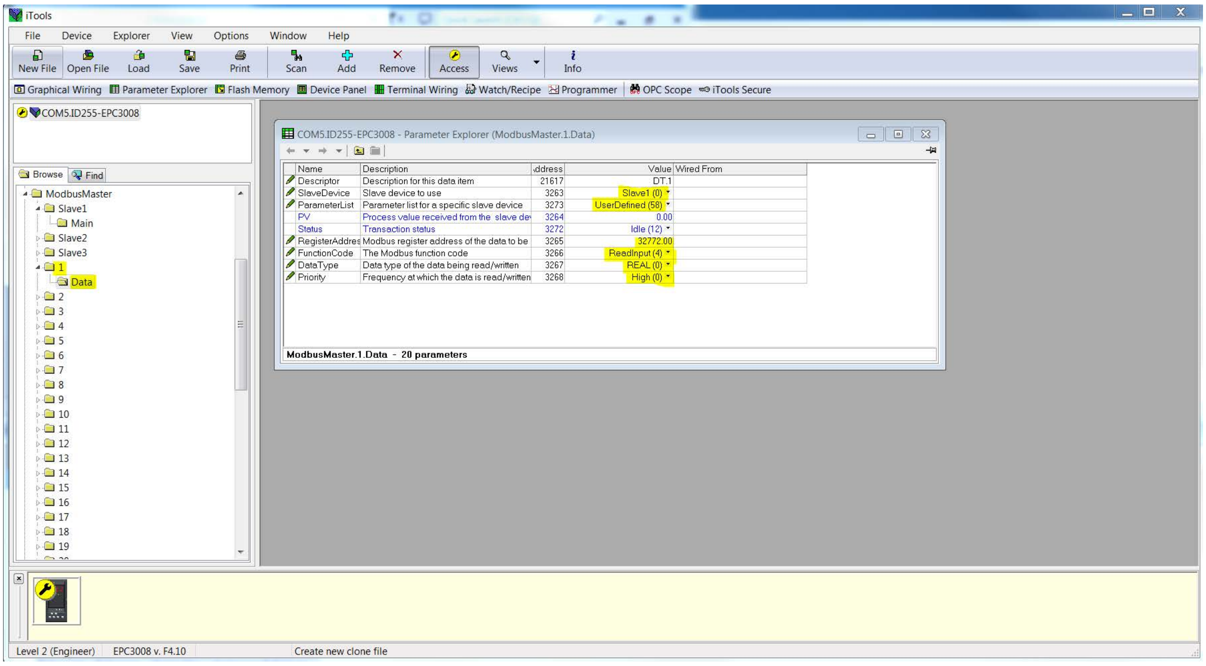


3. To configure a write for a known profile, select parameter to write from the Parameter List drop-down box.

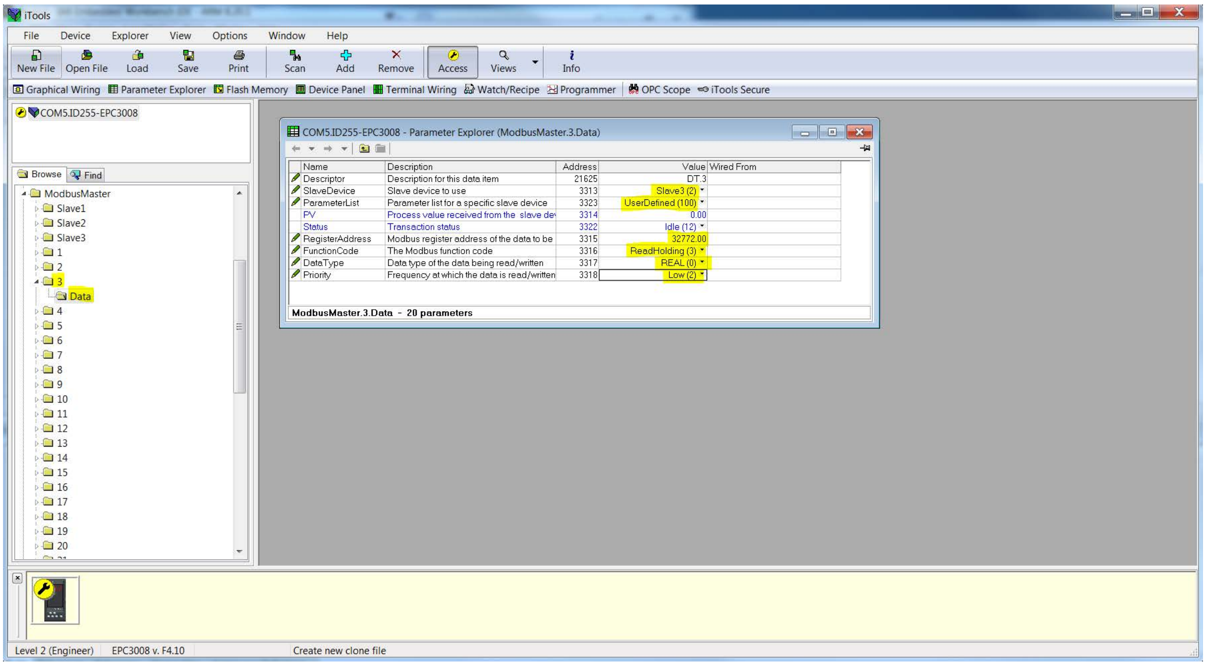
Note: The ‘Value’ parameter is usually wired from the source parameter of the values to be written to the server.



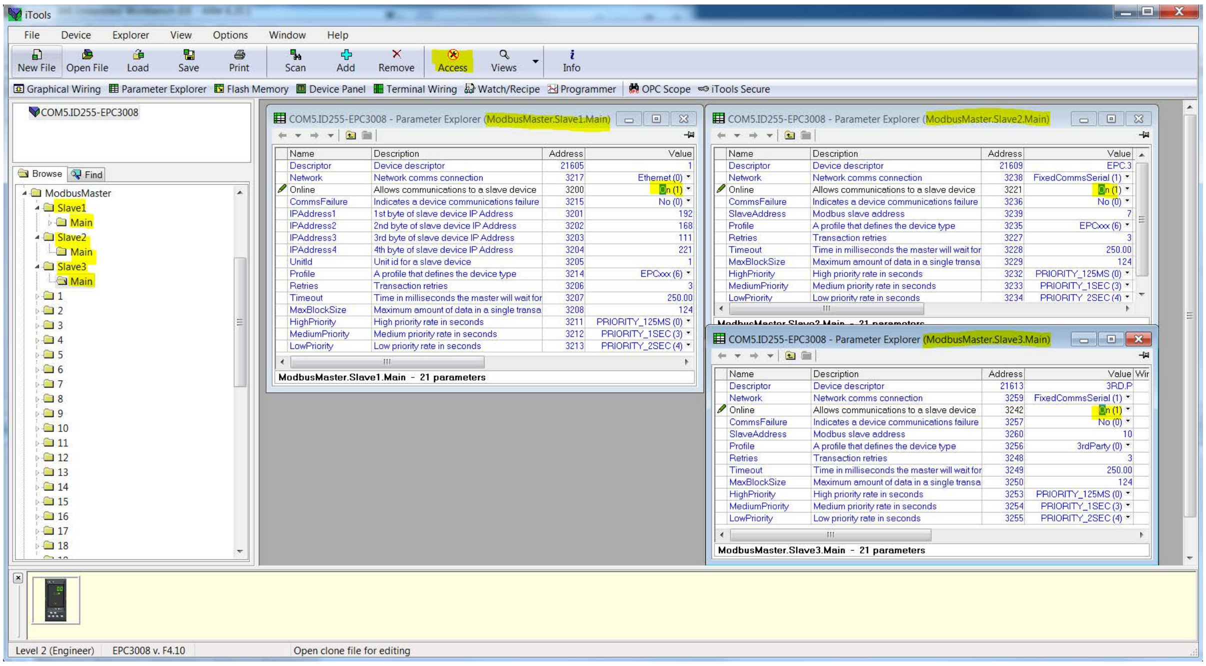
4. For a parameter that is not on the Parameter List. The data configuration has to be done manually. Select “UserDefined” from the Parameter List and configure the register address, function code, the data type and priority of data read/write.



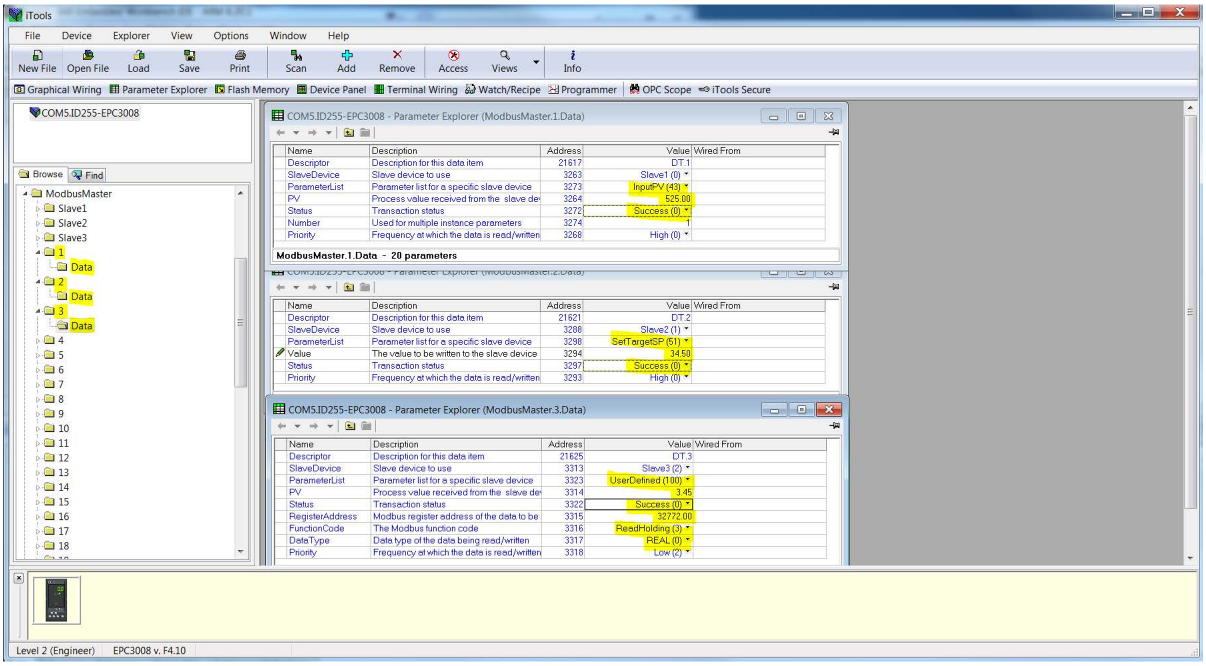
5. For a third party server (unsupported profile), select “UserDefined” from the Parameter List drop-down and configure the register address, function code, the data type and priority of data read/write.



6. To start cyclic communications to the servers. Take the MODBUS Client device out of Config mode and set the Online parameter for each of the servers.



7. The data read and write status should succeed if the wiring, comms configuration, server configuration and data configuration are correct. The PV read will be shown in the Data PV parameter.



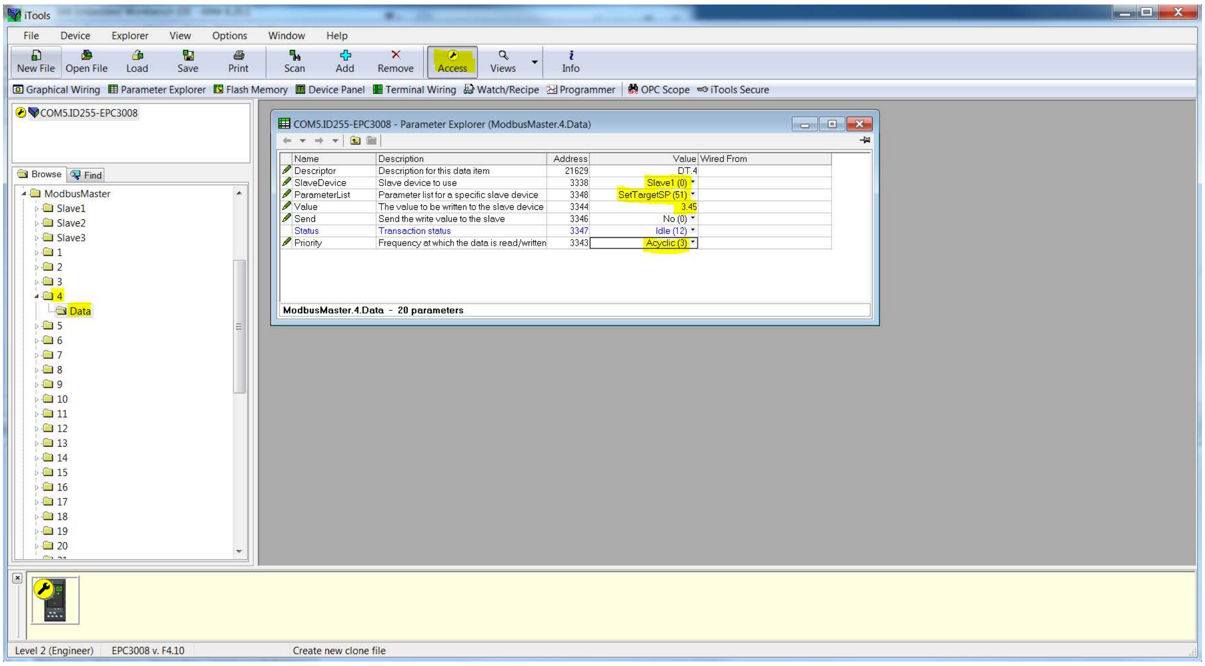
Data Configuration for Acyclic Data Writes

To configure data for Acyclic Data writes:

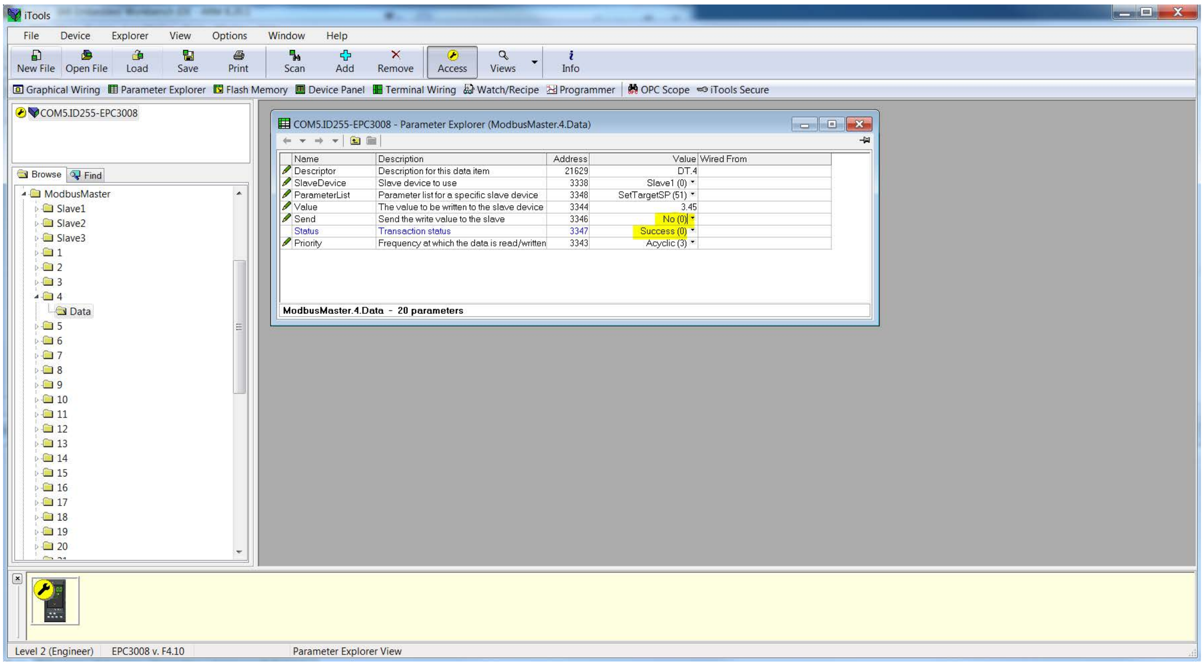
1. Place the MODBUS Client device in Configuration mode.

Note: Cyclic communications to all servers will stop in Configuration mode. We can only set the server online parameter in Operator mode.

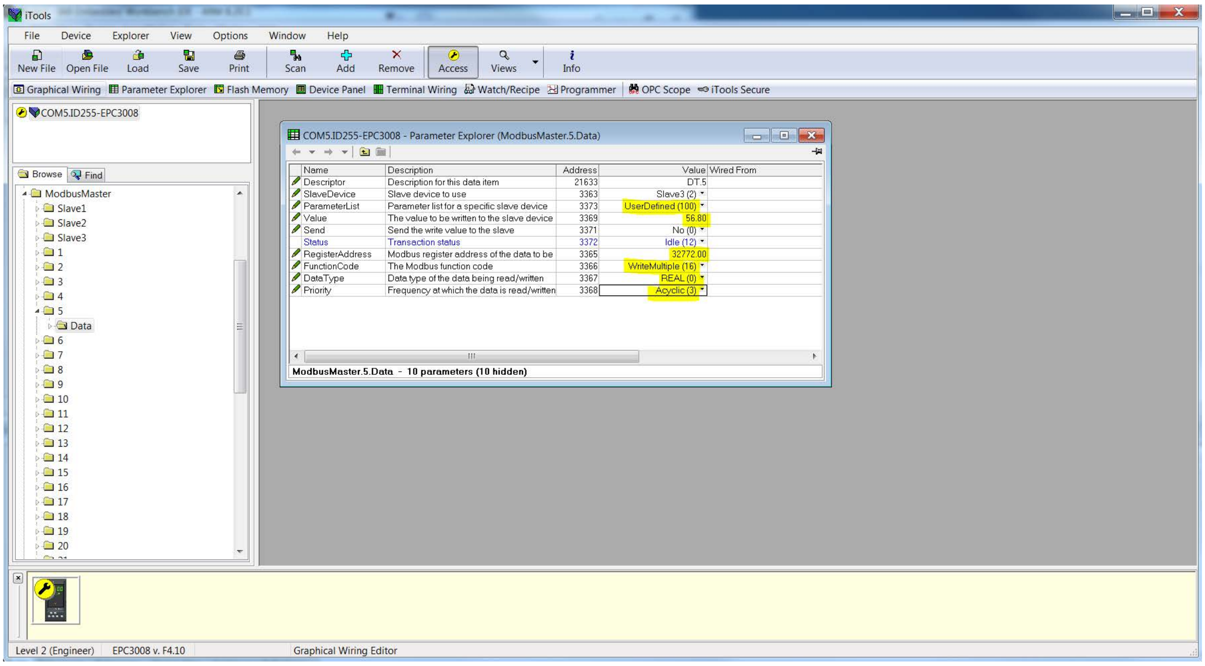
2. For a supported server profile select the server and parameter to write to as well as the value to write and then set the Priority to “Acyclic(3)”.



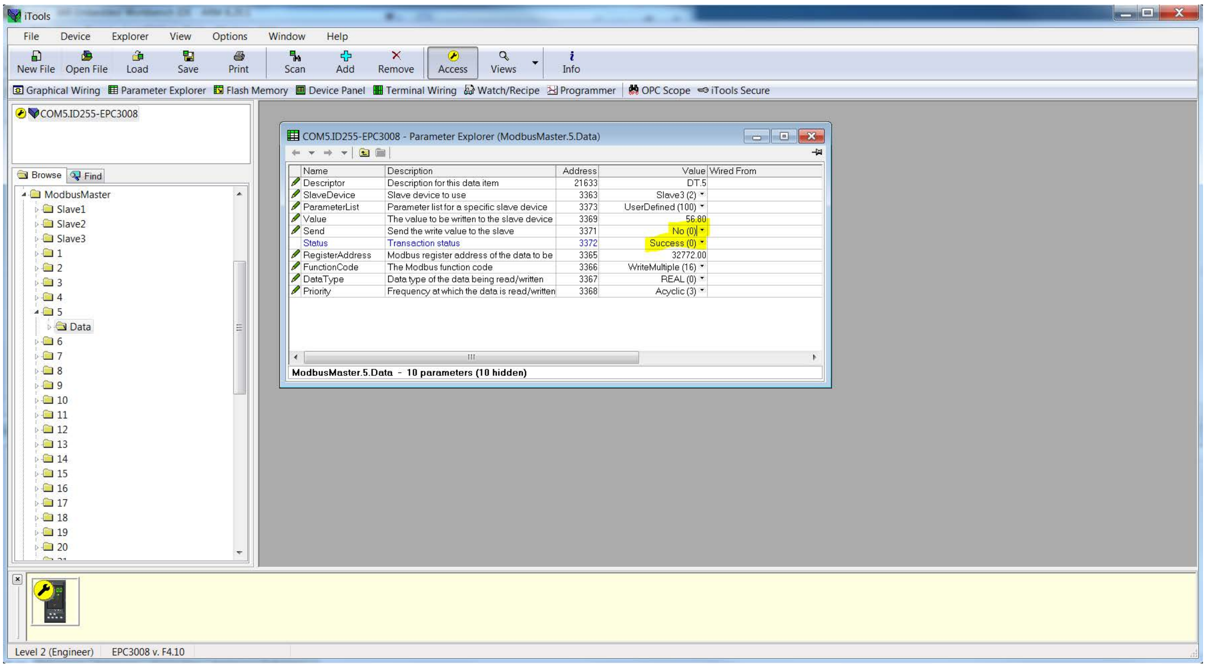
3. To send a write request, set the “Send” parameter. The Status will go to “Pending(13)” briefly before going to “Success” when the parameter has been written. If the write has failed then the Status will show the reason for the failure.



4. For an unsupported server profile (Third party) select the server, select "UserDefined" from the Parameter List drop-down and configure the register address, function code (must be a write), the data type, the value to write and then set the Priority to "Acyclic(3)".



5. To send a write request, set the "Send" parameter. The Status will go to "Pending(13)" briefly before going to "Success" when the parameter has been written. If the write has failed then the Status will show the reason for the failure.

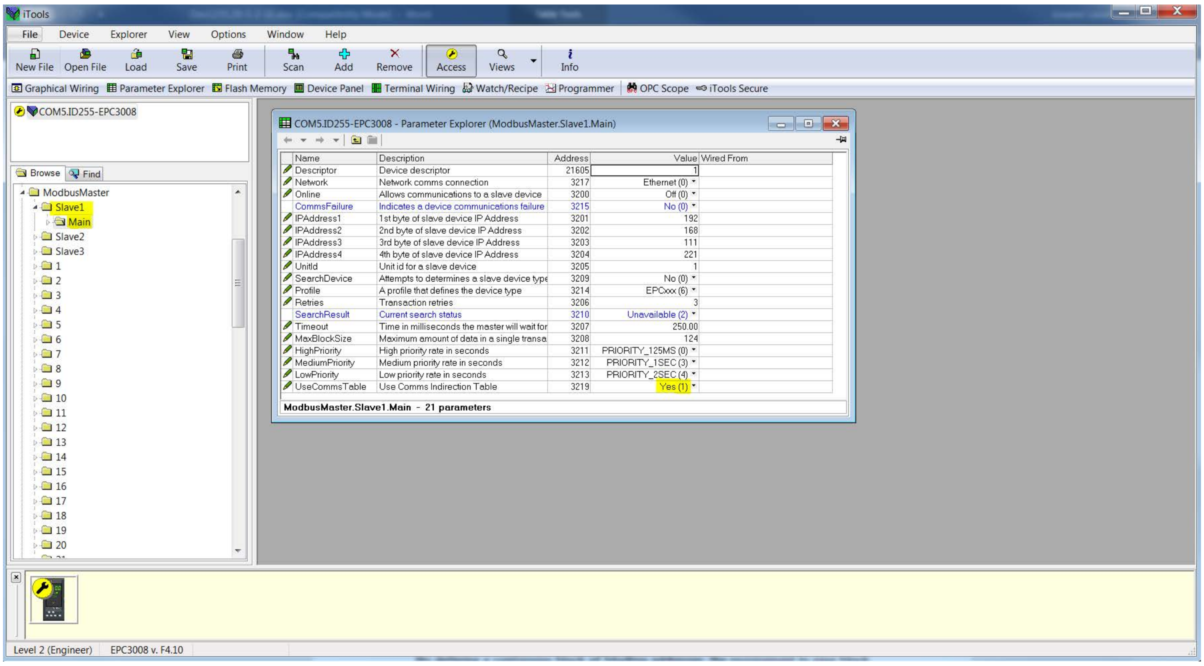


Accessing MODBUS Client Data from MODBUS Indirection Table

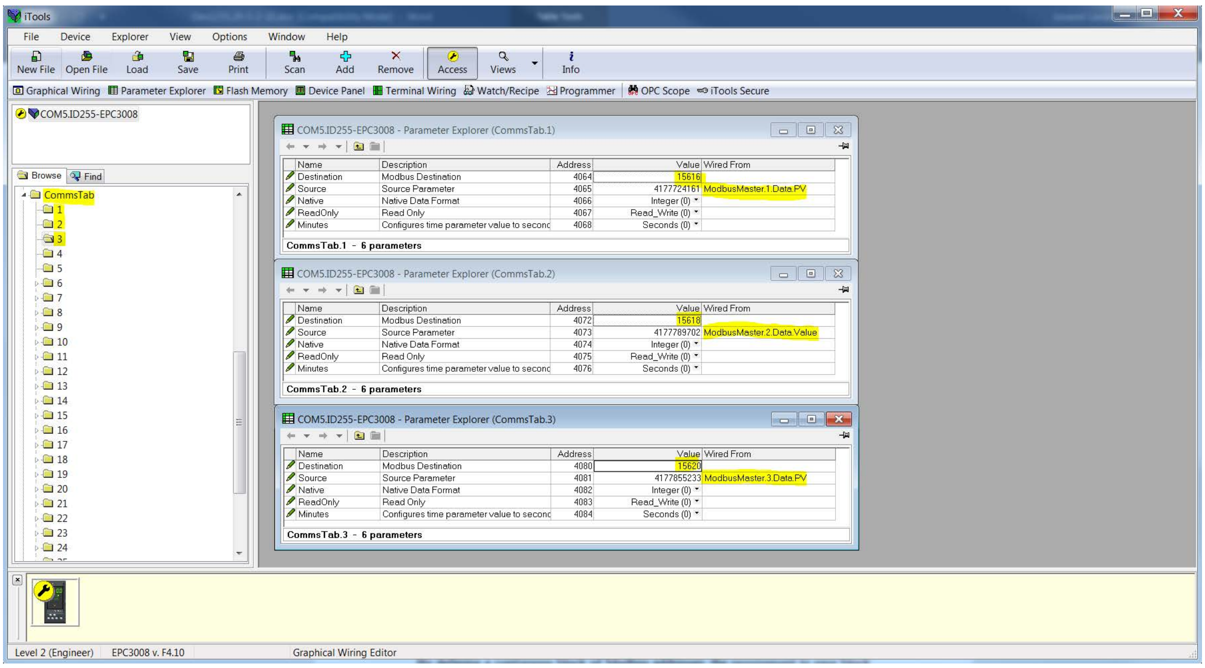
To allow efficient reads from and writes to MODBUS Client data, CommsTab Function Block can be used to map MODBUS Client data into a contiguous block of MODBUS addresses in the range:

15360(0x3C00 Hex) to 15615(0x3CFF Hex)

1. MODBUS Client data can be auto-configured to be accessible from the MODBUS Indirection table by placing the MODBUS Client device into Configuration mode and setting the UseCommsTable parameter from any one of the server configuration window and then taking the MODBUS Client device out of Configuration mode to initialize the CommsTab Function Block settings.

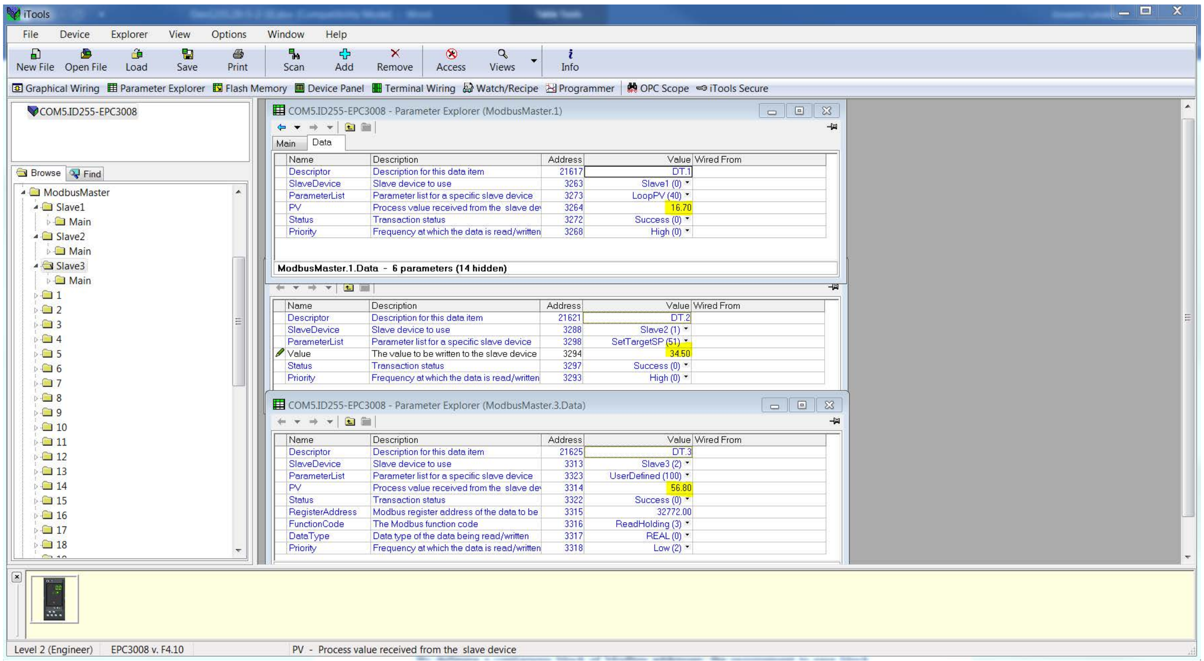


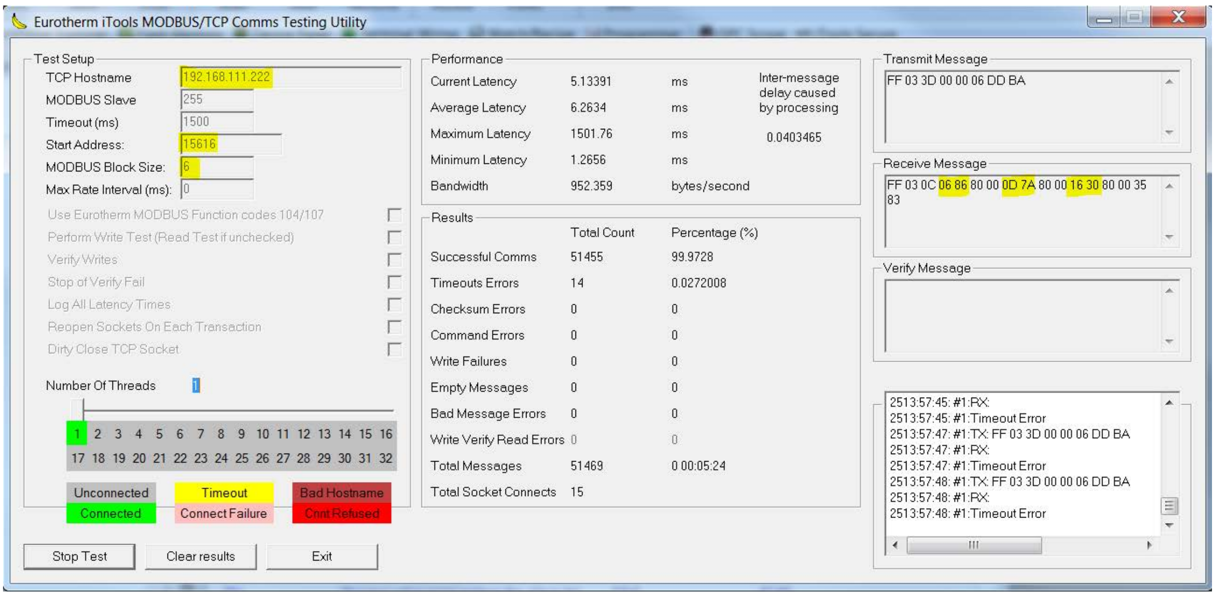
2. In Operator mode, the CommsTab Function Block should now show every configured MODBUS Client data. The user can then change Native, ReadOnly and Minutes parameters from default to configure how the data is presented from the MODBUS indirection table.



3. Screenshots below show MODBUS Client data auto-configured to appear at the MODBUS Indirection table and the values read by a 3rd party MODBUS Client from our MODBUS Client device:

Third party MODBUS TCP Client read data (Hex)	MODBUS Client device data (Decimal)
0686 (Hex)	16.70
0D7A (Hex)	34.50
1630 (Hex)	56.80





Note: There are 32 parameters available for configuration in the CommsTab Function Block, one for each MODBUS Client data. It is left to the user to partition the MODBUS Indirection table for reads and writes for efficient data access.

Packbit

Packbit consists of four blocks. Each block allows 16 individual bits to be packed into a 16 bit integer.

Packbit Parameters

List Header - packbit		Sub-header: 1, 2, 3, 4			
Name Press ⟳ to select parameters	**Parameter Description**	**Value and Description** Press ▽ or △ to change values		**Default**	**Access Level**
In1 to In16	Input bit 1 to Input bit 16. All values less than 0.5 will be treated as FALSE; all other values will be treated as TRUE.	Full float range		0	R/W in L3 and conf.
Output	Output The inputs are mapped to corresponding bits within the Output such that In1 goes to bit0, In2 to bit1 - In16 goes to bit 15			0	R/O
Status	The block Status parameter reflects the status of the Output parameter: if any Input is BAD, this Status will be set according to the Fallback Type.	Good (0) - Normal Operation Channel Off (1) - Channel is configured to be off Over Range (2) - Input signal is greater than configured high limit Under Range (3) - Input signal is less than configured low limit Hardware Status Invalid (4) - Input hardware status invalid Ranging (5) - Input hardware is being ranged i.e. being set-up as required by the range configuration Overflow (6) - Process variable overflow, possibly due to calculation attempting to add a small number to a relatively large number Bad (7) - The process variable is not ok and cannot be relied upon Hardware exceeded (8) - The hardware capabilities have been exceeded at the point of configuration, for example configuration set to 0 to 40V when input hardware is capable of up to 12V No Data (9) - Insufficient input samples to perform calculation No Calibration (13) - Calibration data is corrupt or missing Saturated input (14) - Input hardware is in saturation. This can occur if PV input, CJC input or RTD lead compensation input is outside the working range of the hardware.			R/O
Fall Type	Fallback Type The Output status (and Status parameter) if one of the inputs is bad.	FallGood	If any Input status is BAD, set the Output status (and Status parameter) GOOD and set the Output value as set by the FallBack parameter.		R/O R/W in Conf.
		FallBad	If any Input status is BAD, set the Output status (and Status parameter) BAD and set the Output value as set by the FallBack parameter.		
Fallback	Fallback value The value applied to the Output parameter when any Input is BAD	0 to 65535		0	R/O

Unpackbit

Unpackbit consists of four blocks. Unpackbit is the opposite of packbit and allows a 16 bit integer to be unpacked into 16 individual bits.

Unpackbit Parameters

List Header - unpackbit		Sub-header: 1, 2, 3, 4			
Name Press to select parameters	**Parameter Description**	**Value and Description** Press or to change values		**Default**	**Access Level**
Input	Input. The Input bit positions are unpacked to the outputs as follows: Bit 0 to Out1, Bit1 to Out2...Bit 15 to Out16			0	R/O
Out1 to Out 16	Output 1 to Output 16	Off On		0	R/O
Status	Block Status parameter: if any Input is BAD, this Status will set according to the Fallback Type.	Good (0) - Normal Operation Channel Off (1) - Channel is configured to be off Over Range (2) - Input signal is greater than configured high limit Under Range (3) - Input signal is less than configured low limit Hardware Status Invalid (4) - Input hardware status invalid Ranging (5) - Input hardware is being ranged i.e. being set-up as required by the range configuration Overflow (6) - Process variable overflow, possibly due to calculation attempting to add a small number to a relatively large number Bad (7) - The process variable is not ok and cannot be relied upon Hardware exceeded (8) - The hardware capabilities have been exceeded at the point of configuration, for example configuration set to 0 to 40V when input hardware is capable of up to 12V No Data (9) - Insufficient input samples to perform calculation No Calibration (13) - Calibration data is corrupt or missing Saturated input (14) - Input hardware is in saturation. This can occur if PV input, CJC input or RTD lead compensation input is outside the working range of the hardware			R/O
Fall Type	Fallback Type The Status value if the Input is BAD or out of range.	FallGood	If the Input status is BAD or the value is out of range, set the Status parameter GOOD and set the Output values as though the FallBack value was present on the Input.		R/O
		FallBad	If the Input status is BAD or the value is out of range, set the Status parameter BAD and set the Output values as though the FallBack value was present on the Input.		
Fallback	Fallback value If the Input is BAD or out of range, this value is applied to drive the Outputs as though it was present on the Input.			0	R/O

Counters, Timers, Totalizers

A series of function blocks are available which are based on time/date information. These may be used as part of the control process.

Counters

Up to two counters are available. They provide a synchronous edge triggered event counter.

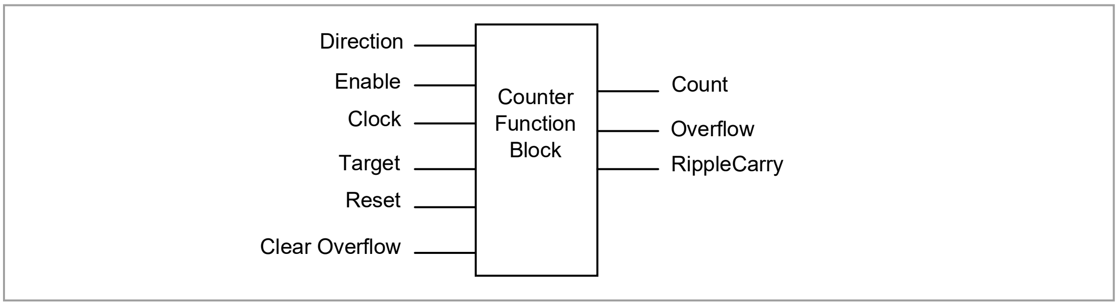


Figure 43: Counter Function Block

When configured as an Up counter, Clock events increment Count until reaching the Target. On reaching Target, RippleCarry is set true. At the next clock pulse, Count returns to zero. Overflow is latched true and RippleCarry is returned false.

When configured as a down counter, Clock events decrement Count until it reaches zero. On reaching zero, RippleCarry is set true. At the next clock pulse, Count returns to the Target count. Overflow is latched true and RippleCarry is reset false

Counter blocks can be cascaded as shown in the diagram below

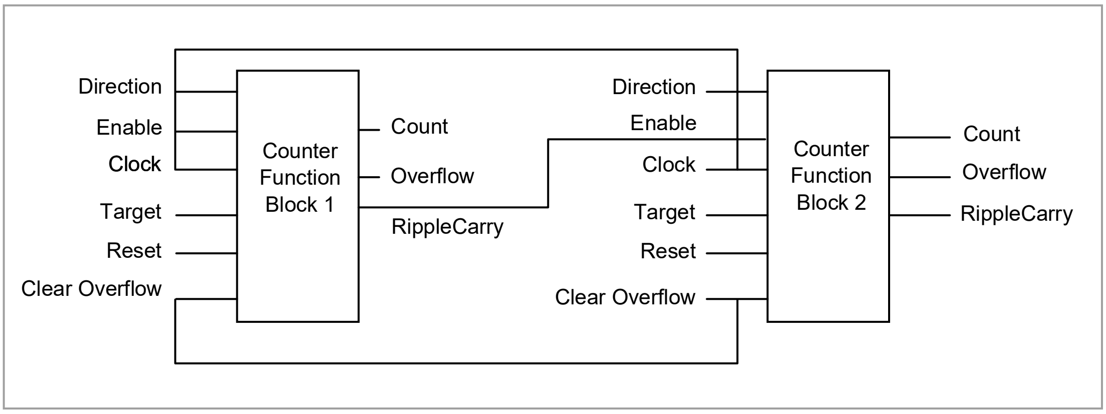


Figure 44: : Cascading Counters

The RippleCarry output of one counter acts as an enabling input for the next counter. In this respect the next counter in sequence can only detect a clock edge if it was enabled on the previous clock edge. This means that the Carry output from a counter must lead its Overflow output by one clock cycle. The Carry output is, therefore, called a RippleCarry as it is NOT generated on an Overflow (i.e. Count > Target) but rather when the count reaches the target (i.e. Count = Target). The timing diagram below illustrates the principle for the Up Counter.

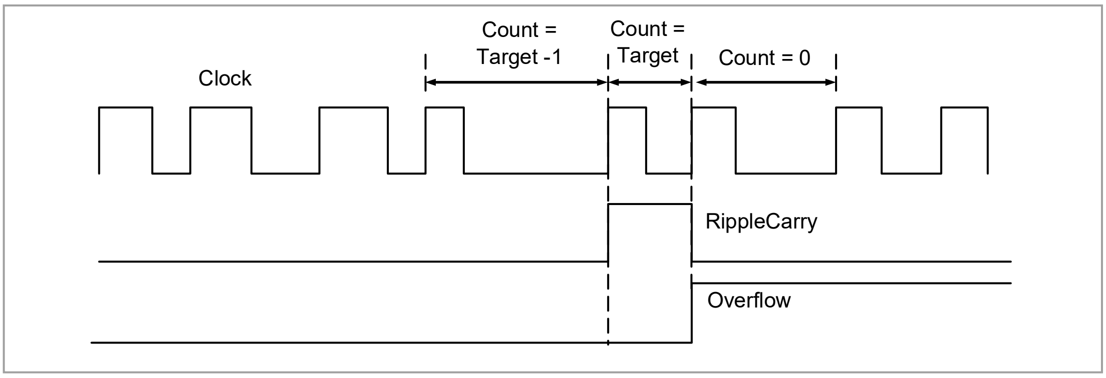


Figure 45: : Timing Diagram for an Up Counter

Counter Parameters

List Header - Count		Sub-headers: 1 to 2			
Name (select button) to select	**Parameter Description**	**Value** Press (down) or (up) to change values		**Default**	**Access Level**
Enable	Counter enable. Counter 1 or 2 is enabled in the Instrument configuration page but they can also be turned on or off in this list	Yes No	Enabled Disabled	Yes	L3
Direction	Defines count up or count down. This is not intended for dynamic operation (i.e. subject to change during counting). It can only be set in configuration level.	Up Down	Up counter Down counter	Up	L3
Ripple Carry	Ripple carry to act as an enabling input to the next counter. It is turned On when the counter reaches the target set	Off On			R/O
Overflow	Overflow flag is held true (Yes) when the counter reaches zero (Down) or passes target (Up)	No Yes			R/O
Clock	Tick period to increment or decrement the count. This is normally wired to an input source such as a digital input.	0 1	No clock input Clock input present	0	R/O if wired
Target	Level to which the counter is aiming	0 to 99999			L3
Count	Counts each time a clock input occurs until the target is reached.	0 to 99999			R/O
Reset	Resets the counter	No Yes	Not in reset Reset	No	L3
Clear O'flow	Clear overflow	No Yes	Not cleared Cleared	No	L3

Timers

Up to four timers can be configured. Each one can be configured to a different type and can operate independently of one another.

Timer Types

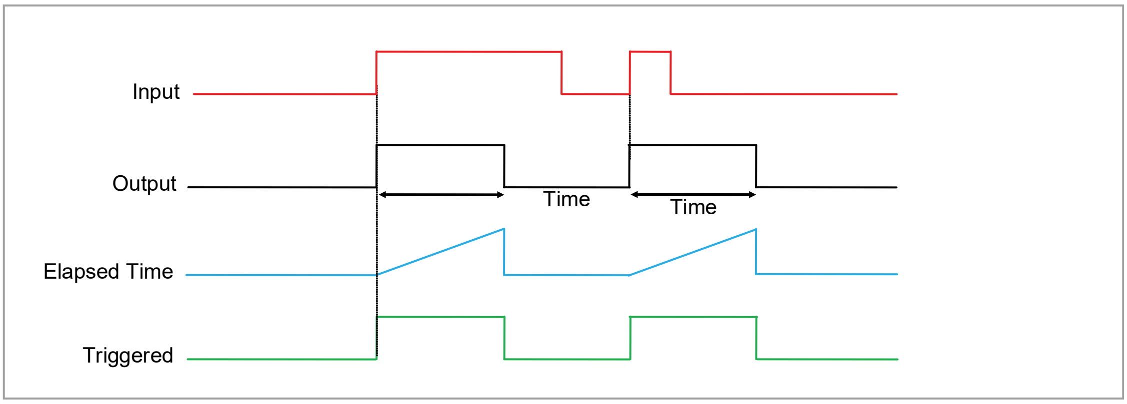
Each timer block can be configured to operate in four different modes. These modes are explained below

On Pulse Timer Mode

This timer is used to generate a fixed length pulse from an edge trigger.

- The output is set to On when the input changes from Off to On.
- The output remains On until the time has elapsed
- If the 'Trigger' input parameter recurs while the Output is On, the Elapsed Time will reset to zero and the Output will remain On
- The triggered variable will follow the state of the output

The diagram illustrates the behaviour of the timer under different input conditions.



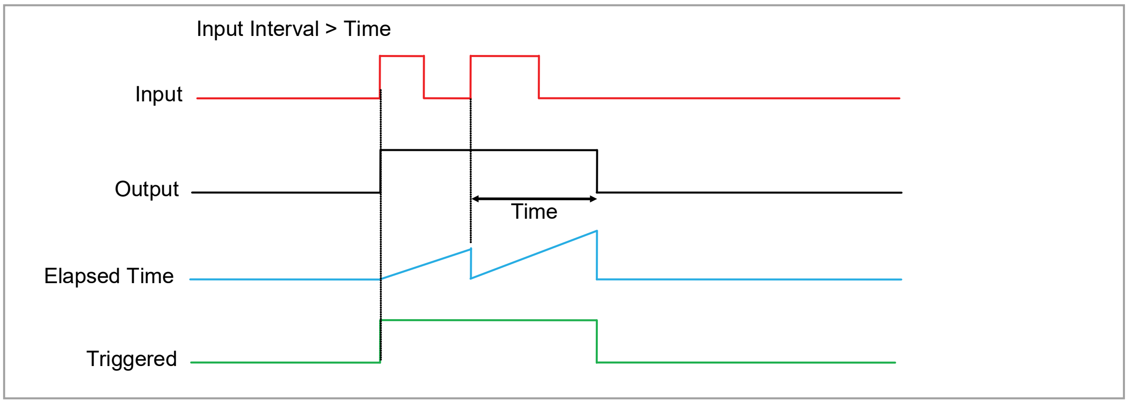


Figure 46: On Pulse Timer Under Different Input Conditions

On Delay Timer Mode

This timer provides a delay between the trigger event and the Timer output.

- The *Output* is OFF when the *Input* is OFF or has been On for less than the delay time
- The elapsed time will increment only when the *Input* is ON and will reset to 0 when the *Input* goes OFF.
- With the Input ON and once the *Time* has elapsed, the *Output* will be set to ON
- The *Output* will remain On until the *Input* is cleared to Off.
- The *Triggered* variable will follow the *Input*

The following diagrams illustrates the behaviour of the timer under different Input conditions.

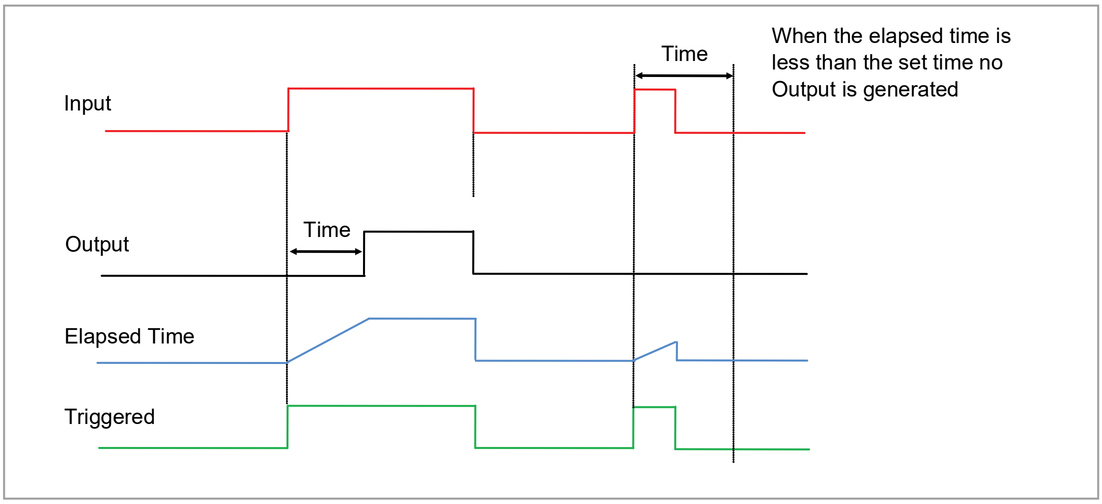


Figure 47: On Delay Timer Under Different Input Conditions

This type of timer is used to ensure that the output is not set unless the input has been valid for a pre-determined period of time, thus acting as a kind of input filter.

One Shot Timer Mode

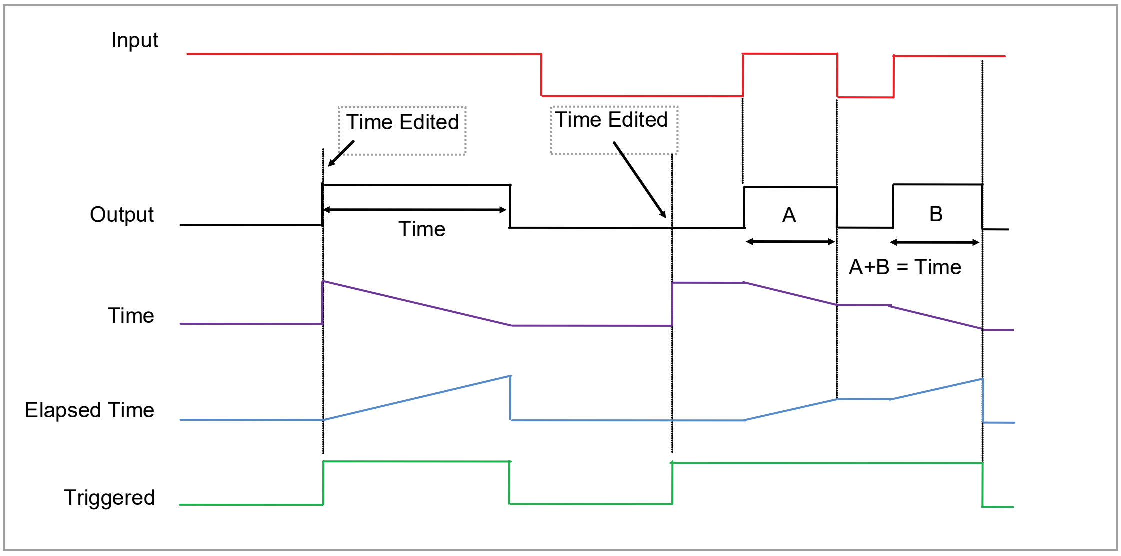
This timer behaves like a simple oven timer.

- When the Time is edited to a non-zero value the Output is set to On
- The Time value is decremented until it reaches zero. The Output is then cleared to Off
- The Time value can be edited at any point to increase or decrease the duration of the On time
- Once set to zero, the Time is not reset to a previous value, it must be edited by the operator to start the next On-Time
- The Input is used to gate the Output. If the Input is set, the time will count down to zero. If the Input is cleared to Off, then the Time will hold and the Output will switch Off until the Input is next set.

NOTICE
Since the Input is a digital wire, it is possible for the operator to NOT wire it, and set the Input value to On which permanently enables the timer.

- The Triggered variable will be set to On as soon as the Time is edited. It will reset when the Output is cleared to Off.

The behaviour of the timer under different input conditions is shown below.



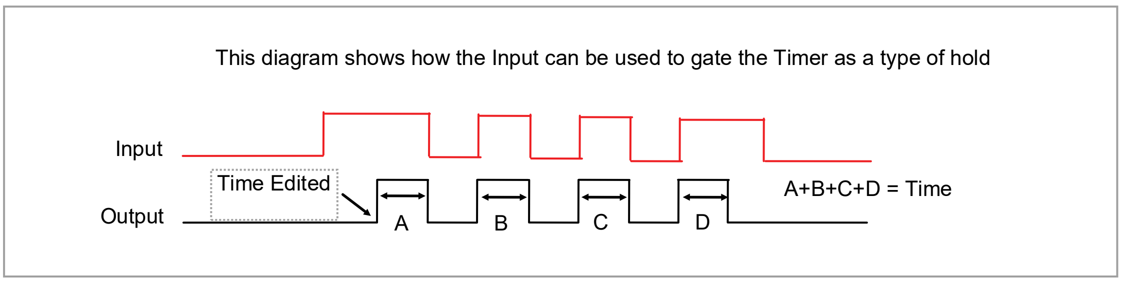


Figure 48: : One Shot Timer

Compressor or Minimum On Timer Mode

This type of timer may also be known as an ‘Off Delay’ function where the output goes ‘on’ when the input goes active and remains on for a specified period after the input goes inactive.

It may be used, for example, to ensure that a compressor is not cycled excessively.

- The output will be set to On when the Input changes from Off to On.
- When the Input changes from On to Off, the elapsed time will start incrementing towards the set Time.
- The Output will remain On until the elapsed time has reached the set Time. The Output will then switch Off.
- If the Input signal returns to On while the Output is On, the elapsed time will reset to 0, ready to begin incrementing when the Input switches Off.
- The Triggered variable will be set while the elapsed time is >0. It will indicate that the timer is counting.

The diagram illustrates the behaviour of the timer under different input conditions.

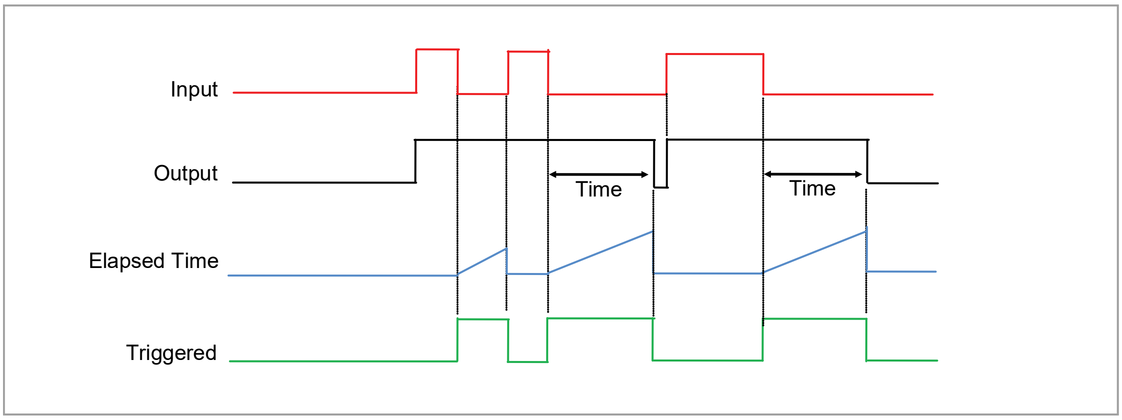


Figure 49: Minimum On Timer Under Different Input Conditions

Timer Parameters

List Header - Timer		Sub-headers: 1 to 4			
Name ⟳ to select	Parameter Description	Value Press ▼ or ▲ to change values		Default	Access Level
Type	Timer type	Off	Timer not configured	Off or as ordered	Conf
		On Pulse	Generates a fixed length pulse from an edge trigger		
		On Delay	Provides a delay between input trigger event and timer output		
		One Shot	Simple oven timer which reduces to zero before switching off		
		Min-On	Compressor timer guaranteeing that the output remains ON for a time after the input signal has been removed		
Time	Duration of the timer. For re-trigger timers this value is entered once and copied to the time remaining parameter whenever the timer starts. For pulse timers the time value itself is decremented.	0:00.0 to 99:59:59			L3
Elapsed Time	Timer elapsed time	0:00.0 to 99:59:59			R/O L3
Input	Trigger/Gate input. Turn On to start timing	Off On	Off Start timing	Off	L3
Output	Timer output	Off On	Output off Timer has timed out		L3
Triggered	Timer triggered (timing). This is a status output to indicate that the timers input has been detected	Off On	Not timing Timer timing		R/O L3

The above table is repeated for Timers 2 to 4.

Totalizers

A totalizer is an electronic integrator, primarily used to record the numeric total over time of a measured value that is expressed as a rate. For example, the number of litres (since reset), based on a flow rate in litres per minute.

There are two totalizer function blocks in 3500 controllers. A totalizer can, by soft wiring, be connected to any measured value. The outputs from the totalizer are its integrated value and an alarm state. The user may set a setpoint which causes the alarm to activate once the integration exceeds the setpoint.

The totalizer has the following attributes:

1. Run/Hold/Reset

In Run the totalizer will integrate its input and continuously test against an alarm setpoint. The higher the value of the input the faster the integrator will run.

In Hold the totalizer will stop integrating its input but will continue to test for alarm conditions.

In Reset the totalizer will be zeroed, and alarms will be reset.

2. Alarm Setpoint

If the setpoint is a positive number, the alarm will activate when the total is greater than the setpoint.

If the setpoint is a negative number, the alarm will activate when the total is lower (more negative) than the setpoint.

If the totalizer alarm setpoint is set to 0.0, the alarm will be off. It will not detect values above or below.

The alarm output is a single state output. It may be cleared by resetting the totalizer, stopping the Run condition, or by changing the alarm setpoint.

3. The total is limited to a maximum of 99999 and a minimum of -99999.
4. The totalizer ensures that resolution is maintained when integrating small values onto a large total.

Totalizer Parameters

List Header - Total		Sub-headers: 1 to 2			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Total	The totalized value	99999 to -99999			R/O L3
In	The value to be totalized	-9999.9 to 9999.9. Note 1:.			L3
Units	Totalizer units	None AbsTemp V, mV, A, mA, PH, mmHg, psi, Bar, mBar, %RH, %, mmWG, inWG, inWW, Ohms, PSIG, %O2, PPM, %CO2, %CP, %/sec, RelTemp Vacuum sec, min, hrs,			Conf
Res'n	Totalizer resolution	XXXXX XXXX.X XXX.XX XX.XXX X.XXXX		XXXXX	Conf
Alarm SP	Sets the totalized value at which an alarm will occur	-99999 to 99999			L3
Alarm OP	This is a read only value which indicates the alarm output On or Off. The totalized value can be a positive number or a negative number. If the number is positive the alarm occurs when Total > + Alarm Setpoint If the number is negative the alarm occurs when Total > - Alarm Setpoint	Off On	Alarm inactive Alarm output active	Off	L3
Run	Runs the totalizer	No Yes	Timer not running Select Yes to run the timer	No	L3
Hold	Holds the totalizer at its current value Note 2:	No Yes	Timer not in hold Hold timer	No	L3
Reset	Resets the totalizer	No Yes	Timer not in reset Timer in reset	No	L3

NOTICE

1. The totalizer stops accumulating if the input is 'Bad'.
2. The Run & Hold parameters are designed to be wired to (for example) digital inputs. Run must be 'on' and Hold must be 'off' for the totalizer to operate.

Application Specific

Humidity Control

Humidity (and altitude) control is a standard feature of the 3500 controller. In these applications the controller may be configured to generate a setpoint profile (see Setpoint Programmer).

Also the controller may be configured to measure humidity using either the traditional Wet/Dry bulb method or it may be interfaced to a solid state sensor.

The controller output may be configured to turn a refrigeration compressor on and off, operate a bypass valve, and possibly operate two stages of heating and/or cooling

Example of Humidity Controller Connections

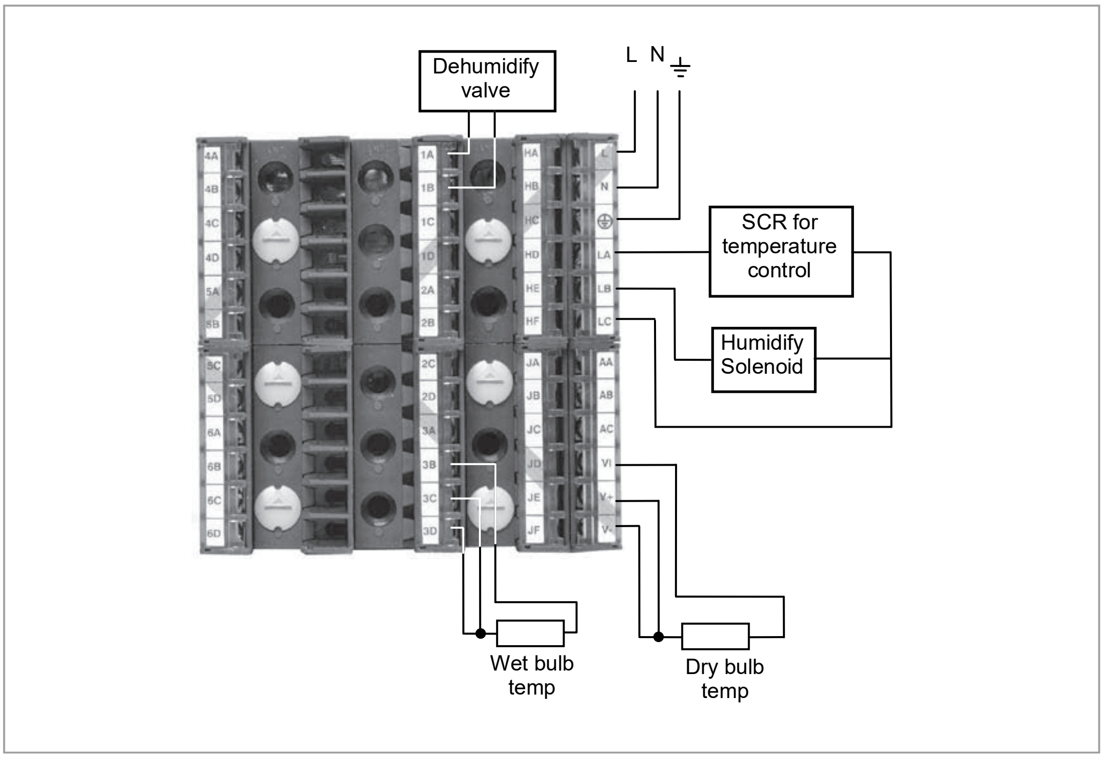


Figure 50: Example of Humidity Controller Connections

In the above example the following modules are fitted. This will change from installation to installation:

Module 1	Analogue or relay to drive dehumidify valve
Module 3	PV input module for wet bulb temperature RTD
Standard Digital I/O	Used as logic outputs for humidify solenoid valve and temperature control SCR
Standard PV Input	For the dry bulb RTD used for the temperature control and humidity calculation

Temperature Control of an Environmental Chamber

The temperature of an environmental chamber is controlled as a single loop with two control outputs. The heating output time proportions electric heaters, usually via a solid state relay. The cooling output operates a refrigerant valve which introduces cooling into the chamber. The controller automatically calculates when heating or cooling is required.

Humidity Control of an Environmental Chamber

Humidity in a chamber is controlled by adding or removing water vapour. Like the temperature control loop two control outputs are required, i.e. Humidify and Dehumidify.

To humidify the chamber water vapour may be added by a boiler, an evaporating pan or by direct injection of atomised water.

If a boiler is being used adding steam increases the humidity level. The humidify output from the controller regulates the amount of steam from the boiler that is allowed into the chamber.

An evaporating pan is a pan of water warmed by a heater. The humidify output from the controller humidity regulates the temperature of the water.

An atomisation system uses compressed air to spray water vapour directly into the chamber. The humidify output of the controller turns on or off a solenoid valve.

Dehumidification may be accomplished by using the same compressor used for cooling the chamber. The dehumidify output from the controller may control a separate control valve connected to a set of heat exchanger coils.

Humidity Parameters

List Header - Humidity		Sub-headers: None			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Res'n	Resolution of the relative humidity	XXXXX XXXX.X XXX.XX XX.XXX X.XXXX			Conf
PsycK	The psychrometric constant at a given pressure (6.66E-4 at standard atmospheric pressure). The value is dependent on the speed of air-flow across the wet bulb, and hence the rate of evaporation. 6.66E-4 is for the ASSMANN ventilated Psychrometer.	0.0 to 10.0		6.66	L3
Pressure	Atmospheric Pressure	0.0 to 2000.0		1013.0 mbar	L3
WetT	Wet Bulb Temperature	Range units			
WetOffs	Wet bulb temperature offset	-100.0 to 100.0		0.0	L3
DryT	Dry Bulb Temperature	Range units			
RelHumid	Relative Humidity is the ratio of actual water vapour pressure (AVP) to the saturated water vapour pressure (SVP) at a particular temperature and pressure	0.0 to 100.0		100	R/O
DewPoint	The dew point is the temperature to which air would need to cool (at constant pressure and water vapour content) in order to reach saturation	-999.9 to 999.9			R/O

List Header - Humidity		Sub-headers: None			
Name ⊙ to select	Parameter Description	Value Press ▽ or △ to change values		Default	Access Level
SBreak	Indicates that one of the probes is broken.	No Yes	No sensor break detection Sensor break detection enabled		Conf

Zirconia (Carbon Potential) Control

A 3500 controller may be supplied to control carbon potential, order code ZC. The controller is often a programmer which generates carbon potential profiles. In this section it is assumed that a programmer is used.

Calculation of PV: The Process Variable can be Carbon Potential, Dewpoint or Oxygen concentration. The PV is derived from the probe temperature input, the probe mV input and remote gas reference input values. Various probe makes are supported. In the 3500 Carbon Potential and Dewpoint can be displayed together.

The following definitions may be useful:

Temperature Control

The sensor input of the temperature loop may come from the zirconia probe but it is common for a separate thermocouple to be used. The controller provides a heating output which may be connected to gas burners or thyristors to control electrical heating elements. In some applications a cooling output may also be connected to a circulation fan or exhaust damper.

Carbon Potential Control

The zirconia probe generates a millivolt signal based on the ratio of oxygen concentrations on the reference side of the probe (outside the furnace) to the amount of oxygen in the furnace.

The controller uses the temperature and carbon potential signals to calculate the actual percentage of carbon in the furnace. This second loop generally has two outputs. One output is connected to a valve which controls the amount of an enrichment gas supplied to the furnace. The second output controls the level of dilution air.

Sooting Alarm

In addition to other alarms which may be detected by the controller, the 3500 can trigger an alarm when the atmospheric conditions are such that carbon will be deposited as soot on all surfaces inside the furnace. The alarm may be connected to an output (e.g. relay) to initiate an external alarm.

Automatic Probe Cleaning

The 3500 has a probe clean and recovery strategy that can be programmed to occur between batches or manually requested. At the start of the cleaning process a ‘snapshot’ of the probe mV is taken, and a short blast of compressed air is used to remove any soot and other particles that may have accumulated on the probe. A minimum and maximum cleaning time can be set by the user. If the probe mV has not recovered to within 5% of the snapshot value within the maximum recovery time set then an alarm is given. This indicates that the probe is ageing and replacement or refurbishment is due.

Endothermic Gas Correction

A gas analyser may be used to determine the CO concentration of the endothermic gas. If a 4-20mA output is available from the analyser, it can be fed into the 3500 to automatically adjust the calculated % carbon reading. Alternatively, this value can be entered manually.

Zirconia Parameters

Zirconia Main

List Header - Zirconia		**Sub-headers: Main**			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
ProbeState	State of the probe and function block Indicates the probe and function block's current operating state.	0	Measuring		RO L3
		1	Burnoff (cleaning)		
		2	CleaningRecovery		
		3	ImpedanceCheck		
		4	ImpedanceRecovery		
		5	BelowMinTemp		
		6	InputBad		
CarbonPotential	Calculated Carbon Potential Indicates the calculated carbon potential in wt.%C. Carbon Potential is a measure of the ability of a given atmosphere composition to diffuse carbon into a heated steel workpiece, expressed as a percentage of carbon in the steel (by weight). The value is clipped in the range from 0 to 2.55wt. %C.				RO L3
DewPoint	Calculated Dew Point Indicates the calculated dew point (in the configured instrument temperature units). The dew point of a gas mixture is the temperature at which condensation and evaporation of its water vapour content are in equilibrium (at constant pressure). Dew point is often used as a process variable for control of an endothermic gas generator. The value is clipped in the range equivalent to -60 to +160 degrees C.				RO L3
Oxygen	Calculated Oxygen The calculated concentration of oxygen in the measured atmosphere (expressed in the units configured by the OxygenUnits parameter).				RO L3
SaturationLimit	Calculated Carbon Saturation Limit The calculated carbon potential above which sooting is likely to occur on surfaces in the furnace. This threshold is sometimes referred to as the 'soot line'.				RO L3

List Header - Zirconia		Sub-headers: Main			
Name (select icon) to select	**Parameter Description**	**Value** Press (down) or (up) to change values		**Default**	**Access Level**
OutputStatus	Status of the calculated outputs This reports the status of the CarbonPotential, DewPoint and Oxygen calculated outputs. If the status is Bad, the value should not be relied upon.	0	Outputs are good		RO L3
		1	Outputs are bad		
SootNotification	Saturation limit exceeded This flag is set to Yes if the following condition is met: CarbonPotential > (SaturationLimit * SootScalar) That is, if the carbon potential in the furnace becomes high enough to potentially cause a deposit of soot on surfaces in the furnace. The SootScalar parameter allows a degree of tolerance to be defined. Typically this parameter could be wired to a digital alarm.	0	No		RO L3
		1	Yes		
COFactor	Defines the local 'CO Factor' in %CO. The default value is 20.0%. This factor is used in the calculation of the carbon potential. Nominally, it represents the percentage of carbon monoxide in the furnace atmosphere, by volume. In practice, however, it is often used as a general compensation factor, to bring the calculated carbon potential into agreement with the value determined by shim stock or multigas analysis. To avoid harsh changes in controller output, an integral balance will be issued whenever this value is changed.			20%	L3
H2Factor	Defines the local 'H2 Factor' in %H2. The default value is 40.0%. This factor is used in the calculation of the dew point. Nominally, it represents the percentage of hydrogen in the furnace atmosphere, by volume. In practice, however, it is often used as a general compensation factor, to bring the calculated dew point into agreement with observed values. To avoid harsh changes in controller output, an integral balance will be issued whenever this value is changed.			40%	L3
ProcessFactor	This value is only used if you set ProbeType to MMI. It defines a 'Process Factor' which is used as a general 'rolled-up' compensation factor to take into account the various parameters of the furnace, its atmosphere and the load being treated. It is often used to bring the calculated carbon potential and/or dew point into agreement with observed values.			140	L3
ProbeIn	Probe millivolts input Voltage reading from the zirconia probe (in millivolts). Acceptable range is from 0mV to 1800mV. If required, a compensation offset can be applied to this value by setting the ProbeOffset parameter.				L3
TemperatureIn	Temperature input The temperature of the measured atmosphere. This will often come from the thermocouple at the zirconia probe tip. If required, a compensation offset can be applied to this value by setting the TempOffset parameter.				L3
ProbeOffset	Probe millivolts input offset If required, you can specify an offset value here (in mV), as a compensation factor for the incoming ProbeIn signal.			0.0	L3
TempOffset	Temperature input offset If required, you can specify a temperature offset here. It is applied to the incoming TemperatureIn signal.			0.0	L3
BelowMinTemp	Below minimum operating temperature This flag is asserted whenever the probe temperature input is below the MinTemperature parameter. This is often used to inhibit alarms and similar.	0	No		RO L3
		1	Yes		
Hold	Hold the controller output This flag is set to Yes when the block is carrying out probe cleaning or a probe impedance check. Typically, in a control strategy, you would use this output to switch the control loop into HOLD mode.	0	No		RO L3
		1	Yes		

List Header - Zirconia		Sub-headers: Main			
Name to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
IntBal	Trigger integral balance Typically, in a control strategy, you would use this output to trigger an integral balance, in order to avoid step changes in the process variable from causing discontinuities ('bumps') in the control loop output. Connect this pin to the IntBal input on the Loop block. Certain events will cause the zirconia block to request an integral balance, for example changing the gas factors or when transitioning into the Measuring state.	0	No		RO L3
		1	Yes		

Zirconia Config

List Header - Zirconia		Sub-headers: ⇕ Config			
Name to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
ProbeType	Zirconia probe type Used to specify the zirconia probe type, so that the correct calculations are used.	3	OxygenOnly	35 Eurotherm AP1	RO L3 RW Config
		25	MMI		
		26	AACC		
		27	Drayton		
		28	Accucarb		
		29	SSI		
		30	MacDhui		
		31	Bosch		
		32	BarberColeman		
		33	AGA/Ferronova		
		34	Probe Millivolts		
		35	Eurotherm AP1		
		36	Eurotherm ACP		
OxygenCalc	Oxygen calculation type Selects the methodology for calculating the oxygen concentration. For most probes, the Nernst equation is most suitable. Different methodologies for Bosch lambda probes and by AGA/Ferronova are also provided. Alternatively, the option to back-calculate the oxygen concentration from a calculated carbon potential is available (NernstCP).	0	Nernst	0 Nernst	RO L3 RW Config
		1	NernstBosch		
		3	AGA Ferronova		
		4	NernstCP		
OxygenUnits	Oxygen output units Selects how the proportion of O2 in the measured atmosphere is expressed.	0	PartialPressure	2 Percent	RO L3 RW Config
		2	Percent		
		6	PartsPerMillion		
COIdeal	Ideal CO percent for oxygen calculation This input is only used if you set OxygenType to NernstCP. It represents the percentage of carbon monoxide in the furnace atmosphere by volume. The function block uses the supplied value as a calibration factor when back-calculating the oxygen concentration from the calculated CarbonPotential.			20.0%	L3
MinTemperature	Minimum operating temperature Defines a minimum operating temperature for the zirconia probe. If TemperatureIn < MinTemperature, the block will not perform any calculations, cleaning or impedance testing.			720.0 C	L3

List Header - Zirconia		Sub-headers: ⇕ Config			
Name ⊙ to select	**Parameter Description**	**Value** Press ⊙ or ⊙ to change values		**Default**	**Access Level**
SootScalar	Soot notification scalar This is a multiplicative scaling factor which can be used to raise or lower the sooting threshold. The SootNotification flag will be set to Yes if the following condition is met: CarbonPotential > (SaturationLimit * SootScalar) Different values of SootScalar may be appropriate for different alloys. It could also be used to approximate the carbide limit.			1.0	L3

Zirconia Clean

List Header - Zirconia		Sub-headers: ⇕ Clean			
Name ⊙ to select	**Parameter Description**	**Value** Press ⊙ or ⊙ to change values		**Default**	**Access Level**
Enable	Enable probe cleaning Set to On to enable automatic probe cleaning or Off to disable it. A clean can always be started using the CleanStart input regardless of this setting.	0 1	Off On	0 Off	L3
Start	Start a probe clean A rising-edge will begin a probe cleaning sequence.	0 1	No Yes	0 No	L3
Abort	Abort a probe clean Setting this input will abort a probe burnoff. Normal operation will resume once the probe recovers. A probe clean may not be started while this input is set true. It may be used to temporarily turn off probe cleaning.	0 1	No Yes	0 No	L3
CleanValve	Open the cleaning air valve Control output for the probe cleaning air valve. Off = valve closed, On = valve open. Typically this will be wired to a digital or relay output.	0 1	Off On		RO L3
TimeToClean	Time remaining until next automatic clean Time remaining until the next automatic probe cleaning sequence is due to start.				RO L3
LastProbemV	The probe mV after the last burnoff The probe mV reading at the end of the last burnoff. If the value is greater than 200mV, this may indicate a problem such as poor adjustment of the cleaning air supply or probe degradation due to heavy sooting.				RO L3
LastRcovTime	Time taken to recover after last burnoff Time taken for the probe mV to return to 95% of its value before the last burnoff began.				RO L3
RecoveryNotification	Maximum recovery time was exceeded This flag is set to Yes if the probe mV reading does not return to 95% of its pre-burnoff value within the permitted recovery time (set by Clean.MaxRcovTime). This indicates probe degradation.	0 1	No Yes		RO L3
TempExceeded	Maximum temperature was exceeded This flag is set to Yes if the probe's temperature exceeded the configured maximum (MaxTemperature) during the last burnoff. This could indicate a potentially damaging exothermic reaction on the probe surface.	0 1	No Yes		RO L3
Aborted	Last burnoff was aborted This flag is set to Yes if the last burnoff was aborted before it could finish.	0 1	No Yes		RO L3
MsgReset	Reset clean status flags A rising-edge on this input will reset the RecoveryWarn, TempExceeded and Aborted status flags.	0 1	No Yes	0 No	L3

List Header - Zirconia		Sub-headers: ⇕ Clean			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
BurnoffTime	Burnoff duration Configures the duration of the burnoff phase of the probe cleaning sequence.			180s	L3
Frequency	Automatic cleaning frequency Configures the interval between automatic probe cleaning sequences.			4 Hours	L3
MaxTemperature	Maximum allowed temperature during burnoff Set the maximum temperature allowed during probe burnoff. The burnoff is aborted if exceeded. This threshold is only a useful diagnostic if the temperature reading is being taken from the probe's own thermocouple. An excessive temperature on the probe thermocouple typically indicates that a potentially damaging exothermic reaction has started on the probe.			1100.0 C	L3
MinRcovTime	Minimum allowed recovery time Sets the minimum recovery time allowed after burnoff, before measurement resumes.			1s	L3
MaxRcovTime	Maximum allowed recovery time Sets the maximum recovery time allowed after burnoff, before measurement resumes. If the probe has still not recovered within this amount of time then measurement will be forced to resume and the RecoveryWarn flag will be set.			90s	L3

Input Monitor

The input monitor may be wired to any variable in the controller. It then provides three functions:

1. Maximum detect
2. Minimum detect
3. Time above threshold

Maximum Detect

This function continuously monitors the input value. If the value is higher than the previously recorded maximum, it becomes the new maximum.

This value is retained following a power fail.

Minimum Detect

This function continuously monitors the input value. If the value is lower than the previously recorded minimum, it becomes the new minimum.

This value is retained following a power fail.

Time Above Threshold

This function increments a timer whenever the input is above a threshold value. If the timer exceeds 24 hours per day, a counter is incremented. The maximum number of days is limited to 255. A timer alarm can be set on the timer so that once the input has been above a threshold for a period, an alarm output is given.

Applications include:

- Service interval alarms. This sets an output when the system has been running for a number of days (up to 255 days)
- Material stress alarms - if the process cannot tolerate being above a level for a period. This is a style of 'policeman' for processes where the high operating point degrades the life of the machine.
- In internal wiring applications in the controller

Input Monitor Parameters

List Header - IPMon		**Sub-headers: 1 or 2**		
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values	**Default**	**Access Level**
Input	The input value to be monitored	May be wired to an input source. The range will depend on the source		L3. R/O if wired
Max	The maximum measured value recorded since the last reset	As above		R/O L3
Min	The minimum measured value recorded since the last reset	As above		R/O L3
Threshold	The input timer accumulates the time the input PV spends above this trigger value.	As above		L3
Days Above	Accumulated days the input has spent above threshold since the last reset.	Days is an integer count of the 24 hour periods only. The Days value should be combined with the Time value to make the total time above threshold.		R/O L3

List Header - IPMon		**Sub-headers: 1 or 2**			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Time Above	Accumulated time above the 'Threshold' since last reset.	The time value accumulates from 00:00.0 to 23:59.9. Overflows are added to the days value			R/O L3
Alm Days	Days threshold for the monitors time alarm. Used in combination with the Alm Time parameter. The Alm Out is set to true if the inputs accumulated time above threshold is higher than the timer high parameters.	0 to 255		0	L3
Alm Time	Time threshold for the monitors time alarm. Used in combination with the Alm Days parameter. The Alm Out is set to true if the inputs accumulated time above threshold is higher than the timer high parameters.	0:00.0 to 99:59:59		0:00.0	L3
Alm Out	Set true if the accumulated time that the input spends above the trigger value is higher than the alarm setpoint.	Off On	Normal operation time above setpoint exceeded		R/O L3
Reset	Resets the Max and Min values and resets the time above threshold to zero.	No Yes	Normal operation Reset values	No	L3
In Status	Monitors the status of the input	Good Bad	Normal operation The input may be incorrectly wired		R/O L3

Logic Maths and multi Operators

Logic Operators

Logic Operators allow the controller to perform logical calculations on **two** input values. These values can be sourced from any available parameter including Analogue Values, User Values and Digital Values.

The parameters to use, the type of calculation to be performed, input value inversion and 'fallback' value are determined in Configuration level. In levels 1 to 3 you can view the values of each input and read the result of the calculation.

'Lgc2' denotes a two input logic operator. When logic operators are enabled a page headed 'Lgc2' can be found using the button. This page contains up to 40 instances which are selected using the or buttons.

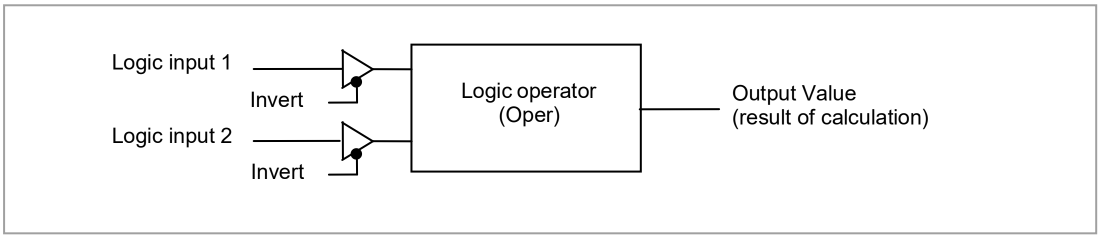


Figure 51: 2 Input Logic Operators

Logic Operators are found under the page header **'Lgc2'**.

Logic 8

Logic 8 operators can perform logic calculations on up to **eight** inputs. The calculations are limited to AND,OR,XOR. They are labelled 'Lgc8' to denote eight input logic operators. When Lgc8 operators are enabled a page headed **'Lgc8'** can be found using the button. This page contains up to four instances which are selected using the or buttons.

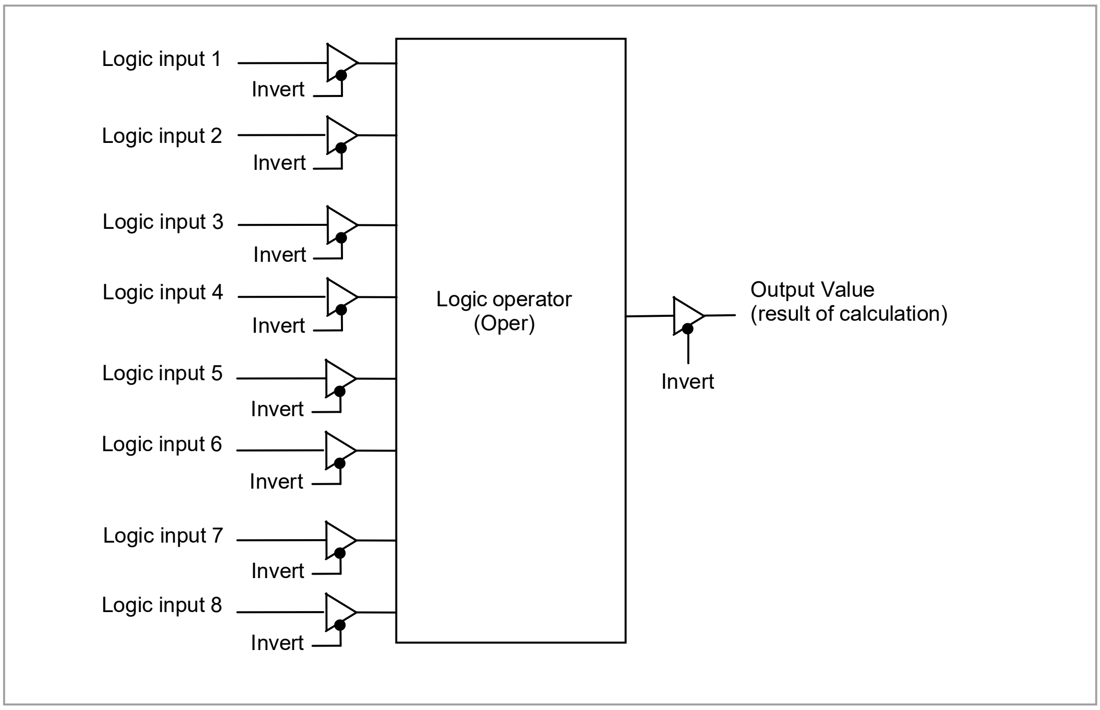


Figure 52: 8 Input Logic Operators

Logic Operations

The following calculations can be performed:

Oper	Operator description	Input 1	Input 2	Output Invert = None
0: OFF	The selected logic operator is turned off			
1: AND	The output result is ON when both Input 1 and Input 2 are ON	0 1 0 1	0 0 1 1	Off Off Off On
2: OR	The output result is ON when either Input 1 or Input 2 is ON	0 1 0 1	0 0 1 1	Off On On Off
3: XOR	Exclusive OR. The output result is true when one and only one input is ON. If both inputs are ON the output is OFF.	0 1 0 1	0 0 1 1	Off On On Off
4: LATCH	Input 1 sets the latch, Input 2 resets the latch.	0 1 0 1	0 0 1 1	
5: ==	Equal. The output result is ON when Input 1 = Input 2	0 1 0 1	0 0 1 1	On Off Off On
6: <>	Not equal. The output result is ON when Input 1 ≠ Input 2	0 1 0 1	0 0 1 1	Off On On Off
7: >	Greater than. The output result is ON when Input 1 > Input 2	0 1 0 1	0 0 1 1	Off On Off Off
8: <	Less than. The output result is ON when Input 1 < Input 2	0 1 0 1	0 0 1 1	Off Off On Off
9: =>	Equal to or Greater than. The output result is ON when Input 1 ≥ Input 2	0 1 0 1	0 0 1 1	On On Off On
10: <=	Less than or Equal to. The output result is ON when Input 1 ≤ Input 2	0 1 0 1	0 0 1 1	On Off On On

NOTICE

1. The numerical value is the value of the enumeration
2. For options 1 to 4 an input value of less than 0.5 is considered false and greater than or equal to 0.5 as true.

Logic Operator Parameters

List Header – Lgc2 (2 Input Operators)		Sub-headers: 1 to 40		
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values	**Default**	**Access Level**
Oper	To select the type of operator	See previous table	None	Conf L3 R/O
Input1	Input 1	Normally wired to a logic, analogue or user value. May be set to a constant value if not wired.	0	L3
Input2	Input 2			

Fall Type	The fallback state of the output if one or both of the inputs is bad	0: FalseBad	The output value is FALSE and the status is BAD.		Conf L3 R/O
		1: TrueBad	The output value is TRUE and the status is BAD		
		2: FalseGood	The output value is FALSE and the status is GOOD		
		3: TrueGood	The output value is TRUE and the status is GOOD.		
Invert	The sense of the input value, may be used to invert one or both of the inputs	0: None	Neither input inverted		Conf L3 R/O
		1: Input1	Invert input 1		
		2: Input2	Invert input 2		
		3: Both	Invert both inputs		
Output	The output from the operation is a boolean (true/false) value.	On Off	Output activated Output not activated		R/O
Status	The status of the result value	Good Bad			R/O

Eight Input Logic Operators

The eight input logic operator may be used to perform operations on eight inputs.

This page contains up to four instances which are selected using the ▲ or ▼ button.

Eight Input Logic Operator Parameters

List Header – Lgc8 (8 Input Operators)		Sub-headers: 1 to 4			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Oper	To select the type of operator	0: OFF 1: AND 2: OR 3: XOR	Operator turned off Output ON when all inputs are ON Output ON when one input is ON Exclusive OR	OFF	Conf L3 R/O
NumIn	This parameter is used to configure the number of inputs for the operation	1 to 8			Conf L3 R/O
Invert	Used to invert selected inputs prior to operation. This is a status word with one bit per input, the left hand bit inverts input 1.	□ □ □ □ □ □ □ □ No inputs inverted ■ ■ ■ ■ ■ ■ ■ ■ All 8 inputs inverted When configuring over comms, the invert parameter is interpreted as a bitfield where: 0x1 - input 1 0x2 - input 2 0x4 - input 3 0x8 - input 4 0x10 - input 5 0x20 - input 6 0x40 - input 7 0x80 - input 8		□	L3
Out Invert	Invert the output	No Yes	Output not inverted Output inverted	No	L3
In1 to In8	Input state 1 to 8	Normally wired to a logic, analogue or user value. When wired to a floating point, values less than or equal to –0.5 or greater than or equal to 1.5 will be rejected (e.g. the value of the lgc8 block will not change). Values between –0.5 and 1.5 will be interpreted as ON when greater than or equal to 0.5 and OFF when less than 0.5. May be set to a constant value if not wired.		Off	L3
Out	Output result of the operator	On Off	Output activated Output not activated		R/O

The eight input logic operator may be used to perform the following operations on 8 inputs:

Oper	Operation Description
0: OFF	The selected logic operator is turned off
1: AND	The output result is ON when ALL 8 inputs are ON
2: OR	The output result is ON when one or more of the 8 inputs are ON
3: XOR	Exclusive OR – the output is ON if an ODD number of inputs are ON. The output is OFF if an even number of inputs are ON.

Maths Operators

Maths Operators (sometimes known as Analogue Operators) allow the controller to perform mathematical operations on two input values. These values can be sourced from any available parameter including Analogue Values, User Values and Digital Values. Each input value can be scaled using a multiplying factor or scalar.

The parameters to use, the type of calculation to be performed and the acceptable limits of the calculation are determined in Configuration level. In access level 3 you can change values of each of the scalars.

'Math2' denotes a two input math operator. When math operators are enabled a page headed 'Math2' can be found using the button. This page contains up to thirty two instances which are selected using the or button.

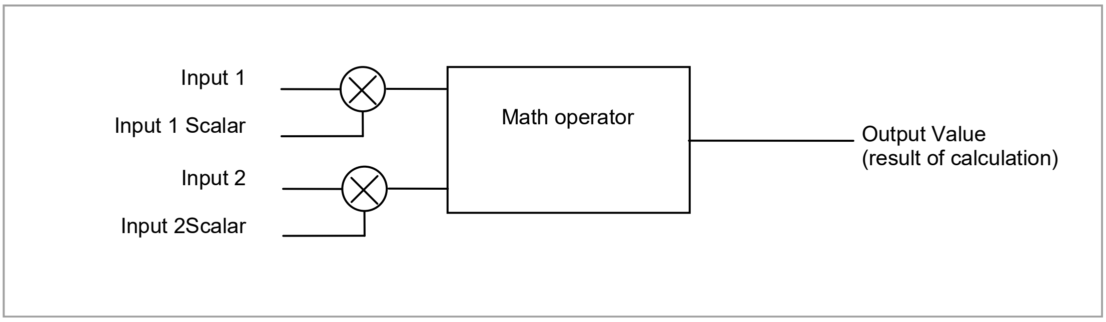
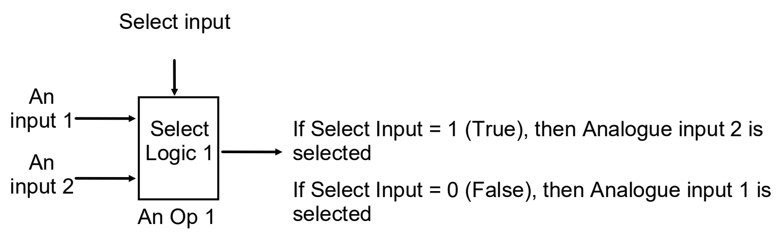


Figure 53: 2 Input Math Operators

Math Operations

The following operations can be performed:

0: Off	The selected analogue operator is turned off
1: Add	The output result is the addition of Input 1 and Input 2
2: Sub	Subtract. The output result is the difference between Input 1 and Input 2 where Input 1 > Input 2
3: Mul	Multiply. The output result is the Input 1 multiplied by Input 2
4: Div	Divide. The output result is Input 1 divided by Input 2
5: AbsDif	Absolute Difference. The output result is the absolute difference between Input 1 and 2
6: SelMax	Select Max. The output result is the maximum of Input 1 and Input 2
7: SelMin	Select Min. The output result is the minimum of Input 1 and Input 2
8: HotSwp	Hot Swap. Input 1 appears at the output provided input 1 is 'good'. If input 1 is 'bad' then input 2 value will appear at the output. An example of a bad input occurs during a sensor break condition.
9: SmpHld	Sample and Hold. Normally input 1 will be an analogue value and input B will be digital. The output tracks input 1 when input 2 = 1 (Sample). The output will remain at the current value when input 2 = 0 (Hold). If input 2 is an analogue value then any non zero value will be interpreted as 'Sample'.
10: Power	The output is the value at input 1 raised to the power of the value at input 2. I.e. input $1^{input\ 2}$
11: Sqrt	Square Root. The output result is the square root of Input 1. Input 2 has no effect.
12: Log	The output is the logarithm (base 10) of Input 1. Input 2 has no effect
13: Ln	The output is the logarithm (base n) of Input 1. Input 2 has no effect
14: Exp	The output result is the exponential of Input 1. Input 2 has no effect
15: 10 x	The output result is 10 raised to the power of Input 1 value I.e. $10^{input\ 1}$. Input 2 has no effect
51: Select	Select input is used to control which Analogue Input is switched to the output of the Analogue Operator. If the select input is true input 2 is switched through to the output. If false input 1 is switched through to the output. See example below: 

When Boolean parameters are used as inputs to analogue wiring, they will be cast to 0.0 or 1.0 as appropriate. Values <= -0.5 or >= 1.5 will not be wired. This provides a way to stop a Boolean updating.

Analogue wiring (whether simple re-routing or involving calculations) will always output a real type result, whether the inputs were booleans, integers or reals.

NOTICE
The numerical value is the value of the enumeration

Math Operator Parameters

List Header – Math2 (2 Input Operators)		**Sub-headers: 1 to 32**		
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values	**Default**	**Access Level**
Operation	To select the type of operator	See previous table	None	Conf
Input1 Scale	Scaling factor on input 1	Limited to max float	1.0	L3
Input2 Scale	Scaling factor on input 2	Limited to max float	1.0	L3
Output Units	Units applicable to the output value	None AbsTemp V, mV, A, mA, PH, mmHg, psi, Bar, mBar, %RH, %, mmWG, inWG, inWW, Ohms, PSIG, %O2, PPM, %CO2, %CP, %/sec, RelTemp Vacuum sec, min, hrs,	None	Conf
Output Res'n	Resolution of the output value	XXXXX. XXXX.X, XXX.XX, XX.XXX, X.XXXX		Conf
Low Limit	To apply a low limit to the output	Max float to High limit (decimal point depends on resolution)	-99999	Conf
High Limit	To apply a high limit to the output	Low limit to Max float (decimal point depends on resolution)	999999	Conf
Fallback	The state of the Output and Status parameters in case of a fault condition. This parameter could be used in conjunction with fallback value	Clip Bad Clip Good Fall Bad Fall Good Upscale DownScale — Descriptions, see section Fallback.		Conf
Fallback Val	Defines (in accordance with Fallback) the output value during fault conditions.	Limited to max float (decimal point depends on resolution)		Conf
Input1 Value	Input 1 value (normally wired to an input source – could be a User Value)	Limited to max float (decimal point depends on resolution)		L3
Input2 Value	Input 2 value (normally wired to an input source – could be a User Value)	Limited to max float (decimal point depends on resolution)		L3
Output Value	Indicates the analogue value of the output	Between high and low limits		R/O
Status	This parameter is used in conjunction with Fallback to indicate the status of the operation. Typically, status is used to flag fault conditions and may be used as an interlock for other operations.	Good Bad		R/O

Sample and Hold Operation

The diagram below shows the operation of the sample and hold feature.

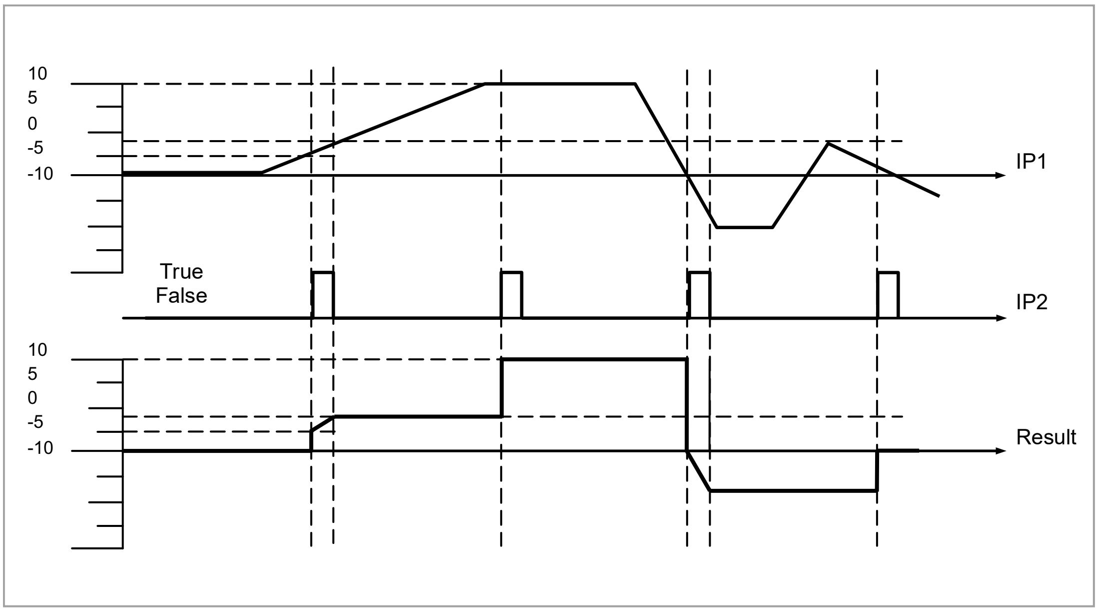


Figure 54: Sample and Hold

Eight Input Analog Multiplexers

The eight Input analog multiplexers may be used to switch one of eight inputs to an output. It is usual to wire inputs to a source within the controller which selects that input at the appropriate time or event. A page headed **'Mux8'** can then be found using the button. This page contains up to eight instances which are selected using or button.

Multiple Input Operator Parameters

List Header – Mux8 (8 Input Operators)		Sub-headers: 1 to 8			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
High Limit	The high limit for all inputs and the fall back value.	Low Limit to 99999 (decimal point depends on resolution)		99999	Conf
Low Limit	The low limit for all inputs and the fall back value.	-99999 to High Limit (decimal point depends on resolution)		-99999	Conf
Fallback	The state of the Output and Status parameters in case of a fault condition. This parameter could be used in conjunction with Fallback Val.	Clip Bad Clip Good Fall Bad Fall Good Upscale DownScale	Descriptions see section Fallback.		Conf
Fallback Val	Used (in accordance with Fallback) to define the output value during fault conditions	-99999 to 99999 (decimal point depends on resolution)			Conf
Select	Used to select which input value is assigned to the output.	Input1 to Input8			L3
Input1 to 8	Input values (normally wired to an input source)	-99999 to 99999 (decimal point depends on resolution)			L3
Output	Indicates the analogue value of the output	Between high and low limits			R/O
Status	Used in conjunction with Fallback to indicate the status of the operation. Typically, status is used to flag fault conditions and may be used as an interlock for other operations.	Good Bad			R/O
Res'n	Indicates the resolution of the output	XXXXX XXXX.X XXX.XX XX.XXX X.XXXX	The resolution of the output is taken from the selected input. If the selected input is not wired, or if its status is bad then the resolution will be set to 1dp		

Fallback

The fallback strategy will come into effect if the status of the input value is bad or if the input value is outside the range of Input Hi and Input Lo.

In this case the fallback strategy may be configured as:-

Fall Good If the input value is above 'High Limit' or below 'Low Limit', then the output value is set to the 'Fallback' value, and the 'Status' is set to 'Good'.

Fall Bad If the input value is above 'High Limit' or below 'Low Limit', then the output value is set to the 'Fallback' value, and the 'Status' is set to 'Bad'.

Clip Good If the input value is above 'High Limit' or below 'Low Limit', then the output value is set to the appropriate limit, and 'Status' is set to 'Bad'. If the input signal is within the limits, but its status is bad, the output is set to the 'Fallback' value.

Clip Bad If the input value is above 'High Limit' or below 'Low Limit', then the output value is set to the appropriate limit, and 'Status' is set to 'Good'. If the input signal is within the limits, but its status is bad, the output is set to the 'Fallback' value

Upscale If the input status is bad, or if the input signal is above 'High Limit' or below 'Low Limit', the output value is set to the 'High Limit'.

Downscale If the input status is bad, or if the input signal is above 'High Limit' or below 'Low Limit', the output value is set to the 'Low Limit'.

Multi Input Operator

The Multi Input Operator function block performs analogue operations on up to eight inputs. The block will simultaneously output the Sum, Average, Maximum and Minimum values of the valid inputs. The outputs may be clipped to user defined limits or be replaced by a fallback value as described in section Fallback Strategy for Multi Input Block.

An outline of the block is shown below and there are four instances of the block in 3500 series controllers.

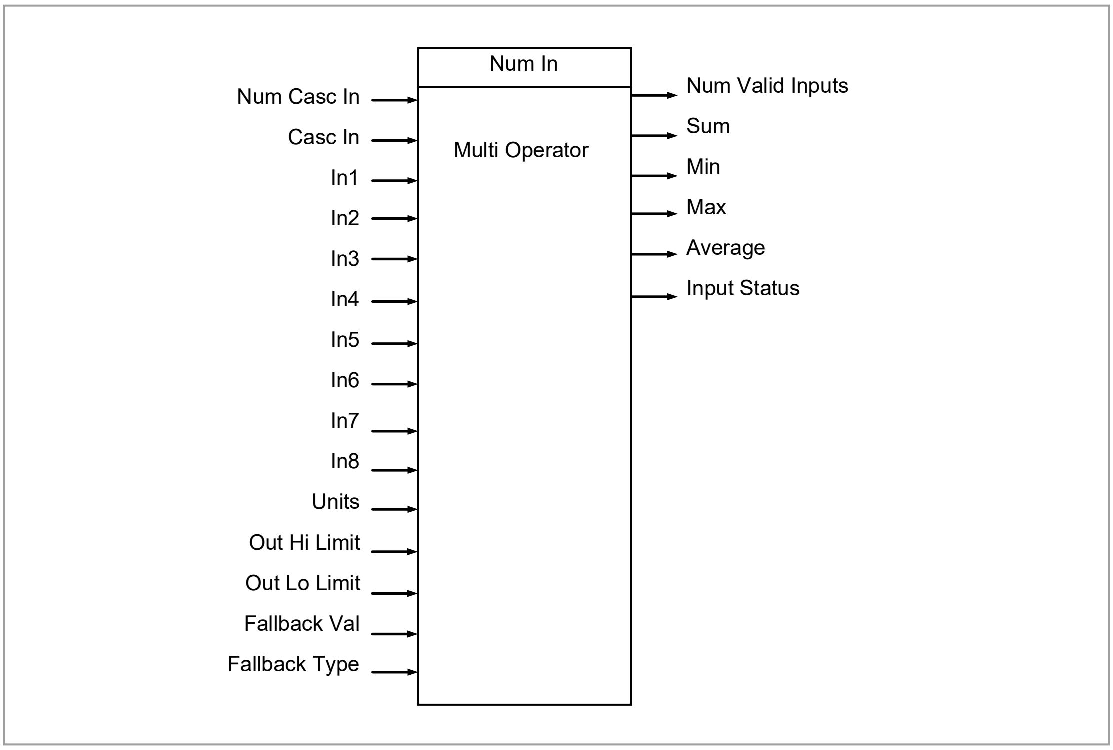


Figure 55: Multi Input Operator Function Block

Number of Inputs

'Num In' determines the number of inputs made available for use. This is settable by the user and is defaulted to two. Take care not to set this number to a value higher than the desired number of inputs as any unused inputs are seen as valid inputs (zero value by default). 'Num Casc In' and 'Casc In' will always be available.

Input Status

'Input Status' gives an indication of the status of the inputs in priority order. 'Casc in' has the highest priority, 'In1' the next highest up to 'In8' the lowest. Should more than one input be bad then the input with the highest priority is shown as bad. When the highest priority bad status is cleared the next highest priority bad status is shown. When all inputs are OK a status of Good is shown.

Number of Valid Inputs

'Num Valid Ins' provides a count of the number of inputs used to perform the calculation within the block. This is required for cascaded operation as detailed below.

Cascaded Operation

The two Multiple Input Operator blocks can be cascaded to allow up to 16 inputs. The diagram shows how the two blocks are configured to find the average of more than eight inputs.

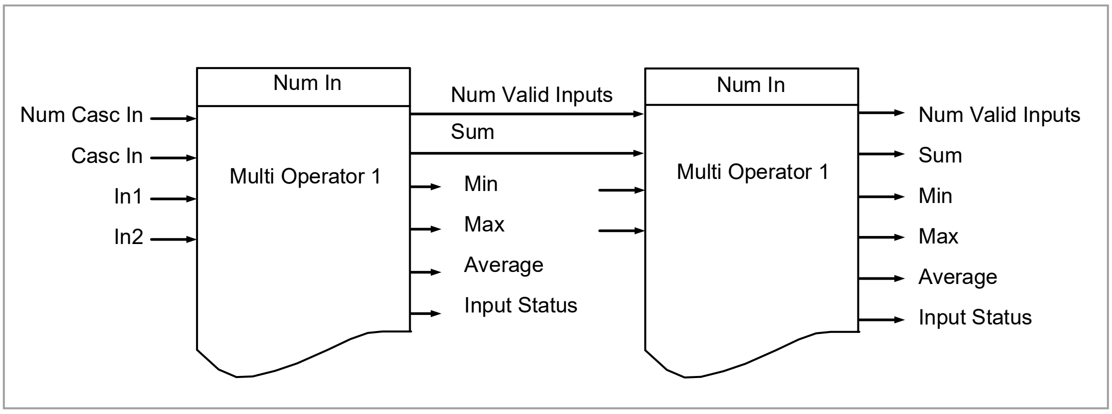


Figure 56: Cascaded Multi Input Operators

If 'Casc In' has 'Good' status, and 'NumCascIn' is not equal to zero, it is assumed that the block is in cascade and these values are used for calculations within the block., and the value given by 'NumCascIn' is added to 'NumValidIn'. When in cascade the sum, min, max and average outputs treat 'Casc in' as an additional input to the block. For example, if 'Casc In' is greater than any number on the rest of the inputs then its value will be output as the maximum.

Fallback Strategy for Multi Input Block

The fallback strategy may be selected in configuration mode as follows:

Clip Good

- The status of the outputs is always good
- If an output is out of range then it is clipped to limits
- If all inputs are Bad, all outputs = 0 (or clipped to limits if 0 is not within the output range)

Clip Bad

- The status of all outputs is Bad if one or more of the inputs is Bad.
- If an output is out of range then it is clipped to limits and the status of that output is set to Bad
- If all inputs are Bad, all outputs = 0 and all status' are set to Bad (or clipped to limits if 0 is not within the output range)

Fall Good

- The status of the outputs is always good
- If an output is out of range then it is set to the fallback value
- If all inputs are Bad, all outputs = fallback value

Fall Bad

- The status of the outputs is bad if one or more of the inputs is bad
- If an output is out of range then it is set to the fallback value and the status is set to bad
- If all inputs are Bad, all outputs = fallback value and all status' are set to bad

Multi Operator Parameters

List Header – MultOp (Multi Input Operators)		**Sub-headers: 1 to 2**		
Name to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values	**Default**	**Access Level**
Num In	Number of inputs selected to use	1 to 8	2	Conf
Casc Num In	Number of cascaded inputs from the previous block	0 - 255	0	
Casc In	The cascaded input from the previous block	-99999 to 99999	0	
In1	Input 1			
In2	Input 2			
In3	Input 3			
In4	Input 4			
In5	Input 5			
In6	Input 6			
In7	Input 7			
In8	Input 8			
Units	Selected units for the I/O	None, Abs Temp, V, mV, A, mA, pH, mmHg, psi, Bar, mBar, %RH, %, mmWg, inWg, inWW, Ohms, psig, %O2, PPM, %CO2, %CP, %/sec, RelTemp, Vacuum, sec, min, hrs	None	
Res'n	Selected resolution of the outputs	XXXXX, XXXX.X, XXX.XX, XX.XXX, X.XXXX		
Out Hi Limit	Upper limit of the outputs	Between 'Out Lo Limit' and maximum display	99999	
Out Lo Limit	Lower limit of the outputs	Between 'Out Hi Limit' and minimum display	-99999	
Fallback	The state of the Output and Status parameters in case of a fault condition. This parameter could be used in conjunction with Fallback Val.	Clip Bad Clip Good Fall Bad Fall Good Descriptions see section Fallback Strategy for Multi Input Block.		Conf
Fallback Val	Value to be output depending on Input Status and fallback type selected			Conf
Num Valid In	Number of inputs used in the calculated outputs			
Sum Out	Sum of the valid inputs			
Max Out	Maximum value of the valid inputs			
Min Out	Minimum value of the valid inputs			
Average Out	Average value of the valid inputs			
In Status	Status of the inputs	Good Bad		

Input Characterization

Input Linearization

The linearization block converts an analog input into an analog output through a user-defined table. This linearization table consists of a series of 32 points defined by input breakpoints (In1 to In32) and output values (Out1 to Out32). In other words, the linearization block implements a piecewise linear curve (a connected sequence of line segments) defined by a series of input coordinates (In1 to In32) and associated output coordinates (Out1 to Out32).

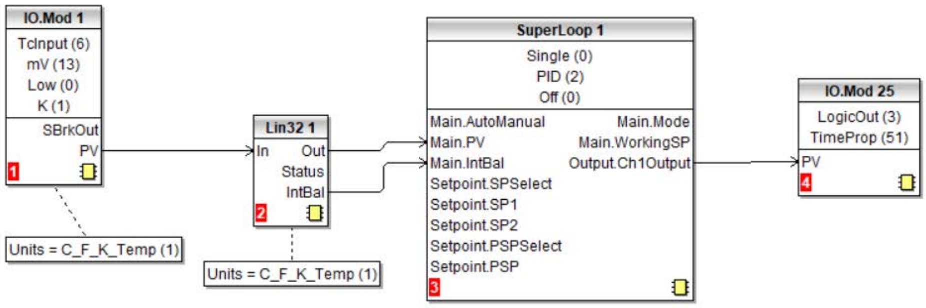
Two of the most typical applications for the LIN32 function block are:

1. Custom linearization of a sensor input
2. Adjustment of the process variable to account for differences introduced by the overall measurement system or to derive a different process variable.

Custom Linearization

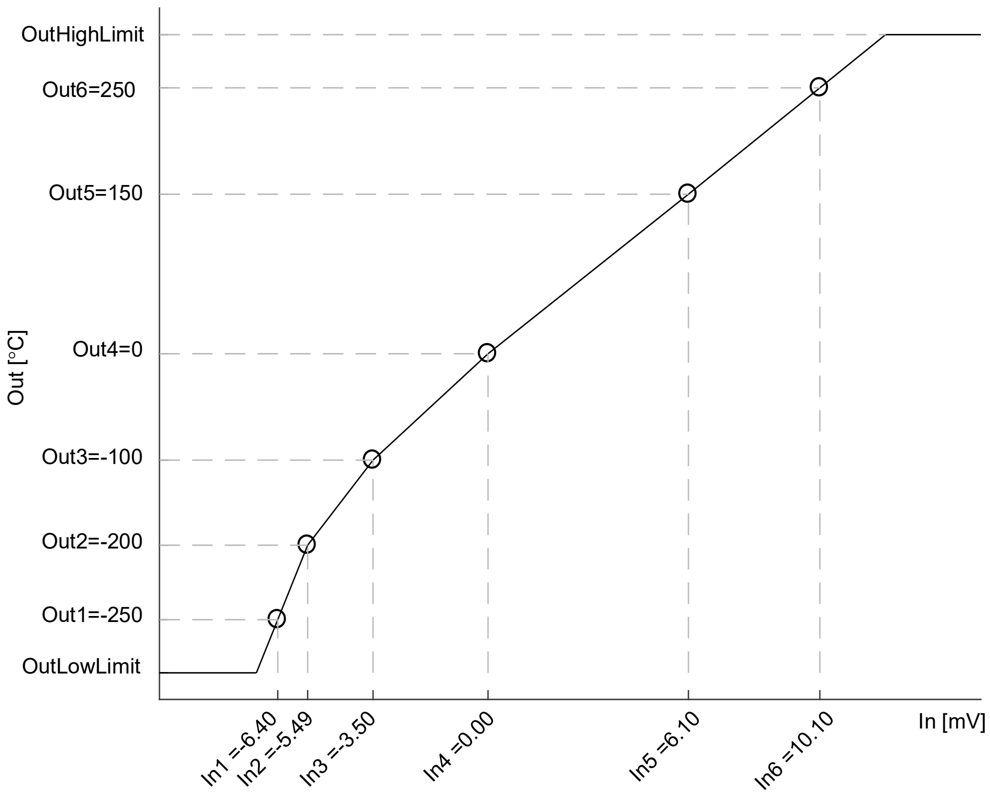
This application allows the user to create their own linearization table.

In the following example the LIN32 block is placed between the Loop block and an Analog Input set to linear and Linearization Type to mV, V, mA, Ohms, etc. In the following example the AI block is set to mV.



The following graph shows a typically increasing linearization curve. The decision of the actual number of points depends of the required accuracy in converting the input electrical signal into the required output value: the higher the number of points, the higher accuracy can be obtained; conversely a lower number of points requires less time to configure the function block. If less than 32 points are used, set the 'NumPoints' parameter to the required number. Points not selected will then be ignored, the curve will continue in a straight line fit to the levels set in 'OutHighLimit' or 'OutLowLimit' and the 'CurveForm' output will be 'Increasing'.

Example 1: Custom Linearization - Increasing Curve

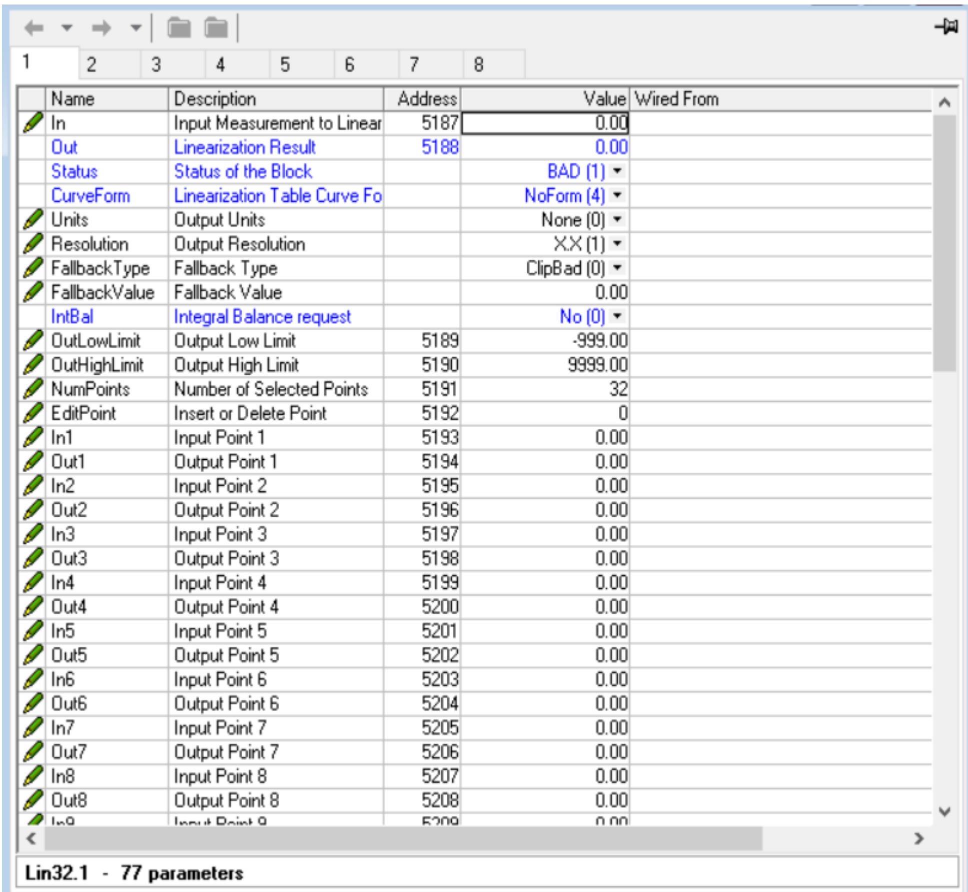


To Setup the Parameters

1. Set the appropriate Fallback type and value, Output units and resolution (editable only in Config mode); Units and resolution of the input and the input breakpoints will be derived by the source wired to 'In'.
2. Set the ‘OutHighLimit’ and ‘OutLowLimit’ to restrict the output of the linearization curve. The ‘OutHighLimit’ must be greater than the ‘OutLowLimit’.
3. Set the 'NumPoints' (6 in this example) to the required number of points for the linearization table. This is an important and required step and the effects of skipping it are reported in the Example 2.
4. Enter values of the first Input breakpoint ‘In1’ and Output value ‘Out1’.
5. Continue with the remaining Input breakpoints and Output values.
6. Wire the ‘IntBal’ parameter to the ‘Loop.Main.IntBal’ parameter. This prevents any proportional or derivative kick in the controller output when any change occurs in the LIN16 configuration parameters.

Points on the linearization curve can be derived from reference tables or can be found by associating the measurements of an external reference (e.g. temperature in degrees Celsius) to the AI electrical readings (e.g. mV or mA).

The iTools view reproduced below shows how the parameters are set up in LIN block 1 for the above example. The list corresponds to the parameters shown on the controller HMI. Parameter help is also available by right clicking the parameter in the iTools list.



Name	Description	Address	Value	Wired From
In	Input Measurement to Linear	5187	0.00	
Out	Linearization Result	5188	0.00	
Status	Status of the Block		BAD (1)	
CurveForm	Linearization Table Curve Fo		NoForm (4)	
Units	Output Units		None (0)	
Resolution	Output Resolution		X.X (1)	
FallbackType	Fallback Type		ClipBad (0)	
FallbackValue	Fallback Value		0.00	
IntBal	Integral Balance request		No (0)	
OutLowLimit	Output Low Limit	5189	-999.00	
OutHighLimit	Output High Limit	5190	9999.00	
NumPoints	Number of Selected Points	5191	32	
EditPoint	Insert or Delete Point	5192	0	
In1	Input Point 1	5193	0.00	
Out1	Output Point 1	5194	0.00	
In2	Input Point 2	5195	0.00	
Out2	Output Point 2	5196	0.00	
In3	Input Point 3	5197	0.00	
Out3	Output Point 3	5198	0.00	
In4	Input Point 4	5199	0.00	
Out4	Output Point 4	5200	0.00	
In5	Input Point 5	5201	0.00	
Out5	Output Point 5	5202	0.00	
In6	Input Point 6	5203	0.00	
Out6	Output Point 6	5204	0.00	
In7	Input Point 7	5205	0.00	
Out7	Output Point 7	5206	0.00	
In8	Input Point 8	5207	0.00	
Out8	Output Point 8	5208	0.00	
In9	Input Point 9	5209	0.00	

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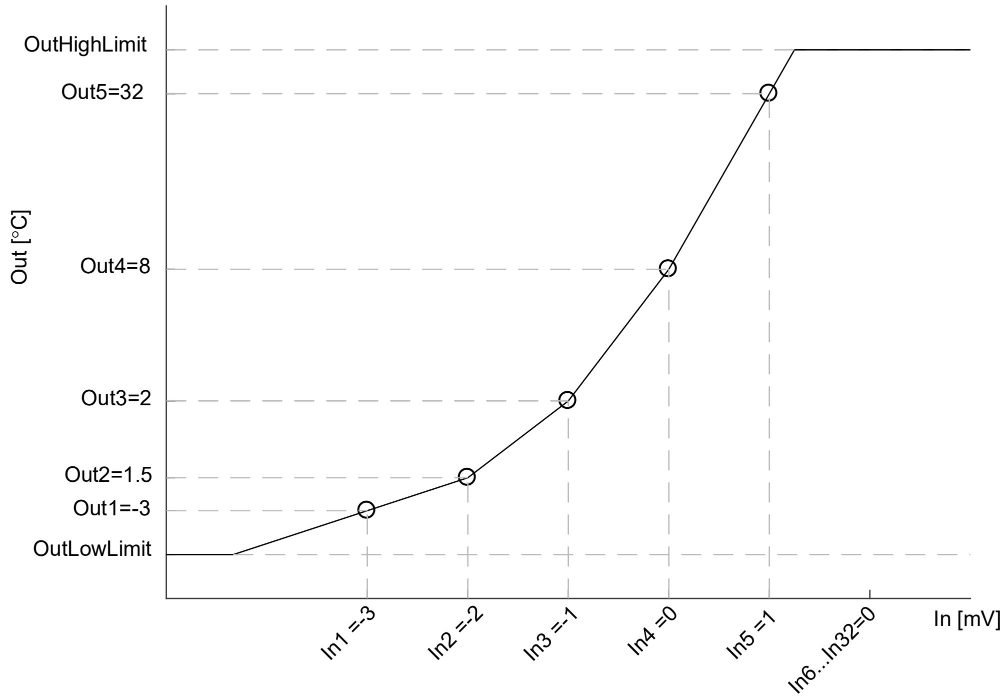
The function block will automatically skip points that do not follow strictly monotonically increasing order of the 'In' coordinates. If at least one point has been skipped the 'CurveForm' parameter will show 'SkippedPoints'. If no valid interval is found the 'CurveForm' parameter will show 'NoForm' and the Fallback strategy will be applied. Other conditions when the Fallback strategy is applied are input source bad status (e.g. sensor break or sensor over-range) and calculated LIN32 output over-range (i.e. less than OutLowLimit or greater than InHighLimit).

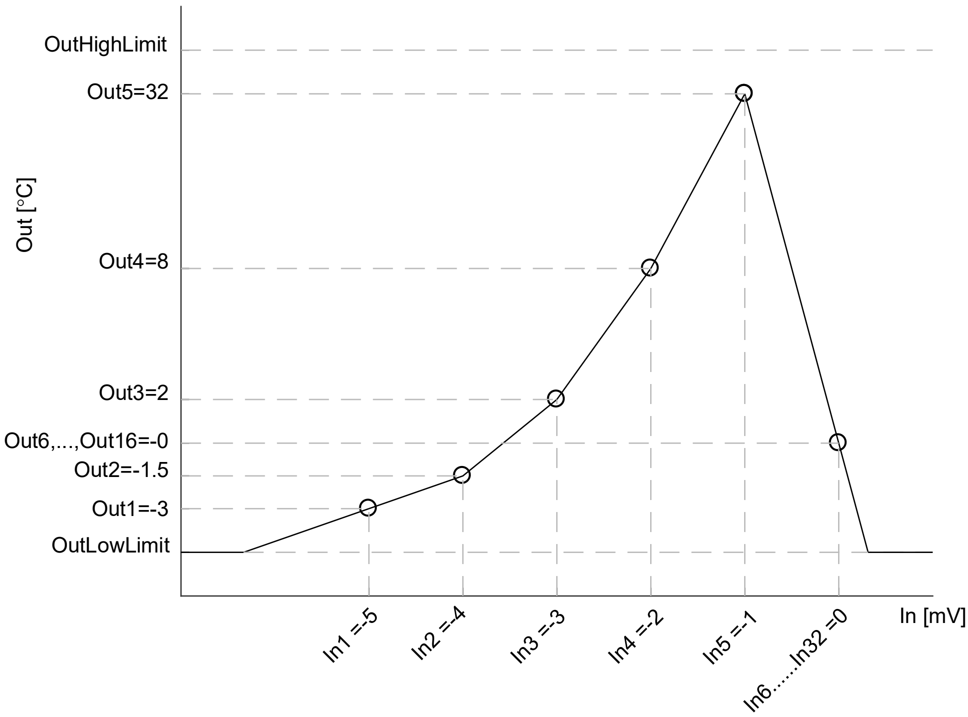
Example 2: Custom Linearization - Skipped Points Curve

If points defaulted to zero have not been deactivated, by reducing 'NumPoints', - AND assuming that at least one of the previous input breakpoints is positive (see the curve below) - then those points will be automatically skipped. The output characteristics will be the same as those obtained by deactivating the points defaulted to zero but the 'CurveForm' will be 'SkippedPoints'.



In1 to In5 will be used. In6 to In32 will be ignored. ‘CurveForm’ will be ‘SkippedPoints’

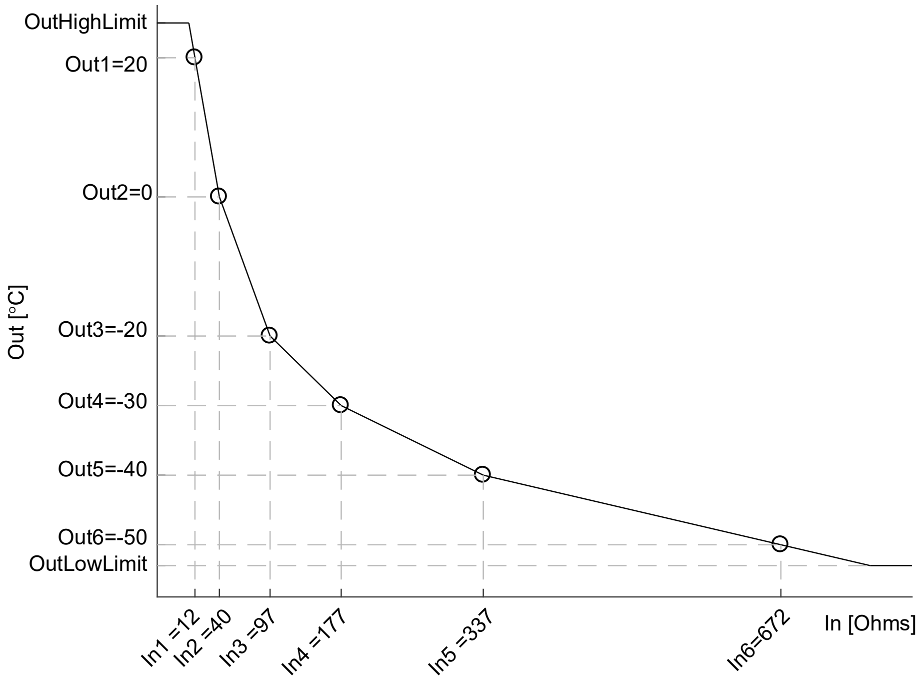
However, when the 'CurveForm' parameter is 'SkippedPoints' (because the number of points 'NumPoints' has not been reduced to the required set) it is not guaranteed that the output characteristics will be increasing or decreasing. In fact, for example, if the input breakpoints are all negative and the final points are zero, then the first "zero" point will be included in the characteristics - see the following picture. Therefore, always set 'NumPoints' to the required value in order to get the expected sensor linearization curve type - increasing, decreasing or free form.



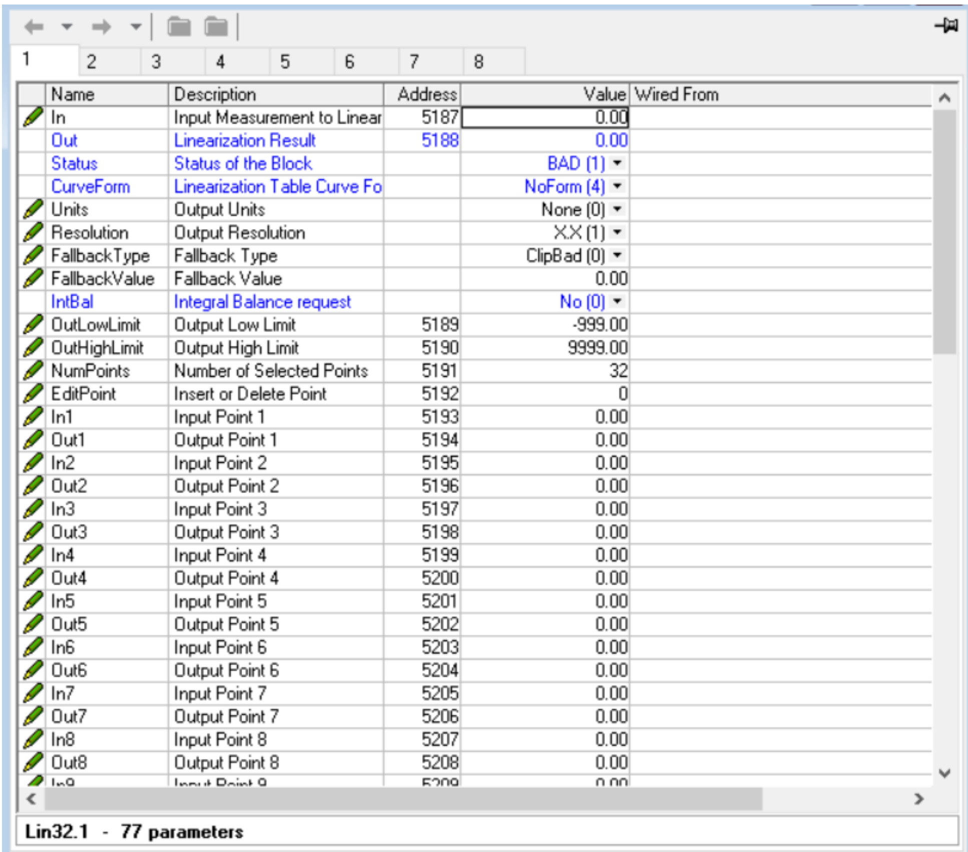
In1 to In5 will be used as well as In6, possibly resulting in a not expected curve. In7, ..., In32 will be ignored. CurveForm will be SkippedPoints.

Example 3: Custom Linearization - Decreasing Curve

The curve may also be a decreasing form as shown below.



The procedure to setup the parameters is the same as in the previous example.



Name	Description	Address	Value	Wired From
In	Input Measurement to Linear	5187	0.00	
Out	Linearization Result	5188	0.00	
Status	Status of the Block		BAD (1)	
CurveForm	Linearization Table Curve Fo		NoForm (4)	
Units	Output Units		None (0)	
Resolution	Output Resolution		X.X (1)	
FallbackType	Fallback Type		ClipBad (0)	
FallbackValue	Fallback Value		0.00	
IntBal	Integral Balance request		No (0)	
OutLowLimit	Output Low Limit	5189	-999.00	
OutHighLimit	Output High Limit	5190	9999.00	
NumPoints	Number of Selected Points	5191	32	
EditPoint	Insert or Delete Point	5192	0	
In1	Input Point 1	5193	0.00	
Out1	Output Point 1	5194	0.00	
In2	Input Point 2	5195	0.00	
Out2	Output Point 2	5196	0.00	
In3	Input Point 3	5197	0.00	
Out3	Output Point 3	5198	0.00	
In4	Input Point 4	5199	0.00	
Out4	Output Point 4	5200	0.00	
In5	Input Point 5	5201	0.00	
Out5	Output Point 5	5202	0.00	
In6	Input Point 6	5203	0.00	
Out6	Output Point 6	5204	0.00	
In7	Input Point 7	5205	0.00	
Out7	Output Point 7	5206	0.00	
In8	Input Point 8	5207	0.00	
Out8	Output Point 8	5208	0.00	
In9	Input Point 9	5209	0.00	

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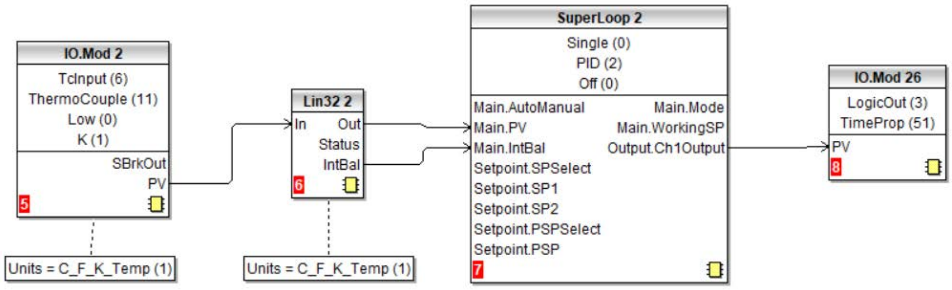
Adjustment of the Process Variable

This application allows the user to compensate for known inaccuracies introduced by the overall measurement system. This not only includes the sensor but also the overall measurement chain. Furthermore, this can also be used to derive a different process variable, for instance, a temperature measured in a different place from where the actual sensor is positioned. The adjustment is made directly on the value, and in the units, of the process variable measured by the controller.

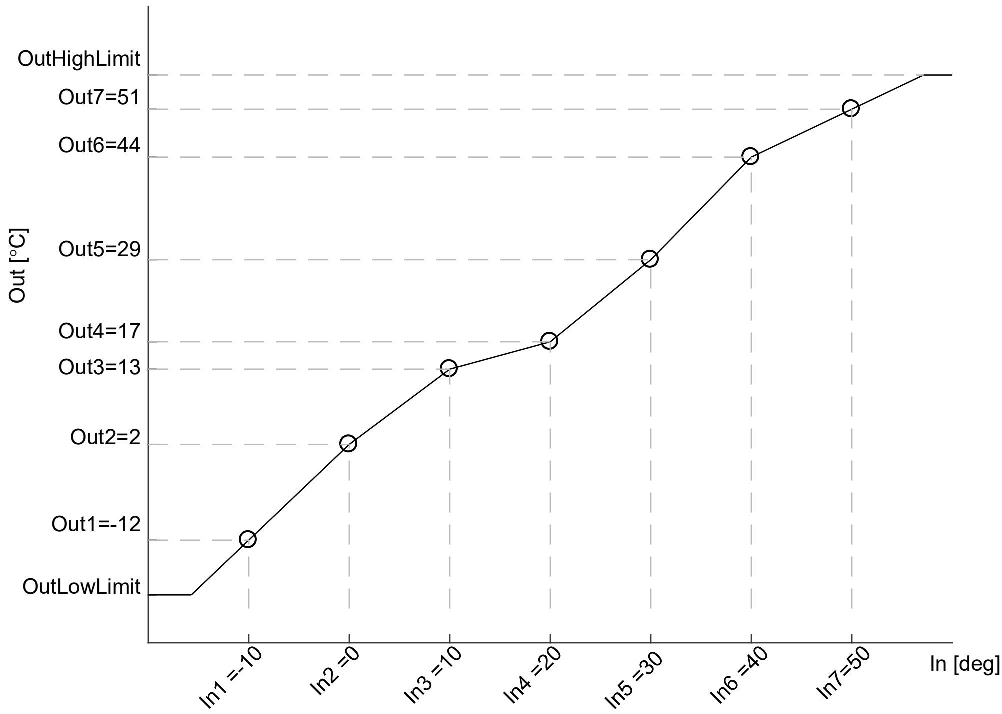
The process variable can be adjusted in different operating conditions (e.g. different temperatures), by using the LIN32 multiple point adjustment curve: this extends the simple PV Offset feature present in the AI block, which just adds or subtracts a single value to the measured PV in all operating conditions.



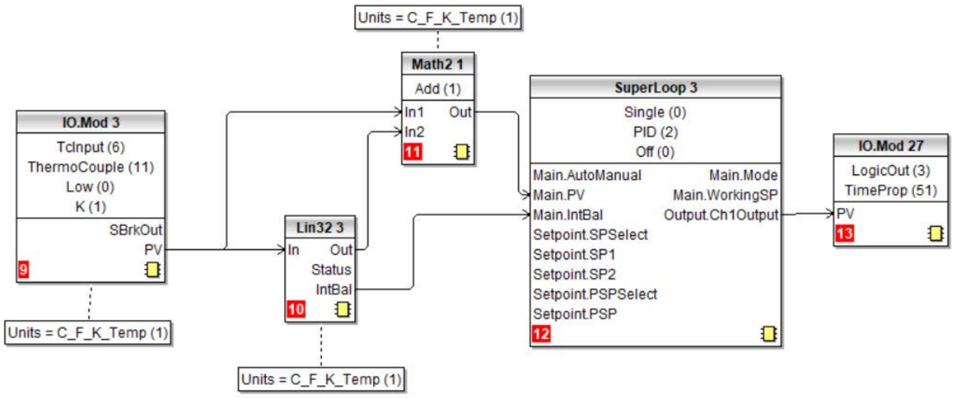
Two alternative configurations can be used:

In the first case the LIN32 table contains the process variable values ‘In1’ to ‘In32’, measured by the controller, and the reference values, ‘Out1’ to ‘Out32’, measured by an external reference.

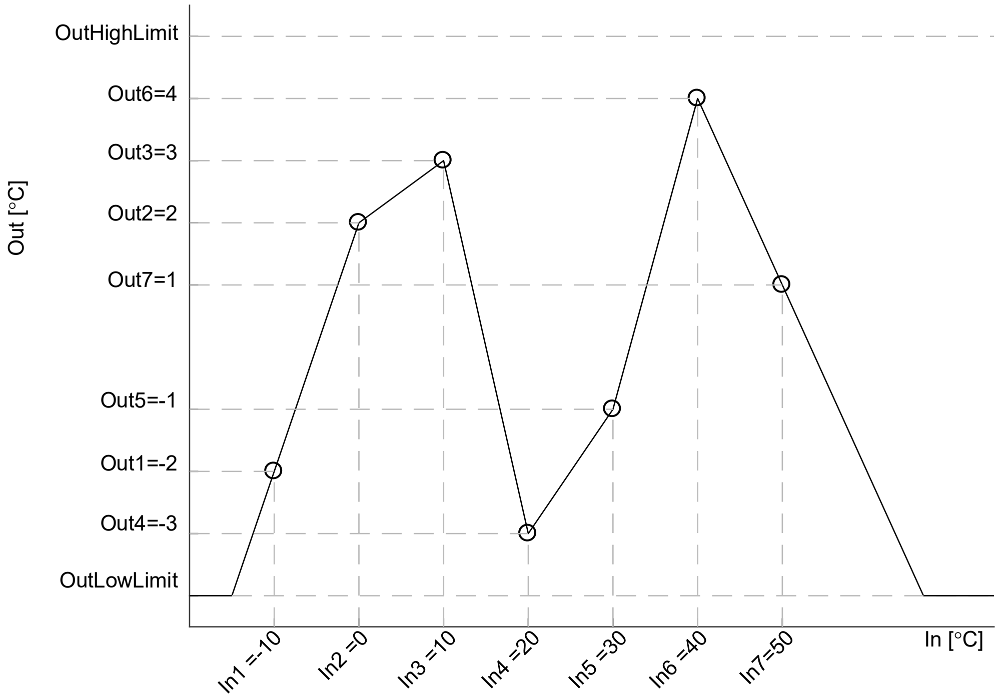
An example is shown below. The same setup procedure detailed before also applies here apart from the different configuration of the AI block. As shown in the graph and in the wiring diagram, the units of both the input and the output of LIN32 are absolute temperatures.



In the second case, for the same application, the LIN32 table stores the offsets between the process variable values measured in the controller and a Math block, set to Add, placed between the Analog Input (AI) and the Loop block. The adjustment is made by adding the offset calculated by the LIN32 block to the measured process variable. In the case of temperature adjustment (and differently from the previous case) the output units of LIN32 should be set to relative temperature. This is in order to select the correct conversion equation when a temperature units change is applied to the offsets (e.g. from degrees Celsius to Fahrenheit).



Because offsets do not follow in general a continuously increasing or decreasing trend, then the 'CurveForm' parameter will be 'FreeForm', 'Increasing' or 'Decreasing' depending on their values: see the following graph as an example of a free form offset curve.



Both the two above mentioned configurations provide the control Loop function block with the same adjusted PV. The values are reported in table for the two examples. The high values of the offsets are only to accentuate in the pictures the action of the adjustment.

Input Breakpoints	Output values: absolute temperature	Alternative output values: relative temperature
-10 deg	-12 deg	-2 deg
0 deg	2 deg	2 deg
10 deg	13 deg	3 deg
20 deg	17 deg	-3 deg
30 deg	29 deg	-1 deg
40 deg	44 deg	4 deg
50 deg	51 deg	1 deg

Input Linearization Parameters

Block – Lin32		**Sub-blocks: 1 to 8**			
Name	**Parameter Description**	**Value**		**Default**	**Access Level**
In	Input measurement to linearize. Wire to the source for the custom linearization	Between InLowLimit and InHighLimit		0	Oper
Out	Linearization Result	Between OutLowLimit and OutHighLimit			Read Only
Status	Status of the block. A value of zero indicates a healthy conversion.	Good Bad	Within operating limits A bad output may be caused by a bad input signal (perhaps the input is in sensor break) or an output which is out of range		Read Only
CurveForm	Linearization Table Curve Form	Freeform Increasing Decreasing SkippedPoints NoForm		NoForm	
Units	Units of the linearized output	None AbsTemp V, mV, A, mA, PH, mmHg, psi, Bar, mBar, %RH, %, mmWG, inWG, inWW, Ohms, PSIG, %O2, PPM, %CO2, %CP, %/sec, RelTemp mBar/Pa/T sec, min, hrs,			Conf
Resolution	Resolution of the output value	XXXXX. XXXX.X, XXX.XX, XX.XXX, X.XXXX			Conf
FallbackType	Fallback Type The fallback strategy will come into effect if the status of the input value is bad or if the input value is outside the range of input high scale and input low scale. In this case the fallback strategy may be configured as shown:	Clip Bad	If the input is outside a limit the output will be clipped to the limit and the status will be BAD	ClipBad	Oper
		Clip Good	If the input is outside a limit the output will be clipped to the limit and the status will be GOOD		
		Fall Bad	The output value will be the fallback value and the output status will be BAD		
		Fall Good	The output value will be the fallback value and the output status will be GOOD		
		Upscale	The output value will be output high scale and the output status will be BAD		
		DownScale	The output value will be the output low scale and the output status will be BAD		
Fallback Value	In the event of a bad status, the output may be configured to adopt the fallback value. This allows the strategy to dictate a 'safe' output in the event of a detected fault.			0	Oper
IntBal	Integral Balance Request	No Yes		No	
OutLowLimit	Adjust to correspond to the low input value	-99999 to OutHighLimit		0	Conf
OutHighLimit	Adjust to correspond to the high input value	OutLowLimit to 99999		0	Conf
NumPoints	Number of Selected Points				
EditPoint	Insert or Delete Points				
In1	Adjust to the first break point			0	Oper
Out1	Adjust to correspond to input 1			0	Oper
…etc up to				0	

Block – Lin32		Sub-blocks: 1 to 8		
Name	**Parameter Description**	**Value**	**Default**	**Access Level**
In32	Adjust to the last break point		0	Oper
Out32	Adjust to correspond to input 32		0	Oper

The 32 point linearization does not require you to use all 32 points. If fewer points are required, then the curve can be terminated by setting the first unwanted value to be less than the previous point.

Conversely if the curve is a continuously decreasing one, then it may be terminated by setting the first unwanted point above the previous one.

Polynomial

List Header – Poly		Sub-headers: 1 to 2			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
Input Lin	To select the input type. The linearization type selects which of the instruments linearization curves is applied to the input signal. The instrument contains a number of thermocouple and RTD linearizations as standard. In addition there are a number of custom linearizations which may be downloaded using iTools to provide linearizations of non-temperature sensors.	J , K, L, R, B, N, T, S, PL2, C, PT100, Linear, SqRoot		J	Conf L3 R/O
Units	Units of the output	None AbsTemp V, mV, A, mA, PH, mmHg, psi, Bar, mBar, %RH, %, mmWG, inWG, inWW, Ohms, PSIG, %O2, PPM, %CO2, %CP, %/sec, RelTemp Vacuum sec, min, hrs,			Conf L3 R/O
Res	Resolution of the output value	XXXXX. XXXX.X, XXX.XX, XX.XXX, X.XXXX		XXXXX	Conf L3 R/O
Input	Input Value The input to the linearization block	Range of the input wired to			L3
Output	Output value	Between Out Low and Out High			Conf L3 R/O
In High	Input high scale	In Low to99999		0	L3
In Low	Input low scale	-99999 to In High		0	L3
Out High	Output high scale	Out Low to 99999		0	L3
Out Low	Output low scale	-99999 to Out High		0	L3
Fall Type	Fallback Type The fallback strategy will come into effect if the status of the input value is bad or if the input value is outside the range of input high scale and input low scale. In this case the fallback strategy may be configured as:	Clip Bad Clip Good Fall Bad Fall Good Upscale DownScale	For an explanation, see Note 1 on page 222 at the end of this section		Conf
Fall Value	Value to be adopted by the output in the event of Status = Bad				L3

List Header – Poly		Sub-headers: 1 to 2			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
Status	Indicates the status of the linearised output:	Good	Good indicates the value is within range and the input is not in sensor break.		L3 R/O
		Bad	Indicates the Value is out of range or the input is in sensor break. Note: This is also effected by the configured fallback strategy		

NOTICE

0: Clip Bad
The measurement is clipped to the limit it has exceeded and its status is set to BAD, such that any function block using this measurement can operate its own fallback strategy. For example the control loop may hold its output.
1: Clip Good
The measurement is clipped to the limit it has exceeded and its status is set to GOOD, such that any function block using this measurement may continue to calculate and not employ its own fallback strategy.
2: Fallback Bad
The measurement will adopt the configured fallback value. Which has been set by the user. In addition the status of the measured value will be set to BAD, such that any function block using this measurement can operate it's own fallback strategy. For example the control loop may hold its output.
3: Fallback Good
The measurement will adopt the configured fallback value. Which has been set by the user. In addition the status of the measured value will be set to GOOD, such that any function block using this measurement may continue to calculate and not employ its own fallback strategy.
4: Up Scale
The measurement will be forced to adopt its high limit, this is like having a resistive pull up on an input circuit. In addition the status of the measurement is set to BAD, such that any function block using this measurement can operate its own fallback strategy. For example the control loop may hold its output.
6: Down Scale
The measurement will be forced to adopt its low limit, this is like having a resistive pull down on an input circuit. In addition the status of the measurement is set to BAD, such that any function block using this measurement can operate its own fallback strategy. For example the control loop may hold its output.

Control Loop Set Up

Two loops are available. Each loop contains two outputs, Channel 1 and Channel 2, each of which can be configured for PID, On/Off or Valve Position (bounded or unbounded) control. In a temperature control loop Channel 1 is normally configured for heating and Channel 2 for cooling. Descriptions given in this section mainly refer to temperature control but generally also apply to other process loops.

What is a Control Loop?

An example of a heat only temperature control loop is shown below:

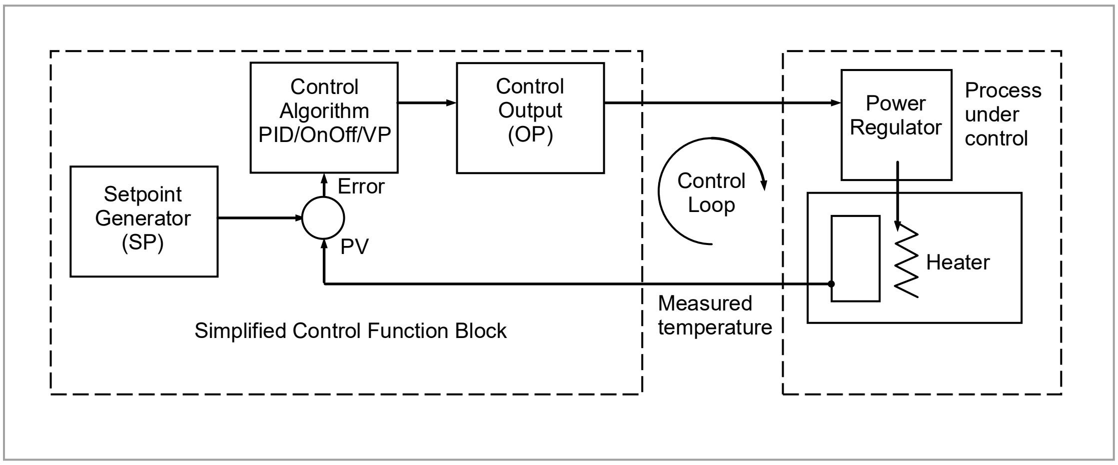


Figure 57: Single Loop Single Channel

The actual measured temperature, or process variable (**PV**), is connected to the input of the controller. The PV is compared with a setpoint (**SP**) (or required temperature). 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. In this controller it is possible to select between a **PID, On/Off, Boundless or Bounded Valve Position** algorithm. The output(s) from the controller (**OP**) are connected to devices on the plant which cause the heating (or cooling) demand to be adjusted resulting in a change in PV which, in turn, is measured by the sensor. This is referred to as closed loop control.

Control Loop Function Blocks

The control loop consists of a number of function blocks. The parameters associated with each function block are presented in sub-headings. Each sub-heading is listed under the overall page header **'Lp-'** (**Lp1** for the first loop and **Lp2** for the second loop).

The function blocks, described in this section are:

Sub-heading	Typical Parameters	Section Number
Main	Overview of the main parameters such as Auto/Manual select, current PV, current output demand, selected setpoint value and working setpoint value	Main Function Block
Setup	To configure control type for each channel of the selected loop	Loop Set Up Function Block
Tune	To set up and run the Auto-tune function	Tuning Function Block

Sub-heading	Typical Parameters	Section Number
PID	To set up 3 term control parameters	PID Function Block
SP	To select and adjust different setpoints, setpoint limits, rate of change of setpoint	Setpoint Function Block
OP	To set up output parameters such as limits, sensor break conditions	Output Function Block
Diag	Diagnostic parameters	Diagnostics Function Block

Main Function Block

The Main function block provides an overview of parameters used by the overall control loop. It allows:

- Auto or Manual operation to be selected
- To stop the loop from controlling for commissioning purposes
- To hold the integral action.
- Read PV and SP values

Parameters can be soft wired as part of a control strategy.

Loop Parameters - Main

A summary of the parameters which provide an overview of Loop 1 (Lp1) or Loop 2 (Lp2) are listed in the following table:

List Header – Lp1 or Lp2		Sub-header: Main			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
AutoMan See also section Auto/Manual.	To select Auto or Manual operation. This performs the same function as the Auto/Manual button described in section To Select Auto/Manual Operation.	Auto	Automatic (closed loop) operation	Auto	L3
		Man	Manual (output power adjusted by the user) operation		
PV	The process variable input value. This is typically wired from an analogue input.	Range of the input source			L3
Inhibit	Used to stop the loop controlling. If enabled the loop will stop control and the output of the loop will be set to the 'Safe' output value. 'Safe' is a parameter found in the Lp1 (or2) OP list. If output rate limit is set the output will go to 'Safe' at the rate limit. On exit from inhibit the transfer will be bumpless. If tracking is configured (see sections Setpoint Tracking and Manual Tracking.) Inhibit will override tracking. Inhibit may be wired to an external source	No Yes	Inhibit disabled Inhibit enabled	No	L3
Target SP	The value of setpoint at which the control loop is aiming. It may come from a number of different sources, such as internal SP and remote SP.	Between setpoint limits			L3

List Header – Lp1 or Lp2		Sub-header: Main			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
WSP	The current value of the setpoint being used by the control loop. It may come from a number of different sources, such as internal SP and Remote SP. The working setpoint is always read-only as it is derived from other sources.	Between setpoint limits			R/O
Work OP	The actual output of the loop before it is split into the channel 1 and channel 2 outputs.				R/O
IntHold	Freeze the integral term at its current value. See also section Integral Hold	No Yes	Integral hold disabled Integral hold enabled	No	L3

Auto/Manual

If On/Off control is configured the output power may be edited by the user but will only allow the power to be set to +100%, 0% or -100%. This equates to heat ON/cool OFF, heat OFF/cool OFF, heat OFF/cool ON.

For PID control the output may be edited between +100% and -100% (if cool is configured). The true output value is subject to limiting and output rate limit.

For valve position control the raise and lower buttons in manual will directly control the raise and lower relay (or triac) outputs. From digital communications it is possible to control the valve by sending nudge commands. A single nudge command will move the valve by 1 minimum on time. In manual mode the natural state will be rest.

If sensor break occurs while the controller is in automatic the controller will output the sensor break output power. However, the user can now switch to manual control. In this case manual will become active and the user can edit the output power. On leaving manual, i.e. returning to automatic control, the controller will again check for sensor break.

If autotune is enabled while in manual mode, the autotune will remain in a reset state such that when the user puts the controller into automatic control the autotune will start.

Loop Set Up Function Block

Loop Set Up configures the type of control required for each channel.

Types of Control Loop

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

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.

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:

P - Proportional band, I - Integral time, D - Derivative time

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, Manual Reset and are described in the following sections.

Motorised Valve Control

This algorithm is designed specifically for positioning motorised valves. It operates in boundless (sometimes called Valve Positioning Unbounded) or bounded mode.

Boundless VP control (VPU) does not require a position feedback potentiometer to operate. It is a velocity mode algorithm which directly controls the direction and velocity of the movement of the valve in order to minimise the error between the setpoint and the PV. It uses triac or relay outputs to drive the valve motor.

☺ A potentiometer may be used with boundless mode but it is used solely for indication of the actual valve position and is not used as part of the control algorithm.

Bounded VP (VPB) control requires a feedback potentiometer as part of the control algorithm.

The control is performed by delivering a ‘raise’ pulse, a ‘lower’ pulse or no pulse in response to the control demand signal via relay or triac outputs.

Motorised Valve Control in Manual mode

Bounded VP controls in manual mode by the fact that the inner positional loop is still running against the potentiometer feedback, so it is operating as a position loop.

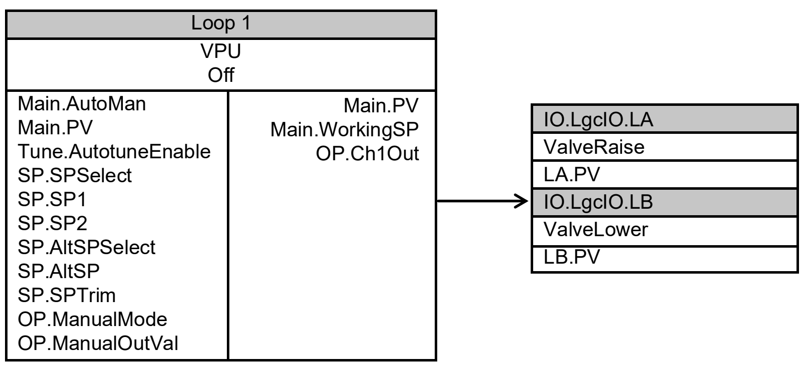
In boundless mode the algorithm is a velocity mode positioner. When manual is selected the algorithm predicts where the valve will move to based on the edit of the manual power. Effectively, when the raise or lower key is pressed, +100% or –100% velocity is used for the duration of the key press and the raise or lower output is turned on. In boundless mode it is essential that the motor travel time is set correctly in order for the integral time to calculate correctly. Motor travel time is defined as valve fully open – valve fully closed - it is not necessarily the time printed on the motor since, if mechanical stops have been set on the motor, the travel time of the actual valve may be different. Also, if the travel time for the valve is set correctly, the position indicated on the controller will fairly accurately match the actual valve position.

Every time the valve is driven to its end stops the algorithm is reset to 0% or 100% to compensate for any changes which may occur due to wear in linkages or other mechanical parts.

This technique makes boundless VP look like a positional loop in manual even though it is not. This enables combinations of heating and cooling e.g. PID heat, VPU cool and have the manual mode work as expected.

Motorised Valve Output Connections

The loop output which has been configured as valve position can be wired to the Logic IO (LA and LB) or to a Dual Output (Relay, Logic or Triac) module. Only one IO Type needs to be configured in the dual IO output since the second will assume the opposite type. For example, if Loop 1 Channel 1 output is wired to Logic IO LA and the IO Type is configured as Valve Raise then IO Type for Logic IO LB will be Valve Lower as shown below.



Loop Parameters - Set up

A summary of the parameters used to configure the type of control are listed in the following table:

List Header – Lp1 or Lp2		Sub-header: Setup			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Ch1 Control Ch2 Control. See also section Types of Control Loop.	Selects the channel 1/2 control algorithm. Different algorithms may be selected for channels 1 and 2. In temperature control applications, Ch1 is usually heating, Ch2 is cooling	Off	Channel turned off	As ordered	Conf L3 R/O
		OnOff	On/off control		
		PID	3 term or PID control		
		VPU	Valve position unbounded		
		VPB	Valve position bounded		
Control Act	Sets the direction of control, i.e. reverse or direct acting	Rev	Reverse acting. The output increases when the PV is below SP. This is the usual setting for heating control.	Rev	Conf L3 R/O
		Dir	Direct acting. The output increases when the PV is above SP. This is the usual setting for cooling control		
PB Units See also section Proportional Band.	Sets the presentation style of the Proportional band.	Eng	Engineering units e.g. C or F	Eng	Conf L3 R/O
		Percent	Per cent of loop span (Range Hi - Range Lo)		
Deriv Type	Selects whether the derivative acts only on PV changes or on Error (either PV or Setpoint changes).	PV	Only changes in PV cause changes to the derivative output. Generally used for process systems particularly using valve control where it reduces wear on valve mechanics.	PV	Conf L3 R/O
		Error	Changes to either PV or SP will cause a derivative output. Derivative on error should be used with a programmer since it tends to reduce ramp overshoot. It is also generally an advantage to use derivative on error for temperature control systems to give a quick response to small setpoint changes.		
The above two parameters do not appear if either Ch1 or Ch2 are configured for Off or OnOff control					
Loop Name	Customised name for the loop	Configured using iTools. See iTools integrated Online Help for further details.			R/O

PID Function Block

The PID function block consists of the following parameters:

Loop Parameters - PID

A summary of the parameters used to optimize the control are listed in the following table:

List Header – Lp1 or Lp2		Sub-header: PID			
Name ⊙ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Sched Type	To choose the type of gain scheduling.	Off	Gain scheduling not active	Off	L3
		Set	The PID set can be selected by the operator.		
		SP	The transfer between one set and the next depends on the value of the setpoint		
		PV	The transfer between one set and the next depends on the value of the process variable		
		Error	The transfer between one set and the next depends on the value of the error		
		OP	The transfer between one set and the next depends on the value of the output		
		Rem	The transfer between one set and the next depends on the value of the remote input		
Num Sets	Selects the number of PID sets in the gain scheduling. This allows the lists to be reduced if the process does not require all three PID sets.	1 to 3		1	L3
Remote Input	This parameter only appears when 'Sched Type' = 'Rem'.	Range units			L3
Active Set	Currently working set.	Set1 Set2 Set3		Set1	R/O
Boundary 1-2	Sets the level at which PID set 1 changes to PID set 2.	Range units The 'Boundary' parameter only applies when 'Sched Type' = 'SP', 'PV', 'Error', 'OP' or 'Rem'			L3
Boundary 2-3	Sets the level at which PID set 2 changes to PID set 3.				
The above 6 parameters are associated with Gain Scheduling described further in section Gain Scheduling.					
PB/PB2/PB3	Proportional band Set1/Set2/Set3. The proportional term, in display units or %, delivers an output which is proportional to the size of the error signal. See also section Proportional Band.	0.0 to 9999.9 (0.0 is not a practical setting)	Engineering units or %	20	L3
Ti/Ti2/Ti3	Integral time constant Set1/Set2/Set3. Removes steady state control offsets by ramping the output up or down in proportion to the amplitude and duration of the error signal. See also section Integral Term.	Off or 1 to 99999	Units = seconds Off = Integral action disabled	360	L3
Td/Td2/Td3	Derivative time constant Set1/Set2/Set3 Determines how strongly the controller will react to the rate of change in the measured value. It is used to control overshoot and undershoot and to restore the PV rapidly if there is a sudden change in demand. See also section Derivative Term.	Off or 1 to 99999	Units = seconds Off = Derivative action disabled	60	L3

List Header – Lp1 or Lp2		**Sub-header: PID**			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
R2G/R2G2/ R2G3	Relative cool gain Set1/Set2/Set3. Only present if cooling has been configured. Sets the cooling proportional band, which compensates for differences between heating power gain and cooling power gain. See also section Relative Cool Gain.	0.1 to 10.0		1.0	L3
CBH/CBH2/ CBH3	Cutback high Set1/Set2/Set3. The number of display units, above setpoint, at which the controller output will be forced to 0% or -100% (OP min), in order to modify undershoot on cool down. See also section High and Low Cutback.	Auto or 0.1 to 9999.9	Auto = 3*PB	Auto	L3
CBL/CBL2/ CBL3	Cutback low Set1/Set2/Set3. The number of display units, below setpoint, at which the controller output will be forced to 100% (OP max), in order to modify overshoot on heat up. See also section High and Low Cutback.				
MR/MR2/MR3	Manual reset Set1/Set2/Set3. Used to remove PV offsets from the setpoint. Manual reset introduces a fixed additional power level to the output. This is the power required to eliminate the steady state error from proportional only control. The manual reset is applied in place of the integral component when integral time is set to Off. See also section Manual Reset.	0.0 to 100.0	%	0.0	L3
LBT/LBT2/LBT3	Loop break time Set1/Set2/Set3 See also section Loop Break.	Off or 1 to 99999	Units = seconds	100	L3
OPHi/2/3	Output high limit for each set	+100	Limits between ‘OPLo’ and 100	100	L3
OPLo/2/3	Output low limit for each set	-100	Limits between ‘OPHi’ and -100	-100	L3

NOTICE

If the control type is set to On/Off, only LBT is shown in the PID list.

Proportional Band

The proportional band (PB), 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 figure 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.

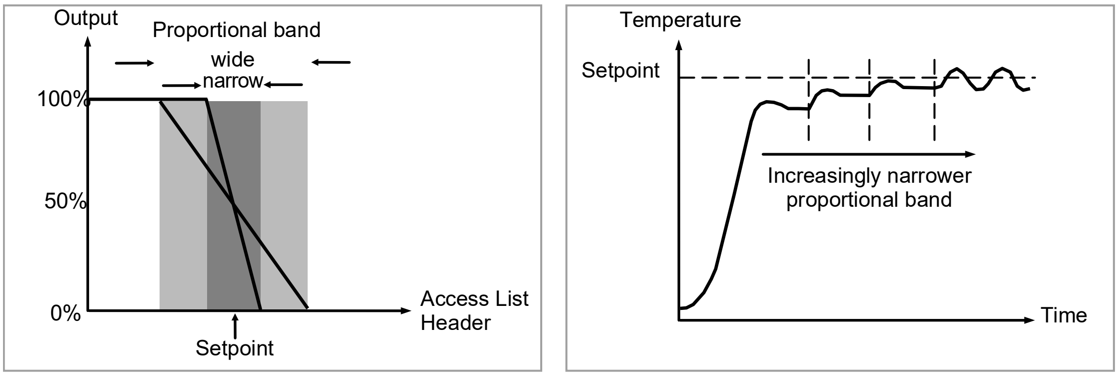


Figure 58: Proportional Action

The above figure 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.

Integral Term

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.

Figure below shows the result of introducing integral action.

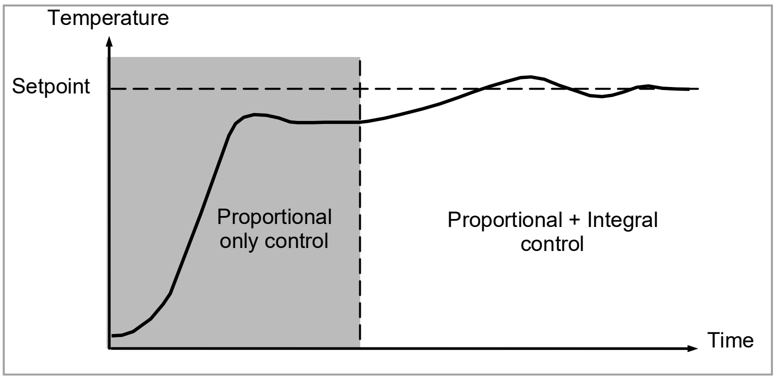


Figure 59: Proportional + Integral Control

The units for the integral term are measured in time (1 to 99999 seconds in 3500 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.

Derivative Term

Derivative action, or rate, provides a sudden shift in output as a result of a rapid change in error, whether or not this is caused by PV alone (derivative on PV) or on SP changes as well (derivative on error selection) – see also section Loop Parameters - Set up. 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.

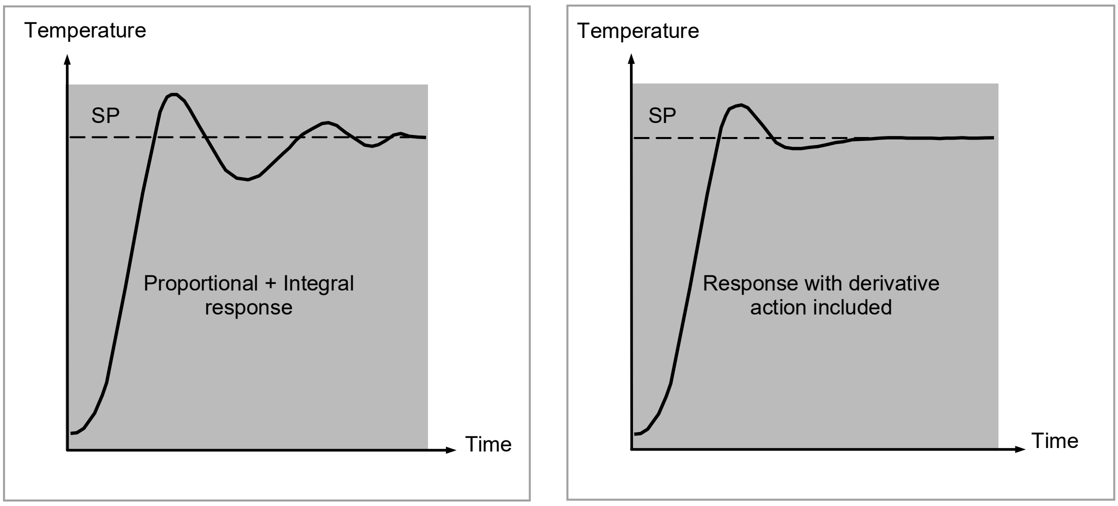


Figure 60: Proportional + Integral + Derivative Action

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, section 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.

Derivative can be calculated on change of PV or change of Error. If configured on error, then changes in the setpoint will be transmitted to the output. For applications such as furnace temperature control, it is common practice to select Derivative on PV to prevent thermal shock caused by a sudden change of output as a result of a change in setpoint.

Relative Cool Gain

The gain of channel 2 control output, relative to the channel 1 control output.

Relative Ch2 Gain compensates for the different quantities of power available to heat, as opposed to that available to cool, a process. For example, water cooling applications might require a relative cool gain of 0.25 because cooling is 4 times greater than the heating process at the operating temperature.

(This parameter is normally set automatically when an Autotune is performed).

High and Low Cutback

Cutback high '**CBH**' and Cutback low '**CBL**' 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 figure below but generally decreases the time to 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.

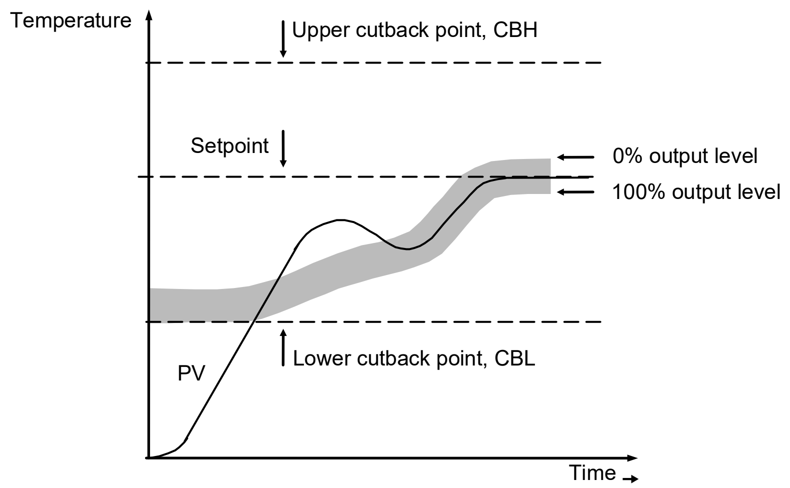


Figure 61: High and Low Cutback

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.

Integral Hold

If enabled, the integral component of the PID calculation will be frozen. Hence, it will hold at its current value but will not integrate any disturbances in the plant. Essentially this is equivalent to switching into PD control with a manual reset value preconfigured.

It may be used, for example, in a situation where the loop is expected to open – it may be necessary to turn heaters off for a short period or switch into manual at low power. In this case it may be an advantage to wire it to a digital input which activates when the heaters are turned off. When the heaters are switched on again the integral is at its previous value minimising overshoot.

Integral De-bump

This is a feature included in the controller which is not accessible to the user. When changing from Manual to Auto control the integral component is forced to:

the output value – the proportional component – the derivative component (I = OP – P – D).

This ensures that no change occurs in output at the point of switch over, and is termed '**Bumpless Transfer**'. The output power will then gradually change in accordance with the demand from the PID algorithm. Bumpless transfer also occurs when changing from Auto to Manual control. At the point of changeover the output power remains the same as the demand in the auto state. It can then be raised or lowered by the operator from this level.

Loop Break

The loop is considered to be broken if the PV does not respond to a change in the output in a given time. Since the time of response will vary from process to process the **Loop Break Time (LBT – PID list)** parameter allows a time to be set before a **Loop Break Alarm (Lp Break - Diag list)** is initiated.

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. This is not to be confused with Load Failure and Partial Load Failure. The loop break algorithm is purely software detection.

Occurrence of a loop break causes the Loop Break Alarm parameter to be set. It does not affect the control action unless it is wired (in software or hardware) to affect the control specifically.

It is assumed that, so long as the requested output power is within the output power limits of a control loop, the loop is operating in linear control and is therefore not in a loop break condition.

However, if the output becomes saturated then the loop is operating outside its linear control region.

Furthermore if the output remains saturated at the same output power for a significant duration, then this could indicate a fault in the control loop. The source of the loop break is not important, but the loss of control could be catastrophic.

Since the worst case time constant for a given load is usually known, a worst case time can be calculated over which the load should have responded with a minimum movement in temperature.

By performing this calculation the corresponding rate of approach towards setpoint can be used to determine if the loop can no longer control at the chosen setpoint. If the PV was drifting away from the setpoint or approaching the setpoint at a rate less than that calculated, the loop break condition would be met.

Loop Break and Autotune

If an autotune is performed the loop break time is automatically set to Ti*2 for a PI or PID Loop or 12*Td for a PD Loop .

For an On/Off controller, loop break detection is also based on loop break time with the PV threshold of 0.1*SPAN where SPAN = Range High – Range Low. Therefore, if the output is at limit and the PV has not moved by 0.1*SPAN in the loop break time a loop break will occur.

For all control configurations other than On/Off (i.e. where the Proportional Band is a valid parameter), if the output is in saturation and the PV has not moved by >0.5*Pb in the loop break time, a loop break condition is considered to have occurred.

If the loop break time is 0(off) the loop break time is not set.

Gain Scheduling

In some processes the tuned PID set may be very different at low temperatures from that at high temperatures particularly in control systems where the response to the cooling power is significantly different from that of the heating power. Gain scheduling allows a number of PID sets to be stored and provides automatic transfer of control between one set of PID values and another. In the case of the 3500 the maximum number of sets is three which means that two boundaries are provided to select when the next PID set is used. When a boundary is exceeded the next PID set is selected bumplessly. Hysteresis is used to stop scheduling oscillation at the boundaries.

Gain scheduling is basically a look up table which can be selected using different strategies or types. Auto tune will tune to the active scheduled PID set.

The following Gain Scheduled types are offered using the parameter 'Sched Type':

Set	The PID set can be selected by the operator. It is possible to use soft wiring to control the selection of the gain sets. This could be linked to the programmer segment, changing the PID settings for individual segments or it could be wired to a digital input so that the working PID set can be set remotely.
SP	The transfer between one set and the next depends on the value of the SP.
PV	The transfer between one set and the next depends on the value of the PV.
Error	The transfer between one set and the next depends on the value of the error.
OP	The transfer between one set and the next depends on the value of the OP demand.
Rem	A remote parameter may be wired into the Scheduler, the PID set is then selected based on the value of this input. An example, might be to automatically change feedforward trim limits in a cascade loop.

The 3500 controller has a maximum of three sets of PID values. The parameter 'Num Sets' allows the number of sets to be limited to one, two or three.

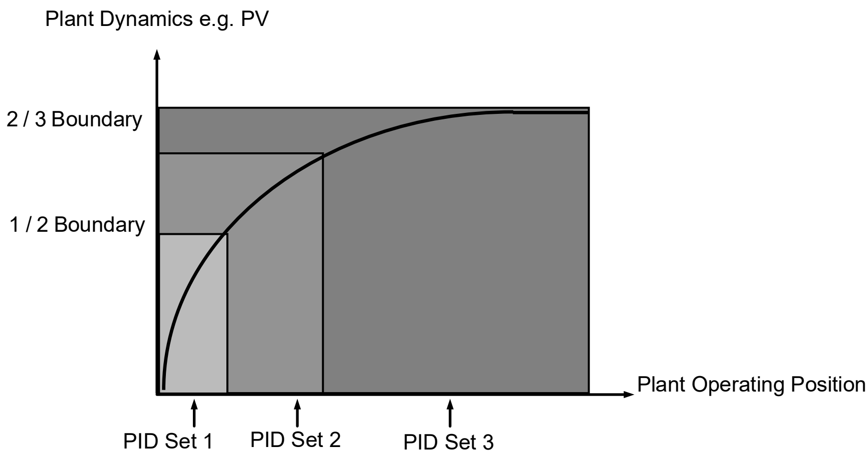


Figure 62: Gain Scheduling over a Wide range of Operating Variable

Tuning Function Block

Tuning involves setting the following parameters.

Proportional Band ‘PB’, Integral Time ‘Ti’, Derivative Time ‘Td’, Cutback High ‘CBH’, Cutback Low ‘CBL’, and Relative Cool Gain ‘R2G’ (applicable to heat/cool systems only).

The controller is shipped with these parameters set to 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 control 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 which 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.

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.

Gain scheduling is provided to allow specific PID settings to be applied at the different operating points of the process.

Initial Settings

In addition to the tuning parameters listed in section Tuning Function Block 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. Before starting a tune the loop conditions should be set as closely as practicable to the actual conditions which will be met in normal operation. 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 Lo**' and '**Output Hi**' both of which are found in the Loop OP list, section Output Function Block. 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.

Remote Output Limits. '**RemOPL**' and '**RemOPHi**' (Loop OP List). If these parameters are used they should be set within the Heat/Cool Limits above.

Heat/Cool Deadband. In controllers fitted with a second (cool) channel a parameter '**Ch2 DeadB**' is also available in the Loop OP list, section Output Function Block, 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 On Time. If either or both of the output channels is fitted with a relay, triac or logic output, the parameter '**Min OnTime**' will appear in the relevant output list (Logic IO List, AA Relay Output List or Relay, Triac or Logic Output Module 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**' is found in the PV Input List.

Output Rate limit. Output rate limit is active during tuning and may affect the tuning results. The parameter 'Rate' is found in the Loop OP List.

Valve Travel Time. If the output is a motor valve positioner the '**Ch1 TravelT**' and '**Ch2 TravelT**' (Loop OP List) should be set as described in section Loop Parameters - Output.

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.
- If the two loops in a 3500 controller are connected for cascade control, the inner loop may tuned automatically but the outer should be tuned manually.
- In a programmer/controller tuning should only be attempted during dwell periods and not during ramp stages. If a programmer/controller is tuned automatically put the controller into Hold during each dwell period whilst autotune is active. It may be worth noting that tuning, carried out in dwell periods which are at different extremes of temperature may give different results owing to non linearity of heating (or cooling). This may provide a convenient way to establish values for Gain Scheduling (see section Gain Scheduling).

☺ If an auto tune is initiated there are two further parameters which need to be set. These are ‘High Output’ and ‘Low Output’. These are found in the ‘Tune’ List, see also section Loop Parameters - Auto-Tune.

Automatic Tuning

Auto Tune is a tool which is used to set the control terms as close as possible to match the characteristics of the process.

It uses the ‘one-shot’ tuner which works by switching the output on and off to induce an oscillation in the process value. For this reason the auto tune process should be done off line but using load conditions as close as possible to those to be found in practice. From the amplitude and period of the oscillation, it calculates the control parameter values listed in the table below.

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 ‘**CBH’**	If CBH and/or CBL is set to ‘**Auto’** these terms will remain at Auto after an autotune, i.e. 3*PB. For autotune to set the cutback values, CBH and CBL 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.
Cutback Low ‘**CBL’**	
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. In software releases up to and including 2.30, if the calculated value is outside this limit, R2G remains at its previous value but all other tuning parameters are changed.
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.

The autotune sequence for different conditions is described in sections Autotune from Below SP – Heat/Cool to Autotune at Setpoint – Heat/Cool.

Loop Parameters - Auto-Tune

A summary of the Autotune parameters is listed in the following table:

List Header – Lp1 or Lp2		**Sub-header: Tune**			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Tune R2G R2G applies only to Ch1/Ch2 (heat/cool) control.	Defines the type of relative cooling gain tuning for the loop. For further information, please refer to section Relative Cool Gain in Well Lagged Processes 'Well Lagged Systems'.	Standard	Tunes the relative cooling gain of the loop using the standard R2G tuning algorithm.	Standard	
		R2GPD	If the process is heavily lagged, this setting should be used.		
		Off	R2G is not calculated automatically. Enter the value manually as described in section Manually Setting Relative Cool Gain.		
Enable	To start auto-tune	Off	Auto-tune not running. If Off is selected during a tune, tuning will stop.	Off	L3
		On	Auto-tune running		
High Output	Set high and low limits to be imposed when auto-tune is running	Between Output Hi and Output Lo overall limits set in the OP block. Max and Min limits -100% to 100%.			L3
Low Output					
State	Reads the progress of auto-tune.	Off	Not running	Off	L3 R/O
		Ready			
		Running	In progress		
		Complete	Auto-tune completed successfully		
		Timeout	Error conditions, see section Failure Modes		
		TI_Limit			
		R2G_Limit			
Stage	Progress of auto-tune	Settling	Displayed during the first minute	Off	L3 R/O
		To SP	Heat (or cool) output on		
		Wait min	Power output off		
		Wait max	Power output on		
		Timeout	See section Failure Modes		
		TI Limit			
		R2G Limit			
Stage Time	Time in current tune stage	0 to 99999 seconds			L3 R/O
Diagnostic	Tuning diagnostics	This parameter is for internal use only			L3

To Auto Tune a Loop - Initial Settings

Set parameters listed in section Initial Settings.

'**Output Hi**' and '**Output Lo**' ('OP' List section Loop Parameters - Output) set the overall output limits. These limits apply at all times during tuning and during normal operation.

Set '**High Output**' and '**Low Output**' ('**Tune**' list section Loop Parameters - Auto-Tune). These parameters set the output power limits during Autotune.

☺ The 'tighter' power limit will always apply. For example if 'High Output' is set to 80% and 'Output Hi' is set to 70% then the output power will be limited to 70%.

☺ 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.

To Start Autotune

Select operator level 3. Auto tune cannot be performed in Configuration level or when the loop is in Manual mode.

a. Press [page key] to select the '**Lp1**' (or 'Lp2') list header,

b. Press [up key] or [down key] to select the '**Tune**' sub-header

c. Press [scroll key] to select '**Enable**'

d. Press [up key] or [down key] to select '**On**'

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 Units**' (Setup list) is set to '**Percent**' or ±1 engineering unit (1 in 1000) if the '**PB Units**' is set to '**Eng**'. Range is defined as 'Range Hi' – 'Range Lo' for process inputs or the range defined in section Input Types and Ranges for temperature inputs.

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

Autotune and Sensor Break

When the controller is autotuning and sensor break occurs, the autotune will abort and the controller will output the sensor break output power '**Sbrk OP**' set up in the OP List. Autotune must be re-started when the sensor break condition is no longer present.

Autotune and Inhibit or Manual

If the Loop Inhibit is asserted or the controller is put into Manual Mode, any tune in progress will be aborted and will need to be re-started once the condition has been removed. Note that it is not possible to start an autotune sequence if the loop is inhibited or in Manual control.

Autotune and Gain Scheduling

When gain scheduling is enabled and an autotune is performed, the calculated PID values will be written into the PID set that is active on completion of the tune. Therefore, the user may tune within the boundaries of a set and the values will be written into the appropriate PID set. However, if the boundaries are close, since the range of the loop is not large, then, at the completion of the tune, it cannot be guaranteed that the PID values will be written to the correct set particularly if the schedule type is PV or OP. In this situation the scheduler (‘Sched Type’) should be switched to ‘Set’ and the ‘Active Set’ chosen manually.

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 20 + 0.75 x (500 - 20) = 380^{o}C.

If Target Setpoint = 500^{o}C and Initial PV = 400^{o}C, then the Tune Control Point will be 400 + 0.75 x (500-400) = 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:

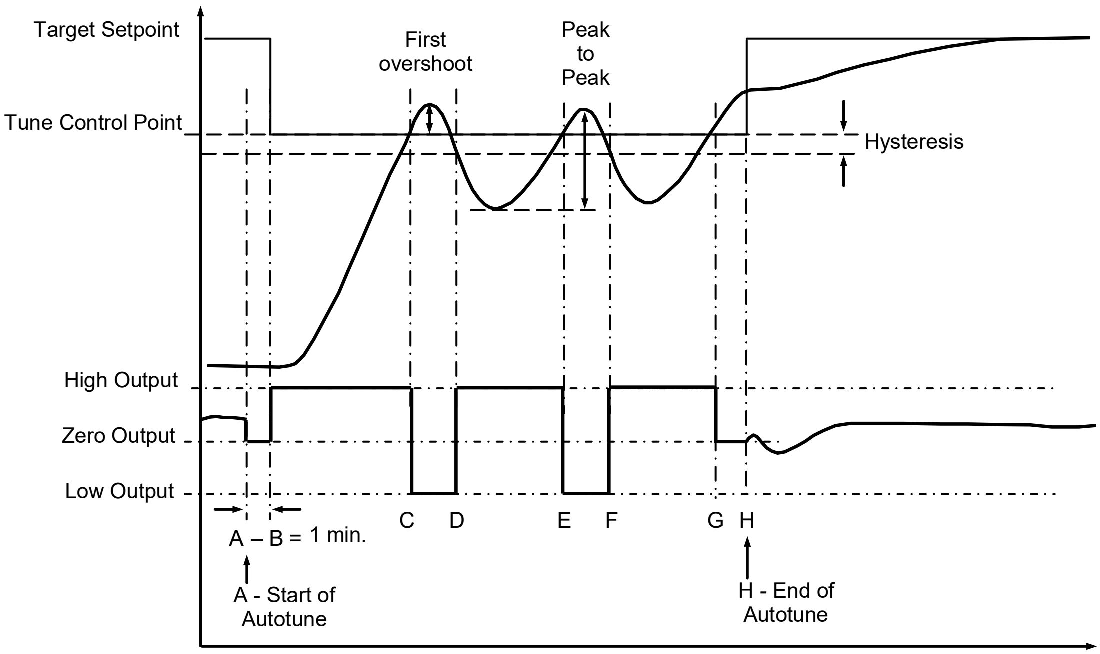


Figure 63: Autotune - Heat/Cool Process

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. ‘**CBL**’ 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. ‘**CBH**’ is calculated from CBL*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.

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.

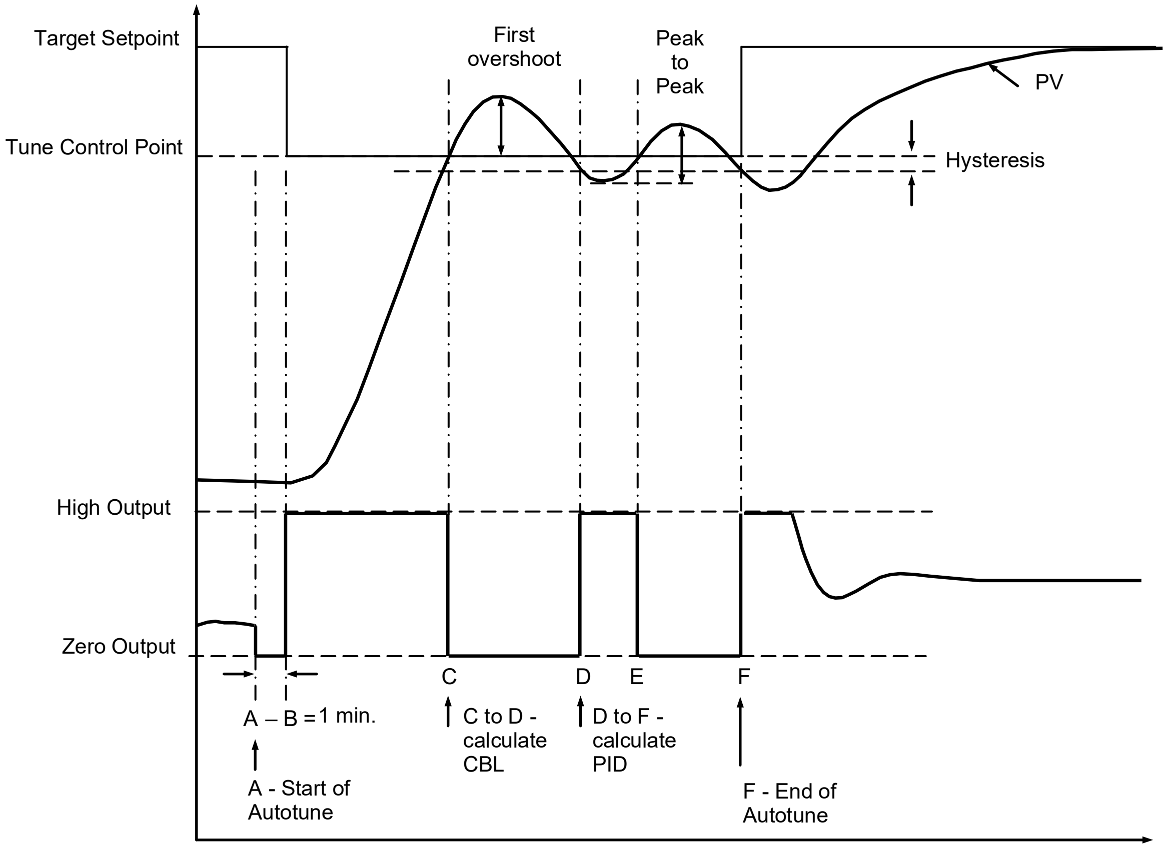


Figure 64: Autotune from below SP – Heat Only

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

NOTICE

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 CBH is calculated – CBL is then set to the same value as CBH.

Autotune at Setpoint – Heat/Cool

It is sometimes necessary to tune at the actual setpoint being used. This is allowable in 3500 series controllers and the sequence of operation is described below.

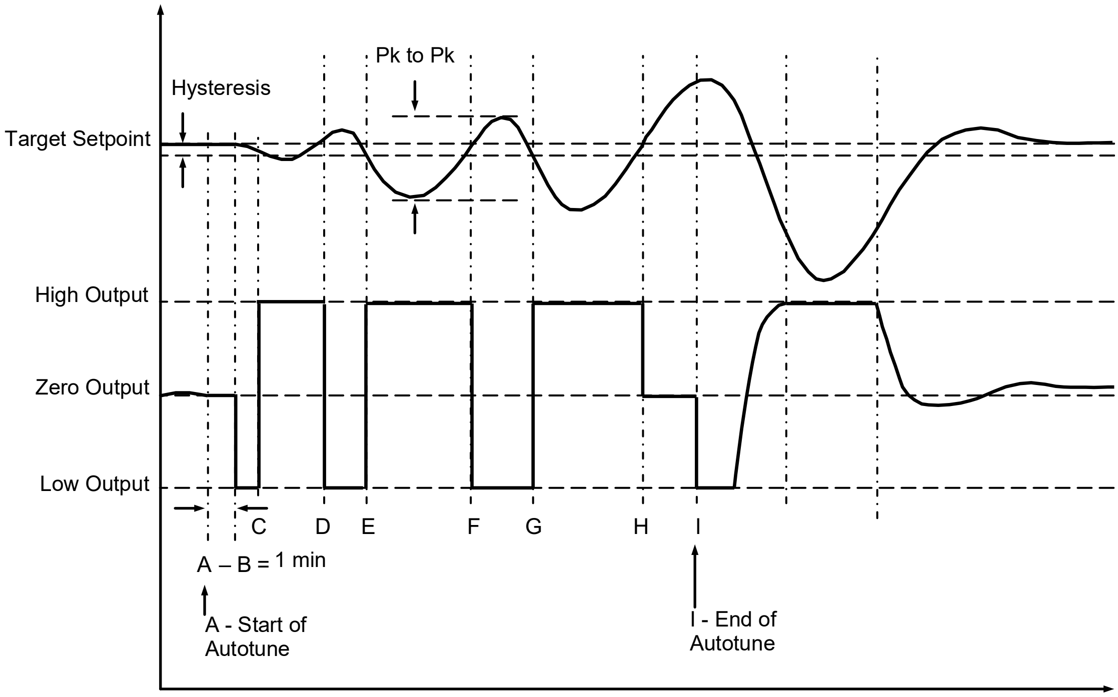


Figure 65: Autotune at Setpoint

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 Units**' (Setup list) is set to '**Percent**'. If '**PBUnits'** is set to '**Eng'** then the SP must remain within ±1 engineering unit (1 in 1000). Range is defined as 'Range Hi' – 'Range Lo' for process inputs or the range defined in section Input Types and Ranges 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.

Failure Modes

The conditions for performing an autotune are monitored by the parameter 'State'. If autotune is not successful error conditions are read by this parameter as follows:

Timeout	This will occur if any one stage is not completed within one hour. It could be due to the loop being open or not responding to the demands from the controller. Very heavily lagged systems may produce a timeout if the cooling rate is very slow.
TI Limit	This will be displayed if Autotune calculates a value for the integral term greater than the maximum allowable integral setting i.e. 99999 seconds. This may indicate that the loop is not responding or that the tune is taking too long.
R2G Limit	The calculated value of R2G is outside the range 0.1 and 10.0. In versions up to and including V2.3, R2G is set to 0.1 but all other PID parameters are updated. R2G limit may occur if the gain difference between heating and cooling is too large. This could also occur if the controller is configured for heat/cool but the cooling medium is turned off or not working correctly. It could similarly occur if the cooling medium is on but heating is off or not working correctly.

Relative Cool Gain in Well Lagged Processes

In the majority of processes Relative Cool Gain R2G is calculated by the autotune algorithm as described in the previous sections – section Autotune from Below SP – Heat/Cool in particular.

There are occasions, however, where an alternative algorithm may be preferred. These are processes which are heavily lagged, where the heat loss to ambient is very small so that natural cooling is extremely slow, and certain high order plants, those that need derivative, Td. This algorithm is known as R2GPD algorithm and has been added to controllers from firmware version V3.30.

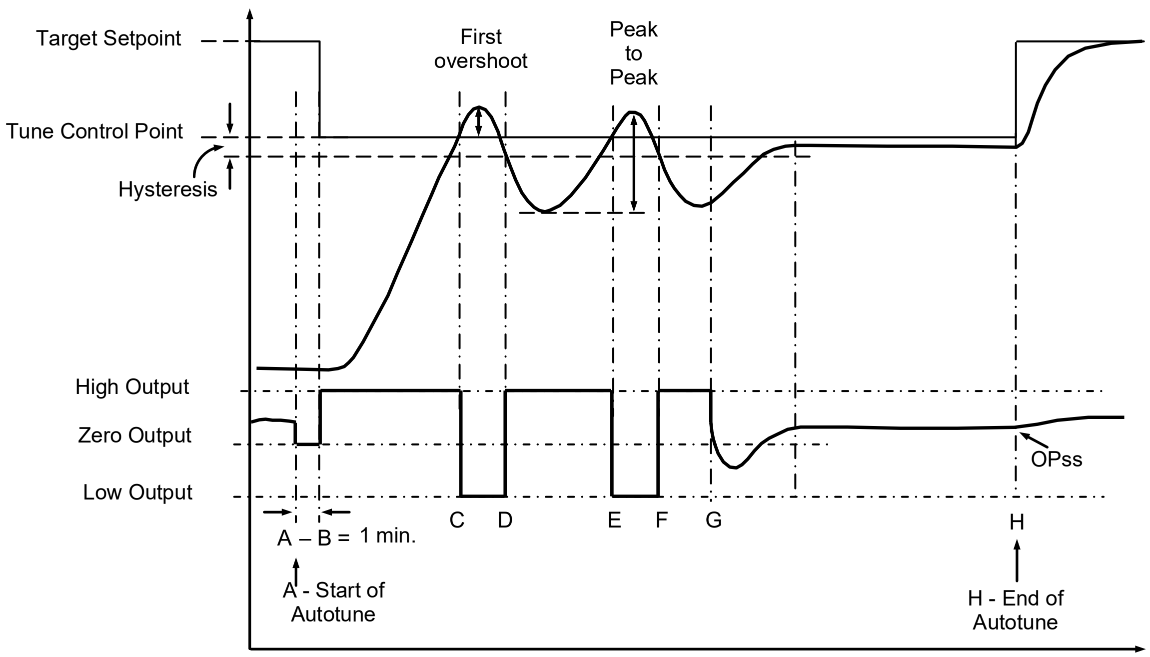
The type of algorithm is selected using the parameter '**Tune R2G**' found in the Auto-Tune list, section Loop Parameters - Auto-Tune. The choices are:

Standard This is the default as described in section Autotune from Below SP – Heat/Cool and is suitable for use on most processes. The benefit of this algorithm is that it is relatively quick. However, in the type of process described in the previous paragraph, it can produce values which are not ideal. These values are generally identified by R2G equal to or very close to 0.1.

R2GPD If the process is known to be heavily lagged or produces values such as those above then R2GPD should be selected. This algorithm extends the autotune period by putting the controller into proportional plus derivative mode (PD) and uses the output power demand value during this period to determine the Relative Cool Gain.

Off The automatic calculation of Relative Cool Gain can be turned off and the value entered manually as described in section Manually Setting Relative Cool Gain.

When Tune R2G = R2GPD, Autotune from below setpoint is described below.



Periods A-F are largely unchanged from the 'Standard' algorithm, section Autotune from Below SP – Heat/Cool, with the following exception:

- Changing the Target Setpoint during period A-B will not change the tuning setpoint.

Period F-H is replaced as follows:

F to G	Heat is applied for a period (F-G) of half the last heat cycle (D-E) to compensate for the last cool cycle
G to H	This is a period in which the controller is put into PD control. The values of proportional term and derivative time for this period of PD control are determined by the algorithm.
H	OPss is the output demand value at the end of this period and is used in the determination of R2G.

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 'CBH' and Low Cutback 'CBL' 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

Manually Setting Relative Cool Gain

If the controller is fitted with a cool channel this should be enabled before the PID values calculated from the table in section Manual Tuning are entered.

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

Then enter the values from the table.

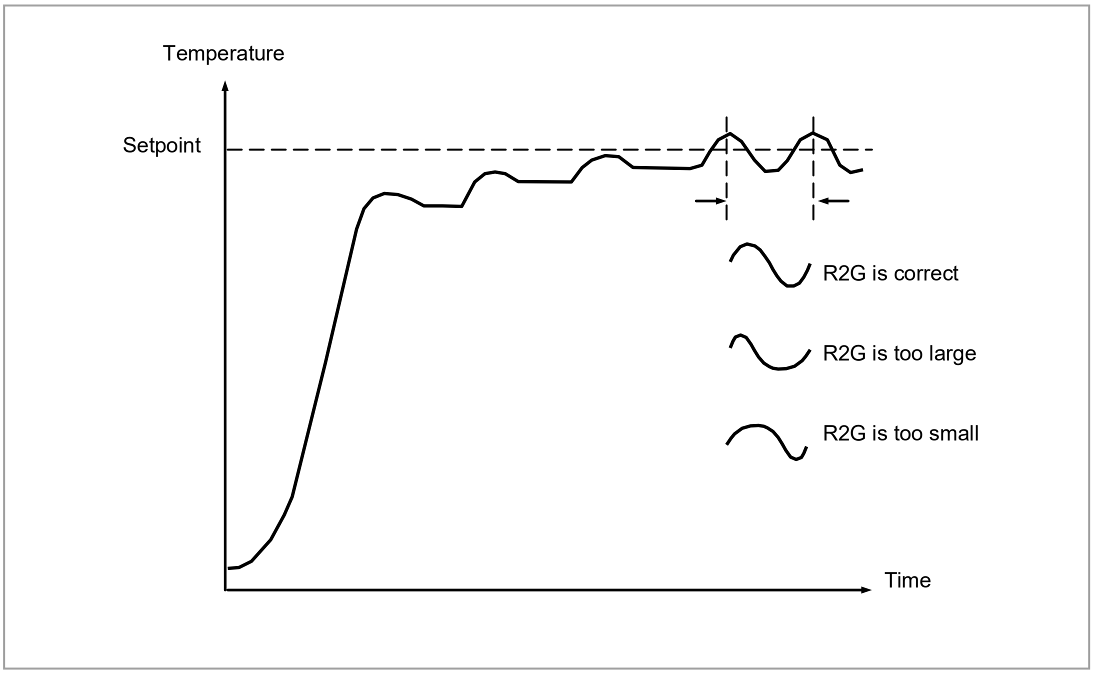


Figure 66: Setting Relative Cool Gain

Manually Setting the Cutback Values

Enter the PID terms calculated from the table in section Manual Tuning 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 'CBL' by the value of the overshoot in display units. If undershoot is observed increase the value of the parameter 'CBH' by the value of the undershoot in display units.

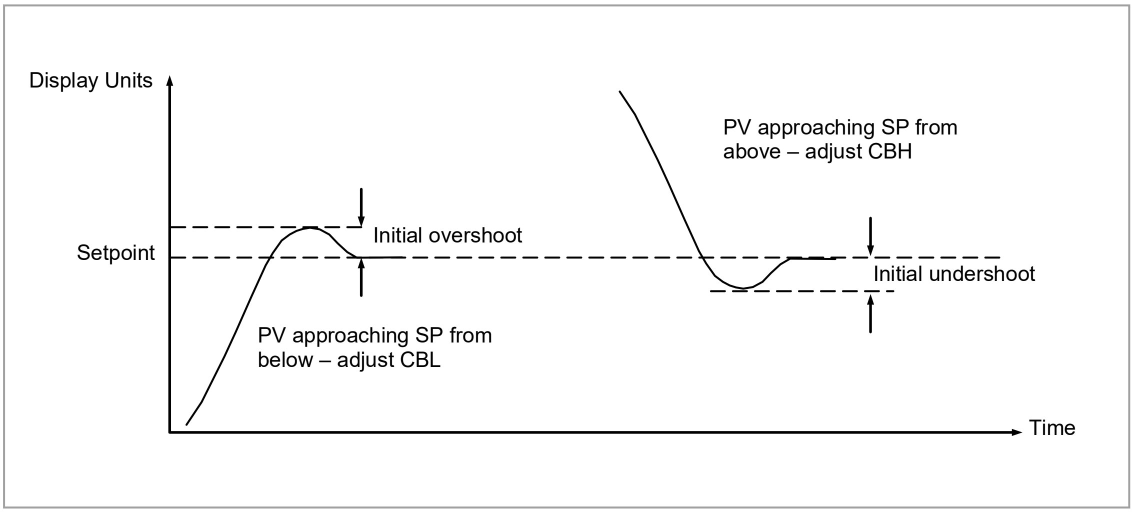


Figure 67: Manual Setting of Cutback

Setpoint Function Block

The controller setpoint is the **Working Setpoint** which may be sourced from a number of alternatives. This is the value ultimately used to control the process variable in a loop.

The working setpoint may be derived from:

1. SP1 or SP2, both of which are manually set by the user and can be switched into use by an external signal or through the user interface.
2. From an external (remote) analogue source
3. The output of a programmer function block. This will, therefore, vary in accordance with the program in use.

The setpoint function block also provides the facility to limit the rate of change of the setpoint before it is applied to the control algorithm. It will also provide upper and lower limits. These are defined as setpoint limits, ‘SP HighLim’ and ‘SP LowLim’, for the local setpoints and instrument range high and low for other setpoint sources. All setpoints are ultimately subject to a limit of ‘Range Hi’ and ‘Range Lo’.

User configurable methods for tracking are available, such that the transfer between setpoints and between operational modes will not cause a bump in the setpoint.

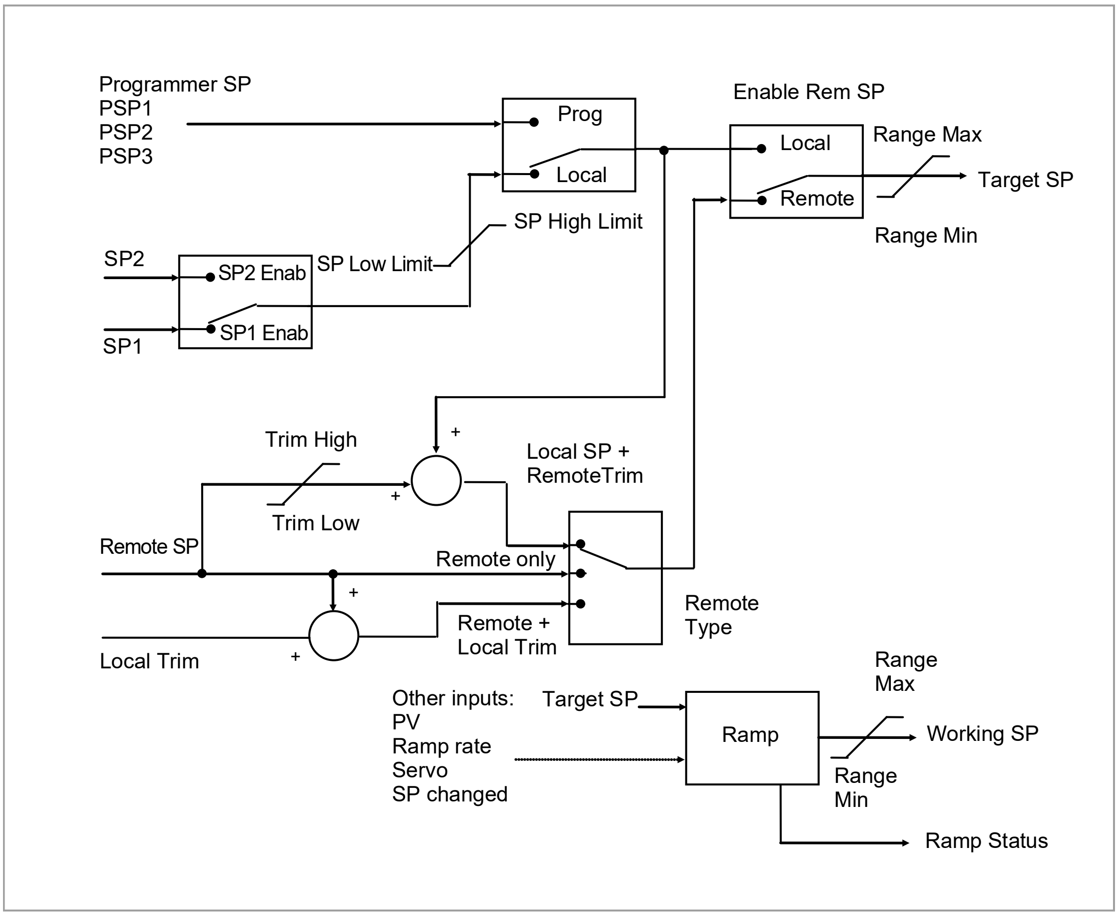


Figure 68: Setpoint Function Block

Loop Parameters - Setpoint

A summary of the parameters used to configure the setpoints are listed in the following table:

List Header – Lp1 or Lp2		Sub-header: SP			
Name ⊙ to select	**Parameter Description**	**Value** Press ▽ or △ to change values		**Default**	**Access Level**
Range Hi	The Range limits provide a set of absolute maximums and minimums for setpoints within the control loop. Any derived setpoints are ultimately clipped to be within the Range limits. If the Proportional Band is configured as % of Span, the span is derived from the Range limits.	-99999 to 99999			Conf
Range Lo					Conf
SP Select	Select local or alternate setpoint	SP1 SP2	Setpoint 1 Setpoint 2	SP1	L3
SP1	Primary setpoint for the controller	Between SP high and SP low limits			L3
SP2	Setpoint 2 is the secondary setpoint of the controller. It is often used as a standby setpoint.				L3
SP HighLim	Maximum limit allowed for the local setpoints	Between Range Hi and SP LowLim		Range Hi	L3
SP LowLim	Minimum limit allowed for the local setpoints	Between SP HiLim and Range Lo		Range Lo	L3
Alt SP En	To enable the alternative setpoint to be used. This may be wired to a source such as the programmer Run input. See note below	No Yes	Alternative setpoint disabled Alternative setpoint enabled		L3
Alt SP	This may be wired to an alternative source such as the programmer or remote setpoint See note below				L3
Rate	Limits the maximum rate at which the working setpoint can change. The rate limit may be used to protect the load from thermal shock which may be caused by large step changes in setpoint.	Off or 0.1 to 9999.9 engineering units per minute		Off	L3
RateDone	Flag which indicates when the setpoint is changing or completed	No Yes	Setpoint changing Complete		R/O
SPRate Disable	Setpoint rate disable. Does not appear if 'Rate' = 'Off'	No Yes	Enabled Disabled	Off	L3
ServoToPV	Servo to PV Enable When Rate is set to any value other than Off and Servo to PV is enabled, changing the active SP will cause the working SP to servo to the current PV before ramping to the new target SP.	No Yes	Disabled Enabled	No	Conf R/O in L3
SP Trim	Trim is an offset added to the setpoint. The trim may be either positive or negative, the range of the trim may be restricted by the trim limits Setpoint trims may be used in a retransmission system. A master zone may retransmit the setpoint to the other zones, a local trim may be applied to each zone to produce a profile along the length of the machine	Between SP Trim Hi and SP Trim Lo			L3
SP Trim Hi	Setpoint trim high limit				L3
SP Trim Lo	Setpoint trim low limit				L3
Man Track	Manual track enable. To allow the Local SP to follow the value of the current PV when the controller is in Manual mode. See also section Manual Tracking	Off On	Manual tracking disabled Manual tracking enabled	Off	L3 R/O

List Header – Lp1 or Lp2		Sub-header: SP			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
SP Track	Setpoint track enable. To allow the Local SP to follow the value of the Remote SP. See also section Setpoint Tracking.	Off On	Setpoint tracking disabled Setpoint tracking enabled	Off	Conf
Track PV	The programmer tracks the PV when it is servoing or tracking. See also section Manual Tuning.				L3 R/O
Track SP	Manual Tracking Value. The SP to track for manual tracking. See also section Setpoint Tracking.				L3 R/O
SPIntBal	SP Integral Balance This is also known as debump in some instances. It forces the integral to be balanced upon changes in target setpoint	Off On		Off	L3 R/O Alterable in config

NOTICE

Connections to the programmer are made automatically when the loop and programmer are enabled and there are no existing connections to these parameters.

Setpoint Limits

The setpoint generator provides limits for each of the setpoint sources as well as an overall set of limits for the loop. These are summarised in the diagram below.

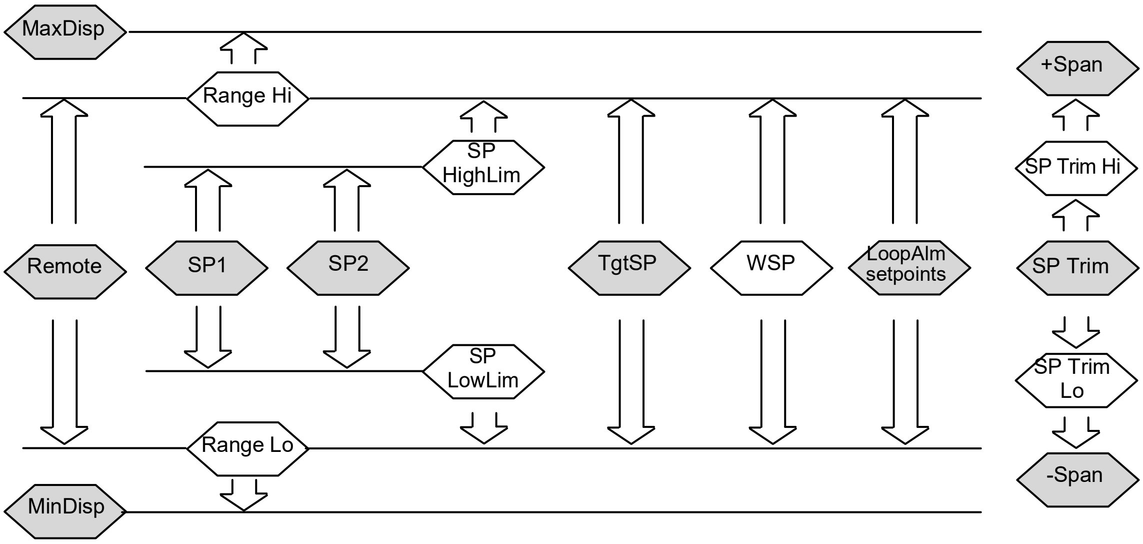


Figure 69: Setpoint Limits

☺ '**Range Hi**' and '**Range Lo**' provide the range information for the control loop. They are used in control calculations to generate proportional bands. Span = Range Hi – Range Lo.

Setpoint Rate Limit

Allows the rate of change of setpoint to be controlled. This prevents step changes in the setpoint. It is a simple symmetrical rate limiter and is applied to the working setpoint which includes setpoint trim. It is enabled by the '**Rate**' parameter. If this is set to Off then any change made to the setpoint will be effective immediately. If it is set to a value then any change in the setpoint will be effected at the value set in units per minute. Rate limit applies to SP1, SP2 and Remote SP.

When rate limit is active the '**RateDone**' flag will display '**No**'. When the setpoint has been reached this parameter will change to '**Yes**'. This flag will be cleared if the target setpoint subsequently changes.

When '**Rate**' is set to a value (other than Off) an additional parameter '**SPRate Disable**' is displayed which allows the setpoint rate limit to be turned off and on without the need to adjust the 'Rate' parameter between Off and a value.

If the PV is in sensor break, the rate limit is suspended and the working setpoint takes the value of 0. On sensor break being released the working setpoint goes from 0 to the selected setpoint value at the rate limit.

Setpoint Tracking

The setpoint used by the controller may be derived from a number of sources. For example:

1. Local setpoints SP1 and SP2. These may be selected through the front panel using the parameter ‘SP Select’, through digital communications or by configuring a digital input which selects either SP1 or SP2. This might be used, for example, to switch between normal running conditions and standby conditions. If Rate Limit is switched off the new setpoint value is adopted immediately when the switch is changed.
2. A programmer generating a setpoint which varies over time, see Setpoint Programmer. When the programmer is running the ‘TrackSP’ and ‘TrackPV’ parameters update continuously so that the programmer can perform its own servo (see also section Servo). This is sometimes referred to as ‘**Program Tracking**’.
3. From a Remote analogue source. The source could be an external analogue input into an analogue input module wired to the ‘Alt SP’ parameter or a User Value wired to the ‘Alt SP’ parameter. The remote setpoint is used when the parameter ‘Alt SP En’ is set to ‘Yes’.

Setpoint tracking (sometimes referred to as **Remote Tracking**) ensures that the Local setpoint adopts the Remote setpoint value when switching from Local to Remote to maintain bumpless transfer from Remote to Local. Bumpless transfer does not take place when changing from Local to Remote. Note that if Rate Limit is applied the setpoint will change at the rate set when changing from Local to Remote.

Manual Tracking

When the controller is operating in manual mode the currently selected SP (SP1 or SP2) tracks the PV. When the controller resumes automatic control there will be no step change in the resolved SP. Manual tracking does not apply to the remote setpoint or programmer setpoint.

Output Function Block

The output function block performs the loop output control algorithms. It selects the correct output sources to be used, determines whether to heat or cool and then applies limits. Power feed forward and non-linear cooling are also applied.

It is this block that manages the output in exception conditions such as start up and sensor break.

The outputs, ‘Ch1 Output’ and ‘Ch2 Output’, are normally connected to an output module where they are converted into an analogue or time proportioned signal for electrical heating, cooling or valve movement.

Loop Parameters - Output

A summary of the parameters used to configure output are listed in the following table:

List Header – Lp1 or Lp2		Sub-header: OP		
Name to select	**Parameter Description**	**Value** Press or to change values	**Default**	**Access Level**
Output Hi	Maximum output power delivered by channels 1 and 2. By reducing the high power limit, it is possible to reduce the rate of change of the process, however, care should be taken as reducing the power limit will reduce the controllers ability to react to disturbance.	Between Output Lo and 100.0%	100.0	L3
Output Lo	Minimum (or maximum negative) output power delivered by channels 1 and 2	Between Output Hi and -100.0%	0.0 or -100.0	L3
Ch1 Output	Channel 1 (Heat) output. The Ch1 output is the positive power values (0 to Output Hi) used by the heat output. Typically this is wired to the control output (time proportioning or DC output).	Between Output Hi and Output Lo		L3 R/O
Ch2 Output	The Ch2 output is negative portion of the control output (0 – Output Lo) for heat/cool applications. It is inverted to be a positive number so that it can be wired into one of the outputs (time proportioning or DC outputs).	Between Output Hi and Output Lo		L3 R/O
Ch2 DeadB	Ch1/Ch2 Deadband is a gap in percent between output 1 going off and output 2 coming on and vice versa. For on/off control this is taken as a percentage of the hysteresis.	Off to 100.0%	Off	L3
The following four parameters only appear if Ch1/2 are configured for valve position control (Ch1/2 Control = VPU/VPB in Lp Setup page)				
Ch1 TravelT	Valve travel time for the channel 1 valve to travel from 0% (closed) to 100% (open). In a Valve positioner application, Channel one is connected to both a Raise and a Lower output. In a Heat/Cool application Channel 1 is the heat valve.	0.0 to 1000.0 seconds		L3
Ch2 TravelT	Travel time for Channel 2 valve to travel from 0% (closed) to 100% (open). In a Heat/Cool application, Channel 2 is the cool valve.	0.0 to 1000.0 seconds		L3
Nudge Raise	Causes the valve to move by one minimum on time towards the CH1 open position See also section Nudge Raise/Lower.			L3
Nudge Lower	Causes the valve to move by one minimum on time towards the CH1 close position See also section Nudge Raise/Lower.			
The following six pot feedback parameters appear if Ch1/2 are configured for VPB – valve position bounded mode				
PotCal	Starts the potentiometer calibration by selecting which potentiometer to calibrate. e.g. if a valve is used to control the cooling of a process, then the ch2 potentiometer must be calibrated. Note: Potentiometer input modules must be fitted and wired directly to the loops Ch1 or Ch2 pot position parameters. See section Potentiometer Input and Example: To Calibrate a VP Output for details on pot calibration	Off – Pot cal disabled CH1 – Calibrate channel 1 CH2 – Calibrate channel 2		Conf
Ch1 Pot Pos	The position of the channel 1 actuator as measured by a pot position feedback. This is used by the bounded VP control algorithm as the PV of the positional loop. Note: ‘PotCal’ can be used to automatically calibrate the potentiometer feedback.			L3

List Header – Lp1 or Lp2		**Sub-header: OP**			
Name ⊙ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Ch1 Pot Brk	Indicates the Channel 1 pot is broken. This parameter requires that the pot position is wired from an input channel. This value is taken from the wire.	Off On		Off	L3
Ch2 Pot Pos	The position of the channel 2 actuator as measured by a pot position feedback. This is used by the bounded VP control algorithm as the PV of the positional loop				L3
Ch2 Pot Brk	Indicates the Channel 2 pot is broken. This value is taken from the wire and is provided by the pot input module.	Off On		Off	L3
PotBrk Mode	Defines the action which takes place if the feedback potentiometer becomes open circuit. An alarm message is given whenever the fault occurs.	Raise	The valve is opened		L3
		Lower	The valve is closed		
		Rest	The valve remains in its current position		
		Model	The controller tracks the actual position of the valve and sets up a model of the system so that it continues to control when the potentiometer becomes faulty		
Rate	Limits the rate at which the output from the PID can change. Output rate limit is useful in preventing rapid changes in output from damaging the process or the heater elements. See also section Output Rate Limit.	Off to 9999.9 percent per minute		Off	L3
Ch1 OnOff Hyst	Channel hysteresis - only shown when the channel is configured as OnOff. See also section Effect of Control Action, Hysteresis and Deadband.	0.0 to 200.0		10.0	L3
Ch2 OnOff Hyst		0.0 to 200.0		10.0	L3
Sbrk Mode	To set the action which takes place in the event of a sensor break. See also section Sensor Break Mode.	SbrkOP	The output will be the value configured by 'Sbrk OP' (the next parameter)..	SbrkOP	L3
		Hold	Freeze the current output level at the point when sensor break occurs		
Sbrk OP	Sets the level which the output power goes to in the event of a sensor break, and 'SbrkMode' is set to 'SbrkOP'. See also section Sensor Break Mode.	Clipped between 'Output Hi' and 'Output Lo'			L3
Safe OP	Sets the output level to be adopted when the loop is inhibited.	Clipped between 'Output Hi' and 'Output Lo'			L3
Man Mode	Selects the mode of manual operation.	Track	In auto the manual output tracks the control output such that a change to manual mode will not result in a bump in the output.		L3
		Step	On transition to manual the output becomes the ForcedOP.		
		LastMOP	On transition to manual the output will be the manual op value as last set by the operator.		
ManOP	The output when the loop is in manual. Note: In manual mode the controller will still limit the maximum power to the power limits, however, it could be dangerous if the instrument is left unattended at a high power setting. It is important that the over range alarms are configured to protect your process. *We recommend that all processes are fitted with an independent over range "policeman"*	Between Output Hi and Output Lo			R/O in L3
ForcedOP	Forced manual output value. When 'Man Mode' = 'Step' the manual output does not track and on transition to manual the target output will step from its current value to the 'ForcedOP' value.	-100.0 to 100.0		0.0	L3

List Header – Lp1 or Lp2		Sub-header: OP			
Name ⊙ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Manual Startup	Manual start up mode.	Off	Controller will power up in automatic or manual mode as set when it was powered down.	Off	Conf R/O in L3
		On	Controller will always power up in manual mode		
Pff En	Power feedforward enable. This adjusts the output signal to compensate for changes in voltage to the controller supply. See also section Power Feed Forward.	No	Disabled		
		Yes	Enabled		
Pwr In	Measured power input				R/O in L3
Cool Type	Selects the type of cooling channel characterisation to be used. Can be configured as water, oil or fan cooling. See also section Cooling Algorithm.	Linear Oil Water Fan	These are set to match the type of cooling medium applicable to the process		Conf R/O in L3
FF Type	Feedforward type The following four parameters appear if FF Type ≠ None See also section Feedforward.	None	No signal fed forward	None	Conf
		Remote	A remote signal fed forward		
		SP	Setpoint fed forward		
		PV	PV fed forward		
FF Gain See also section Feedforward.	Defines the gain of the feedforward value, the feed forward value is multiplied by the gain				Conf
FF Offset	Defines the offset of the feedforward value this is added to the scaled feedforward. See also section Feedforward.				L3
FF Trim Lim	Feedforward trim limits the effect of the PID output. Defines symmetrical limits around the PID output, such that this value is applied to the feedforward signal as a trim. See also section Feedforward.				L3
FF OP	The calculated Feedforward Value. See also section Feedforward.				R/O in L3
Track OP	Output track. This is the value for the loop output to track when OP Track is Enabled. Output Track forces the control output to a defined value. The PID is kept in AUTO and tracks the output. The track value is wireable or user settable. This mode is similar to the loop entering manual.	-100 to 100%			L3
Track En	When enabled, the output of the loop will follow the track output value. The loop will bumplessly return to control when tracking is turned off.	Off On	Disabled Enabled		L3
RemOPL	Remote output low limit. Can be used to limit the output of the loop from a remote source or calculation. This must always be within the main limits.	-100.0 to 100.0			L3
RemOPH	Remote output high limit	-100.0 to 100.0			L3

Output Limits

The diagram shows where output limits are applied.

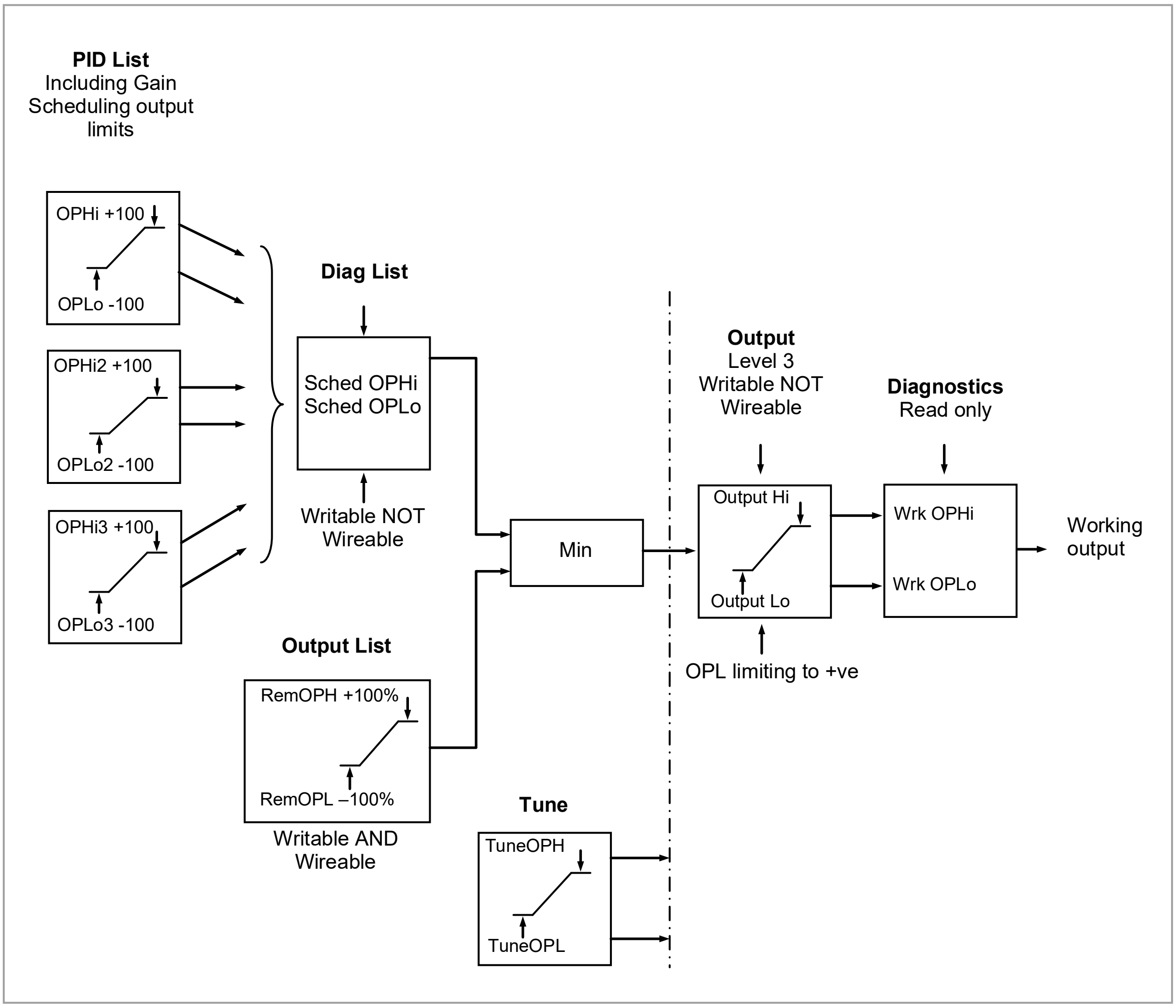


Figure 70: Output Limits

- Individual output limits may be set in the PID list for each set of PID parameters when gain scheduling is used.
- The parameters ‘Sched OPHi’ and ‘Sched OPHLo’, found in the Diagnostics List, may be set to values which override the gain scheduling output values.
- A limit may also be applied from an external source. These are ‘RemOPH’ and ‘RemOPLo’ (Remote output high and low) found in the Output List. These parameters are wireable. For example they may be wired to an analogue input module so that a limit may applied through some external strategy. If these parameters are not wired ±100% limit is applied every time the instrument is powered up.
- The tightest set (between Remote and PID) is connected to the output where an overall limit is applied using parameters ‘Output Hi’ and ‘Output Lo’ settable in Level 3.
- ‘Wrk OPHi’ and ‘Wrk OPHLo’ found in the Diagnostics list are read only parameters showing the overall working output limits.

The tune limits are a separate part of the algorithm and are applied to the output during the tuning process. The overall limits ‘Output Hi’ and ‘Output Lo’ always have priority.

Output Rate Limit

The output rate limiter is a simple rate of change limiter which will prevent the control algorithm demanding step changes in output power. It may be set in percent per minute.

The rate limit is performed by determining the direction in which the output is changing, and then incrementing or decrementing the Working Output (‘Work OP’ in the Main list) until ‘Work OP’ = the required output (Target OP).

The amount by which to increment or decrement will be calculated based on the sampling rate of the algorithm (i.e. 110ms) and the rate limit that has been set. If the change in output is less than the rate limit increment the change will take effect immediately.

The rate limit direction and increment will be calculated on every execution of the rate limit. Therefore, if the rate limit is changed during execution, the new rate of change will take immediate effect. If the output is changed whilst rate limiting is taking place, the new value will take immediate effect on the direction of the rate limit and in determining whether the rate limit has completed.

The rate limiter is self-correcting such that if the increment is small and is lost in the floating point resolution, the increment will be accumulated until it takes effect.

The output rate limit will remain active even if the loop is in manual mode

Sensor Break Mode

Sensor break is detected by the measurement system and a flag is passed to the control block which indicates sensor failure. On the loop being informed that a sensor break has occurred it may be configured using ‘**Sbrk Mode**’ to respond in one of two ways. The output may go to a pre-set level or remain at its current value.

The pre-set value is defined by the parameter ‘**SbrkOP**’. If rate limit is not configured the output will step to this value otherwise it will ramp to this value at the rate limit.

If configured as ‘**Hold**’ the output of the loop will stay at its last good value. If Output Rate Limit (Rate) has been configured a small step may be seen as the working output will limit to the 2 second old value.

On exit from sensor break the transfer is bumpless – the power output will ramp from its pre-set value to the control value.

Forced Output

This feature enables the user to specify what the output of the loop should do when moving from automatic control to manual control. The default is that the output power will be maintained and is then editable by the user. If forced manual is enabled, two modes of operation can be configured. The forced manual step setting means the user can set a manual output power value and on transition to manual the output will be forced to that value. If '**TrackEn**' is enabled the output steps to the forced manual output and then subsequent edits to the output power are tracked back into the manual output value.

The parameters associated with this feature are '**ForcedOP**' and '**Man Mode**' = '**Step**'.

Power Feed Forward

Power feedforward is used when driving a heating element. It monitors the line voltage and compensates for fluctuations before they affect the process temperature. The use of this will give better steady state performance when the line voltage is not stable.

It is mainly used for digital type outputs which drive contactors or solid state relays. Because it only has value in this type of application it can be switched off using the parameter '**Pff En**'. It should also be disabled for any non-electric heating process. It is generally not necessary when analogue thyristor control is used since compensation for power changes is included in the thyristor driver.

Consider a process running at 25% power, with zero error and then the line voltage falls by 20%. The heater power would drop by 36% because of the square law dependence of power on voltage. A drop in temperature would result. After a time, the thermocouple and controller would sense this fall and increase the ON-TIME of the contactor just enough to bring the temperature back to set point. Meanwhile the process would be running a bit cooler than optimum which may cause some imperfection in the product.

With power feedforward enabled the line voltage is monitored continuously and ON-TIME increased or decreased to compensate immediately. In this way the process need never suffer a temperature disturbance caused by a line voltage change.

'Power Feedforward' should not be confused with 'Feedforward' which is described in section Feedforward.

Cooling Algorithm

The method of cooling may vary from application to application and is selected using the parameter '**Cool Type**'.

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.

Oil Cooling

Being non-evaporative, oil cooling is pulsed in a linear manner. It is deep and direct and will not need such a high cool gain as fan cooling.

Water cooling

A complication with water-cooling comes if the zone is running well above 100°C.

Usually the first few pulses of water will flash off into steam giving a greatly increased cooling capacity due to the latent heat of evaporation.

When the zone settles down, less or even no evaporation is a possibility and the cooling is less severe.

To handle evaporative cooling choose the water cool mode from the controller parameter list.

This technique delivers much shortened pulses of water for the first few percent of the cooling range, when the water is likely to be flashing off into steam. This compensates for the transition out of the initial strong evaporative cooling.

Fan Cooling

This is much gentler than water cooling and not so immediate or decisive because of the long heat transfer path through the finned aluminium cooler and barrel.

With fan cooling, a cool gain setting of 3 upwards would be typical and delivery of pulses to the blower would be linear, i.e. the on time would increase proportionally with percentage cool demand determined by the controller.

Feedforward

Feedforward is a value, which is scaled and added to the PID output, before any limiting. It can be used for the implementation of cascade loops or constant head control. Feedforward is implemented such that the PID output is limited to trim limits and acts as a trim on a FF value. The FF value is derived either from the PV or setpoint by scaling the PV or SP by the '**FF Gain**' and '**FF Offset**'. Alternatively, a remote value may be used for the FF value, this is not subject to any scaling. The resultant FF value is added to the limited PID OP and becomes the PID output as far as the output algorithm is concerned. The feedback value then generated must then have the FF contribution removed before being used again by the PID algorithm. The diagram below shows how feedforward is implemented

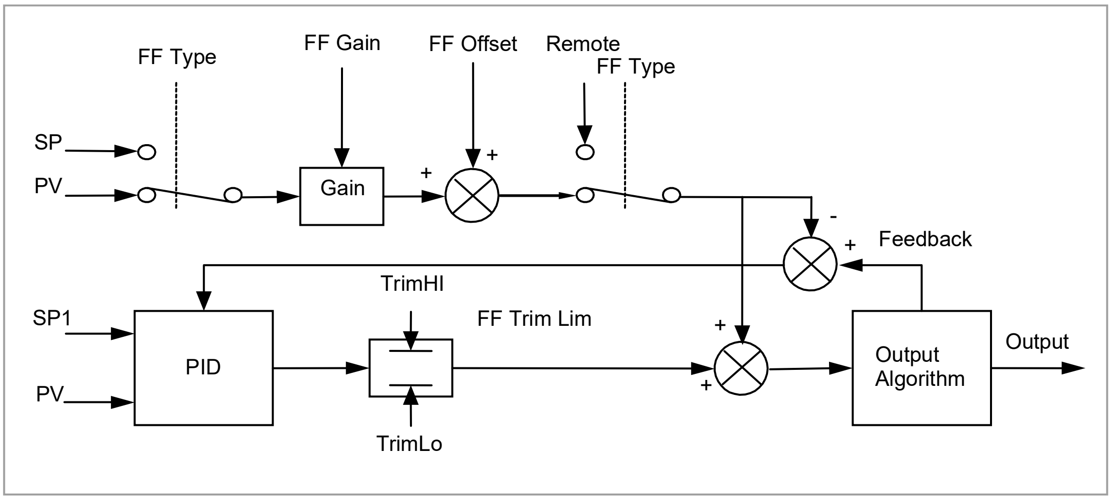


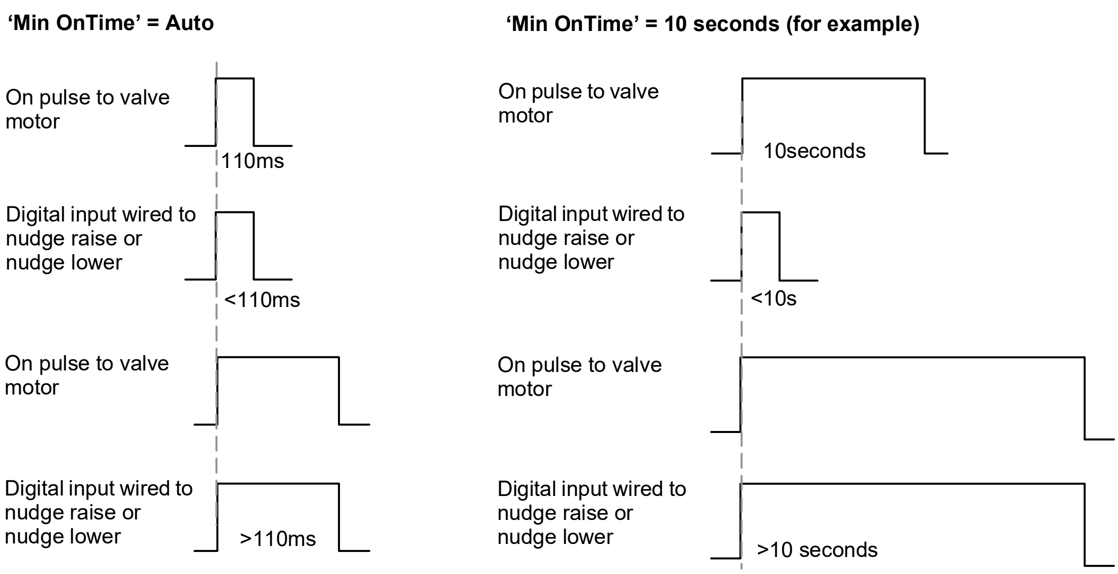
Figure 71: Implementation of Feedforward

Nudge Raise/Lower

These parameters may be wired to digital inputs (for example a pushbutton) to allow the valve to be manually nudged open or closed. The duration of the nudge is determined by the value of the parameter 'Min OnTime' which will be found in the fixed relay output list AA section AA Relay Parameters but more appropriately for valve postion outputs in the Dual Relay or Triac output modules section Relay, Logic or Triac Outputs.

The minimum on/off time should be set large enough to overcome the inertia of the valve or the slack in the linkage but not so slow that the valve opens and closes too widely which may cause oscillation of the output and consequent changes in the temperature. If a relay is used to drive the valve the 'Min OnTime' should be set in the order of seconds so that the relay does not switch too rapidly which may cause premature wear. For this reason it is often preferable to switch valve motors using triacs.

To nudge the valve press the pushbutton momentarily. The shortest time that the valve can open or close is 110ms. If the pushbutton is depressed for longer than 110ms the valve will open or close for as long as the pushbutton is depressed, until it is fully open/closed, as shown in the diagram below:.



NOTICE
If the digital input signal is held on, the valve will drive fully open or closed.

Effect of Control Action, Hysteresis and Deadband

For temperature control '**Control Act**' 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 and is set in the units of the PV. In heating applications the output will turn off when the PV is at setpoint. It will turn on again when the PV falls below SP by the hysteresis value. Examples of this are shown below in Figure 72 Deadband OFF and Figure 73 Deadband ON (set at 50% of Cooling) for a heat and cool controller.

The hysteresis is used to prevent the output from chattering at the control setpoint. If the hysteresis is set to 0 then even the smallest change in the PV when at setpoint will cause the output to switch. The hysteresis should be set to a value which provides an acceptable life for the output contacts, but which does not cause unacceptable oscillations in the PV.

If this performance is unacceptable, it is recommended that you try PID control.

Deadband '**Ch2 DeadB**' 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 first example.

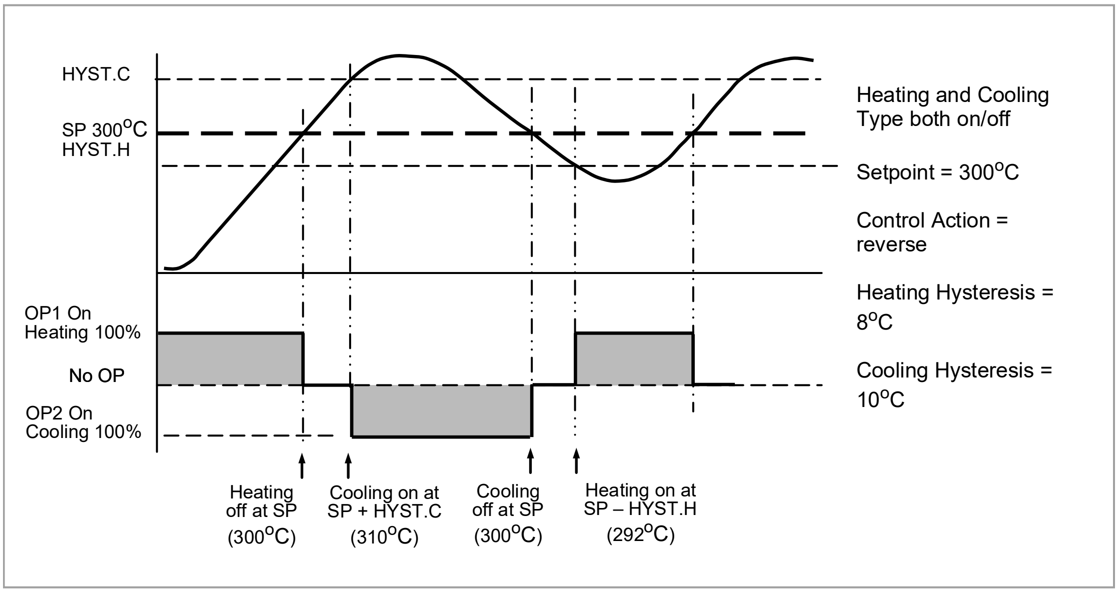


Figure 72: Deadband OFF

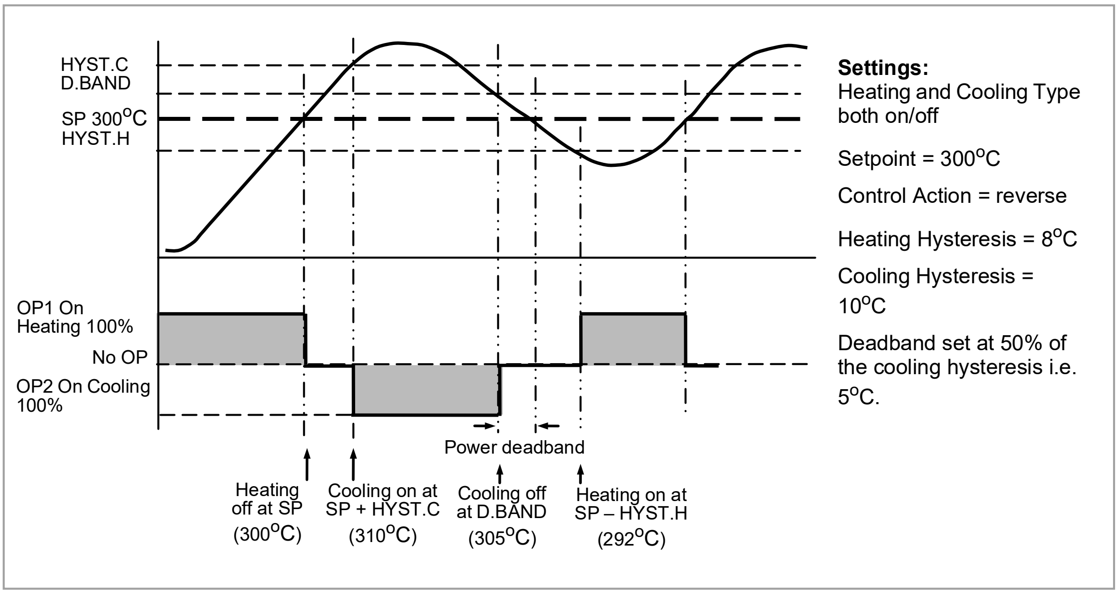


Figure 73: Deadband ON (set at 50% of Cooling)

Diagnostics Function Block

These are generally read only parameters which may be used for diagnostic purposes.

They may be wired to produce an application specific strategy. For example, the loop break alarm may be wired to the PV of the AA Relay or other output module to produce a physical output if the loop break time is exceeded.

List Header – Lp1 or Lp2		Sub-header: Diag			
Name ⊙ to select	**Parameter Description**	**Value** Press ⊙ or ⊙ to change values		**Default**	**Access Level**
Error	The difference between the setpoint and the PV.	Range limits			L3 R/O
Loop Mode	Reads the mode of the loop i.e. it is Auto, Manual or Off mode. See sections The Operator Buttons and To Select Auto/Manual Operation.	Auto	Automatic		In iTools only
		Man	Manual		
		Off	Loop off		
Target OP	The requested control output, this could be the target of the active output if an output rate limit is configured.				L3 R/O
Wrk OPHi	Working output high limit. This is the value used to limit the output power of the loop and is derived from the gain scheduled limit, the remote limit and the safety limit.	Wrk OPLo to 100%			L3 R/O
Wrk OPLo	Working output low limit. This is the value used to limit the output power of the loop and is derived from the gain scheduled limit, the remote limit and the safety limit.	-100% to Wkg OPHi			L3 R/O
Lp Break	Loop break alarm. This is active when the loop break time LBT, set in the PID list (section Loop Break) is exceeded	No	Loop break not in alarm		L3 R/O
		Yes	Active		
Prop OP	Shows the contribution of the Proportional term to the control output.				L3 R/O
InOP	Shows the contribution of the Integrator to the control output.				L3 R/O
Deriv OP	Shows the contribution of the Derivative to the control output.				L3 R/O
SensorB	Indicates the status of the sensor break	Off	No sensor break alarm		L3 R/O
		On	Sensor break		

List Header – Lp1 or Lp2		Sub-header: Diag		
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values	**Default**	**Access Level**
Sched PB	The scheduled proportional band	These are the current values of the control time constants as set in the PID list and determined by Gain Scheduling		L3
Sched Ti	The scheduled integral time			
Sched Td	The scheduled Derivative time			
Sched R2G	The scheduled relative cool gain			
Sched CBH	The scheduled cutback high			
Sched CBL	The scheduled cutback low			
Sched MR	The scheduled manual reset			
Sched LpBrk	The scheduled loop break time			
Sched OPHi	The scheduled output high limit			
Sched OPLo	The scheduled output low limit			

Setpoint Programmer

The purpose of a setpoint programmer is to vary the setpoint in a controlled manner over a set period of time.

The resulting **Program** is divided into a flexible number of **Segments** - each being a unit of time. The total number of segments available in 3500 controller is **500** (or a maximum of **50 per program**) and it is possible to store up to **50 separate programs** (as long as the maximum number of segments does not exceed 500).

It is often necessary to switch external devices at particular times during the program. Up to eight digital 'event' outputs can be programmed to operate during those segments.

Up to Two Programmer blocks are provided. The dual controller allows two process variables to be controlled and is suitable for applications such as environmental chambers controlling, for example, temperature and humidity.

An example of a dual program and two event outputs is shown below.

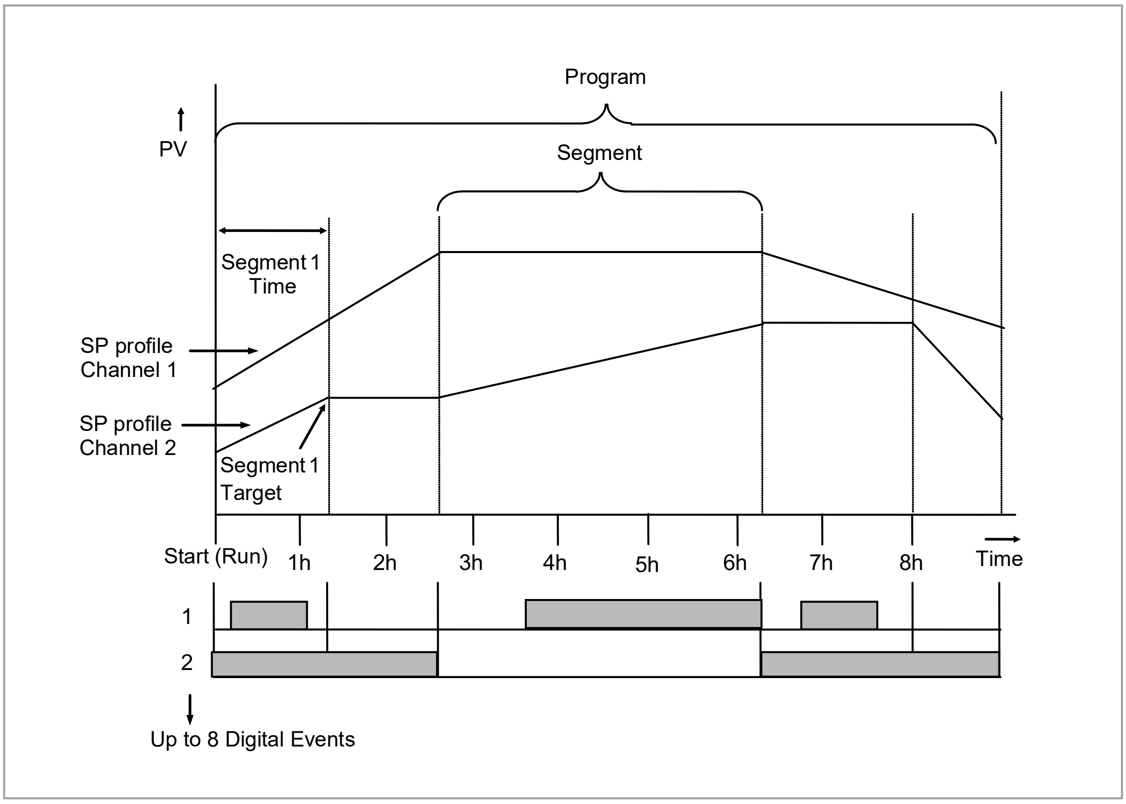


Figure 74: Simple Two Profile Setpoint Program

NOTICE
Event 1 may be a 'Timed Event', as shown above, whereby an on and off time can be set in each segment. See section Time Event.

Dual Programmer Modes

There are three modes in which the dual programmer can be configured. These are:

SyncStart Programmer

In a SyncStart programmer the two profiles will start running together when 'RUN' is initiated. It is possible to configure a SyncStart programmer for Ch1 to 'wait' for a segment in Ch2 to catch up and vice versa. Wait is described in section Wait. A SyncStart programmer can operate as a Ramp Rate programmer or Time to Target programmer (see Programmer Types) in each segment in the same way as the previous single program version.

SyncAll Programmer

In a SyncAll programmer the two profiles automatically synchronize at the end of every segment. However, in order to simplify its operation, this programmer is only available as a Time to Target programmer (see Programmer Types).

Single Channel Programmer

By default Channel 1 is run and is intended to be used with a single process variable.

NOTICE
The modes are configured in the Instrument Display Configuration Page – 'Inst Opt' described in section Instrument Options.

Programmer Types

Time to Target Programmer

Each segment consists of a **single duration parameter** and a set of **target values** for the profiled variables.

1. The **duration** specifies the time that the segment takes to change the profiled variables from their current values to the new targets.
2. A **dwell** type segment is set up by leaving the target setpoint at the previous value.
3. A **Step** type segment is set up by setting the segment time to zero.

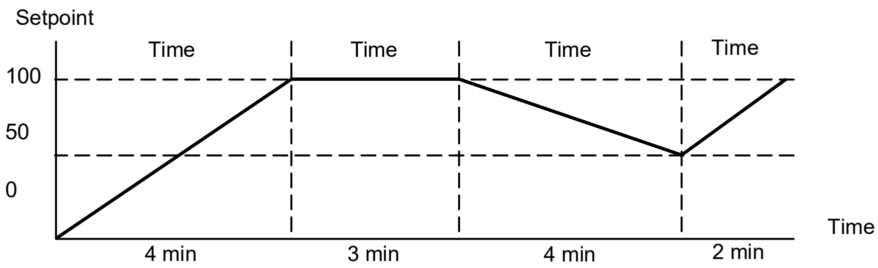


Figure 75: All Segments Configured as Time-to-Target

A SyncAll programmer can only be set as a Time to Target programmer

Ramp Rate Programmer

A ramp rate programmer specifies it's ramp segments as maximum setpoint changes per time unit.

Each segment can be specified by the operator as **Ramp Rate, Dwell or Step** – see section Segment Types for a full listing of segment types.

1. Ramp Rate – the setpoint changes at a rate in units/time
2. Dwell – the time period is set – there is no need to set the target value as this is inherited from the previous segment
3. Step – specify target setpoint only – the controller will use that setpoint when the segment is reached

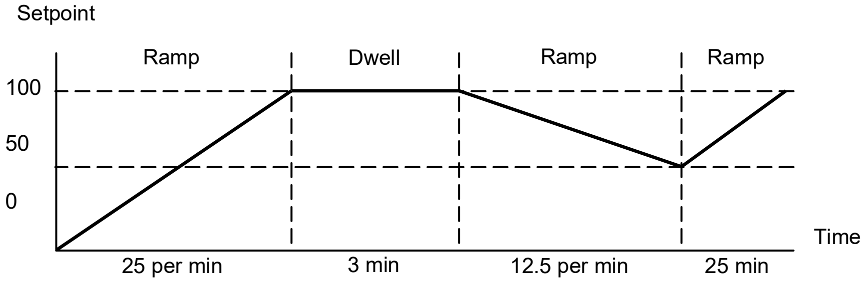


Figure 76: Ramp Rate Programmer

A SyncStart programmer can be set as a Ramp Rate or Time to Target programmer.

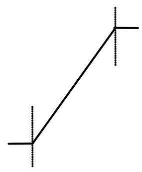
Segment Types

Depending on the type of program configured, a segment may be set as:

Rate

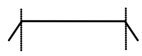
A Ramp segment provides a controlled change of setpoint from an original to a target setpoint. The duration of the ramp is determined by the rate of change specified. Two styles of ramp are possible in the range, Ramp-Rate or Time-To-Target.

The segment is specified by the target setpoint and the desired ramp rate. The ramp rate parameter is presented in engineering units (°C, °F, Eng.) per real time units (Seconds, Minutes or Hours). If the units are changed, all ramp rates are re-calculated to the new units and clipped if necessary



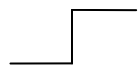
Dwell

The setpoint remains constant for a specified period at the specified target. The operating setpoint of a dwell is inherited from the previous segment.



Step

The setpoint changes instantaneously from its current value to a new value at the beginning of a segment. A Step segment has a minimum duration of 1 second.



Time

A time segment defines the duration of the segment. In this case the target setpoint is defined and the time taken to reach this value. A dwell period is set by making the target setpoint the same value as the previous setpoint.

GoBack

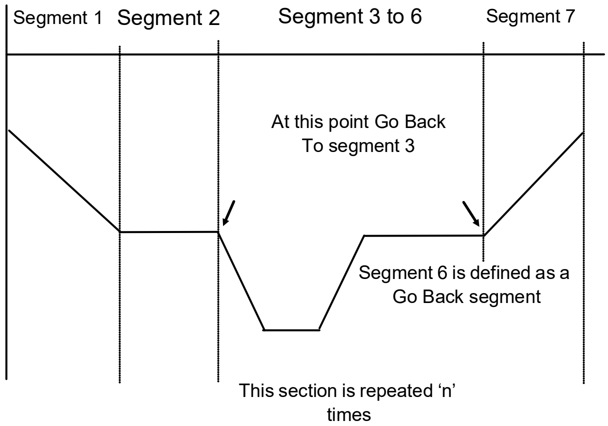
Go Back allows segments in a program to be repeated a set number of times. The diagram shows an example of a program which is required to repeat the same section a number of times and then continue the program.

When planning a program it is advisable to ensure that the end and start setpoints of the program are the same otherwise it will step to the different levels.

‘Goback Seg’ specifies the segment to go back to

‘Goback Cycles’ specifies the number of times the goback loop is executed

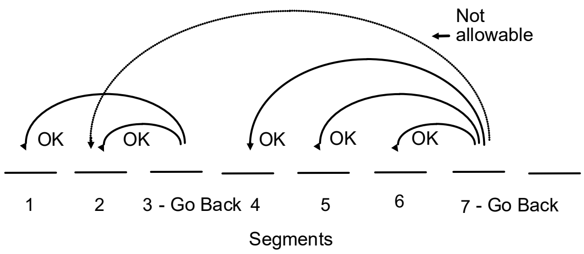
Overlapping Goback loops are disallowed



NOTICE

If a second or more 'Go Back' segments are created, they cannot return to a segment before the previous 'Go Back' segment as shown.

In this diagram a Go Back segment can be created from 3 to 2 or 1. Go Back segments can also be created from 7 to 6 or 5 or 4 but not from 7 to 2 or 1



Wait

Wait specifies the criterion for which a segment cannot proceed to the next segment. Any segment can be defined as 'Wait' in the 'Program Edit' page. The next parameter is then '**Wait For**' and here you define the criterion.

'Wait For' criteria:

None	No action
PrgIn1	Wait until Input 1 is true
PrgIn2	Wait until Input 2 is true
PrgIn 1&2	Wait until Inputs 1 AND 2 are true
PrgIn 1or2	Wait until Inputs 1 OR 2 is true
PVWaitIP	Wait until Wait criteria is true
Ch2Seg	Wait if the specified segment in channel B has not reached its target

The above parameters may be wired to configure a Wait strategy. Examples of a simple strategy are, wait for a digital input or program event to become true or wait for a segment in program channel 1 to reach a defined PV before allowing Ch 2 to proceed to the next segment.

In a SyncStart programmer synchronization is achieved by selecting 'Wait For' = 'Ch2Sync' in the Program Edit menu.

Wait criteria for ‘PVWaitIP’ is that this parameter has reached a specified threshold. This is set by the parameter ‘**WaitVal**’. The following example shows various settings possible:

‘Wait For’ set to ‘PVWaitIP’ PSP = 100 ‘WaitVal’ = 5	
PVWait	Segment will wait until
Abs Hi	PVWaitIP >= 5
Dev Lo	PVWaitIP >= 95
Abs Lo	PVWaitIP <= 5
Dev Hi	PVWaitIP <= 105

Constraints:

If Wait on Segment were offered on both channels without restrictions, it would be possible to set up a program such that both channels would have to wait for one another. An example is illustrated in the diagram below. Ch1 Seg 3 is set to wait for Ch2 Seg 1, followed by Ch2 Seg 3 set to wait for Ch1 Seg 2. It will not be possible to set conflicting situations in the controller since the following restrictions are imposed:

The ‘Ch2Seg’ option is only offered in Channel 1

The ‘Ch2Seg’ must be ascending

Segment	1	2	3
Channel 1 Wait Segment			
Channel 2 Wait Segment			

Call

A CALL segment is only available when single programmer mode is configured. Call segments may only be selected in instruments offering multiple program storage.

The Call segment allows programs to be nested within each other.

To prevent re-entrant programs from being specified, only higher number programs may be called from a lower program.

i.e. program 1 may call programs 2 through 50, but program 49 may only call program 50.

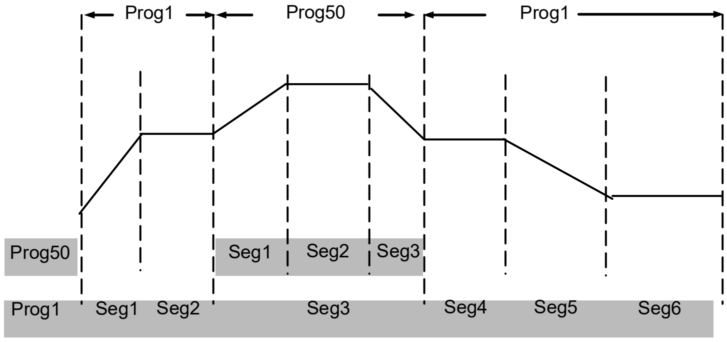
When a CALL segment is selected the operator may specify how many cycles the called program will execute. The number of cycles is specified in the calling program. If a called program has a number of cycles specified locally, they will be ignored.

A CALL segment will not have a duration, a CALL segment will immediately transfer execution to the called program and execute the first segment of that program.

Called programs do not require any modification, the calling program treats any END segments as return instructions.

The example shows Prog 50 (Ramp/Dwell/Ramp) inserted in place of segment 3/Program1.

Prog 50 can be made to repeat using the ‘Cycles’ parameter



End

A program may contain one End segment. This allows the program to be truncated to the number of segments required.

The end segment can be configured to have an indefinite dwell at the last target setpoint or to reset to the start of the program or to go to a defined level of power output (SafeOP). This is selectable by the user.

If a number of program cycles are specified for the program, then the End segment is not executed until the last cycle has completed

Event Outputs

All segments, except GoBack, Wait and End Segments, have configurable events.

Two types of events are provided namely, PV Events and Time Events.

PV Event

PV Events are essentially a simplified analogue alarm per segment based on the programmer PV input. The PV Event Output (PVEventOP) may be used to trigger the required response.

- Each Segment has one *PV Event Type (Off, Hi, Lo, Band*)*
- Each Segment has one *PV Event Threshold/User value*
- Each channel has one *PV Event Input (for the monitored variable)*
- Each channel has one *PV Event OP (Off, On)*

*** Band refers to deviation of the PV parameter from Programmer Setpoint (i.e. there is no reference input).**

If 'PV Event' is set to anything other than 'None' then the following parameter will be 'PV Threshold'. This sets the level at which the PV Event will be triggered.

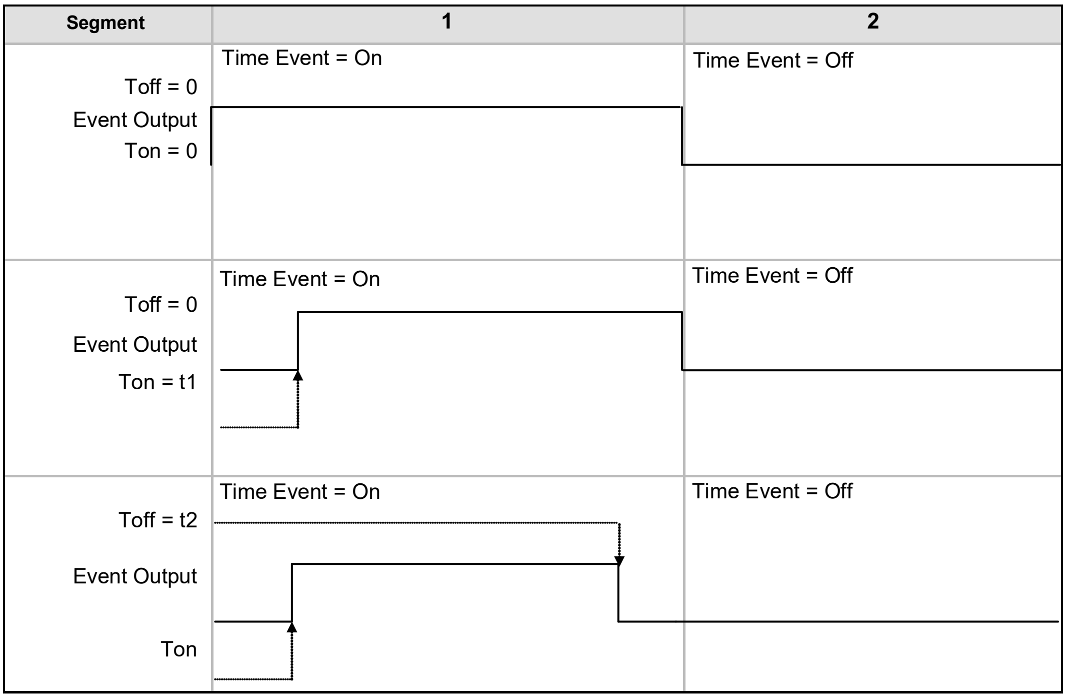
NOTICE
If PV Event is activated in a segment then it is not possible to set a User Value in that segment, see section User Values.

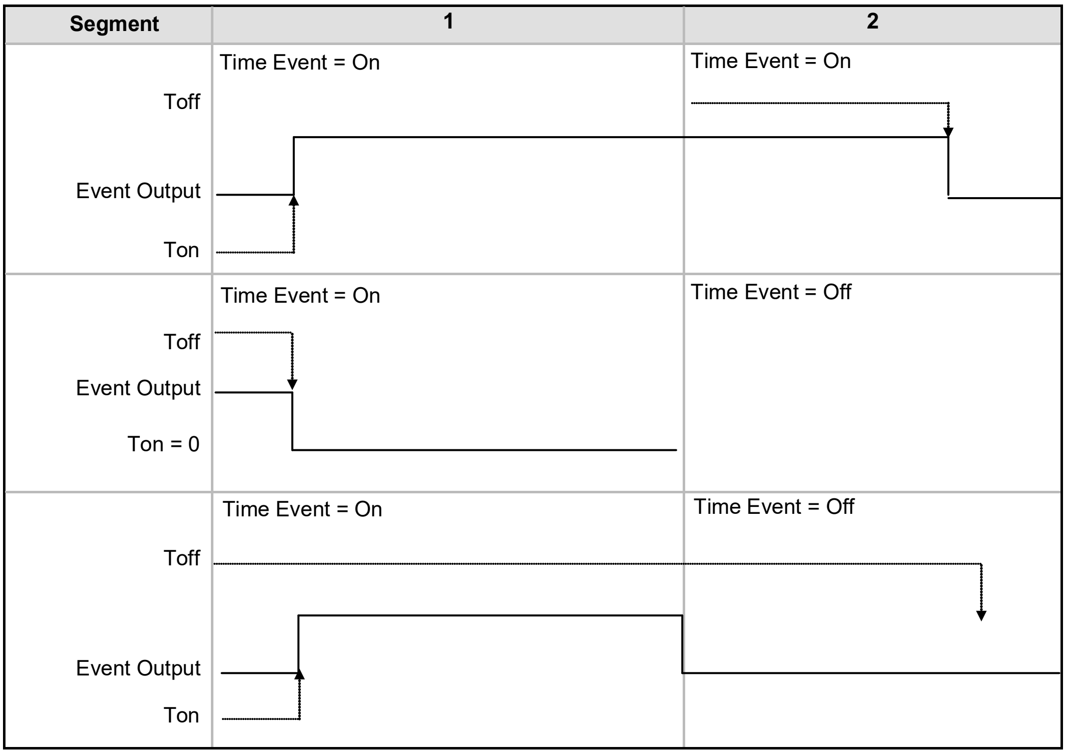
Time Event

Digital events can simply be the turning on of a digital output for the duration of a segment. An extension of this is the Time Event. In this case the first digital event can have a delay (On Time) and an (Off Time) specified. 'On Time' defines when the digital output will turn on after the beginning of the segment and 'Off Time' defines when the digital output will turn off. The reference point for the On and Off times is the **start of the segment.**

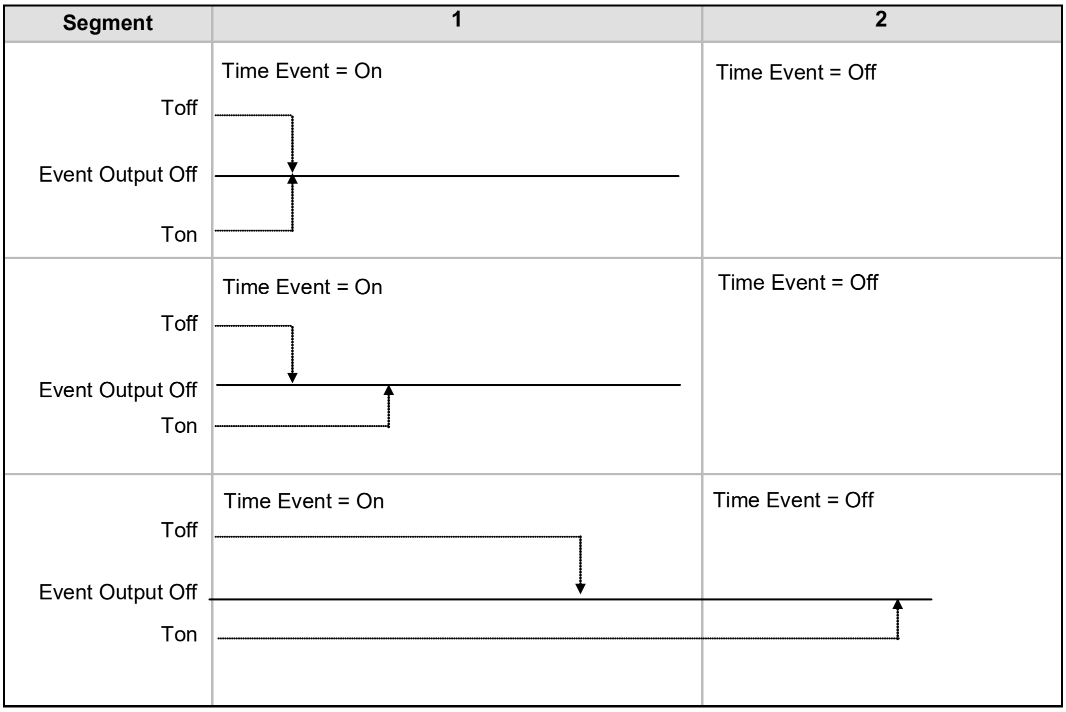
- Only the first digital event may be configured as a Time Event.
- Each segment has one Time Event parameter (OFF, Event1).
- The first piano key is replaced by 'T' if a time event is configured (and is not alterable)

Editing of the Time Events follows a number of simple rules to make programming easier for the operator - These are shown in the diagrams below; assume On Time= **Ton**, Off Time= **Toff**



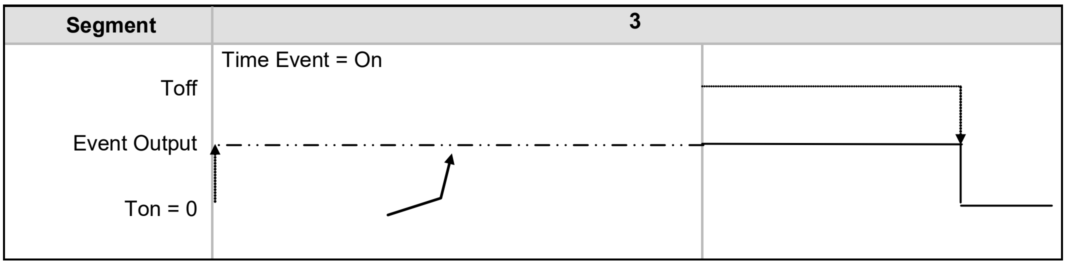


- To configure an event which straddles two segments configure Ton in Segment n and Toff in segment n+1.

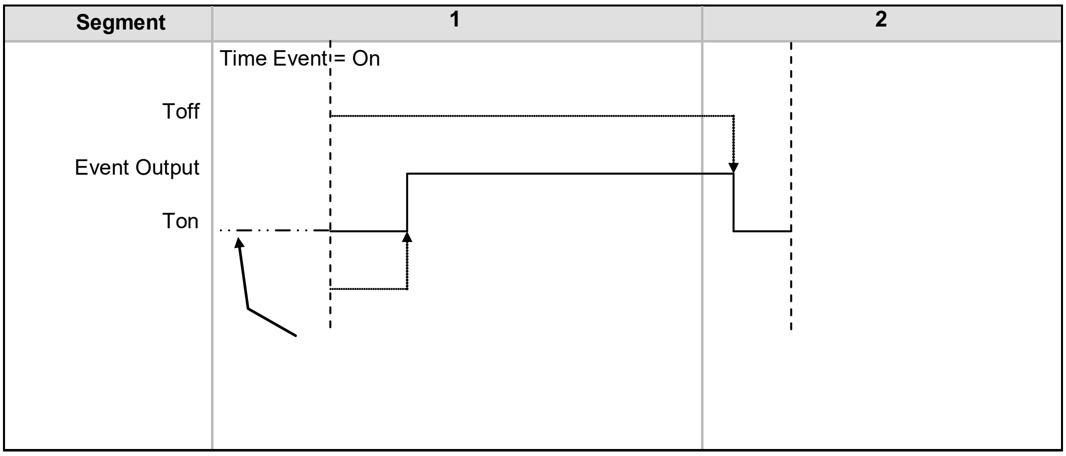


- Ton and Toff are extended by G.Soak periods. If Ton = 0, the output goes hi at the start of the segment but Toff is not decremented while Gsoak Wait is applied. Timed event outputs are on a total of Gsoak Wait + (Toff – Ton).

The following additional features are available in dual programmer versions:



- When Ton > 0, Timed event is On after Gsoak Wait + Ton. This may be seen in the following diagram.



NOTE: In the event of a power fail, time events timing will be unaffected.

User Values

User values are general purpose analogue values which may be set up in any Time, Rate, Dwell or Step segment provided a PV Event is not configured in that segment. When the segment is entered the analogue value is transferred to the ‘UserValOP’ parameter. This parameter may be wired to a source within the controller for use in a particular application dependent strategy. A different value may be set in each segment in which the ‘UsrVal’ is called up. One example of its use is to set different output powers in different segments by wiring the ‘UserValOP’ to the output power parameter.

Resolution for ‘UsrVal’ is derived from ‘RstUVal’. To adjust resolution, softwire a ‘user value’ to ‘RstUVal’ and configure its resolution as required.

The User Value may be given a customised name using iTools, iTools integrated Online Help.

Holdback

Holdback freezes the program if the process value (PV) does not track the setpoint (SP) by more than a user defined amount. The instrument will remain in HOLDBACK until the PV returns to within the requested deviation from setpoint. The display will flash the HOLD beacon.

In a **Ramp** it indicates that the PV is lagging the SP by more than the set amount and that the program is waiting for the process to catch up.

Holdback maintains the correct soak period for the product.

Each program can be configured with a holdback value. Each segment determines the holdback function.

Holdback will cause the execution time of the program to extend, if the process cannot match the demanded profile.

Holdback state will not change the user's access to the parameters. The parameters will behave as if in the RUN state.

The diagram below demonstrates that the demanded setpoint (SP) will only change at the rate specified by the program when the PV's deviation is less than the holdback value. When the Deviation between the setpoint and PV is greater than the holdback value (HBk Val) the setpoint ramp will pause until the deviation returns to within the band.

The next segment will not start until the deviation between Setpoint and PV is less than the holdback value.

Four types of Holdback are available:

None	Holdback is disabled for this segment.
High	Holdback is entered when the PV is greater than the Setpoint **plus** HBk Val.
Low	Holdback is entered when the PV is lower than the Setpoint **minus** HBk Val.
Band	Holdback is entered when the PV is **either** greater than the Setpoint **plus** HBk Val **or** lower than the Setpoint **minus** HBk Val

Guaranteed Soak

Guaranteed Soak (guaranteed time work piece stays at SP within a specified tolerance) is achieved in the previous single programmer version by using Holdback Band during a dwell segment. Since only one holdback value per program is available, this imposes a limitation where different tolerance values are required to guarantee the soak.

In the software version 2 programmer (Including single channel), Holdback Type in Dwell segments is replaced by a Guaranteed Soak Type (G.Soak) which can be set as Off, Lo, Hi or Band. A Guaranteed Soak Value (G.Soak Val) is available in Dwell segments and this provides the ability to set different values in any Dwell segment.

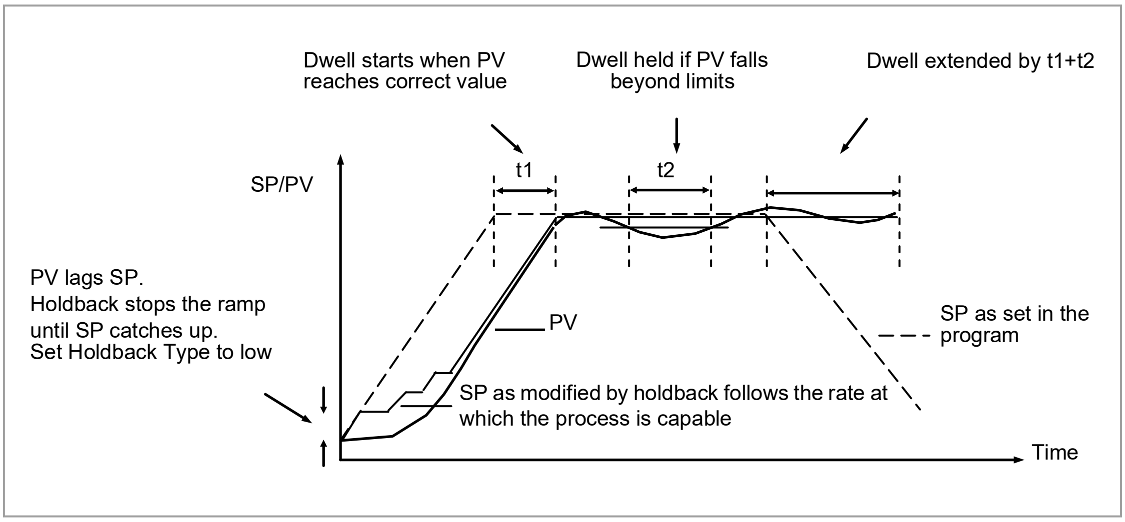


Figure 77: Effect of Guaranteed Soak

PID Select

It is possible to set up three sets of PID values, see section Control Loop Set Up. Any one of these sets may be activated in any segment of the program, except if the segment is configured as Wait, Goback or End. There are two parameters to configure. In the 'Program Setup' page configure the parameter 'PID Set?' to 'Yes'. In the 'Program Edit' page configure 'PID Set' to the most suitable set for the chosen segment. If 'PID Set?' = 'No' in the Program Setup page the choice of PID sets is not given in the segments.

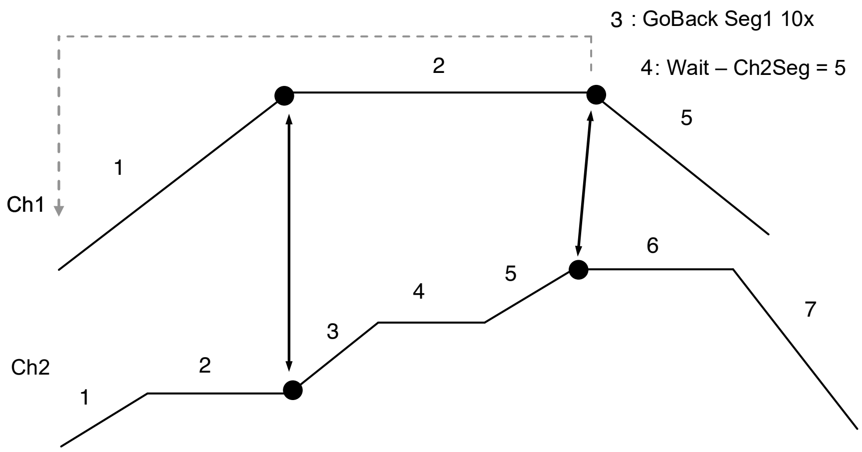
The last PID set in the program (SET1 by default) will be applied during these segments. When reset the usual PID strategy for the loop takes over.

Sync Point – 'Goback' Interaction

Sync. points cause a segment in channel 1 to wait for a segment in Channel 2 and visa versa. To configure a Sync. Point the 'Wait For' parameter is set to 'Ch2Sync'. Several scenarios are possible which require clarification:

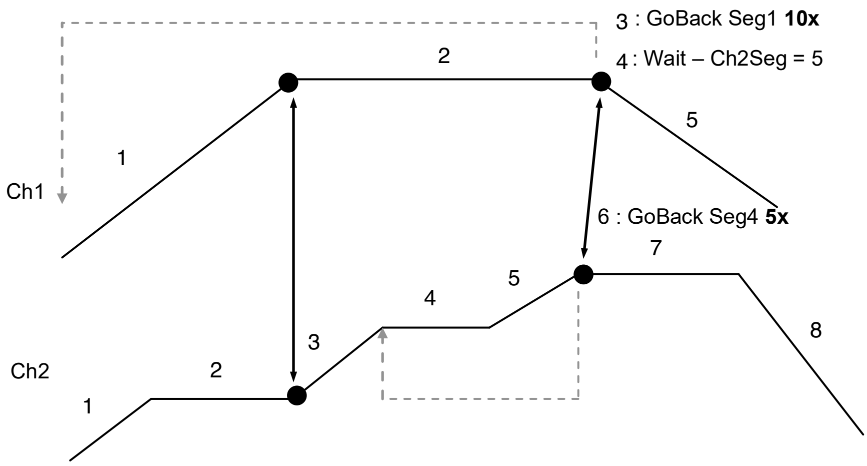
1. Channel 2 does not have a valid corresponding Go Back:

Channel 1 repeats segments 1 and 2, 11 times – the first time (prior to Go Back) the Sync. points are observed and evaluated as specified. During the Go Back however, as there are no Go Backs specified in channel 2, the Sync. points are ignored.



2. 'GoBack' in Channel 2 does not cover a sync. point:

In this scenario the first Sync. point is never covered during the 'GoBack' cycles in Channel 2; this Sync. point will therefore be ignored during the 'GoBack' cycles of Channel 1. The second Sync. point is covered for 5 'GoBack' cycles and therefore constitutes a valid Sync. point during the 5 cycles. During the remaining 'GoBack' cycles of Channel 1, Sync. point 2 will be ignored.



PrgIn1 and PrgIn2

These are events called Program Input 1 and 2 which can be wired to any parameter. They are used in 'wait' segments to prevent the program continuing until the event becomes true. Example 1 in section Examples Showing How to Set up and Run Dual Programmers shows how these might be used.

Program Cycles

If the Program Cycles parameter is chosen as greater than 1, the program will execute all of its segments (including calls to other programs) then repeat from the beginning. The number of cycles is determined by the parameter value. The Program Cycles parameter has a range of 0 to 9999 where 0 is enumerated to 'Cont' (continuous).

Program cycles apply to both channels. In the event that one channel completes a cycle before the second channel has finished the first channel will automatically wait until the second channel has completed. In other words there is an implied sync. point at the end of each cycle, so, channel 1 will wait for channel 2 (and visa versa) to complete the first cycle before progressing to the next.

Servo

Servo can be set in configuration so that when a program is run the setpoint can start from the initial controller setpoint or from the current process value. Whichever it is, the starting point is called the servo point. This can be set in the program.

Servo to PV will produce a smooth and bumpless start to the process.

Servo to SP may be used in a Ramp Rate programmer to guarantee the time period of the first segment.

NOTICE
In a Time to Target programmer the segment duration will always be determined by the setting of the Segment Duration parameter.

Power Fail Recovery

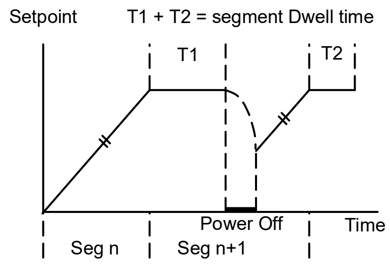
In the event of power fail to the controller, a strategy may be set in configuration level, which defines how the controller behaves on restoration of the power. These strategies include:

Continue	The program setpoint returns immediately to its last value prior to the power down, then return to the target setpoint at the ramp rate set for that segment. This may cause full power to be applied to the process for a short period to heat the process back to its value prior to the power failure.
Ramp back	This will servo the program setpoint to the measured value (the PV Input parameter value), then return to the target setpoint at the ramp rate set for that segment or the last rate available if in a dwell segment. The setpoint is not allowed to step change the program setpoint. The outputs will take the state of the segment which was active before power was interrupted.
Reset	The process is aborted by resetting the program. All event outputs will take the reset state.
The display does not warn the operator that a power interruption has occurred.	

Ramp back (Power fail during Dwell segments.)

If the interrupted segment was a Dwell, then the ramp rate will be determined by the previous ramp segment.

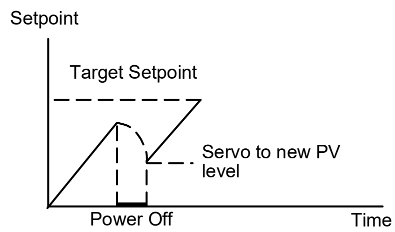
On achieving the Dwell setpoint, the dwell will continue from the point at which the power was interrupted.



NOTICE
If a previous ramp segment does not exist, i.e. the first segment of a program is a dwell, then the Dwell will continue at the "servo to PV" setpoint.

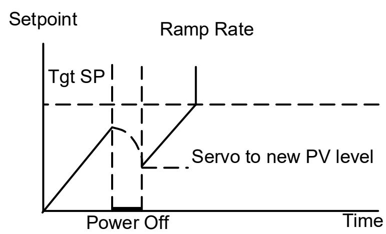
Ramp back (power fail during Ramp segments)

If the interrupted segment was a ramp, then the programmer will servo the program setpoint to the PV, then ramp towards the target setpoint at the previous ramp rate. Previous ramp rate is the ramp rate at power fail.



Ramp back (power fail during Time-to-target segments)

If the programmer was defined as a Time-to-Target programmer then when the power is returned the previous ramp rate will be recovered. The Time remaining will be recalculated. The rule is to maintain RAMP RATE, but alter TIME REMAINING.



Sensor Break Recovery

On sensor break, the program state changed to HOLD if the current state is RUN or HOLDBACK. Sensor break is defined as status bad on the PV Input parameter. If the program state is in HOLD when PV input status returns to OK, the program state is automatically set back to RUN.

Operating a Program

The program may be operated from the RUN/HOLD button on the front of the controller or via digital inputs or via digital communications or via parameters found in the Program Setup lists.

Run

In run the programmer working setpoint varies in accordance with the profile set in the active program. A program will always run – non configured programs will default to a single Dwell end segment.

Reset

In reset the programmer is inactive and the controller behaves as a standard controller. It will:

1. Continue to control with the setpoint determined by the next available source, SP1, SP2, Alternative Setpoint.
2. Allow edits to all segments
3. Return all controlled outputs to the configured reset state.

Hold

A programmer may only be placed in Hold from the Run or Holdback state. In hold the setpoint is frozen at the current programmer setpoint and the time remaining parameter frozen at its last value. In this state you can make temporary changes to program parameters such as a target setpoint, ramp rates and times. These changes will only remain effective until the end of the currently running segment, when they will be overwritten by the stored program values.

Skip Segment

This is a parameter found in the Program Setup List, section Program Set Up. It moves immediately to the next segment and starts the segment from the current setpoint value.

Advance Segment

This is a parameter found in the Program Setup List, section Program Set Up. It sets the program setpoint equal to the target setpoint and moves to the next segment.

Fast

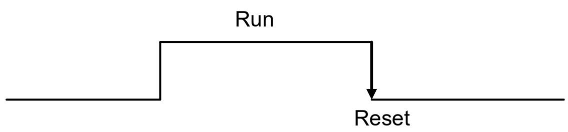
Executes the program at 10x the normal speed. It is provided so that programs can be tested **but the process should not be run in this state**.

Fast is only available in Level 3.

Run/Hold/Reset Digital Inputs

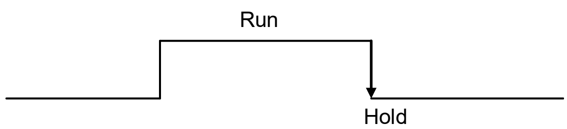
The dual programmer and the single programmer available in version 1 software can have Run, Hold and Reset wired, for example, to three digital inputs so that these functions can operate the program externally. The software version 2 programmer has in addition Run/Reset and Run/Hold parameters which can provide the same functions via two digital inputs. Hold/Run may be implemented by inverting the Run/Hold input (Hold will only work if already in Run state). The triggering actions are as follows:

Run/Reset



Hold or Reset can also be operated from the user interface when in Run

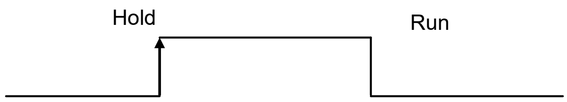
Run/Hold



The program can be Reset from the user interface when in Run or Hold.

Hold/Run

- Invert the Run/Hold input for Hold/Run functionality shown below.

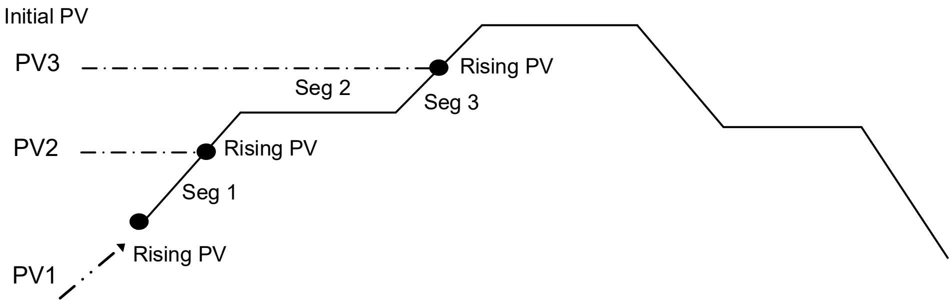


Only go into Hold if previously in Run.
It will be possible to Reset from the user interface when in Hold or Run.

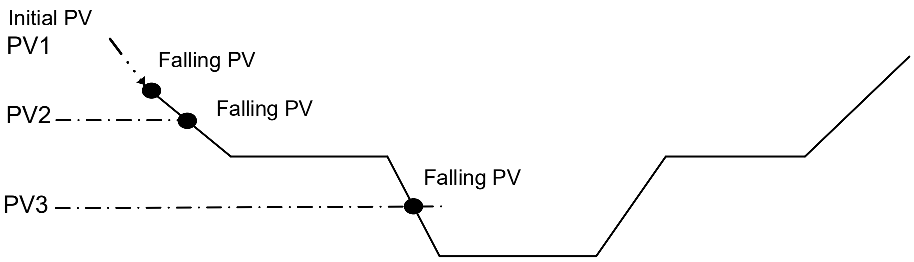
For a SyncAll and SyncStart programmer the digital inputs are used to control BOTH program channels.

PV Start

When Run is initiated PV start (for each channel) allows the program to automatically advance to the correct point in the profile which corresponds to the current PV. For example, if the process is already at PV3 when run is initiated then the program will start from the third segment as shown in the diagram below.



The user may specify the start point based on a Rising PV as shown in the diagram above or on a Falling PV as shown below depending on type of profile being run.



When PV Start is used, the program always servos to PV (i.e. servo to SP will be ignored).

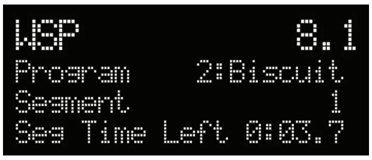
In a 'SyncAll' programmer, 'PVStart' is only configurable in channel 1. Channel 2 will also servo to PV in the segment determined for PVStart by channel 1. In such cases, Channel 1 PSP and Channel 2 PSP may reach the end of segment at different times, but 'Sync' will take place prior to execution of the next segment.

Example: To Run, Hold or Reset a Program

When the controller is ordered as a programmer a Programmer Summary screen is available in operator mode which allows quick access to the programmer.

The example below uses this screen.

Do This	The Display You Should See	Additional Notes
1. From any display press until the 'Programmer User Display' is shown		
2. Press to '**Program**' 3. Press or to choose the program number to be run		In this example Program Number 2 is chosen and has been given a user defined name. In the 3504 Program names can be entered using the off-line programming package 'iTools'.

4. Press RUN/HOLD button or select ‘Status’ and set this to ‘Run’. A pop up is displayed where the program number may be selected prior to run.		‘RUN’ is displayed in the indicator beacons section of the main display. The view shown here shows current working setpoint, program being run, current segment number and time left to complete this segment.
5. To Hold a program press RUN/HOLD button		Press RUN/HOLD button again to continue the program. When the program is complete ‘RUN’ will flash
6. To Reset a program press RUN/HOLD button for at least 3 seconds		‘RUN’ will extinguish and the controller will return to the HOME display shown in section Normal Operation.

NOTICE

1. An alternative way to run, hold or reset the program from this screen, is to scroll to ‘Program Status’ using ↻ and select ‘Run’, ‘Hold’ or ‘Reset’ using ▲ or ▼
2. If the program number has been previously selected the program can be run, held or reset just by pressing the RUN/HOLD button

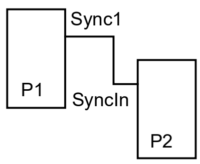
Program Set Up

Parameters in the ‘**Program Setup**’ page allow you to configure and view parameters common to all programs for both program channels 1 and 2. This page of parameters is only available in configuration level. Press as many times as necessary to select the ‘**Program Setup**’ page.

The following table lists parameters available.

List Header – Program Setup		**Sub-header: Ch1 or Ch2**			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
Channel	To select program channel 1 or 2 (Not shown in Single Channel programmer)	Ch1	Program channel 1		Conf
		Ch2	Program channel 2		
Units	This parameter will adopt the units of the parameter to which the programmer ‘PVIn’ is wired. For example, Programmer ‘PVIn’ could be wired to ‘Loop TrackSP’ and ‘Loop MainPV’ wired to ‘PVInput’. The units will adopt the units set in PVInput list.	See display units list, section Display Units.			R/O Alterable if not wired
Resolution	As units the resolution is set by the parameter it is wired to.	XXXXX to X.XXX.X			R/O Alterable if not wired
PV Input	The programmer uses the PV input for a number of functions In holdback, the PV is monitored against the setpoint, and if a deviation occurs the program is paused. The programmer can be configured to start its profile from the current PV value (servo to PV). The programmer monitors the PV value for Sensor Break. The programmer holds in sensor break. The ‘PVStart’ feature uses the PV value to search for the segment in which the program starts.	The PV Input is normally wired from the loop TrackPV parameter. Note that this input is automatically wired when the programmer and loop are enabled and there are no existing wires to track interface parameters. Track interface parameters are Programmer.Setup, PVInput, SPInput, Loop.SP, AltSP, Loop.SP, AltSPSelect.			Conf
SP Input	The programmer needs to know the working setpoint of the loop it is trying to control. The SP input is used in the servo to setpoint start type. Note that SP Input is normally wired from the loop Track SP parameter	SP Input is normally wired from the loop Track SP parameter as the PV input.			Conf
Servo	The programmer may be configured to start from either the PV or the working setpoint. See also section Servo.	PV	Start program from current PV value.		Conf
		SP	Start program from the current working setpoint. If the program has been configured to use PVStart (start from the segment in which the PV resides), servo to SP will be ignored.		
Power Fail	Power fail recovery strategy See also section Power Fail Recovery.	Ramp	Ramp back to program setpoint at the previous ramp rate		Conf
		Reset	Reset program		
		Cont	Continue program		
Rate Res	Configures the display resolution of ramp rates (see Program Edit page). (Not Shown for SyncAll programmer)	XXXX.X to X.XXXX			Conf
Max Events	To set the maximum number of output events required for the program. This is for convenience to avoid having to scroll through unwanted events when setting up each segment	1 to 8			Conf

List Header – Program Setup		Sub-header: Ch1 or Ch2			
Name ⊙ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
PVEvent?	Enable PV Event provides an alarm facility on Programmer's 'PVInput'. PV Event Type and Threshold are defined in each Segment.	No		No	Conf
		Yes	PV Event parameters are listed in the Program Edit page.		
TimeEvent?	Enables the first Event Output to be configured as a Time Event - each segment may then specify an on and an off time, with respect to the start of the segment, for the event.	No		No	Conf
		Yes	Time Event parameters are listed in the Program Edit page		
UserVal?	Enables a single analogue value to be set in every segment. It is only available if 'Ch1/Ch2PV Event' = 'None' in the Program Edit page.	No	User value not shown	No	Conf
		Yes	User value shown in every segment		
Gsoak?	Enable Guaranteed soak ensures that the work piece remains at the specified dwell setpoint for a minimum of the specified duration. This parameter is only shown for SyncStart programmers	No	No guaranteed	No	Conf
		Yes	Guaranteed soak parameters are listed in the Program Edit page for all Dwell segments.		
DelayedStart?	Enables a time period to be set between starting Run and the program actually running	No	The program will run immediately	No	Conf
		Yes	Delayed start is listed in the Program Status page. It is also listed in the pop up associated with the RUN/HOLD key.		
PID Set?	Enables PID set. The setting configured in each segment will automatically select the relevant PID Set for the loop wired to the Programmer. Upon completion of the program, PID setting of the loop will be reset to values prior to execution of the program See also section PID Select.	No	PID control is under the control of loop settings	No	Conf
		Yes	PID Set is listed in the Program Edit page.		
Prog Reset	Program reset is provided so that it may be wired from digital inputs to reset the program. RESET is an INPUT only. The Program is held in RESET while the reset input is TRUE	No/Yes	Can be wired to logic inputs to provide remote program control		R/O
Prog Run	Program run is an input to the programmer. When it is switched from False (0) to True (1) the programmer runs its program. ☺ Reset will override this input. At the end of a program, the Program will not re-run until Program Run has been set to False and back to True.	No/Yes			R/O
Prog Hold	Holds the program while the input is true. ☺ Reset overrides this input.	No/Yes			R/O
Prog RunHold	Program Run Hold is an input to the programmer. While it is in the True (1) state, it runs the program. When it is switched from True(1) to False (0) the programmer Holds its program. ☺ Reset overrides this input in all states. Hold overrides this input when in Run state. At the end of a program, the Program will not re-run until Program Run Hold has been set to False and back to True.	No/Yes	These parameters can be wired to provide a Run/Hold facility. See section Run/Hold/Reset Digital Inputs.		R/O

List Header – Program Setup		**Sub-header: Ch1 or Ch2**			
Name ⊙ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Prog RunReset	Program Run Reset is an input to the programmer. While it is in the True (1) state, it runs the program. When it is switched from True(1) to False (0) the programmer Resets its program. ☺ Reset and Hold will override this input when in Run state. At the end of a program, the Program will not re-run until Program Run Reset has been set to False and back to True.	No/Yes			R/O
Advance	Set the program setpoint equal to the target setpoint and advance to the next segment.	No	Ignore	No	Conf
		Yes	Go to next segment		
SkipSeg	Skip to the next segment and start the segment at the current program setpoint value.	No	Ignore	No	Conf
		Yes	Go to next segment		
Event 1 to 8	Outputs showing event states	On Off			R/O
End of Seg	Flag showing end of segment state	On Off			R/O
PVEventOP	Provides an output for the PV event which can be wired for use in a control strategy (Only shown if 'PVEvent?' = Yes)	Off On			R/O
UserValOP	This is a wireable parameter which adopts the value set by 'Usr Val' in the Programmer Status list available in operator levels. In segments that specify 'PVEvent' 'UserValOP' is set to this value. (Only shown if 'UserVal?' = Yes)	0.0			R/O
Sync Input	On a Dual Loop Instrument synchronised start is achieved by wiring the Sync1 output from the master Programmer to the SyncIP of the slave Programmer - see Sync1 for further details The synchronise input may also be used to synchronise programs executed on different instruments. At the end of a segment the programmer will inspect the sync. input, if it is True (1) then the programmer will advance to the next segment. It is typically wired from the end of segment output of another programmer.	0 1			Conf
Sync1	Synchronised start is achieved by wiring the 'Sync1' output from the Master channel (P1) to 'SyncIn' of the Slave channel (P2). Program control is then fully transferred to the Master channel where the program number is selected and Run/Hold/Reset commands executed. See iTools Integrated Online Help for further details. By default the 3500 is supplied so that both programs run together.				R/O
PrgIn1	These are events called Program Input 1 and 2 and can be wired to any parameter. They may be used in a 'wait' segment to prevent the program continuing until the event becomes true	Off On			Conf
PrgIn2					
PVWaitIP	PV wait input for a wait segment. This analogue input may be used to stop the execution of the next segment. This is achieved by using a Wait Segment, and selecting 'PVWaitIP' for the Wait For parameter. PV Wait may then be configured as appropriate to determine the criterion for waiting - see 'Ch1 (Ch2) PV Wait' in the Program Edit page for further details.	Range units			Conf

List Header – Program Setup		Sub-header: Ch1 or Ch2			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
ProgError	Provides messages if an invalid entry is made to a program. The message appears in the form of a pop up on the controller display or as a message over digital communications.	0: No Error			
		1: Sensor Break	Due to sensor break, it is not possible to run the program. Source of the sensor break is the PV Input to the Programmer block.		
		2: Empty Program	Program currently selected for execution has no segments		
		3: Over Range	Program currently selected for execution contains setpoints that reside outside the loop setpoint limits.		

Program Edit

To set up or edit a program, use the parameters in the '**Program Edit**' lists. Parameters are similar for each programmer type but are listed individually here for clarity. Use of PROG button will provide a short cut to the Program Status page in operator levels and Program Setup page in configuration level.

To Edit a SyncAll Programmer

Select the program number to be created or edited. (Press ⊜ followed by ⊚ or ⊚).

Programs can be created and edited in all levels.

This gives access to parameters which allow you to set up each segment of the selected program.

The following table lists these parameters:

List Header – Program Edit (Sync All)		**Sub-header: 1 to 50. These may also have user defined program names**			
Name ⊚ to select	**Parameter Description**	**Value** Press ⊚ or ⊚ to change values		**Default**	**Access Level**
Program	Program number or program name (If configured)	1 to 50			L3
Segments Used	This value automatically increments when another segment is added	1 to 50		1	R/O
Ch1PVStart	PV Start determines the starting point for program channel 1. See also section PV Start.	Off			L3
		Rising			
		Falling			
Ch2PVStart	PV Start determines the starting point for program channel 2. See also section PV Start.	Off			L3
		Rising			
		Falling			
Ch1HldBk Value	Channel 1 holdback value. Sets the deviation between SP and PV at which holdback is applied to programmer channel 1. This value applies to the whole program. This parameter only appears if	Minimum setting 0			L3
Ch2HldBk Value	Channel 2 holdback value. Sets the deviation between SP and PV at which holdback is applied to programmer channel 2. This value applies to the whole program.	Minimum setting 0			L3
Cycles	Number of times the whole program repeats	Cont	Repeats continuously		L3
		1 to 9999	Program executes once to 9999 times		
Segment	To select the segment to set up	1 to 50			L3
Segment Type	To define the type of segment. See also section Segment Types.	End	Last segment in the program	End	L3
		Time	Time duration of the segment		
		Wait	Wait for event before progressing to the next segment		
		GoBack	Go back to a previous segment and repeat. See section GoBack.		
If 'Segment Type' = 'Time' the following parameters are shown.					
Ch1 Target SP	The setpoint value required in program channel 1 at the end of the selected segment	Within the setpoint limits			L3
Ch2 Target SP	The setpoint value required in program channel 2 at the end of the selected segment	Within the setpoint limits			L3

List Header – Program Edit (Sync All)		Sub-header: 1 to 50. These may also have user defined program names			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
Duration	Sets the time to execute the segment.	0:00:00 to 500:00 1 sec to 500 hours			L3
Ch1 Hldbck Type	Sets the type of holdback applicable to the selected segment in program channel 1	Off	No holdback applied		L3
		Low	Deviation low		
Ch2 Hldbck Type	Sets the type of holdback applicable to the selected segment in program channel 2	High	Deviation high		L3
		Band	Deviation high and low		
Ch1 PV Event	PV Event provides an alarm facility on the main PV in Ch1. Each segment may be configured with an independent threshold value and alarm type. 'PVEventOP' is set accordingly in each segment to indicate the state of the PV Event See also section Event Outputs	None	No PV event in this segment	None	L3
		Abs Hi	Event is triggered when the PV becomes greater than the threshold.		
		Abs Lo	Event is triggered when the PV becomes less than the threshold.		
		Dev Hi	Event is triggered when the PV becomes higher than the program setpoint by the amount of the threshold.		
		Dev Lo	Event is triggered when the PV becomes lower than the program setpoint by the amount of the threshold.		
		Band	Event is triggered when the PV differs from the program setpoint by the amount of the threshold.		
Ch1 PV Thresh	Channel 1 PV threshold. This only appears if 'Ch1 PV Event' ≠ None. It sets the trip level at which the event is true	Range limits		0.0	L3
Time Event	The first Event Output may be switched on and off under program control. See also section Time Event.	Off		Off	L3
		Event 1			
On Time	Time at which the 'Time Event' is true. Only appears if 'Time Event' ≠ Off See section Time Event for error conditions	0:00:00 to 500.00		0:00:00	L3
Off Time	Time at which the 'Time Event' is false. Only appears if 'Time Event' ≠ Off See section Time Event for error conditions	0:00:00 to 500.00		0:00:00	L3
UsrVal	General purpose user value, only available when PV Event is not configured. this parameter may be given a customised name, see iTools integrated Online Help. ☺ a Reset User Value may be set in the Programmer Status page in operator level.	Range limits. Resolution for 'UsrVal' is derived from 'RstUVal'. To adjust resolution, softwire a 'user value' to 'RstUVal' and configure its resolution as required.		0.0	L3
PID Set	PID Set allows automatic selection of the PID Set (scheduling) used by the loop wired to the programmer for the selected segment. The PID parameters for each set are defined by the loop. Each segment stores a PIDSet number which is applied to the loop as the program progresses.	Set1	PID set 1	Set1	L3
		Set2	PID set 2		
		Set3	PID set 3		
End Type	Only shown if 'Segment Type' = End. Defines the action to be taken at the end of the program	Dwell	The program will remain at last SP indefinitely	Dwell	L3
		Reset	The program will return to controller only mode		
		SafeOP	The output value goes to a predefined level. The value is set in the list LP – OP see Control Loop Set Up.		

List Header – Program Edit (Sync All)		**Sub-header: 1 to 50. These may also have user defined program names**			
Name ⊙ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Event Outs	To define the state of up to eight event outputs in the selected segment □□□□□□□□ to ■■■■■■■■ or T□□□□□□□ to ■■■■■■■■ T = Time event: □ = event off; ■ = event on	□	Off	□	L3
		■	On		
		T	Time event. This will be shown in the first event only when 'Time Event = Event 1'. See section Time Event.		

List Header – Program Edit (Sync All)		**Sub-header: 1 to 50. These may also have user defined program names**			
On the next press of ⊙ the next 'Segment' is selected.					
If 'Segment Type' = 'Wait' the following parameter is shown.					
Wait For	Allows you to select the condition to become true before proceeding	PrgIn1	Wait until input 1 is true		L3
		PrgIn2	Wait until input 2 is true		
		PrgIn1n2	Wait until input 1 AND input 2 is true		
		PrgIn1or2	Wait until input 1 OR input 2 is true		
		PVWaitIP	Wait segment concludes when 'PVWaitIP' satisfies criterion specified by 'ChX PV Wait' - this option is used to Wait Until a specified value has been reached by 'PVWaitIP'.		
The following two or four parameters are shown if 'Wait For' = 'PVWaitIP'					
Ch1 PV Wait also Ch2 PV Wait	Configures the type of analogue event to be applied to the PVWaitIP parameter for the selected channel. See section Example 2: Configure Segment 3 to Wait For Digital Input LA. for an example.	None	No alarm type applied	None	L3
		Abs Hi	Absolute high		
		Abs Lo	Absolute low		
		Dev Hi	Deviation high		
		Dev Lo	Deviation low		
		Dev Band	Deviation band		
Ch1 Wait Val also Ch2 Wait Val	This sets the value at which the 'Ch1/2 PV Wait' parameter becomes active. It is not shown if 'Ch1/2 PV Wait' = 'None'	Range units		0	L3
On the next press of ⊙ the next 'Segment' is selected.					
If 'Segment Type' = 'GoBack' the following two parameters are shown					
GoBack Seg	This is shown if 'Segment Type' = 'GoBack'. It defines the segment to go back to.	1 to the number of segments defined			L3
GoBack Cycles	To set the number of times the section of the program is repeated. See section GoBack.	1 to 999		1	L3
On the next press of ⊙ the next 'Segment' is selected.					

To Edit a Syncstart Programmer

Select the program number to be created or edited. (Press ▤ followed by ▲ or ▼).

Programs can be created and edited in all levels.

This gives access to parameters which allow you to set up each segment of the selected program.

The following table lists these parameters:

List Header – Program Edit (Sync Start)		Sub-header: 1 to 50. These may also have user defined program names			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
Prg 1 or 2	Program number or program name (If configured) It is also possible to toggle between Ch1 and Ch2 programs using PROG. See note below.	1 to 50			L3
Segments Used	This value automatically increments when another segment is added	1 to 50		1	R/O
PV Start	PV Start determines the starting point for program channel 1. See also section PV Start.	Off Rising Falling		Off	L3
Holdback Value	Value at which holdback is applied in those segments where Holdback Type is configured. It is deviation between SP and PV. See also section Holdback.	Range units		0	L3
Ramp Units	Time unit applied to the segment	Sec Min Hour	Seconds Minutes Hours		L3
Cycles	Number of times the whole program repeats	Cont 1 to 9999	Repeats continuously Program executes once to 9999 times		L3
Segment	To select the segment to set up. A segment number can only be selected for editing after a segment type has been configured.	1 to 50			L3
Segment Type	To define the type of segment. See also section Segment Types.	End Rate Time Dwell Step Wait GoBack	Last segment in the program Rate of change of SP Time duration of the segment Duration at previous SP Immediate change to new SP Wait for event before progressing to the next segment Go back to a previous segment and repeat. See section GoBack.	End	L3
Target SP	To set the desired setpoint value at the end of the segment. This appears for Rate, Time or Step segment types	Range units			L3
Ramp Rate	To set the rate of change of setpoint. This only appears if 'Segment Type' = 'Rate'	Units/time			L3
Duration	Only appears if 'Segment Type' = Dwell or Time. It sets the length of the dwell period	0:00:00 to 500.0		0:00:00	L3
Holdback Type	Sets the deviation between SP and PV at which holdback is applied to programmer channel 2. The value is set by 'Holdback Value' and applies to the whole program.	Off Low High Band	No holdback applied to the segment Holdback is applied when PV<SP by the Holdback Value Holdback is applied when PV>SP by the Holdback Value Holdback is applied when PV<>SP by the Holdback Value		L3

List Header – Program Edit (Sync Start)		Sub-header: 1 to 50. These may also have user defined program names			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
PV Event	Only appears if ‘PVEvent?’ in the Program Setup table = ‘Yes’. It is also not shown if ‘Segment Type’ = ‘Wait’, ‘GoBack’ or ‘End’. See also section PV Event.	None Abs Hi Abs Lo Dev Hi Dev Lo Dev Band	No PV event Absolute high Absolute low Deviation high Deviation low Deviation band	None	L3
PV Threshold	Only appears when a PV Event is configured. sets the level at which the PV event becomes active	Range units		0	L3
Time Event	To set the type of time event applicable in the selected segment for program channel 2. Only appears if ‘TimeEvent?’ in the Program Setup table = ‘Yes’ See also section Time Event.	Off Event1	No time event configured Event 1 configured as a time event	Off	L3
On Time	Time wrt the start of the segment at which the event is true. Only appears if ‘Time Event’ ≠ Off See section Time Event for error conditions.	0:00:00 to 500.00		0:00:00	L3
Off Time	Time wrt the start of the segment at which the event is false. Only appears if ‘Time Event’ ≠ Off See section Time Event for error conditions.	0:00:00 to 500.00		0:00:00	L3
UsrVal	General purpose user value, only available when PV Event is not configured. this parameter may be given a customised name, see iTools integrated Online Help. A Reset User Value may be set in the Programmer Status page in operator level.	Range limits. Resolution for ‘UsrVal’ is derived from ‘RstUVal’. To adjust resolution, softwire a ‘user value’ to ‘RstUVal’ and configure its resolution as required.			L3
PID Set	To select the PID set for the selected segment	Set1 Set2 Set3	PID set 1, 2 or 3 will be used in the selected segment	Set1	L3
GSoak Type	This parameter is only shown if the ‘Segment Type’ = ‘Dwell’ and ‘Gsoak?’ is enabled in the Program SetUp page. If the PV deviates by more than an amount set by the ‘G. Soak Value’ then the program will be put into hold until the deviation becomes less than G. Soak Value. See also section Guaranteed Soak.	Off Low High Band	No guaranteed soak applied Program is held if PV<SP+G.Soak Value Program is held if PV>SP+G.Soak Value Program is held if PV<>SP+G.Soak Value	Off	L3
G. Soak Value	Sets the value for the guaranteed soak	Range units			L3
If ‘Segment Type’ = ‘GoBack’ the following two parameters are shown					
GoBack Seg	This is shown if ‘Segment Type’ = ‘GoBack’. It defines the segment to go back to.	1 to the number of segments defined			L3
GoBack Cycles	To set the number of times the section of the program is repeated. See section GoBack.	1 to 999		1	L3
If ‘Segment Type’ = ‘Wait’ the following parameter is shown					

List Header – Program Edit (Sync Start)		Sub-header: 1 to 50. These may also have user defined program names			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Wait For	Only appears if 'Segment Type' = 'Wait'. It allows you to select the event to become true before proceeding	PrgIn1	Wait for the program event 1		L3
		PrgIn2	Wait for the program event 2		
		PrgIn1n2	Wait for the program event 1 AND 2		
		PrgIn1or2	Wait for the program event 1 OR 2		
		PVWaitIP	Wait segment concludes when 'PVWaitIP' satisfies criterion specified by 'ChX PV Wait' - this option is used to Wait Until a specified value has been reached by 'PVWaitIP		
		Ch2Sync	In SyncStart mode, the two channels of a program start simultaneously but will end as and when prescribed by their respective profiles. Select 'Ch2Sync' to specify points in the program where the two channels must wait for completion of the segment in BOTH channels (synchronise) before moving on. Only offered in channel 1, where 'Ch2Seg' specifies the synchronisation segment.		
The following two parameters are shown if 'Wait For' = 'PVWaitIP'					
PV Wait	Configures the type of analogue event to be applied to the PVWaitIP parameter for the selected channel	None	No alarm type applied	None	L3
		Abs Hi	Absolute high		
		Abs Lo	Absolute low		
		Dev Hi	Deviation high		
		Dev Lo	Deviation low		
		Dev Band	Deviation band		
WaitVal	This sets the value at which the 'Ch1/2 PV Wait' parameter becomes active. It is not shown if 'Ch1/2 PV Wait' = 'None'	Range units		0	L3
The following parameter is shown if 'Wait For' = 'Ch2Sync'					
Ch2Seg	Defines the channel 2 segment to wait for. Ch2Seg values must be consecutive in any program, e.g. if Ch1Seg1 is set to wait for Ch2Seg3 followed by a further wait in Ch1Seg2 then the segment to wait for in Ch2 must be >3.	1 to 50		1	L3
The following parameter is shown if the 'Segment Type' = 'End'					
End Type	Only shown if 'Segment Type' = End. Defines the action to be taken at the end of the program	Dwell	The program will remain at last SP indefinitely	Dwell	L3
		SafeOP	The output value goes to a predefined level. The value is set in the list LP – OP see Control Loop Set Up.		
		Reset	The program will return to controller only mode		

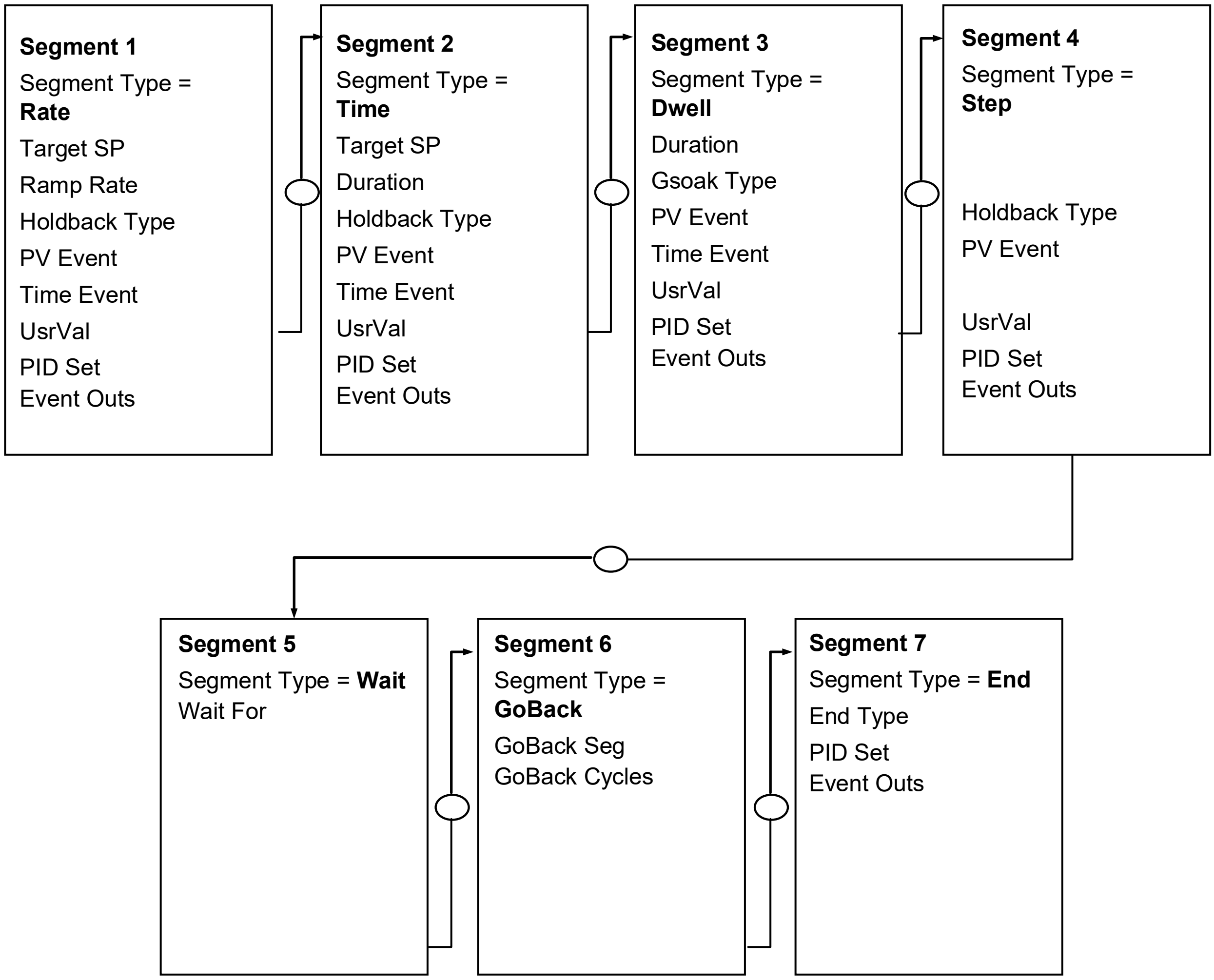
List Header – Program Edit (Sync Start)		Sub-header: 1 to 50. These may also have user defined program names			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
Event Outs	To define the state of up to eight event outputs in the selected segment ☐☐☐☐☐☐☐☐ to ■■■■■■■■ or T☐☐☐☐☐☐☐ to ■■■■■■■■ T = Time event: ☐ = event off; ■ = event on	☐	Off	☐	L3
		■	On		
		T	Time event. This will be shown in the first event only when 'Time Event = Event 1'. See section Time Event.		

NOTICE

When setting up segments in Ch1 and Ch2 you may either set up the same segment, first in Ch1 then in Ch2, in which case use to switch between the two programmer channels. Alternatively, you may wish to set up all segments in Ch1 then all segments in Ch2.

Summary of Parameters which appear for different Segment Types

Pressing will scroll through the parameters listed in the above table. When the last parameter in a segment is configured the next press of will take you to the next segment number. This will always be an 'End' segment until it is configured differently. The following table shows a summary of the parameters which appear for different 'Segment Types' (For this summary it is assumed that Holdback Type, PV Event, and Time Event are set to Off).



To Edit a Single Channel Programmer

By default, when the program is configured as a Single Programmer in the 'Inst Opt' page, only programmer channel 1 can be run.

The parameters shown in the following table apply and are as follows:

List Header – Program Edit		**Sub-header: 1 to 50. These may also have user defined program names**			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Program	Program number or program name (If configured)	1 to 50			L3
Segments Used	This value automatically increments when another segment is added	1 to 50		1	R/O
Holdback Value	Allows a value to be entered to activate 'Holdback'.				L3
Ramp Units	Time unit applied to the segment	Sec Min Hour	Seconds Minutes Hours	Sec	L3
Cycles	Number of times the whole program repeats	Cont 1 to 9999	Repeats continuously Program executes once to 9999 times		L3
Segment	To select the segment to set up. A segment number can only be selected for editing after a segment type has been configured.	1 to 50			L3

List Header – Program Edit		Sub-header: 1 to 50. These may also have user defined program names			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Segment Type	To define the type of segment. See also section Segment Types.	End Rate Time Dwell Step Wait GoBack Call	Last segment in the program Rate of change of SP Time duration of the segment Duration at previous SP Immediate change to new SP Wait for event before progressing to the next segment Go back to a previous segment and repeat. See section GoBack. To insert a new program into the current program. See section Call.	End	L3
Target SP	To set the desired setpoint value at the end of the segment. This appears for Rate, Time or Step segment types	Range units			L3
Ramp Rate	To set the rate of change of setpoint. This only appears if 'Segment Type' = 'Rate'	Units/time			L3
Duration	Only appears if 'Segment Type' = Dwell or Time. It sets the length of the dwell period	0:00:00 to 500.0		0:00:00	L3
Holdback Type	Defines the type of holdback to be applied to the segment. See section Holdback.	Off Low High Band	No holdback applied to the segment Holdback is applied when PV<SP by the Holdback Value Holdback is applied when PV>SP by the Holdback Value Holdback is applied when PV<>SP by the Holdback Value		L3
PV Event	Only appears if 'PVEvent?' in the Program Setup table = 'Yes'. See also section PV Event.	None Abs Hi Abs Lo Dev Hi Dev Lo Dev Band	No PV event Absolute high Absolute low Deviation high Deviation low Deviation band	None	L3
PV Threshold	Only appears when a PV Event is configured. sets the level at which the PV event becomes active	Range units		0	L3
Time Event	To set the type of time event applicable in the selected segment for program channel 2. Only appears if 'TimeEvent?' in the Program Setup table = 'Yes' See also section Time Event.	Off Event1			L3
On Time	Time wrt the start of the segment at which the event is true. Only appears if 'Time Event' ≠ Off	0:00:00 to 500.00		0:00:00	L3
Off Time	Time wrt the start of the segment at which the event is false. Only appears if 'Time Event' ≠ Off	0:00:00 to 500.00		0:00:00	L3

List Header – Program Edit		Sub-header: 1 to 50. These may also have user defined program names			
Name ⊙ to select	**Parameter Description**	**Value** Press ▽ or △ to change values		**Default**	**Access Level**
UsrVal	General purpose user value, only available when PV Event is not configured. this parameter may be given a customised name, see iTools integrated Online Help. ☺ A Reset User Value may be set in the Programmer Status page in operator level.	Range limits. Resolution for 'UsrVal' is derived from 'RstUVal'. To adjust resolution, softwire a 'user value' to 'RstUVal' and configure its resolution as required.			L3
PID Set	To select the PID set for the selected segment	Set1 Set2 Set3	PID set 1, 2 or 3 will be used in the selected segment	Set1	L3
GSoak Type	The parameter is only shown if the 'Segment Type' = 'Dwell' and 'Gsoak?' is enabled in Program SetUp. Guaranteed Soak ensures that the work piece remains at the specified dwell setpoint for a minimum of the specified duration. Guaranteed Soak continuously monitors the difference between the PV and the programmer setpoint. 'GSoak Type' specifies whether the guaranteed soak tests for deviations above or below the setpoint. See also section Guaranteed Soak.	Off Low High Band	No guaranteed soak applied Program is held if PV<SP+G.Soak Value Program is held if PV>SP+G.Soak Value Program is held if PV<>SP+G.Soak Value	Off	L3
G. Soak Value	Value used in evaluation of Guaranteed Soak in Dwell segments.	Range units			L3
If 'Segment Type' = 'GoBack' the following two parameters are shown					
GoBack Seg	This is shown if 'Segment Type' = 'GoBack'. It defines the segment to.		1 to the number of segments defined		L3
GoBack Cycles	To set the number of times the section of the program is repeated. See section GoBack.		1 to 999	1	L3
If 'Segment Type' = 'Wait' the following parameter is shown.					
Wait For	Wait For allows you to select the event to become true before proceeding	PrgIn1 PrgIn2 PrgIn1n2 PrgIn1or2 PVWaitIP	Wait for the program event 1 Wait for the program event 2 Wait for the program event 1 AND 2 Wait for the program event 1 OR 2 Wait segment concludes when 'PVWaitIP' satisfies criterion specified by 'ChX PV Wait' - this option is used to Wait Until a specified value has been reached by 'PVWaitIP		L3
If 'Wait For' = 'PVWaitIP' the following two parameters are shown					
PV Wait	Configures the type of alarm to be applied to the 'PVWaitIP' parameter	None Abs Hi Abs Lo Dev Hi Dev Lo Dev Band	No alarm type applied Absolute high Absolute low Deviation high Deviation low Deviation band	None	L3
WaitVal	This sets the value at which the 'PV Wait' parameter becomes active. It is not shown if 'PV Wait' = 'None'	Range units		0	L3
If 'Segment Type' = 'Call' the following two parameters are shown					

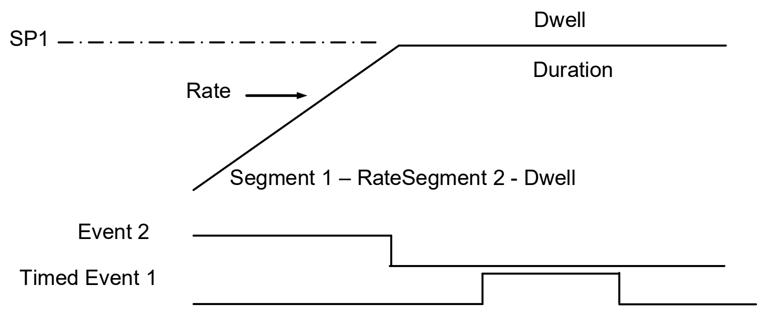
List Header – Program Edit		Sub-header: 1 to 50. These may also have user defined program names			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Call Program	Enter the program number to be inserted in place of the selected segment. Only shown if ‘Segment Type’ = ‘Call’.	UP to 50 (current program number excluded)			L3
Call Cycles	Defines the number of times the inserted program repeats. Only shown if ‘Segment Type’ = ‘Call’.	Cont	Repeats continuously		
		1 to 999	Program executes 1 to 999 times		
End Type	Only shown if ‘Segment Type’ = ‘End’. Defines the action to be taken at the end of the program	Dwell	The program will remain at last SP indefinitely	Dwell	L3
		SafeOP	The power output will go to a defined level		
		Reset	The program will return to controller only mode		
Event Outs	To define the state of up to eight event outputs in the selected segment □□□□□□□□ to ■■■■■■■■ or T□□□□□□□ to ■■■■■■■■ T = Time event: □ = event off; ■ = event on	□	Off	□	L3
		■	On		
		T	Time event. This will be shown in the first event only when ‘Time Event = Event 1’. See section Time Event.		

Examples Showing How to Set up and Run Dual Programmers

The following sections show some examples of setting up program parameters.

Example 1: Configure a Rate followed by a Dwell Segment

This example applies to Single Channel and SyncStart programmers only. For a SyncAll programmer the procedure is similar except the segments are set up as Time type segments only.



1. In ‘Program Setup’ select the channel to be set up using ▲ or ▼. For convenience it is also possible to toggle between Ch1 and Ch2 using the PROG button. To set Event 1 to be a timed event press ⟳ to select ‘TimeEvent?’ and ▲ or ▼ to ‘Yes’. TimeEvent is only available in the Ch1 list and applies to both channels.
2. In ‘Program Edit’ select the program number to be set up. Using ⟳, scroll through the parameters setting their values as required using ▲ or ▼ at each parameter
3. At ‘Segment Type’, press ▲ to ‘Rate’
4. At ‘Target SP’, press ▲ to the required target SP

5. At 'Ramp Rate', press ⏶ to the required rate of change of SP
6. Scroll through the remaining parameters and set these as required. At 'Event Outs' set Event 2 to ■
7. The list then returns to Segment (number 2)
8. At 'Segment Type', press ⏶ to 'Dwell'
9. At 'Duration', set this to the time required for the Dwell. It is also possible to set up a guaranteed soak for this segment so that it does not proceed until the segment has been at SP for the required time
10. At 'Time Event', set this to 'Event 1.

☺ 'Time Event' will only be displayed if 'TimeEvent?' has been turned on in configuration level in the 'Program Setup' page. Then set the time delay into the segment at which the event is to turn on, followed by the time when it is to turn off.

NOTICE
On and Off times are both referenced to the start of the segment – please refer to section Time Event for further details

Example 2: Configure Segment 3 to Wait For Digital Input LA.

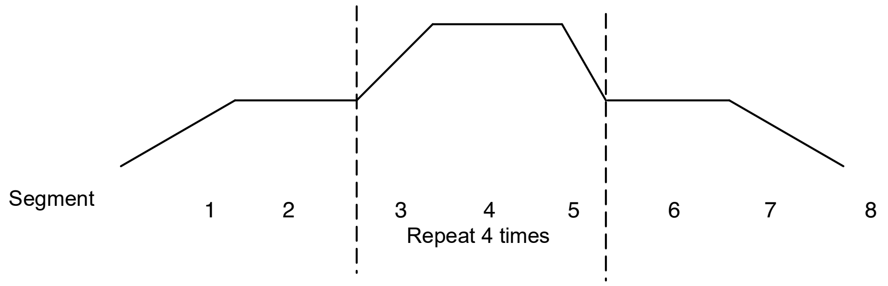
Refer to section Function Block Wiring for step by step instructions to wire a parameter through the user interface.

1. In configuration level, select 'Program Setup' page and the parameter 'PrgIn1'
2. Press A/MAN, the display will show 'Wire From'
3. Press ⊜ until LgcIO LA is shown followed by ⊙ to select PV
4. Press A/MAN again and ⊙ to OK
5. In the 'Program Setup' page the parameter 'PrgIn1' will have the symbol ▦ displayed to the left of the parameter name to indicate that it has been wired to a parameter.
6. In 'Program Edit' page select 'Wait' as the 'Segment Type' in the relevant segment
7. Then select 'Wait For' = 'PrgIn1'
8. When the program is run the program will not progress to the next segment until digital input LA becomes true.

Other strategies may be set up using a similar procedure.

Example 3: To Repeat a Section of a Program

This uses a GoBack segment



1. Segments 1 to 5 of the program are set up as described in Example 1
2. At Segment 6 adjust ‘Segment Type’ = ‘GoBack
3. At ‘GoBack Seg’ set the value to 3 using ▲ or ▼
4. At ‘GoBack Cycles’ set the value to 4 using ▲ or ▼
5. At Segment 7 continue to set the program as described in Example 1

Example 4: To Run a Dual Programmer

Programs can be run in operator level 1, 2 or 3

1. Choose the Summary screen which is most appropriate, see section Summary Pages.
2. Press RUN/HOLD button. Run may also be activated from an external source if a digital input has been configured, or via digital communications
3. If a delayed start has been configured the display will ask for a time delay to be entered, then press RUN/HOLD again as prompted. The program will run at the end of the delay time
4. If no program has been set up or other error detected (see section Program Set Up, Prog error) an error message is displayed, otherwise the program will start to run
5. Briefly press RUN/HOLD button to hold the program or hold this button down for 3 seconds to reset the program
6. The beacons on the top banner show the status of the program e.g. RUN, HLD.

Assuming the Program Status screen has been selected as the summary screen the progress of the program can be read from a list of parameters in this view. These are typically:

1. Program number or name if a program name has been configured
2. Current segment Number and Type
3. Segment time left
4. Delayed start. Counts down to 0 before starting the program execution. The delay may be cancelled by setting it to 0 while counting down.
   ☺ When the delay is 1 minute and as the resolution is I minute, the delay is decremented and appears to have a value of 0 for 1 minute.
5. Current Status (Run, Hold or Reset)
6. PSP – the current value of the setpoint

7. Segment Target – the value of the SP required at the end of the segment
8. Segment Rate
9. Cycles left
10. Fast run
11. Status of event outputs
12. Program time left
13. Segment time left
14. The above parameters are also available for Ch2. It is possible to toggle between channel 1 and channel 2 using 

Alternative Ways to Edit a Program

- iTools may be used to enter or edit programs.
- A program may also be set up using SCADA communications.

☺ If iTools Program Editor is connected then any editable program related parameter cannot be changed for a period of time (approximately 1 minute). After this period these parameters are released and they then become alterable.

Single Programmer Earlier Versions

Software versions 1.XX contained a single control loop and a single programmer block. For reference, this section lists the parameters which were available in these versions

Creating or Editing a Single Program

Press ⊜ as many times as necessary to select the '**Program**' page, or, in configuration level, press the PROG button and this will select the first sub-header - '**All**'. This allows you to configure and view parameters common to all programs in the controller.

The following is a list of the parameters.

List Header – Program		Sub-header: All (only available in configuration level)			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
PV Input	The programmer uses the PV input for a number of functions In holdback, the PV is monitored against the setpoint, and if a deviation occurs the program is paused. The programmer can be configured to start its profile from the current PV value (servo to PV). The programmer monitors the PV value for Sensor Break. The programmer holds in sensor break.	The PV Input is normally wired from the loop TrackPV parameter. ☺ This input is automatically wired when the programmer and loop are enabled and there are no existing wires to track interface parameters. Track interface parameters are Programmer.Setup, PVInput, SPInput, Loop.SP, AltSP, Loop.SP, AltSPSelect.			Conf
SP Input	The programmer needs to know the working setpoint of the loop it is trying to control. The SP input is used in servo to setpoint start.	SP Input is normally wired from the loop Track SP parameter as the PV input.			Conf
Servo	The transfer of program setpoint to PV Input (normally the Loop PV) or the SP Input (normally the Loop setpoint).	PV SP	See also section Servo.		Conf
Power Fail	Power fail recovery strategy	Ramp Reset Cont	See section Power Fail Recovery.		Conf
Sync Input	The synchronise input is a way of synchronising programs. At the end of a segment the programmer will inspect the sync. input, if it is True (1) then the programmer will advance to the next segment. It is typically wired from the end of segment output of another programmer. Only appears if 'SyncMode' = 'Yes'	0 1	This will normally be wired to the 'End of Seg' parameter, see iTools integrated Online Help.		Conf
Max Events	Sets the maximum number of output events required for the program. This is for convenience to avoid having to scroll through unwanted events in every segment	1 to 8			Conf
SyncMode	Allows multiple controllers to be synchronised at the end of each segment	No Yes	Sync output disabled Sync output enabled		Conf
Prog Reset	Flag showing reset state	No/Yes	Can be wired to logic inputs to provide remote program control		R/O
Prog Run	Flag showing run state	No/Yes			R/O
Prog Hold	Flag showing hold state	No/Yes			R/O
Event 1 to 8	Flags showing event states	No/Yes			R/O
End of Seg	Flag showing end of segment state	No/Yes			R/O

Now select the program number to be created or edited. (Press ⊚ followed by ▲ or ▼).

Programs can be created and edited in Level 3 or configuration level.

This gives access to parameters which allow you to set up each segment of the selected program.

The following table lists these parameters:

List Header – Program		**Sub-header: 1 to 50**			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Segments Used	This value automatically increments when another segment is added	1 to 50		1	R/O
Holdback Value	Deviation between SP and PV at which holdback is applied. This value applies to the whole program.	Minimum setting 0			L3
Ramp Units	Time units applied to the segments	Sec Min Hour	Seconds Minutes Hours		L3
Cycles	Number of times the whole program repeats	Cont 1 to 9999	Repeats continuously Program executes once to 9999 times		L3
Segment	To select the segment to set up	1 to 50			L3
Segment Type	To define the type of segment. See also section Segment Types.	End Rate Time Dwell Step Call	Last segment in the program Rate of change of SP Duration to new SP Duration at previous SP Rapid change to new SP To insert a new program in the current program	End	L3
End Type	Only shown if 'Segment Type' = 'End'. Defines the action to be taken at the end of the program	Dwell Reset	The program will remain at last SP indefinitely The program will return to controller only mode	Dwell	L3
Call Program	Only shown if 'Segment Type' = 'Call'. Enter the program number to be inserted in place of the selected segment	Up to 50 (current program number excluded)			L3
Call Cycles	Only shown if 'Segment Type' = 'Call'. Defines the number of times the inserted program repeats	Cont 1 to 999	Repeats continuously Program executes once to 999 times		L3
Holdback Type	Sets the type of holdback applicable to the selected segment	Off Low High Band	No holdback applied Deviation low Deviation high Deviation high and low		L3
Duration	Only shown if 'Segment Type' = 'Dwell' or 'Time'. Sets the time to execute the segment.	0:00.0 to 500:00 0.1 sec to 500 hours			L3
Target SP	Only shown if 'Segment Type' = 'Rate', 'Time' or 'Step'. To enter the SP which is to be achieved at the end of the segment				L3
Ramp Rate	Only shown if 'Segment Type' = 'Rate'. To enter the rate in units/time at which the SP is required to change	0.1 to 9999.9 units per sec, min or hour			L3
Event Outs	To define the state of up to eight event outputs in the selected segment □□□□□□□□ to ■■■■■■■■	□ = Off ■ = On			L3

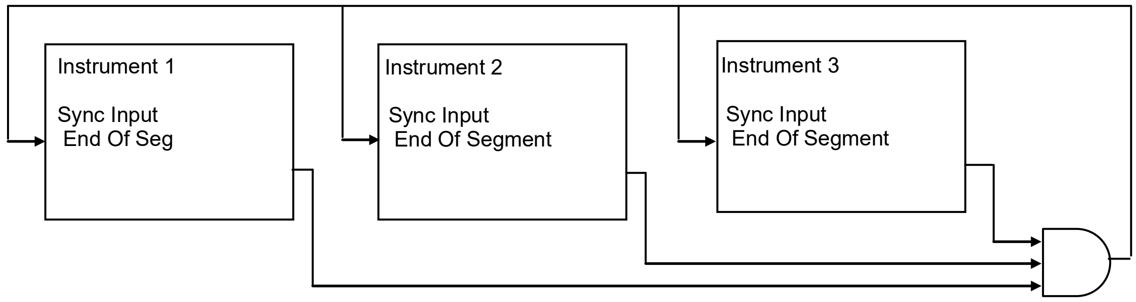
Sync mode

This mode will allow two or more single loop controller/programmers to by synchronised together. This means that the start of each segment (excluding the first) will begin at the same time. Two or more instruments may be synchronised by wiring the “end of segment” and “sync input” parameters between units. (see diagram below).

Set “SyncMode” to Yes.

NOTICE
‘SyncMode is no longer available in the dual programmer

Wire instruments as follows:



At the end of a segment, the program will be put into a temporary hold state (program status will continue to show that the program is running), the hold beacon will flash, the end_of_segment parameter will be true. Once all segments have completed, the SyncInput goes high and the next segment is started.

If the “SyncMode” is disabled, the “End_Of_Segment” parameter is guaranteed to be true for 1 tick at the end of every segment.

Switch Over

This facility is commonly used in temperature applications which operate of a wide range of temperature. A thermocouple may be used to control at lower temperatures and a pyrometer then controls at very high temperatures. Alternatively two thermocouples of different types may be used.

The diagram below shows a process heating over time with boundaries which define the switching points between the two devices. The higher boundary (2 to 3) is normally set towards the top end of the thermocouple range and this is determined by the ‘Switch Hi’ parameter. The lower boundary (1 to 2) is set towards the lower end of the pyrometer (or second thermocouple) range using the parameter ‘Switch Lo’. The controller calculates a smooth transition between the two devices.

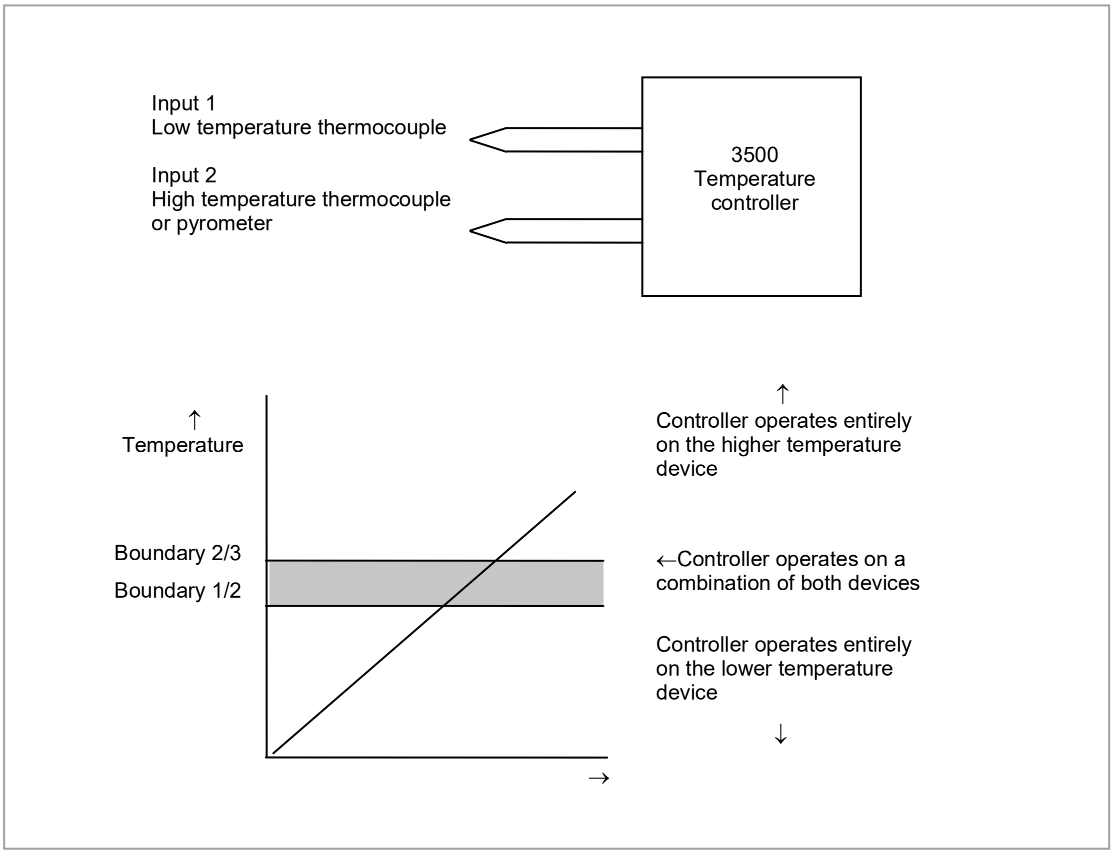


Figure 78: Thermocouple to Pyrometer Switching

Example: To Set the Switch Over Levels

Select Level 3 or configuration level

1. Press ⊡ as many times as necessary to display the ‘SwOver’ header
2. Press ⊙ to scroll to ‘Switch Hi’
3. Press ▲ or ▼ to a value which is suitable for the pyrometer (or high temperature thermocouple) to take over the control of the process
4. Press ⊙ to scroll to ‘Switch Lo’
5. Press ▲ or ▼ to a value which is suitable for the low temperature thermocouple to control the process

Switch Over Parameters

List Header – SwOver		Sub-headers: None			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
Input Hi	Sets the high limit for the switch over block. It is the highest reading from input 2 since it is the high range input sensor.	Input range			L3
Input Lo	Sets the low limit for the switch over block. It is the lowest reading from input 1 since it is the low range input sensor				L3
Switch Hi	Defines the high boundary of the switchover region	Between Input Hi and Input Lo			L3
Switch Lo	Defines the low boundary of the switchover region.				L3
Input 1	The first input value. This must be the low range sensor.	These will normally be wired to the thermocouple/pyrometer input sources via the PV Input or Analogue Input Module. The range will be the range of the input chosen.			R/O if wired
Input 2	The second input value. This must be the high range sensor				R/O if wired
Fall Value	In the event of a bad status, the output may be configured to adopt the fallback value. This allows the strategy to dictate a safe output in the event of a fault being detected	Between Input Hi and Input Lo		0.0	L3
Fall Type	Fall back type	Clip Bad Clip Good Fall Bad Fall Good Upscale Downscale	See section Fallback.	Clip Bad	Conf
Selected IP	Indicates which input is currently selected	Input 1 Input 2	0: Input 1 has been selected 1: Input 2 has been selected 2: Both inputs are used to calculate the output		R/O
ErrMode	The action taken if the selected input is BAD	UseGood	0: Assumes the value of a good input If the currently selected input is BAD the output will assume the value of the other input if it is GOOD	UseGood	Conf
		ShowBad	1: If selected input is BAD the output is BAD		
Switch PV	The process variable produced from the 2 input measurements				R/O
Status	Status of the switchover block	Good Bad			R/O

Transducer Scaling

The 3500 controller includes two transducer calibration function blocks. These are software function blocks which provide a method of offsetting the calibration of the controller input when compared to a known input source.

This section describes the full procedures for setting up fixed parameters and for performing transducer calibration in Level 3 and Configuration access levels.

Transducer scaling is often performed, however, as a routine operation on a machine to take out system errors. For this reason a limited set of calibration parameters can be made available in operator levels 1 and 2 by configuring the parameter **'Cal Enable'** (section Transducer Scaling Parameters) to **'Yes'**. The relevant calibration parameters are found in the Transducer Summary pages, Txdr1 or Txdr2, (section Transducer).

Transducer scaling can be applied to any input or derived input, i.e. the PV Input or Analogue Input fitted in one of the module slots. These can be wired in configuration level to the above inputs.

Four types of calibration are explained in this section in Level 3 or configuration levels:

- Auto-tare
- Shunt Calibration
- Load Cell Calibration
- Comparison Calibration

Auto-Tare Calibration

The auto-tare function is used, for example, when it is required to weigh the contents of a container but not the container itself.

The procedure is to place the empty container on the weigh bridge and 'zero' the controller. Since it is likely that following containers may have different tare weights the auto-tare feature can be made available in all operator access levels by configuring the parameter **'Cal Enable'** to **'Yes'**. The procedure to enter a tare offset is described in section Tare Calibration. and is the same in all access levels.

Tare calibration may be carried out no matter what type of transducer is in use.

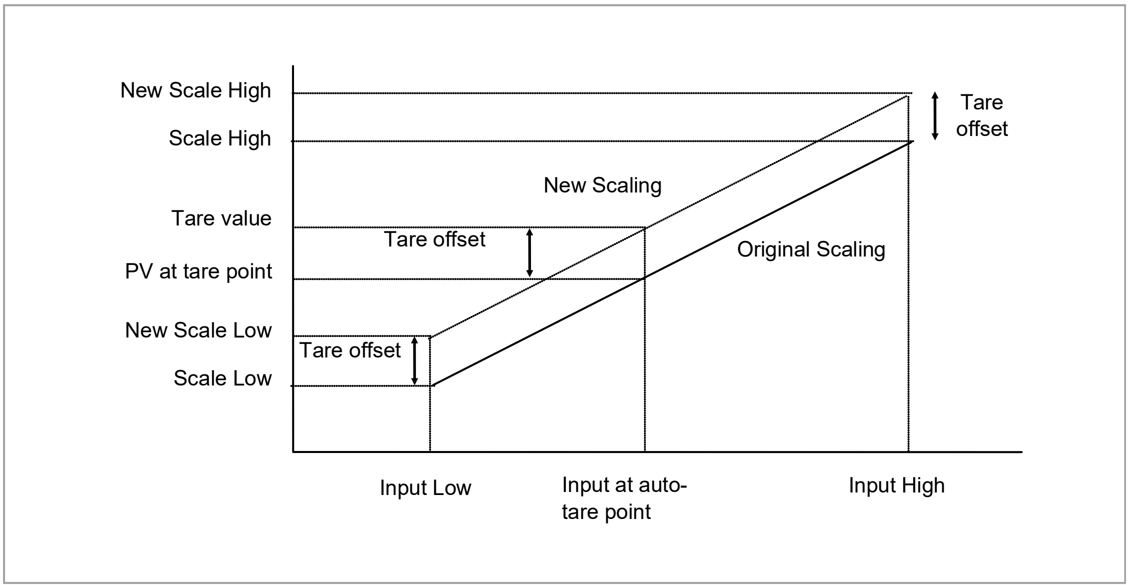


Figure 79: Effect of Auto Tare

Transducer Summary Page

If the Transducer function block has been enabled then a transducer summary page is available in operator level 1 and 2. This means that calibration of the transducers can be done at this level although with some small limitations.

Tare Calibration

The 3500 controller has an auto-tare function which is used, for example, when it is required to weigh the contents of a container but not the container itself.

The procedure is to place the empty container on the weighbridge and 'zero' the controller. Since it is likely that following containers may have different tare weights the auto-tare feature is available in the controller at access level 1 (provided 'Cal Enable' is set to 'Yes' in configuration level).

The procedure is as follows:

Do This	The Display You Should See	Additional Notes
1. Place the empty container on the weigh bridge		
2. Press until the Txdr1 (or 2) page is displayed 3. Press until 'Start Tare' is displayed		
4. Press or to select 'Yes'		The controller automatically calibrates to the tare weight which is measured by the transducer and stores this value. During this measurement the displays shown here will be shown
		If the calibration is successful, the message Cal Passed will be shown.
		If the calibration fails the message Cal Failed will be shown. This may be due to the measured input being out of range
		This will also be shown in the parameter list

Strain Gauge

A strain gauge consists of a resistive four wire measurement bridge where all four arms are in balance when no pressure is being measured. It is energised by the transducer power supply, normally 5Vdc or 10Vdc, which is a module fitted into any slot. It is calibrated by switching a calibration resistor across one arm of the four wire measurement bridge. For this reason the calibration is referred to as 'Shunt' calibration. The value of this resistor is chosen so that it represents 80% of the span of the transducer.

Some transducers have the calibration resistor fitted internally in the transducer itself. In this case the parameter 'Shunt' in the transducer power supply module is set to 'External'. If the transducer does not have a calibration resistor fitted, set 'Shunt' = 'Internal'. In this case the controller uses its calibration resistor which is mounted in the power supply module. The value of this resistor is 30.1KΩ. Consult the data provided by the transducer manufacturer to determine if this resistor is correct for the transducer in use. If not it will be necessary to fit resistors externally to achieve the correct value.

Calibration Using the Calibration Resistor Mounted in the Transducer.

This is illustrated using the following example:

Strain Gauge range 0 to 3000 psi, output 3.33mV/V (this figure is quoted by the manufacturer - Dynisco model PT420A)

Transducer power supply set to 10 Volt excitation (fitted in module position 4). This produces a full load output of 33.3mV

Physical Wiring

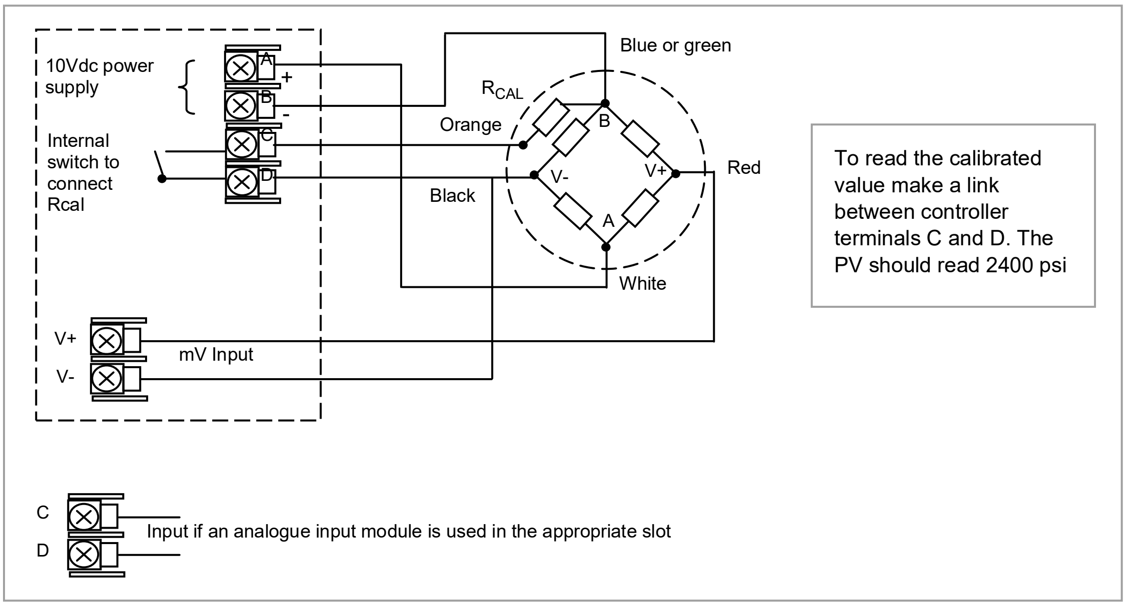


Figure 80: Pressure Transducer Wiring Diagram

The above example uses the Dynisco model PT420A. Use 6 conductor, shielded cable. Attach cable to shield to ground at one end only. **NOTE**: DYNISCO cable assemblies are constructed with shield wired to transducer mating connector, so do not attach shield to instrument.

Set the transducer power supply module parameter 'Shunt' to 'External'.

Configure Parameters for Strain Gauge Calibration

Configure the controller as follows:

Step	Description		
1	PV Input values (see example section Configure the Input)	IO Type	40mV
		Lin Type	Linear
		Units	PSI or as required
		Res'n	XXXX.X
		Disp Hi	3000
		Disp Lo	0
		Range Hi	33.30
		Range Lo	0
		Fallback	Upscale
2	Transducer Power Supply module (see example section Configure the Transducer Power Supply Module)	Voltage	10 Volts
		Shunt	Internal if the calibration resistor is fitted in the controller External if the calibration resistor is fitted in the transducer
3	Txdr Values (see example section Transducer Values)	Cal Type	Shunt
		Cal Enable	Yes
		Range Max	3000
		Clear Cal	No. If set to yes this will clear the previous calibration. It may be necessary to reset some of the values in this table. For example, Input Hi and Scale Hi.
		Input Hi	3000
		Scale Hi	2400 (80% of 3000)
4	Internal (Soft) wiring (see example section Internal (Soft) Wiring)	Txdr Input Value from PVInput PV	If an analogue input module is used wire the Txdr Input to the PV of the module
		TransPSU PV from Txdr ShuntState	The operation for Shunt calibration is made fully automatic when this wire is made

Configuration Examples

The following sections show examples of how these parameters are configured. Skip this section if this explanation is not required or if the calibration is being carried out in access levels 1 or 2.

Enable a Transducer Function Block

In configuration level:

Do This	The Display You Should See	Additional Notes
1. Press ⊜ as many times as necessary to select the 'Inst ⇕ Enb' page. 2. Press ⊙ tto scroll to 'TrScale En' and ⊙ or ⊙ to enable	Inst Enb Totalise En ☐☐ TrScale En ■☐ UsrText En ☐☐☐☐☐☐☐☐	☐ ☐ Both transducer inputs disabled ■ ■ Both transducer inputs enabled

Configure the Input

Set input to 33.3mV where 0mV = reading of 0.0 and 33.3 mV = reading of 3000.0

In configuration level:

Do This	The Display You Should See	Additional Notes
1. Press as many times as necessary to select the input to be calibrated	PVInput IO Type ⬍40 mV Lin Type Linear Units psi	Configure 'IO Type' to 40mV, 'Lin Type' to Linear and 'Units' as required
2. Use to scroll to the required parameter 3. Use or to change parameter values	PVInput Disp Hi 3000.0 Disp Lo 0.0 Range Hi ⬍33.30	Configure 'Disp Hi' and 'Disp Lo' to correspond to strain gauge range, 0 to 3000 Configure 'Range Hi' and 'Range Lo' to the input mV range 0 – 33.30mV

Configure the Transducer Power Supply Module

In configuration level:

Do This	The Display You Should See	Additional Notes
1. Press as many times as necessary to select the module in which the Transducer Power Supply is fitted	Mod 4A Ident TdcrPSU Meas Value 0 PV 0	In this example Mod 4. As a single output module only 4A is available
2. Press to scroll to 'Shunt' and or to change to 'External' 3. Press to scroll to 'Voltage' and or to change to '10 Volts'	Mod 4A Status OK Shunt ⬍External Voltage 10 Volts	External refers to the calibration resistor R_{CAL} fitted externally to the controller (internally in the transducer). An excitation of 10V will give an input of 3.33mV/V i.e. 33.3mV

Transducer Values

In configuration level:

Do This	The Display You Should See	Additional Notes
1. Press as many times as necessary to select the Transducer to be calibrated	Txdr ⬍1 Cal Type Shunt Cal Enable Yes Range Max 3000	In this example transducer 1 is being used. Configure 'Cal Type' = 'Shunt' 'Cal Enable' = 'Yes' (this enables cal parameters, and calibration may be done in operator levels). Set 'Range Max' and 'Range Min' to the range of the transducer – 0 to 3000 psi

2. Use ⟳ to select 'Scale Hi'	Txdr 1 Scale Hi 2400.0 Scale Lo 0 Cal Band ⇕0.5	'Scale Hi' should be set to 80% of the maximum range of the transducer. In this case 2400.0 The controller takes a number of measurements to determine when the calibration should take place. Cal Band sets the allowed difference between two consecutive averages. If set to 0.5 the averages must be within ±0.5 before calibration takes place. A lower setting requires the controller to settle for a longer period. Calibration accuracy is not necessarily affected other than setting at extremes.

Internal (Soft) Wiring

Assuming the PV input on terminals V+ and V- are used, internally wire transducer 'Input Value' from 'PVInput PV'.

In configuration level:

Do This	The Display You Should See	Additional Notes
1. From any display press to select 'Txdr' page 2. Press ⟳ to scroll to the parameter to 'Input Value'	Txdr 1 ShuntState Off Cal Active Off Input Value ⇕3.9 ↑ Indicates parameter selected	This locates the parameter you want to wire TO
3. Press A/MAN to display 'WireFrom'	WireFrom ------------------	In configuration mode the A/MAN button is the Wire button.
4. Press to navigate to the 'PVInput' list header 5. Press ⟳ to scroll to 'PV'	WireFrom PVInput PV	
6. Press A/MAN	PVInput PV →Cancel →OK	This 'copies' the parameter to be wired FROM
7. Press ⟳ as instructed to confirm	Txdr 1 ShuntState Off Cal Active Off Input Value 3.9 ↑ Indicates that the parameter is wired.	This 'copies' the parameter to be wired FROM This 'pastes' the parameter If you want to inspect this press A/MAN. Press A/MAN again to go back to the display above.

Repeat the above steps to wire 'TransducerPSU PV' from Transducer 'ShuntState'

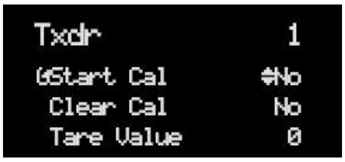
Internal wiring through the controller front panel is also explained in section Soft Wiring. Internal wiring may also be created using iTools.

Strain Gauge Calibration

The display views shown below are taken from the configuration level. The calibration can be carried out in operator levels unless it has been blocked.

Remove all pressure from the transducer

Then:

Do This	The Display You Should See	Additional Notes
1. Press to select ‘Start Cal’ and or to Yes		A pop up message will appear for 1.5 seconds showing that calibration has commenced
		If successful another pop up will be displayed for 1.5 seconds. If the calibration failed an acknowledge pop up will appear. This might happen, for example, if ‘Lo Cal’ is done with the full load applied.

Calibration Using the Internal Calibration Resistor

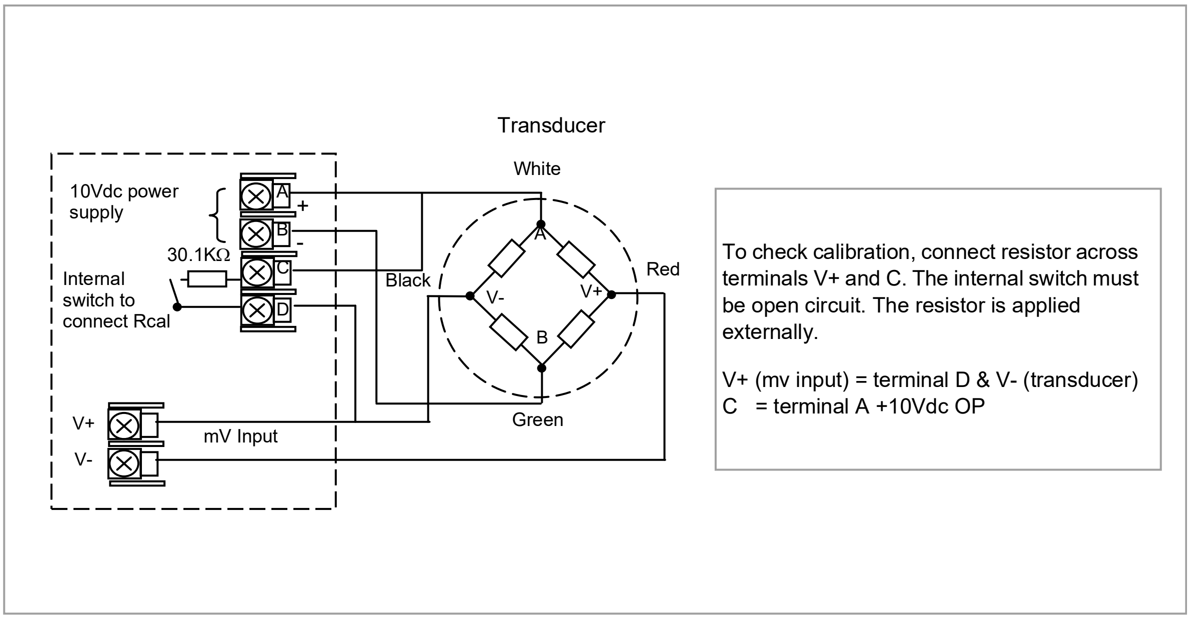


Figure 81: Strain Gauge Wiring Diagram - Internal Calibration Resistor

Connect the transducer as shown above.

Configuration of input and soft wiring is the same as described in the Configuration Examples section Configuration Examples.

Set the transducer power supply ‘Shunt’ parameter to ‘Internal’

The calibration procedure is the same as described in the previous section.

Load Cell

A load cell provides an analogue output which can be in Volts, milli-Volts or milli-Amps. This may be connected to the PV Input or Analogue Input.

The method of calibration is performed on load cells using the transducer power supply module. The unloaded cell is first measured to establish a zero reference.

A known reference weight is then placed on the load cell and a high end calibration is performed.

In practice there may be a residual output from the load cell and this can be offset in the controller.

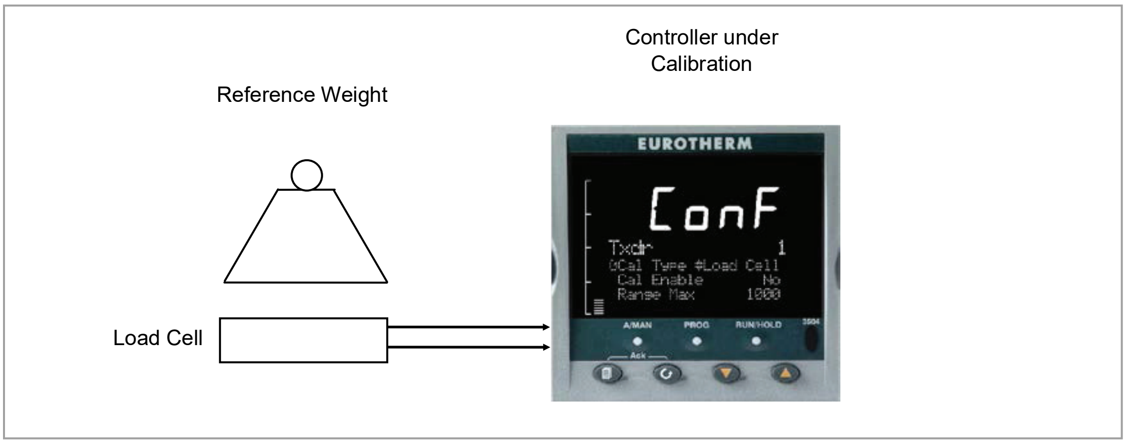


Figure 82: Load Cell

To Calibrate a Load Cell

This is illustrated using the following example:

Load cell Range 0 to 2000 grams, load cell output 2mV/V (quoted by the manufacturer)

Transducer power supply set to 10 Volt excitation (fitted in module position 4). This produces a full load output of 20.0mV

Physical Wiring

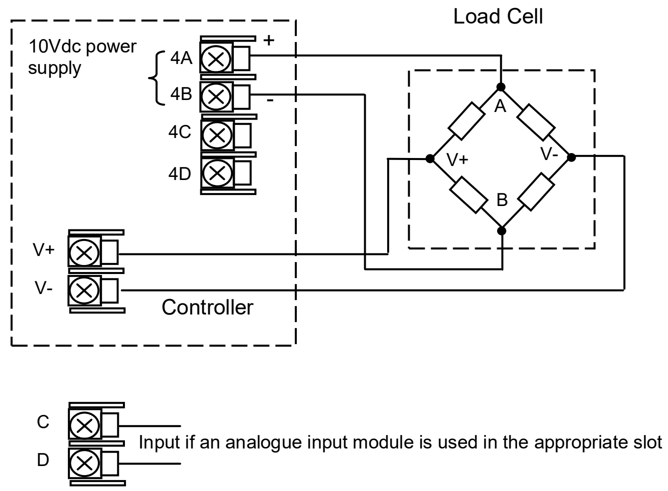


Figure 83: Load Cell Wiring Diagram

Configure Parameters

Configure the controller as follows:

Step	Description		
1	PV Input values (see example section PV Input Scaling)	IO Type	40mV
		Lin Type	Linear
		Units	None or as required
		Res'n	XXXX.X
		Disp Hi	2000
		Disp Lo	0
		Range Hi	20.00
		Range Lo	0
		Fallback	Upscale
2	Transducer Power Supply module (see example section Transducer Power Supply)	Voltage	10 Volts
		Shunt	Not applicable
3	Txdr Values (see also section Transducer Scaling Parameters)	Cal Type	Load Cell
		Cal Enable	Yes
		Range Max	2000
		Clear Cal	No. If set to yes this will clear the previous calibration.
		Input Hi	2000
		Scale Hi	Not applicable
4	Internal (Soft) wiring (see example section Soft Wiring)	Txdr Input Value from PVInput PV	If an analogue input module is used wire the Txdr Input to the PV of the module

Configuration Examples

The following sections show examples of how these parameters are configured. Skip this section if this explanation is not required or if the calibration is being carried out in access levels 1 or 2.

Configure the Input

Set input to 20mV where 0mV = reading of 0 and 20.0 mV = reading of 2000

In configuration level:

Do This	The Display You Should See	Additional Notes
1. From any display press as many times as necessary to select the input to be calibrated	PVInput IO Type ⇕40 mV Lin Type Linear Units None	Configure IO Type to 40mV, Lin Type to Linear and Units as required
2. Use to scroll to the required parameter 3. Use or to change parameter values	PVInput Disp Hi 2000.0 Disp Lo 0.0 Range Hi ⇕20.00	Configure 'Disp Hi' and 'Disp Lo' to correspond to load cell range – 0 to 2000 Configure 'Range Hi' and 'Range Lo' to input mV range 0 – 20mV
	PVInput PV 0.1 Offset 0.0 Lo Point 0.0	Do not set offsets at this stage.

Configure the Transducer Power Supply Module

In configuration level:

Do This	The Display You Should See	Additional Notes
1. From any display press as many times as necessary to select the module in which the Transducer Power Supply is fitted	Mod ⇕4A Ident TdcrPSU Meas Value 0 PV 0	In this example Mod 4. As a single output module only 4A is available
2. Press to scroll to 'Voltage' and or to change to '10 Volts'	Mod 4A Status OK Shunt External Voltage ⇕10 Volts	An excitation of 10V will give and input of 2mV/V i.e. 20.0mV. 'Shunt' has no effect for a load cell.

Transducer Values

In configuration level:

Do This	The Display You Should See	Additional Notes

1. From any display press [page button] as many times as necessary to select the Transducer to be calibrated	Txdr 1 Cal Type ⇕Load Cell Cal Enable Yes Range Max 2000	In this example transducer 1 is being used. Configure Cal Type = Load Cell Cal Enable = Yes (this enables cal parameters, and calibration may be done in operator levels). Set Range Max and Range Min to the range of the transducer, 0 to 2000 grams
2. Press [scroll button] to select further parameters	Txdr 1 Input Hi 1001.4 Input Lo 0.1 Scale Hi ⇕1200.0	It is not necessary to set 'Input Hi' and 'Input Lo' or 'Scale Hi' and 'Scale Lo'.
	Txdr 1 Scale Lo ⇕9 Cal Band 1.0 Cal Active Off	The controller takes a number of measurements to determine when the calibration should take place. Cal Band sets the allowed difference between two consecutive averages. If set to 1.0 the average must be within ±1.0 before calibration takes place. A lower setting requires the controller to settle for a longer period. Calibration accuracy is not necessarily affected other than extreme settings.

Load Cell Calibration

Do This	The Display You Should See	Additional Notes
1. Remove all load from the load cell		
2. Press [scroll button] to scroll back to 'Start Cal' and [down button] or [up button] to 'Yes'	Txdr 1 Range Min 0 Start Tare No Start Cal ⇕Yes	This starts the low calibration point. A pop up message will appear for 1.5 seconds showing that calibration has commenced
	Txdr Cal Passed	If successful a pop up will be displayed for 1.5 seconds. If calibration fails an acknowledge pop up will appear. This might happen, for example, if low calibration is done with the full load applied.
3. Add a load to the load cell (this would normally be at full scale of the transducer but may be done with lower weights)		
4. Press [scroll button] to scroll to 'Start Hi Cal' and [down button] or [up button] to 'Yes'	Txdr 1 Start Tare No Start Cal No Start Hi Cal ⇕Yes	The controller repeats the same procedure as for the low Calibration point
	Txdr 1 Scale Lo 9 Cal Band 1.0 Cal Active On	During calibration Cal Active = On Input Value is the PV before scaling Output Value is the output from the transducer scaling block.

Offsets

It is possible that a residual output from the transducer exists which means that there is an error in the span and/or zero reading. The residual output is likely to occur under the no load condition, in which case it can be compensated for by applying a simple offset as follows:

Do This	The Display You Should See	Additional Notes
1. In the PV Input list scroll to Offset and adjust until the no load condition reads 0.0		Configure IO Type to 40mV, Lin Type to Linear and Units as required.

If a different error occurs at both high and low points a two point offset can be applied as follows:

Do This	The Display You Should See	Additional Notes
1. In the PV Input list scroll to Lo Offset and adjust until the no load condition reads 0.0		Lo Point should be set to 0 to correspond to the transducer range
2. In the PV Input list scroll to Hi Offset and adjust until the full load condition reads 2000.0		Hi Point should be set to 2000 to correspond to the transducer range. High and Low offsets are also described in section Two Point Offset.

Comparison

Comparison calibration is used to calibrate the controller against a known reference instrument.

The load is removed (or taken to a minimum) from both instruments. The controller low end calibration is done using the ‘Start Calibration’ parameter. This enables a ‘CalAdjust’ parameter which is a scaling factor on the ‘Output Value’ to read the same as the reference instrument. The Output Value may be wired for use in a control strategy and displayed, for example, on a user screen

To calibrate the high end, add a weight to both transducers and when the reading has become stable select the ‘Start Hi Cal’ parameter then enter the new reading from the reference instrument into ‘CalAdjust’.

The Output Value can be internally wired as the measured value in a particular control strategy.

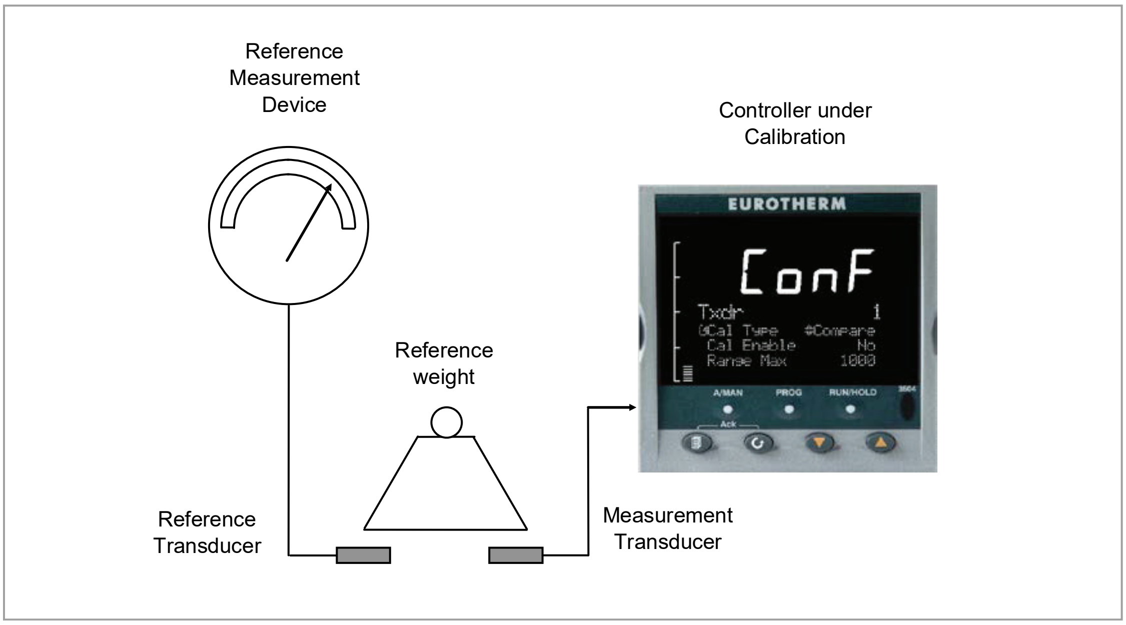


Figure 84: Comparison Calibration

Physical Wiring

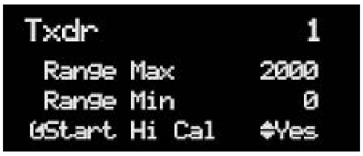
As Load Cell

Configure Parameters

Configure the controller the same as for the load cell except set the Txdr ‘Cal Type’ to ‘Compare’

Comparison Calibration

Do This	The Display You Should See	Additional Notes
1. Remove or reduce the load from the load cell to establish a low end reference		

2. Press to scroll to 'Start Cal' and or to 'Yes'		This starts the low calibration point.
3. A 'Cal Adjust' parameter becomes available. Use or to enter the difference between the controller measured value and the reference instrument reading.		A value must be entered before the controller will proceed to the next state.
4. Confirm the value		
5. **Add a load to the load cell (this would normally be at full scale of the transducer but may be done with lower weights)**		
6. Press to scroll to 'Start Hi Cal' and or to 'Yes'		
7. Repeat 3 and 4 above for the high point		The 'Output Value' parameter should now read the same as the reference instrument

Transducer Scaling Parameters

The following parameters allow the transducer type to be configured and calibrated:

List Header – Txdr		Sub-headers: 1 or 2			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
Cal Type	Used to select the type of transducer calibration to perform See descriptions at the beginning of this section.	0: Off 1: Shunt 2: Load Cell 3: Compare	Transducer type unconfigured Shunt calibration Load Cell Comparison	Off	Conf
Cal Enable	To make the transducer ready for calibration. Must be set to Yes to allow calibration to be done at L1. This includes Tare Cal.	No Yes	Not ready Ready	No	Conf
Range Max	The maximum permissible range of the scaling block	Range minimum to maximum display (99999)		1000	Conf
Range Min	The minimum permissible range of the scaling block	Minimum display (-19999) to Range max		0	Conf
Start Tare	Begin tare calibration	No Yes	 Start tare calibration	No	L1 if ‘Cal Enable’ = ‘Yes’
Start Cal	Starts the Calibration process. ☺ for Load Cell and Comparison calibration ‘Start Cal’ starts the first calibration point.	No Yes	 Start calibration	No	L1 if ‘Cal Enable’ = ‘Yes’
Start Hi Cal	For Load Cell and Comparison calibration the ‘Start High Cal’ must be used to start the second calibration point.	No Yes	 Start high calibration	No	L1 if ‘Cal Enable’ = ‘Yes’
Clear Cal	Clears the current calibration constants. This returns the calibration to unity gain	No Yes	 To delete previous calibration values	No	L3
Tare Value	Enter the tare value of the container	Range between maximum display and minimum display			Conf
Input Hi	Sets the scaling input high point	Range between Input Lo and maximum display			L3
Input Lo	Sets the scaling input low point	Range between Input Hi and minimum display			L3
Scale Hi	Sets the scaling output high point. Usually the same as the ‘Input Hi’	Range between Scale Lo and maximum display			L3
Scale Lo	Sets the scaling output low point. Usually 80% of ‘Input Lo’	Range between Scale Hi and minimum display			L3
Cal Band	The calibration algorithms use the threshold to determine if the value has settled. When switching in the shunt resistor, the algorithm waits for the value to settle to within the threshold before starting the high calibration point.	0.0 to 99.999			Conf
Shunt State	Indicates when the internal shunt calibration resistor is switched in. Only appears if ‘Cal Type’ = ‘Shunt’	Off On	Resistor not switched in Resistor switched in		L1
Cal Active	Indicates calibration taking place	Off On	Inactive Active		L1 R/O
Input Value	The input value to be scaled.	Minimum display – Maximum display (-9999.9 to 9999.9)			L3
Output Value	The Input Value is scaled by the block to produce the Output Value	Range between Scale Hi and Scale Lo			L3
Output Status	The sensor break/fault status of the PV output	Good Bad			Conf

List Header – Txdr		Sub-headers: 1 or 2			
Name ⟳ to select	**Parameter Description**	**Value** Press ▼ or ▲ to change values		**Default**	**Access Level**
Cal Status	Indicates the progress of calibration	0: Idle 1: Active 2: Passed 3: Failed	No calibration in progress Calibration in progress Calibration Passed Calibration Failed		L1 R/O

Parameter Notes

Enable Cal

This may be wired to a digital input for an external switch. If not wired, then the value may be changed.

When enabled the transducer parameters may be altered as described in the previous sections. When the parameter has been turned On it will remain on until turned off manually even if the controller is power cycled.

Start Tare

This may be wired to a digital input for an external switch. If not wired, then the value may be changed.

Start Cal

This may be wired to a digital input for an external switch. If not wired, then the value may be changed.

It starts the calibration procedure for:

Shunt Calibration

The low point for Load Cell Calibration

The low point for Comparison Calibration

Start Hi Cal

This may be wired to a digital input for an external switch. If not wired, then the value may be changed.

It starts:

The high point for Load Cell Calibration

The high point for Comparison Calibration

Clear Cal

This may be wired to a digital input for an external switch. If not wired, then the value may be changed.

When enabled the input will reset to default values. A new calibration will overwrite the previous calibration values if Clear Cal is not enabled between calibrations.

User Values

User values are registers provided for use in calculations. They may be used as constants in equations or temporary storage in extended calculations. Up to 40 User Values are available. Each User Value can then be set up in the '**UserVal**' page.

User Value Parameters

List Header – UsrVal		Sub-headers: 1 to 16		
Name to select	**Parameter Description**	**Value** Press or to change values	**Default**	**Access Level**
Units	Units assigned to the User Value	None Abs Temp °C/°F/°K, V, mV, A, mA, PH, mmHg, psi, Bar, mBar, %RH, %, mmWG, inWG, inWW, Ohms, PSIG, %O2, PPM, %CO2, %CP, %/sec, RelTemp °C\°F\°K(rel), Vacuum Custom 1, Custom 2, Custom 3, Custom 4, Custom 5, Custom 6, sec, min, hrs,		Conf
Res'n	Resolution of the User Value	XXXXX to X.XXXX		Conf
High Limit	The high limit may be set for each user value to prevent the value being set to an out-of-bounds value.		99999	L3
Low Limit	The low limit of the user value may be set to prevent the user value from being edited to an illegal value. This is important if the user value is to be used as a setpoint.		-99999	L3
Value	To set the value within the range limits	See note 1		L3
Status	Can be used to force a good or bad status onto a user value. This is useful for testing status inheritance and fallback strategies.	Good (0) - Normal Operation Channel Off (1) - Channel is configured to be off Over Range (2) - Input signal is greater than configured high limit Under Range (3) - Input signal is less than configured low limit Hardware Status Invalid (4) - Input hardware status invalid Ranging (5) - Input hardware is being ranged i.e. being set-up as required by the range configuration Overflow (6) - Process variable overflow, possibly due to calculation attempting to add a small number to a relatively large number Bad (7) - The process variable is not ok and cannot be relied upon Hardware exceeded (8) - The hardware capabilities have been exceeded at the point of configuration, for example configuration set to 0 to 40Vdc when input hardware is capable of up to 12Vdc No Data (9) - Insufficient input samples to perform calculation No Calibration (13) - Calibration data is corrupt or missing Saturated input (14) - Input hardware is in saturation. This can occur if PV input, CJC input or RTD lead compensation input is outside the working range of the hardware.		

NOTICE
If ‘Value’ is wired into but ‘Status’ is not, then, instead of being used to force the Status it will indicate the status of the value as inherited form the wired connection to ‘Value’.

User Text

User defined text can be applied to selected parameters in controllers from software versions 2.30+. User text is particularly useful when used in conjunction with User Pages, see iTools integrated Online Help for further details. It is configured using iTools configuration package – it cannot be configured through the controller user interface, and is implemented in two ways:

1. A fixed set of boolean parameters, shown in the table below, have dedicated user strings. The 'Value' of these parameters may be customised and it will then be shown as such in the enumeration of that parameter.

Function block	Default Text	Dedicated User String	iTools Browser
Two Input Logic Operators, see logic operators section Logic Operations.	Off On	OutUsrTxtOff OutUsrTxtOn	Lgc2 (1 to 24)
Eight Input Logic Operators, see logic operators section Logic 8.	Off On	OutUsrTxtOff OutUsrTxtOn	Lgc8 (1 to 2)
Programmer Event Outputs 1 to 8, see programmer section Event Outputs.	Off On	EO1UsrTxtOff to EO8UsrTxtOff EO1UsrTxtOn to EO8UsrTxtOn	Programmer (1 to 2)
Programmer PV Event Outputs 1 to 8, see programmer section PV Event.	Off On	PVEOUsrTxtOff PVEOUsrTxtOfn	Programmer (1 to 2)

2. Eight user text blocks are available in which user defined text can be applied to both Boolean and Analogue parameters. Boolean parameters, not listed in 1 above, may be wired to Two Input Logic Operator blocks when user text blocks are in full use.

The parameter list for the User Text block is as follows:

Parameter	Upper Limit	Lower Limit	Availability	Description
Input	32767	-32766	iTools configuration package, or read only in the controller display but can be wired through the controller	Input to be enumerated
Output	8 characters		iTools configuration package, or read only in the controller display but can be wired through the controller interface.	String from custom list with a value field that matches the current input
Custom list	100 characters		Comma separated list of values and strings	Configured by iTools

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 section.

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 AMS2750G clause 3.2 Instrumentation (Table 7 Instruments and instrument calibration, 3.2.5 Results and Records, 3.2.6 Instrument correction and offsets)” Including Instruction for the application and removal of offsets defined in clause 3.2.4.

To Check Input Calibration

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

Precautions

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

- 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.
- RTD and CJC calibration must not be carried out without prior mV calibration.
- 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.
- 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.
- Allow at least 10 minutes for the controller to warm up after switch on.

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 as described in section PV Input Scaling. The example described in section Example: To Scale a Linear Input: assumes that the display is set up to read 75.0 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.

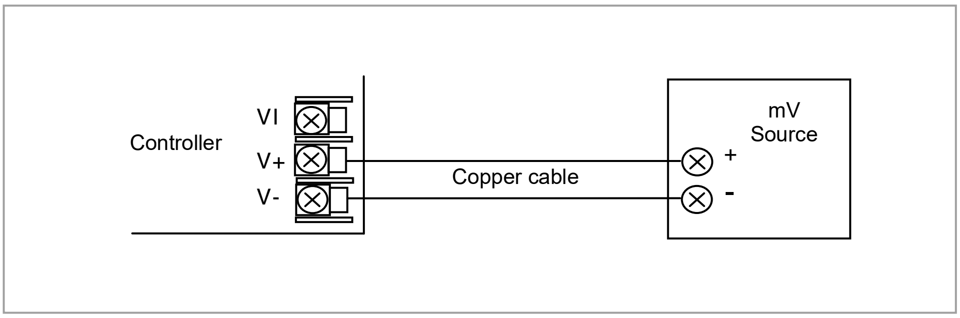


Figure 85: Connections for mV Calibration

☺ Ensure that no offsets (see section Two Point Offset) have been set in the controller.

Set the mV source to 4.000mV. Check the display reads 75.0 ±0.25% ± 1LSD (least significant digit).

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

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.

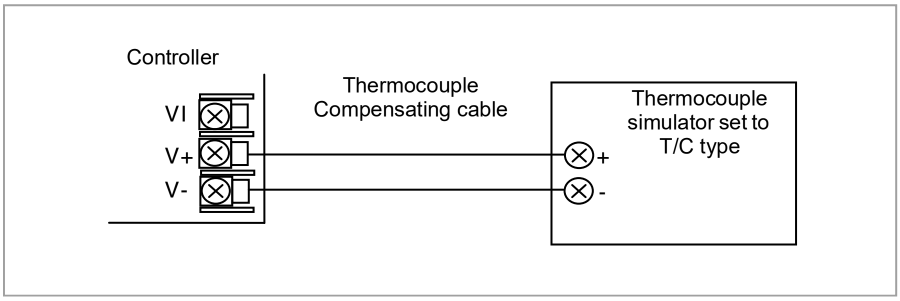


Figure 86: Connections for Thermocouple Calibration

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

Adjust the mV source 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 maximum 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.

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.

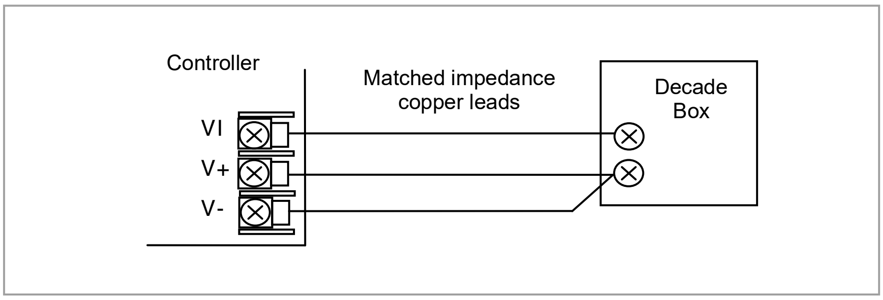


Figure 87: Connections for RTD Calibration

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.

Input Calibration

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

Inputs which can be calibrated:

- **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 ranges are 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.

Precautions

Observe the precautions stated in section Precautions.

To Calibrate mV Range

Calibration of the mV range is carried out using a 50mV source, connected as shown in the diagram below. mA calibration is included in this procedure.

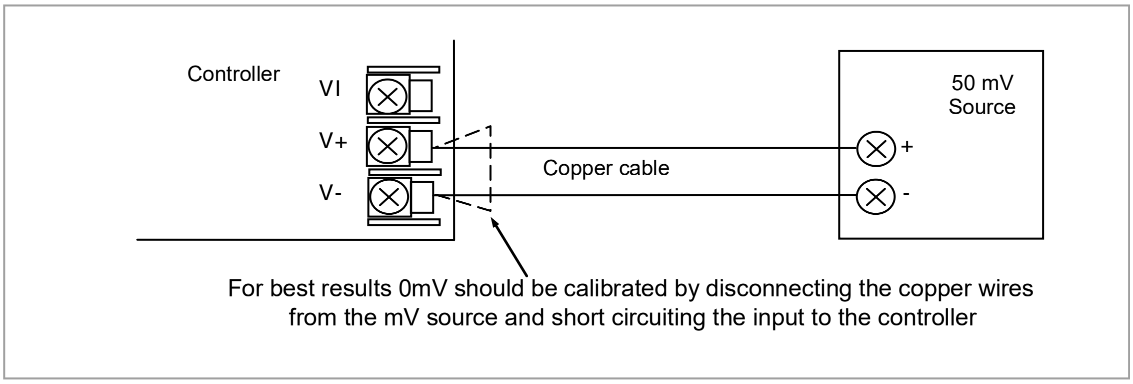


Figure 88: Connections for mV Calibration

To calibrate the PV Input:

Do This	The Display You Should See	Additional Notes
1. From any display press [Page] as many times as necessary to select the input to be calibrated	PVInput IO Type 40 mV Lin Type Linear Units None	This may be 'PVInput' or a 'DC Input' module.
2. Press [Scroll] to select '**Cal State**'	PVInput Offset 0.0 SBrk Value 0.0 Cal State Idle	
3. **Set mV source for 0mV** (or apply a short circuit as indicated).		
4. Press [Up] or [Down] to choose '**Lo-0mV**'	PVInput Offset 0.0 SBrk Value 0.0 Cal State Lo-0mV PVInput Offset 0.0 SBrk Value 0.0 Cal State Confirm	'**Confirm**' will automatically be requested.
5. Press [Up] or [Down] to sselect 'Go'	PVInput Offset 0.0 SBrk Value 0.0 Cal State Go PVInput Offset 0.0 SBrk Value 0.0 Cal State Busy PVInput Offset 0.0 SBrk Value 0.0 Cal State Passed	The controller will automatically perform the calibration procedure. The calibration can be aborted at any stage. Press [Up] or [Down] to select 'Abort'. After a brief flicker of the display 'Cal State' will return to 'Idle'.

Do This	The Display You Should See	Additional Notes
6. Press ▲ or ▼ to ‘**Accept**’	PVInput Offset 0.0 SBrk Value 0.0 Cal State ⇕Accept	It is also possible to ‘Abort’ at this stage. The controller then returns to the ‘Idle’ state. By pressing Accept, this means that the calibration will be used for as long as the controller is switched on. When the controller is switched off the calibration will revert to that set during manufacture. To use the new calibration permanently select ‘Save User’ as described in the next section
7. **Set mV source for 50mV** (or remove the short circuit).		
8. Press ▲ or ▼ to select ‘**Hi-50mV**’ 9. Now repeat 5 and 6 above to calibrate the high mV range	PVInput Offset 0.0 SBrk Value 0.0 Cal State ⇕Hi-50mV	The controller will again automatically calibrate to the injected input mV. If it is not successful then ‘**Fail**’ will be displayed

To Save the New Calibration Data

Do This	The Display You Should See	Additional Notes
10. Press ▲ or ▼ to select ‘**Save User**’	PVInput Offset 0.0 SBrk Value 0.0 Cal State⇕Save User	The new calibration data will be used following a power down of the controller

To Return to Factory Calibration

Do This	The Display You Should See	Additional Notes
11. Press ▲ or ▼ to select ‘**Load fact**’	PVInput Offset 0.0 SBrk Value 0.0 Cal State⇕Load Fact	The factory calibration will be reinstated

Thermocouple Calibration

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

This can be carried out using an external CJC reference source such as an ice bath or using a thermocouple mV source. Replace the copper cable shown in the previous diagram with the appropriate compensating cable for the thermocouple in use.

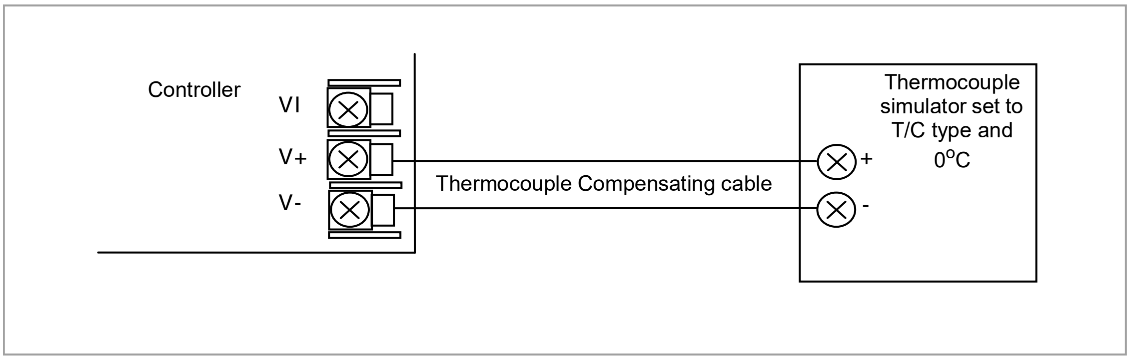


Figure 89: Connections for Thermocouple Calibration

Set the mV source to **internal compensation** for the thermocouple in use and set the output for **0mV**. Then:

Do This	The Display You Should See	Additional Notes
1. This example is for PV Input configured as a type K thermocouple		
2. From the '**Cal State**', press ▲ or ▼ to select '**CJC**'		
3. Press ▲ or ▼ to select '**Go**' 4. The remaining procedure is the same as described in the previous section		The controller automatically calibrates to the CJC input at 0mV. As it does this the display will show 'Busy' then 'Passed', assuming a successful calibration. If it is not successful then 'Failed' will be displayed. This may be due to an incorrect input mV

RTD Calibration

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 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 can take place.
- The instrument should be powered up for at least 10 minutes.

Before using or verifying RTD calibration:

- The mV range must be calibrated first.

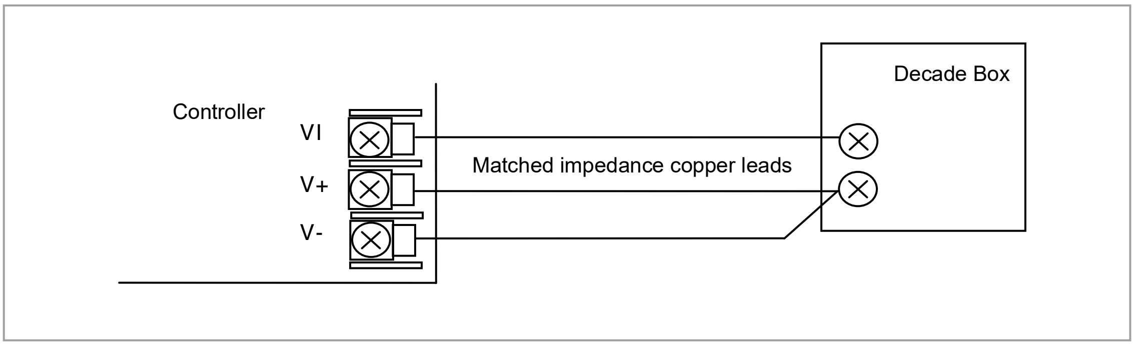


Figure 90: Connections for RTD Calibration

Do This	The Display You Should See	Additional Notes
1. This example is for PV Input configured as a Pt100 RTD		
2. With 'Cal State' selected, press ⊕ or ⊖ to select '**Lo-150ohm**'		
3. **Set the decade box for 150.00Ω**		
4. Press ⊕ or ⊖ to choose '**Go**'		The controller automatically calibrates to the injected 150.00Ω input. As it does this the display will show 'Busy' then 'Pass', assuming a successful calibration. If it is not successful then 'Failed' will be displayed. This may be due to an incorrect input resistance
5. **Set the decade box for 400.00Ω**		
6. Repeat the procedure for '**Hi-400ohm**'		The calibration data can be saved or you can return to Factory Calibration as described in sections To Save the New Calibration Data and To Return to Factory Calibration.

Calibration Parameters

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

List Header - PV Input		Sub-headers: None			
Name to select	**Parameter Description**	**Value** Press or to change values		**Default**	**Access Level**
Cal State	Calibration state of the input	Idle	Normal operation	Idle	Conf L3 R/O
		Lo-0mv	Low input calibration for mV ranges		
		Hi-50mV	High input calibration for mV ranges		
		Lo-0v	Low input calibration for V/Thermocouple ranges		
		Hi-8V	High input calibration for V/thermocouple ranges		
		Lo-0v	Low input calibration for HZ Volts range		
		Hi-1V	High input calibration for HZ Volts range		
		Lo-150ohm	Low input calibration for RTD range		
		Hi-400ohm	High input calibration for RTD range		
		Load Fact	Restore factory calibration values		
		Save User	Save the new calibration values		
		Confirm	To start the calibration procedure when one of the above has been selected		
		Go	Starting the automatic calibration procedure		
		Busy	Calibration in progress		
		Passed	Calibration successful		
		Failed	Calibration unsuccessful		

The above list shows the parameters which appear during a normal calibration procedure. The full list of possible values follows – the number is the enumeration for the parameter.

1: Idle

2: Low calibration point for Volts range

3: High calibration point for Volts range

4: Calibration restored to factory default values

5: User calibration stored

6: Factory calibration stored

11: Idle

12: Low calibration point for HZ input

13: High calibration point for the HZ input

14: Calibration restored to factory default values

15: User calibration stored

16: Factory calibration stored

20: Calibration point for factory rough calibration

21: Idle

22: Low calibration point for the mV range

23: Hi calibration point for the mV range

24: Calibration restored to factory default values

25: User calibration stored

26: Factory calibration stored

30: Calibration point for factory rough calibration

31: Idle

32: Low calibration point for the mV range

33: High calibration point for the mV range

34: Calibration restored to factory default values

35: User calibration stored

36: Factory calibration stored

41: Idle

42: Low calibration point for RTD calibration (150 ohms)

43: Low calibration point for RTD calibration (400 ohms)

44: Calibration restored to factory default values

45: User calibration stored

46: Factory calibration stored

51: Idle

52: CJC calibration used in conjunction with Term Temp parameter

54: Calibration restored to factory default values

55: User calibration stored

56: Factory calibration stored

200: Confirmation of request to calibrate

201: Used to start the calibration procedure

202: Used to abort the calibration procedure

210: Calibration point for factory rough calibration

212: Indication that calibration is in progress

213: Used to abort the calibration procedure

220: Indication that calibration completed successfully

221: Calibration accepted but not stored

222: Used to abort the calibration procedure

223: Indication that calibration failed

Valve Position Output Calibration

Calibration of the VP output is associated with whichever digital output has been configured to drive the valve. Suitable outputs are the Logic IO. Relay, Logic or Triac Output Module. The calibration of the VP output is described in section Example: To Calibrate a VP Output.

If a feedback potentiometer is being used, the calibration of this is performed in the Potentiometer Input Module and is described in section Potentiometer Input Scaling.

DC Output and Retransmission Calibration

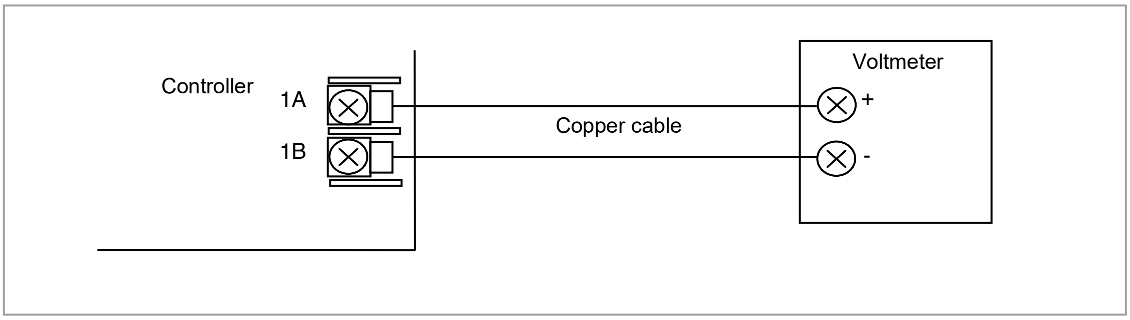


Figure 91: Calibration of DC Output Module

The following procedure is particularly relevant to retransmission outputs where the absolute value of the output must correspond with the device (such as a chart recorder) being used to monitor the retransmitted value.

Connect a voltmeter to the output to be calibrated. The example shown in Figure 91 Calibration of DC Output Module shows position 1 fitted with a DC Output module.

Select Configuration level.

1. Press ⊜ to select the list header for the module to be calibrated. In this example '**Mod 1A**'
2. Press ⊜ to scroll to '**Cal State**'
3. Press ⊕ or ⊖ to select '**Lo**' to calibrate the low point. Then '**Confirm**', then '**Go**'.
4. '**Trim**' will be shown.
5. Press ⊜ again to scroll to '**Cal Trim**'
6. Press ⊕ or ⊖ to adjust the value read by the voltmeter to **1.00V**. The value shown on the controller display is arbitrary and has the range -32768 to 32767.
7. Return to '**Cal State**'. This can be done by pressing ⊜ followed by ⊕.
8. Press ⊕ or ⊖ to '**Accept**'. The display will return to '**Idle**'.
   a. It is now necessary to calibrate the high point.
9. Press ⊕ or ⊖ to select '**Hi**' to calibrate the high point. Then '**Confirm**', then '**Go**'.
10. '**Trim**' will be shown.
11. Press ⊜ again to scroll to '**Cal Trim**'
12. Press ⊕ or ⊖ to adjust the value read by the voltmeter to **9.00V**. The value shown on the controller display is arbitrary and has the range -32768 to 32767.
13. Return to '**Cal State**'. This can be done by pressing ⊜ followed by ⊕.
14. Press ⊕ or ⊖ to '**Accept**'. The display will return to '**Idle**'.
15. The above procedure should be repeated for all retransmission outputs.

Config Lock

Introduction

Config Lock is available as an orderable option and is protected by Feature Security.

Config Lock allows users to help prevent unauthorized viewing, reverse engineering or cloning of controller configurations. This includes application specific internal (soft) wiring, limited access to certain Configuration level and Operator level parameters via comms (by iTools or a third party comms package).

When Config Lock is enabled, users are prevented from accessing soft wiring from any source, and it is not possible to Load or Save the configuration of the instrument via iTools or by using the Save/Restore facility.

Altering configuration and/or operator parameters via Comms may also be restricted when Config Lock is implemented.

Once the security function has been set up for a particular application it may be cloned into every other identical application without further configuration.

Using Config Lock

When Config Lock is supplied, four Config Lock parameters are displayed in the ‘Instrument - Security’ list in iTools.

- **ConfigLockPassword**
  This password is selected by the OEM. Any alpha/numeric text can be used and the field is editable whilst the Config Lock Status is ‘Unlocked’. A minimum of eight characters should be used. It is not possible to clone the Config Lock Security Password. (Highlight the complete row before entering).
- **ConfigLockEntry**
  Enter the Config Lock password to activate and deactivate Config Lock. The controller must be in configuration level to enter this password. When the correct password is entered the **ConfigLockStatus** will toggle between ‘Locked’ and ‘Unlocked’. (Highlight the complete row before entering). Three login attempts are allowed before lockout which is followed by a 90 minute password lockout period.
- **ConfigLockStatus**
  Read only showing ‘Locked’ or ‘Unlocked’.
  - If Unlocked two lists are available which allow an OEM to restrict which parameters are alterable when the controller is in Operator and Configuration Access levels.
  - Parameters added in the **ConfigLockConfigList** WILL be available to the operator when the controller is in Configuration level. Parameters not added in this list will not be available to the operator.
  - Parameters added to the **ConfigLockOperList** will NOT be available to the operator when the controller is in Operator access level.
  - If the **ConfigLockStatus** is ‘Locked’ these two lists are not shown. The controller configuration is prevented from being cloned and the internal wiring cannot be accessed via comms.
- **ConfigLockParameterLists**
  This parameter is only writeable when the **ConfigLock Status** is ‘Unlocked’.

- When ‘Off’, Operator type parameters are alterable in Operator access level and Config parameters are alterable in Configuration access level (all within other limitations such as high and low limits).
- When ‘On’, parameters added to the **ConfigLockConfigList** WILL be available to the operator when the controller is in configuration level. Parameters not added in this list will not be available to the operator. Parameters added to the **ConfigLockOperList** will NOT be available to the operator when the controller is in Operator access level.
- The table at the end of this section shows an example for just two parameters ‘Alarm 1 Type’ (configuration type parameter) and ‘Alarm 1 Threshold’ (operator type parameter).

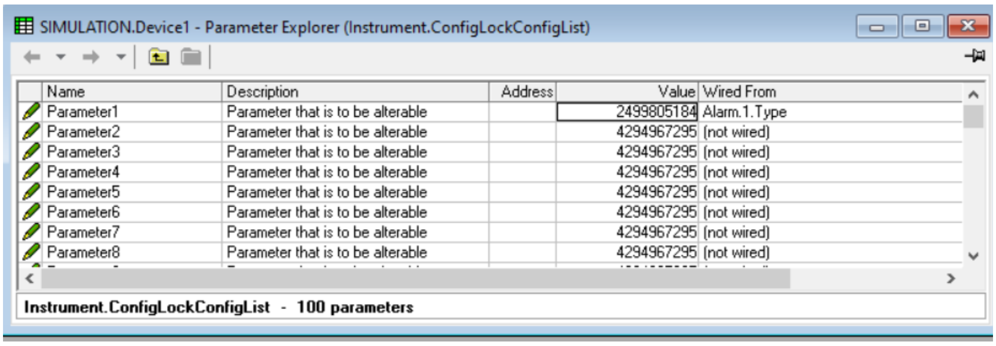
When entering or exiting Config Lock a few seconds should be allowed for iTools to synchronize.

Config Lock Configuration List

The **ConfigLockConfigList** allows the OEM to choose up to 100 configuration parameters which are to remain Read/Write while in Configuration level and Config Lock is enabled. In addition to these the following parameters are always writeable in configuration mode:

Config Lock Password Entry, Comms Configuration password, Controller Coldstart parameter.

The required parameters may be by dragged and dropped from a browser list (on the left hand side) into the Wired From cell in the **ConfigLockConfigList**. Alternatively, double click into the ‘WiredFrom’ cell and select the parameter from the pop-up list. These parameters are those chosen by the OEM which are to remain alterable when Config Lock is enabled and the controller is in Configuration access level.

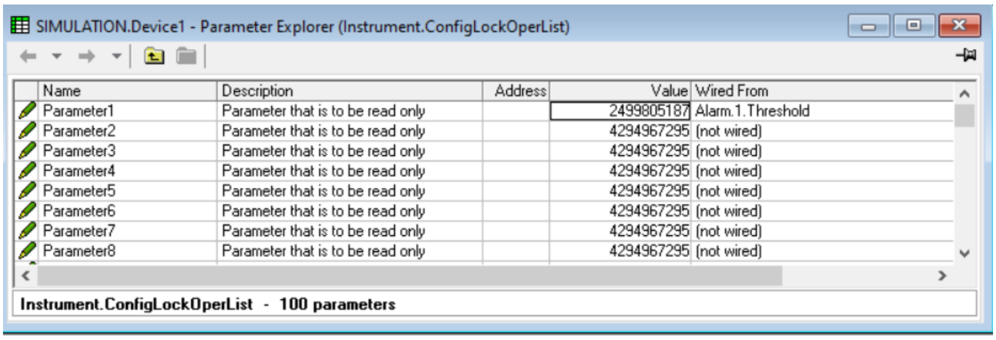


The view shows the first eight parameters of which Parameter 1 has been populated with a configuration parameter (Alarm 1 Type). Examples of configuration parameters include Alarm Types, Input Types, Range Hi/Lo, Modules Expected, etc.

When the Config Lock Status is Locked, this list is not shown.

Config Lock Operator List

The **ConfigLockOperatorList** operates in the same way as the **ConfigLockConfigList** except the parameters selected are those which are available in Operator access level. Examples are programmer mode, alarm setting parameters, etc. The example below shows 'Alarm 1 Threshold' which is to be read only in Operator access level.



The example shows the first 8 of 100 parameters of which the first has been selected as 'Alarm 1 Threshold'. This parameter is to be read only when Config Lock is enabled and the controller is in Operator access level.

When the **ConfigLockStatus** is Locked, this list is not shown.

Effect of the 'Config Lock ParamList' Parameter

The table below shows the availability of the two 'Alarm 1' parameters set up in the previous pages when the **ConfigLockParamList** parameter is turned On or Off.

'Alarm 2' is used as an example of all parameters which have not been included in Config Lock.

'ConfigLockParamLists'	**Parameter**	**Controller in Configuration Access**		**Controller in Operator Access**	
		Alterable	Not alterable	Alterable	Not alterable
On	A1 Type	✓			✓
	A2 Type		✓		✓
	A1 Threshold		✓		✓
	A2 Threshold	✓		✓	
Off	A1 Type	✓			✓
	A2 Type	✓			✓
	A1 Threshold	✓		✓	
	A2 Threshold	✓		✓	

The iTools views shown in the next page show how this example is presented in the iTools browser:

'ConfigLockParamLists' On

The iTools views shown below show the alterability of the alarm parameters used in the previous examples. Alarm 1 has been set up in Config Lock. Alarm 2 is used as an example of parameters not set up in Config Lock.

Text in black shows parameters are alterable. Text in blue is not alterable.

Controller in Configuration Mode

'Alarm 1 Type' is alterable
'Alarm 1 Threshold' is not alterable

Name	Description	ddress	Value
Type	Alarm type	536	AbsHi (1)
Status	Alarm status	2113	Off (0)
Input	Input to be evaluated	2114	47.50
Threshold	Threshold	13	999.70
Hysteresis	Hysteresis	47	2.30

'Alarm 2 Type' is not alterable
'Alarm 2 Threshold' is alterable

Name	Description	ddress	Value
Type	Alarm type	537	AbsLo (2)
Status	Alarm status	2137	Off (0)
Input	Input to be evaluated	2138	47.49
Threshold	Threshold	14	-10.00
Hysteresis	Hysteresis	68	1.00

Controller in Operator Mode

'Alarm 1Type' is not alterable
'Alarm 1 Threshold' is not alterable

Name	Description	ddress	Value
Type	Alarm type	536	AbsHi (1)
Status	Alarm status	2113	Off (0)
Input	Input to be evaluated	2114	47.48
Threshold	Threshold	13	999.70
Hysteresis	Hysteresis	47	2.30

'Alarm 2 Type' is not alterable
'Alarm 2 Threshold' is alterable

Name	Description	ddress	Value
Type	Alarm type	537	AbsLo (2)
Status	Alarm status	2137	Off (0)
Input	Input to be evaluated	2138	47.45
Threshold	Threshold	14	-10.00
Hysteresis	Hysteresis	68	1.00

'ConfigLockParaLists' Off

Controller in Configuration Mode

'Alarm 1 Type' is alterable
'Alarm 1 Threshold' is alterable

Name	Description	ddress	Value
Type	Alarm type	536	AbsHi (1)
Status	Alarm status	2113	Off (0)
Input	Input to be evaluated	2114	47.46
Threshold	Threshold	13	999.70

'Alarm 2 Type' is alterable
'Alarm 2 Threshold' is alterable

Name	Description	ddress	Value
Type	Alarm type	537	AbsLo (2)
Status	Alarm status	2137	Off (0)
Input	Input to be evaluated	2138	47.47
Threshold	Threshold	14	-10.00

Controller in Operator Mode

'Alarm 1 Type' is not alterable
'Alarm 1 Threshold' is alterable

Name	Description	ddress	Value
Type	Alarm type	536	AbsHi (1)
Status	Alarm status	2113	Off (0)
Input	Input to be evaluated	2114	47.56
Threshold	Threshold	13	999.70

'Alarm 2 Type' is not alterable
'Alarm 2 Threshold' is alterable

Name	Description	ddress	Value
Type	Alarm type	537	AbsLo (2)
Status	Alarm status	2137	Off (0)
Input	Input to be evaluated	2138	47.50
Threshold	Threshold	14	-10.00

Notes:

1. Parameters are alterable within other set limits.
2. The availability applies to access through comms.

User Switches

A User Switch provides a general purpose boolean switch. It is most useful when incorporated in a User Page where it can perform a specific task suited to the particular application. Eight User Switches are available and each may be configured as:-

Auto Reset - the switch remains On for a minimum of 110ms after which is is automatically set to Off.

Manual Reset – the switch remains On until it is set to Off manually.

The text associated with the State parameter (Off / On by default) may be changed using iTools to suit the application requirements.

User Switch Parameters

The parameters are only available if one or more User Switch function blocks are enabled. Use ⊜ to page to the Switch heading.

List Header – Switch		Sub-headers: 1 to 8			
Name ⊜ to select	**Parameter Description**	**Value** Press ▽ or △ to change values		**Default**	**Access Level**
Type	The selected switch may be configured as Manual or Automatic reset	ManReset AutoReset	the switch remains On until it is set to Off manually. the switch remains On for a minimum of 110ms after which is isautomatically set to Off.	ManReset	Conf
State	Shows the state of the switch. It is normal to wire this parameter to a digital function within the controller such as a programmer event. The state of the switch is then determined by the event. If it is not wired then the state may changed here.	Off * On *	Switch off Switch on	Off	L3

* The text associated with the switch may be configured in iTools so that it displays a more meaningful message. Examples are, Open/Closed, Up/Down, etc.

To Configure User Switches

Do This	The Display You Should See	Additional Notes
1. From any display press ⊜ as many times as necessary to select Switch 2. Select the required switch number using △ or ▽		
3. Press ⟳ to select switch Type and △ or ▽ to select AutoReset or manReset		Repeat 3 to select State. The state may be changed if not wired.

Modbus Scada Table

The SCADA table provides fixed single register Modbus values for use with Third Party Modbus clients in SCADA packages or plcs. If parameters are not available in this table they can be added from an indirection table using their Modbus addresses. Scaling of the parameters has to be configured – the Modbus client scaling has to match the 3500 parameter resolution to ensure the decimal point is in the correct position.

WARNING

This facility is intended for use by suitably qualified personnel responsible for developing SCADA or plc interfaces.

SCADA Addresses

The address field in iTools displays the parameter's Modbus address. These addresses should be used when accessing parameters over comms. If a parameter has no address the CommsTab feature can be used to map the parameter to a modbus address, however, it should be noted that the address field will not be updated. The following Modbus addresses have been reserved for use with the CommsTab Function Block, by default they have no associated parameter:

ModBus Range	Modbus Range (HEX)
15360 to 15615	0x3C00 to 0x3CFF

SCADA Table

Refer to iTools integrated Online Help for the latest and most up-to-date parameter addresses.

The table lists the parameters, along with their limits and resolution, which have assigned Modbus addresses. They are available in scaled integer format.

Wherever possible use an OPC client with the iTools OPCserver as the server. In this arrangement the parameters are all referenced by name and the values are floating point so the decimal point for all parameters is inherited.

Some parameters have more than one address, for example ‘Alarm1.Block’. The lower number is to maintain a compatibility with earlier instruments.

Dual Programmers via SCADA Comms

It is possible to edit and run programs for either asynchronous or synchronous programmers using SCADA communications. As programs can be run by any programmer and segments are located in a free formatted pool, the SCADA addresses of Program/Segment parameters are dependent upon a number of factors and hence a set procedure must be followed.

Parameter Tables

The following table lists the offsets for Programmer parameters that are available over SCADA comms:

Program General Data Table			
Offset	**Parameter**	**Offset**	**Parameter**
0	Comms.ProgramNumber	23	Programmer.SyncIn
1	Program.HoldbackVal	24	Programmer.FastRun
2	Program.RampUnits	25	Programmer.AdvSeg
3	Program.DwellUnits	26	Programmer.SkipSeg
4	Program.Cycles	27	Program.Ch2RampUnits
5	Programmer.PowerFailAct	28	Program.Ch2DwellUnits
6	Programmer.Servo	29	Program.PVStart
7	Programmer.SyncMode	30	Program.Ch2PVStart
8	Programmer.ResetEventOuts	31	Program.Ch2HoldbackVal
9	Programmer.CurProg	32	Program.Ch1HoldbackVal
10	Programmer.CurSeg	33	Program.Ch1RampUnits
11	Programmer.ProgStatus	34	Programmer.PrgIn1
12	Programmer.PSP	35	Programmer.PrgIn2
13	Programmer.CyclesLeft	36	Programmer.PVEventIP
14	Programmer.CurSegType	37	Programmer.ProgInvalid
15	Programmer.SegTarget	38	Programmer.PVEventOP
16	Programmer.SegRate	39	Programmer.GoBackCyclesLeft
17	Programmer.ProgTimeLeft	40	Programmer.DelayTime
18	Programmer.PVIn	41	Programmer.ProgReset
19	Programmer.SPIn	42	Programmer.ProgRun
20	Programmer.EventOuts	43	Programmer.ProgHold
21	Programmer.SegTimeLeft	44	Programmer.ProgRunHold
22	Programmer.EndOfSeg	45	Programmer.ProgRunReset

Example Programmer 1/2 Setup Parameters

The following table shows the Tag Addresses for Programmer 1 and Programmer 2 Setup and Run parameters, calculated by adding the offsets shown in the previous table to Programmer 1 Number (5184) and Programmer 2 Number (5248).

Program General Data Table			
Address	**Parameter**	**Offset**	**Parameter**
5184/5248	Programmer 1/2 Comms ProgramNumber	5207/5271	Programmer 1/2 Synchronise Input
5185/5249	Programmer 1/2 Holdback Value	5208/5272	Programmer 1/2 Fast Run
5186/5250	Programmer 1/2 Ramp Units	5209/5273	Programmer 1/2 Advance Segment
5187/5251	Programmer 1/2 Dwell Units	5210/5274	Programmer 1/2 Skip Segment
5188/5252	Programmer 1/2 Number of Cycles	5211/5275	Programmer 1/2 Ch2 Ramp Units
5189/5253	Programmer 1/2 Action on Power Fail	5212/5276	Programmer 1/2 Ch2 Dwell Units
5190/5254	Programmer 1/2 Servo Action	5213/5277	Programmer 1/2 PV Start
5191/5255	Programmer 1/2 Synchronisation Mode	5214/5278	Programmer 1/2 Ch2 PV Start
5192/5256	Programmer 1/2 Reset Event Outputs	5215/5279	Programmer 1/2 Ch2 Holdback Value
5193/5257	Programmer 1/2 Current Program Number	5216/5280	Programmer 1/2 Ch1 Holdback Value
5194/5258	Programmer 1/2 Current Running Segment	5217/5281	Programmer 1/2 Ch1 Ramp Units
5195/5259	Programmer 1/2 Program Status	5218/5282	Programmer 1/2 Digital Input 1
5196/5260	Programmer 1/2 Setpoint	5219/5283	Programmer 1/2 Digital Input 2
5197/5261	Programmer 1/2 Number of CyclesLeft	5220/5284	Programmer 1/2 PV Wait Input
5198/5262	Programmer 1/2 Current Segment Type	5221/5285	Programmer 1/2 Program Error
5199/5263	Programmer 1/2 Current Target SP Value	5222/5286	Programmer 1/2 PV Event Output
5200/5264	Programmer 1/2 Segment Ramp Rate	5223/5287	Programmer 1/2 Number of Cycles Left
5201/5265	Programmer 1/2 Program Time Left	5224/5288	Programmer 1/2 Delayed Start
5202/5266	Programmer 1/2.PV Input	5225/5289	Programmer 1/2 Program Reset
5203/5267	Programmer 1/2 Setpoint Input	5226/5290	Programmer 1/2 Program Run
5204/5268	Programmer 1/2 Event Output 1	5227/5291	Programmer 1/2 Program Hold
5205/5269	Programmer 1/2 Segment Time Left	5228/5292	Programmer 1/2 Program Run Hold input
5206/5270	Programmer 1/2 End of Segment	5229/5293	Programmer 1/2 Program Run Reset Input

Programmer Segment Address Assignment

The following table shows the address ranges set aside for the Programmer segments:

Area		Start Address	Start Address hex
Programmer1	Program General Data	5184	0x1440
Programmer2	Program General Data	5248	0x1480
Reserved for future expansion: 5312 (0x14C0) – 5375 (0x14FF)			
Programmer1 (Sync Ch1)	Segment1	5376	0x1500
	Segment2	5408	0x1520
	Segment3	5440	0x1540
	Segment4	5472	0x1560
	Segment5	5504	0x1580
	Segment6	5536	0x15A0
	Segment7	5568	0x15C0
	Segment8	5600	0x15E0
	Segment9	5632	0x1600
	Segment10	5664	0x1620
	Segment11	5696	0x1640
	Segment12	5728	0x1660
	Segment13	5760	0x1680
	Segment14	5792	0x16A0
	Segment15	5824	0x16C0
	Segment16	5856	0x16E0
	Segment17	5888	0x1700
	Segment18	5920	0x1720
	Segment19	5952	0x1740
	Segment20	5984	0x1760
	Segment21	6016	0x1780
	Segment22	6048	0x17A0
	Segment23	6080	0x17C0
	Segment24	6112	0x17E0
	Segment25	6144	0x1800

Area		Start Address	Start Address hex
Programmer1 (Sync Ch1)	Segment26	6176	0x1820
	Segment27	6208	0x1840
	Segment28	6240	0x1860
	Segment29	6272	0x1880
	Segment30	6304	0x18A0
	Segment31	6336	0x18C0
	Segment32	6368	0x18E0
	Segment33	6400	0x1900
	Segment34	6432	0x1920
	Segment35	6464	0x1940
	Segment36	6496	0x1960
	Segment37	6528	0x1980
	Segment38	6560	0x19A0
	Segment39	6592	0x19C0
	Segment40	6624	0x19E0
	Segment41	6656	0x1A00
	Segment42	6688	0x1A20
	Segment43	6720	0x1A40
	Segment44	6752	0x1A60
	Segment45	6784	0x1A80
	Segment46	6816	0x1AA0
	Segment47	6848	0x1AC0
	Segment48	6880	0x1AE0
	Segment49	6912	0x1B00
	Segment50	6944	0x1B20

Area		Start Address	Start Address hex
Programmer2 (Sync Ch2)	Segment1	6976	0x1B40
	Segment2	7008	0x1B60
	Segment3	7040	0x1B80
	Segment4	7072	0x1BA0
	Segment5	7104	0x1BC0
	Segment6	7136	0x1BE0
	Segment7	7168	0x1C00
	Segment8	7200	0x1C20
	Segment9	7232	0x1C40
	Segment10	7264	0x1C60
	Segment11	7296	0x1C80
	Segment12	7328	0x1CA0
	Segment13	7360	0x1CC0
	Segment14	7392	0x1CE0
	Segment15	7424	0x1D00
	Segment16	7456	0x1D20
	Segment17	7488	0x1D40
	Segment18	7520	0x1D60

Area		**Start Address**	**Start Address hex**
Programmer2 (Sync Ch2)	Segment19	7552	0x1D80
	Segment20	7584	0x1DA0
	Segment21	7616	0x1DC0
	Segment22	7648	0x1DE0
	Segment23	7680	0x1E00
	Segment24	7712	0x1E20
	Segment25	7744	0x1E40
	Segment26	7776	0x1E60
	Segment27	7808	0x1E80
	Segment28	7840	0x1EA0
	Segment29	7872	0x1EC0
	Segment30	7904	0x1EE0
	Segment31	7936	0x1F00
	Segment32	7968	0x1F20
	Segment33	8000	0x1F40
	Segment34	8032	0x1F60
	Segment35	8064	0x1F80
	Segment36	8096	0x1FA0
	Segment37	8128	0x1FC0
	Segment38	8160	0x1FE0
	Segment39	8192	0x2000
	Segment40	8224	0x2020
	Segment41	8256	0x2040
	Segment42	8288	0x2060
	Segment43	8320	0x2080
	Segment44	8352	0x20A0
	Segment45	8384	0x20C0
	Segment46	8416	0x20E0
	Segment47	8448	0x2100
	Segment48	8480	0x2120
	Segment49	8512	0x2140
	Segment50	8544	0x2160
Reserved for future expansion: 8576 (0x2180) - 10175 (0x27BF)			

Parameters Available in Every Segment of a Programmer

The following table lists the offsets for Segment parameters that are available over SCADA comms:

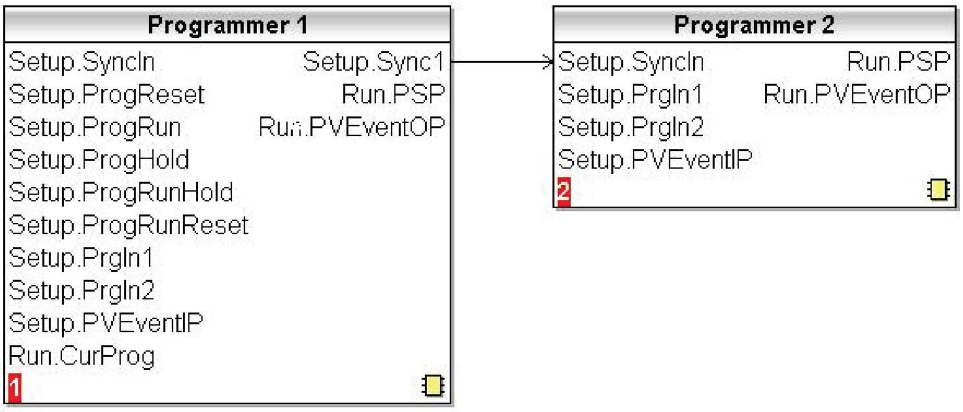
Segment Data Table			
Offset	Parameter	Offset	Parameter
0	Segment.Type	12	Segment.GobackCycles
1	Segment.Holdback	13	Segment.PVEvent
2	Segment.CallProgNum	14	Segment.PVThreshold
3	Segment.Cycles	15	Segment.UserVal
4	Segment.Duration	16	Segment.GsoakType
5	Segment.RampRate	17	Segment.GsoakVal
6	Segment.TargetSP	18	Segment.TimeEvent
7	Segment.EndAction	19	Segment.OnTime
8	Segment.EventOutputs	20	Segment.OffTime
9	Segment.WaitFor	21	Segment.PIDSet
10	Segment.SyncToCh2Seg	22	Segment.PVWait
11	Segment.GobackSeg	23	Segment.WaitVal

Example: Programmer 1/2 Segment 1 Parameters

The following table shows the Tag addresses for parameters available in Segment 1 for Programmers 1 and 2.

Segment Data Table – Programmer 1/2			
Tag Address	**Parameter**	**Tag Address**	**Parameter**
5376/6976	Segment 1Type	5388/6988	Segment 1 Goback Cycles
5377/6977	Segment 1 Holdback	5389/6989	Segment 1 PV Event
5378/6978	Segment 1 Program to be Called	5390/6990	Segment 1 PV Event Threshold
5379/6979	Segment 1 Number of Call Cycles	5391/6991	Segment 1 User Value
5380/6980	Segment 1 Duration	5392/6992	Segment 1 Guaranteed SoakType
5381/6981	Segment 1 RampRate	5393/6993	Segment 1 Garanteed Soak Value
53826982	Segment 1 Target Setpoint	5394/6994	Segment 1 Time Event
5383/6983	Segment 1 End Type	5395/6995	Segment 1 On Time
5384/6984	Segment 1 Digital Event Outputs	5396/6996	Segment 1 Off Time
5385/6985	Segment 1 Wait For	5397/6997	Segment 1 PID Set
5386/6986	Segment 1 Synchronise to Channel 2 Segment	5398/6998	Segment 1 PV Wait Event
5387/6987	Segment 1 Goback Segment	5399/6999	Segment 1 Wait Value

Synchronous Programmers



In this configuration, Programmer2 is a server to Programmer1. A program will have two profiles, Channel1 run by Programmer1 and Channel2 run by Programmer2. The program only needs to be loaded into the master programmer. To edit the program and to configure the programmers the following procedure should be followed:

1. Write the program number which is to be edited to the Comms.ProgramNumber parameter located in the master programmers general data area, in this case the master programmer is Programmer1 and hence the address to be written to is:

   Programmer1 Program General Data Start address (5184) + Comms.ProgNum Offset (0) = 5184

2. It is then possible to configure the other Programmer/Program parameters, for example, the address to write to change the value of the PowerFailAct is:

   Programmer1 Program General Data Start address (5184) + PowerFailAct Offset (5) = 5189

3. To edit Segment1 Channel1 data, use Programmer1 (Sync Ch1) Segment1 Start address plus the parameter offset, for example, to configure the segment type the address to be written to is:

   Programmer1 Segment1 Data Start address (5376) + Segment.Type Offset (0) = 5376

To configure Ch1 TargetSP the address to be written to is:

Programmer1 Segment1 Data Start address (5376) + Segment.TargetSP Offset (6) = 5382

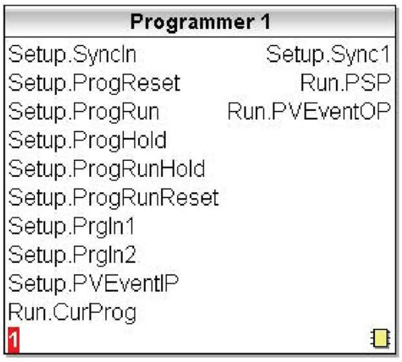
4. To edit Segment1 Channel2 data, use Programmer2 (Sync Ch2) Segment1 Start address plus the parameter offset, for example, to configure Ch2 TargetSP the address to be written to is:

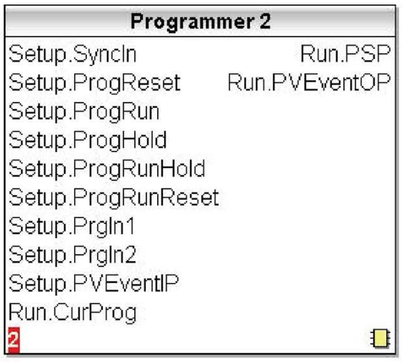
   Programmer2 Segment1 Data Start address (6976) + Segment.TargetSP Offset (6) = 6982

For additional segments repeat steps 3 and 4 using the corresponding segment numbers i.e.:

Ch	Segment 1	Segment 2	Segment *n*
1	Programmer 1 Segment 1 Data	Programmer 1 Segment 2 Data	Programmer1 Segment *n* Data
2	Programmer 2 Segment 1 Data	Programmer 2 Segment 2 Data	Programmer2 Segment *n* Data

Asynchronous Programmers





In this configuration each programmer can be loaded with its own program. To edit the separate programs and to configure the programmers the following procedure should be followed:

1. Write the program number that is to be edited for Programmer1 to the Comms.ProgNumber parameter located in Programmer1 general data area, the address to be written to is:

Programmer1 Program General Data Start address (5184) + Comms.ProgNum Offset (0) = 5184

2. It is then possible to configure the other parameters for Programmer1/Program, for example, the address to write to change the value of the PowerFailAct is:

Programmer1 Program General Data Start address (5184) + PowerFailAct Offset (5) = 5189

3. To edit the programs Segment data, use the segment numbers start address plus the parameter offset, for example, to configure the segment type of Segment1 the address to be written to is:

Programmer1 Segment1 Data Start address (5376) + Segment.Type Offset (0) = 5376

To configure the segment type of Segment2 the address to be written to is:

Programmer1 Segment2 Data Start address (5408) + Segment.Type Offset (0) = 5408

4. To configure Programmer2/Program repeat steps 1 through to 3 using Programmer2 addresses, for example:

Step1 (this does not affect Programmer1 Program Number):

Programmer2 Program General Data Start address (5248) + Comms.ProgNum Offset (0) = 5248

Step2:

Programmer2 Program General Data Start address (5248) + PowerFailAct Offset (5) = 5253

Step3:

Programmer2 Segment1 Data Start address (6976) + Segment.Type Offset (0) = 6976

Programmer2 Segment2 Data Start address (7008) + Segment.Type Offset (0) = 7008

EI-Bisynch Parameters

818, 902/3/4 mnemonic	818, 902/3/4 Parameter	3500 parameter	Hex / decimal
PV	Measured Value	Loop - PV	Decimal
SP	Working Setpoint	Loop - Working Setpoint	Decimal
OP	Output	Loop - Manual Output	Decimal
SW	See "Status Word Table" below	See "Status Word Table" below	HEX
OS	See "Optional Status Word Table" below	See "Optional Status Word Table" below	HEX
XS	See "Extended Status Word Table" below	See "Extended Status Word Table" below	HEX
01	See "Digital output status word 1" below.	See "Digital output status word 1" below.	HEX
02	See "Digital output status word 2" below.	See "Digital output status word 2" below.	HEX
03	See "Digital output status word 3" below.	See "Digital output status word 3" below.	HEX
04	See "Digital output status word 4" below.	See "Digital output status word 4" below.	HEX
05	See "Digital output status word 5" below.	See "Digital output status word 5" below.	HEX
06	See "Digital output status word 6" below.	See "Digital output status word 6" below.	HEX
1A	Alarm 1	Alarm - 1 - Threshold	Decimal
2A	Alarm 2	Alarm - 2 - Threshold	Decimal
ER	Error	Loop - Diag - Error	Decimal
SL	Local Setpoint (SP1)	Loop - Target Setpoint	Decimal
S2	Setpoint 2 (SP2)	Loop - Setpoint 2	Decimal
RT	Local setpoint trim	Loop - Setpoint Trim	Decimal
MP	V.P. Pot Value	Loop - Ch1 Valve Position	Decimal
RI	Remote Input	Loop - Scheduler Remote Input	Decimal
TM	Time remaining in current program segment	Programmer - Segment time remaining	Decimal
LR	Loops remaining for current program	Programmer - Cycles left	Decimal
r1-r8	Ramp rate 1-8	Programmer - (Ramp) Segment Rates	Decimal
l1-l8	Ramp level 1-8	Programmer - (Ramp) Segment Target setpoints	Decimal
t1-t8	Dwell time 1-8	Programmer - (Dwell) Segment durations	Decimal
Hb	Holdback value	Programmer - Holdback	Decimal
Lc	Loop count	Programmer - Cycles remaining	Decimal
RR	Ramp Rate	Loop - Setpoint Rate Limit Value	Decimal
HO	Max.Heat	Loop - Output High Limit	Decimal
LO	Max Cool	Loop - Output Low Limit	Decimal
RH	Remote Heat Limit	Loop - Remote Output High Limit	Decimal
RC	Remote Cool Limit	Loop - Remote Output Low Limit	Decimal
HS	Setpoint 1 maximum	Loop - Setpoint Hi	Decimal
LS	Setpoint 1 minimum	Loop - Setpoint Lo	Decimal
H2	Setpoint 2 maximum	UserVals - UserVal2	Decimal
L2	Setpoint 2 minimum	UserVals - UserVal3	Decimal
H3	Local setpoint maximum	UserVals - UserVal4	Decimal
L3	Local setpoint minimum	UserVals - UserVal5	Decimal
2H	Remote Max Scalar	UserVals - UserVal6	Decimal
2L	Remote Min Scalar	UserVals - UserVal7	Decimal
CH	Cycle time for channel 1	Mod1 - Chn1 - Min On Time (Same as MT in 3500)	Decimal
XP	Proportional Band	Loop - Proportional Band	Decimal
TI	Integral time	Loop - Integral Time	Decimal
MR	Manual reset	Loop - Manual Reset	Decimal
TD	Derivitive time	Loop - Derivative Time	Decimal
HB	Cutback High	Loop - Cutback High	Decimal
LB	Cutback Low	Loop - Cutback Low	Decimal

818, 902/3/4 mnemonic	818, 902/3/4 Parameter	3500 parameter	Hex / decimal
RG	Relative cool gain	Loop - Relative Cool/Ch2 Gain	Decimal
P2	Proportional Band 2	Loop - Proportional Band 2	Decimal
I2	Integral time 2	Loop - Integral Time 2	Decimal
R2	Manual reset 2	Loop - Manual Reset 2	Decimal
D2	Derivative tune 2	Loop - Derivative Time 2	Decimal
G2	Relative cool gain 2	Loop - Relative Cool/Ch2 Gain 2	Decimal
AU	Approach 2	UserVals - UserVal14	Decimal
HC	Heat cool deadband	Loop - Channel 2 Deadband	Decimal
CC	Cool cycle time	Mod2 – Ch1 - MinOnTime	Decimal
C2	Channel 2 cycle time	UserVals - UserVal1	Decimal
AL	Approach limit	UserVals - UserVal8	Decimal
TT	Travel time	Loop - Ch1 Travel Time	Decimal
Tt	Travel time down	UserVals - UserVal11	Decimal
MT	Minimum on time	Mod1 - Chn1 - Min On Time (Same as CH in 3500)	Decimal
TP	Valve update time	UserVals - UserVal12	Decimal
LE	Motor low limit	UserVals - UserVal13	Decimal
EH	Motor high limit	UserVals - UserVal9	Decimal
PE	Emissivity	Standard PV - Emissivity	Decimal
BP	Power level at sensor break	Loop - Safe Output Value	Decimal
TR	Adaptive tune trigger point	UserVals - UserVal10	Decimal
V0	Software version	Software version	HEX
II	Instrument Identity	Instrument ID (3508 = E480 / 3504 = E440)	HEX
1H	Display Maximum	Instrument - Display - Bar graph max	Decimal
1L	Display Minimum	Instrument - Display - Bar graph min	Decimal

(SW) Status Word

Status Word (SW)		
Bit	**818, 902/3/4 Function (Clear/Set)**	**3500 Support**
0	Data Format (Free/Fixed)	Data Format (Free/Fixed)
1	Sensor Break (No/Yes)	Loop Sensor Break (No/Yes)
2	Key Lock (Enabled/Disabled)	Key Lock (Keys Enabled/Keys Locked)
3	Spare	N/A
4	Spare	N/A
5	Param changed via keys (No/Yes)	Not Supported - Ignored
6	Spare	N/A
7	Spare	N/A
8	Alarm 2 state (Off/On)	Alarm 2 output
9	Spare	N/A
10	Alarm 1 state (Off/On)	Alarm 1 output
11	Spare	N/A
12	Alarm Active (No alarm/New Alarm1 or 2)	Alarm 1 OR Alarm 2
13	SP2 Active (SP1/SP2)	Loop - Setpoint Select (SP1/SP2)
14	Remote Active (Local/Remote)	Loop - Alternate Setpoint Enable (No/Yes)
15	Manual Mode (Auto/Man)	Loop - AutoMan (Auto/Manual)

(OS) Optional Status Word

Optional Status Word (OS)		
Bit	**818, 902/3/4 Function (Clear/Set)**	**3500 Support**
0	Values of the first nibble (Bits 0-3) represent	Supported as described.
1	Program Status. Value of 0=Reset, 2=Run,	
2	3=Hold, 4=End, 5=Ramp End, 6=in holdback	
3	Value of 1 is not used	
4	Hold Logged (R/O).	May be cleared over comms but not set.
5	Skip Current Segment (w/o)	Supported as described.
6	Ramp / Dwell	Supported as described.
7	Digital Input Lock	Not Supported - Ignored - always returns zero.
8	Segment Number LSB	Shows segment number 1-8, read only.
9	Seg No	
10	Seg No	
11	Segment Number MSB	
12	Digital O/P2 (Off/On)	Not supported - Ignored - always returns zero.
13	Digital O/P1 (Off/On)	Relay AA status
14	Digital Input 2 (Off/On)	Fixed Digital I/O 2
15	Digital Input 1 (Off/On)	Fixed Digital I/O 1

(XS) Extended Status Word

Extended Status word (XS)		
Bit	**818, 902/3/4 Function (Clear/Set)**	**3500 Support**
0	Self Tune (Off/On)	Fully supported
1	Adaptive Tune (Off/On)	Not supported - Ignored - always returns zero.
2	Spare	N/A
3	Spare	N/A
4	PID Control (SP+PID/PID Independ't)	Not supported - Ignored - always returns zero.
5	Active PID set (PID1/PID2)	Supported as described.
6	Digital OP 0 (OP2) (Off/On)	Relay AA status
7	Spare	N/A
8	This Nibble (bits 8-11) represent	Supported as described.
9	program number.	
10		
11		
12	Valve positioners	Not supported -
13	Values are as follows (0=Outputs Off, 1=	This nibble is ignored and always returns zero.
14	Lower Output on, 2=Raise Output on, 3=	
15	Lower Nudge, 4=Raise Nudge)	

Digital Output Status Word1 (01)

DigOpStat1 (01)		
Bit	**818, 902/3/4 Function (Clear/Set)**	**3500 Support**
0	Ramp 1 to Output 3	Digital Event bit 3 for segment 1 (ramp 1)
1	Dwell 1 to Output 3	Digital Event bit 3 for segment 2 (dwell 1)
2	Ramp 2 to Output 3	Digital Event bit 3 for segment 3 (ramp 2)
3	Dwell 2 to Output 3	Digital Event bit 3 for segment 4 (dwell 2)
4	Ramp 3 to Output 3	Digital Event bit 3 for segment 5 (ramp 3)
5	Dwell 3 to Output 3	Digital Event bit 3 for segment 6 (dwell 3)
6	Ramp 4 to Output 3	Digital Event bit 3 for segment 7 (ramp 4)
7	Dwell 4 to Output 3	Digital Event bit 3 for segment 8 (dwell 4)
8	Ramp 5 to Output 3	Digital Event bit 3 for segment 9 (ramp 5)
9	Dwell 5 to Output 3	Digital Event bit 3 for segment 10 (dwell 5)
10	Ramp 6 to Output 3	Digital Event bit 3 for segment 11 (ramp 6)
11	Dwell 6 to Output 3	Digital Event bit 3 for segment 12 (dwell 6)
12	Ramp 7 to Output 3	Digital Event bit 3 for segment 13 (ramp 7)
13	Dwell 7 to Output 3	Digital Event bit 3 for segment 14 (dwell 7)
14	Ramp 8 to Output 3	Digital Event bit 3 for segment 15 (ramp 8)
15	Dwell 8 to Output 3	Digital Event bit 3 for segment 16 (dwell 8)

Digital Output Status Word2 (02)

DigOpStat1 (02)		
Bit	**818, 902/3/4 Function (Clear/Set)**	**3500 Support**
0	End to output 3	Digital Event bit 3 for End segment
1-15	Not used / Spare	Not used / Spare

Digital Output Status Word3 (03)

DigOpStat1 (03)		
Bit	**818, 902/3/4 Function (Clear/Set)**	**3500 Support**
0	Ramp 1 to Output 4	Digital Event bit 4 for segment 1 (ramp 1)
1	Dwell 1 to Output 4	Digital Event bit 4 for segment 2 (dwell 1)
2	Ramp 2 to Output 4	Digital Event bit 4 for segment 3 (ramp 2)
3	Dwell 2 to Output 4	Digital Event bit 4 for segment 4 (dwell 2)
4	Ramp 3 to Output 4	Digital Event bit 4 for segment 5 (ramp 3)
5	Dwell 3 to Output 4	Digital Event bit 4 for segment 6 (dwell 3)
6	Ramp 4 to Output 4	Digital Event bit 4 for segment 7 (ramp 4)
7	Dwell 4 to Output 4	Digital Event bit 4 for segment 8 (dwell 4)
8	Ramp 5 to Output 4	Digital Event bit 4 for segment 9 (ramp 5)
9	Dwell 5 to Output 4	Digital Event bit 4 for segment 10 (dwell 5)
10	Ramp 6 to Output 4	Digital Event bit 4 for segment 11 (ramp 6)
11	Dwell 6 to Output 4	Digital Event bit 4 for segment 12 (dwell 6)
12	Ramp 7 to Output 4	Digital Event bit 4 for segment 13 (ramp 7)
13	Dwell 7 to Output 4	Digital Event bit 4 for segment 14 (dwell 7)
14	Ramp 8 to Output 4	Digital Event bit 4 for segment 15 (ramp 8)
15	Dwell 8 to Output 4	Digital Event bit 4 for segment 16 (dwell 8)

Digital Output Status Word4 (04)

DigOpStat1 (04)		
Bit	**818, 902/3/4 Function (Clear/Set)**	**3500 Support**
0	End to output 4	Digital Event bit 4for End segment
1-15	Not used / Spare	Not used / Spare

Digital Output Status Word5 (05)

Bit	818, 902/3/4 Function (Clear/Set)	3500 Support
0	Ramp 1 to Output 2	Digital Event bit 2 for segment 1 (ramp 1)
1	Dwell 1 to Output 2	Digital Event bit 2 for segment 2 (dwell 1)
2	Ramp 2 to Output 2	Digital Event bit 2 for segment 3 (ramp 2)
3	Dwell 2 to Output 2	Digital Event bit 2 for segment 4 (dwell 2)
4	Ramp 3 to Output 2	Digital Event bit 2 for segment 5 (ramp 3)
5	Dwell 3 to Output 2	Digital Event bit 2 for segment 6 (dwell 3)
6	Ramp 4 to Output 2	Digital Event bit 2 for segment 7 (ramp 4)
7	Dwell 4 to Output 2	Digital Event bit 2 for segment 8 (dwell 4)
8	Ramp 5 to Output 2	Digital Event bit 2 for segment 9 (ramp 5)
9	Dwell 5 to Output 2	Digital Event bit 2 for segment 10 (dwell 5)
10	Ramp 6 to Output 2	Digital Event bit 2 for segment 11 (ramp 6)
11	Dwell 6 to Output 2	Digital Event bit 2 for segment 12 (dwell 6)
12	Ramp 7 to Output 2	Digital Event bit 2 for segment 13 (ramp 7)
13	Dwell 7 to Output 2	Digital Event bit 2 for segment 14 (dwell 7)
14	Ramp 8 to Output 2	Digital Event bit 2 for segment 15 (ramp 8)
15	Dwell 8 to Output 2	Digital Event bit 2 for segment 16 (dwell 8)

Digital Output Status Word6 (06)

DigOpStat1 (06)		
Bit	**818, 902/3/4 Function (Clear/Set)**	**3500 Support**
0	End to output 2	Digital Event bit 2 for End segment
1-15	Not used / Spare	Not used / Spare

Additional mnemonics, typically from 2400

Mnemonic	3500 parameter	Hex / decimal
A1	Alarm 1 - Threshold Value	Decimal
A2	Alarm 2 - Threshold Value	Decimal
A3	Alarm 3 - Threshold Value	Decimal
A4	Alarm 4 - Threshold Value	Decimal
A5	Alarm 5 - Threshold Value	Decimal
A6	Alarm 6 - Threshold Value	Decimal
A7	Alarm 7 - Threshold Value	Decimal
A8	Alarm 8 - Threshold Value	Decimal
AH	Loop - Autotune High Output Power Limit	Decimal
AK	Instrument Diagnostics - Global Ack	Decimal
AT	Loop - Autotune Enable	Decimal
Aa	Alarm 7 - Threshold Value	Decimal
Ab	Alarm 8 - Threshold Value	Decimal
Ag	AA Relay - Value	Decimal
C1	User Value 1 - Value	Decimal
C2	User Value 2 - Value	Decimal
C3	User Value 3 - Value	Decimal
C4	User Value 4 - Value	Decimal
C5	User Value 5 - Value	Decimal
C6	User Value 6 - Value	Decimal
C7	User Value 7 - Value	Decimal
C8	User Value 8 - Value	Decimal
C9	User Value 9 - Value	Decimal
CJ	Std PV - CJC Temperature	Decimal
CP	Programmer - Current Program	Decimal
CR	Loop - Setpoint Rate Limit Value	Decimal
CS	Programmer - Current Segment	Decimal
Ca	User Value 10 - Value	Decimal
Cb	User Value 11 - Value	Decimal
Cc	User Value 12 - Value	Decimal
Cd	User Value 13 - Value	Decimal
Ce	User Value 14 - Value	Decimal
Cf	User Value 15 - Value	Decimal
Cg	User Value 16 - Value	Decimal
Cj	Mod3 - Chn1 - CJC Temperature	Decimal
E5	Not supported in V4.0+, RTC support has been removed	Decimal
E6	Not supported in V4.0+, RTC support has been removed	Decimal
EE	Comms error code	Decimal
H1	Instrument - Display - Bar Graph Max	Decimal
HA	Alarm 1 - Threshold Value	Decimal
HD	Loop - Cutback High 3	Decimal
IM	Instrument Mode (Read only - 2400 offers read / write)	Decimal
L1	Instrument - Display - Bar Graph Min	Decimal

Mnemonic	3500 parameter	Hex / decimal
LA	Alarm - 2 - Threshold Value	Decimal
LC	Loop - Cutback Low 2	Decimal
LD	Loop - Cutback Low 3	Decimal
LT	Loop - Setpoint Trim	Decimal
Lr	Programmer - Cycles left	Decimal
MU	Mod1 - Chn2 - Min On Time	Decimal
MV	Mod1 - Chn3 - Min On Time	Decimal
O1	Loop - Channel 1 Output Value	Decimal
O2	Loop - Channel 2 Output Value	Decimal
OR	Loop - Output Rate Limit Value	Decimal
RD	Loop - Setpoint Rate Limit Disable	Decimal
S1	Loop - Setpoint 1	Decimal
SC	Not supported in V4.0+, RTC support has been removed	Decimal
SR	Loop - Alternate Setpoint Enable	Decimal
SS	Loop - Setpoint Select	Decimal
ST	Instrument - Set Instrument Into Standby	Decimal
TE	Loop - Derivative Time 2	Decimal
TF	Loop - Derivative Time 3	Decimal
TH	Loop - Remote Output High Limit	Decimal
TJ	Loop - Integral Time 2	Decimal
TK	Loop - Integral Time 3	Decimal
TL	Loop - Remote Output Low Limit	Decimal
W1	Analogue Operator 1 - Value	Decimal
W2	Analogue Operator 2 - Value	Decimal
W3	Analogue Operator 3 - Value	Decimal
W4	Analogue Operator 4 - Value	Decimal
W5	Analogue Operator 5 - Value	Decimal
W6	Analogue Operator 6 - Value	Decimal
W7	Analogue Operator 7 - Value	Decimal
W8	Analogue Operator 8 - Value	Decimal
W9	Analogue Operator 9 - Value	Decimal
WA	Instrument - Diagnostics - New Alarm	Decimal
WD	Programmer - Program Run	Decimal
Wa	Analogue Operator 10 - Value	Decimal
Wb	Analogue Operator 11 - Value	Decimal
Wc	Analogue Operator 12 - Value	Decimal
Wd	Analogue Operator 13 - Value	Decimal
We	Analogue Operator 14 - Value	Decimal
Wf	Analogue Operator 15 - Value	Decimal
Wg	Analogue Operator 16 - Value	Decimal
Wh	Analogue Operator 17 - Value	Decimal
Wi	Analogue Operator 18 - Value	Decimal
Wj	Analogue Operator 19 - Value	Decimal
Wk	Analogue Operator 20 - Value	Decimal
Wl	Analogue Operator 21 - Value	Decimal
Wm	Analogue Operator 22 - Value	Decimal
Wn	Analogue Operator 23 - Value	Decimal
Wo	Analogue Operator 24 - Value	Decimal
X2	Loop - Proportional Band 2	Decimal
X3	Loop - Proportional Band 3	Decimal
X5	Not supported in V4.0+, RTC support has been removed	Decimal
X6	Not supported in V4.0+, RTC support has been removed	Decimal
Z1	Analogue Switch 1 - Status	Decimal

Mnemonic	3500 parameter	Hex / decimal
Z2	Analogue Switch 2 - Status	Decimal
Z3	Analogue Switch 3 - Status	Decimal
Z4	Analogue Switch 4 - Status	Decimal
a1	Module 1 - Channel 1 - Value	Decimal
a2	Module 1 - Channel 2 - Value	Decimal
a3	Module 1 - Channel 3 - Value	Decimal
a4	Module 2 - Channel 1 - Value	Decimal
a5	Module 2 - Channel 2 - Value	Decimal
a6	Module 2 - Channel 3 - Value	Decimal
as	Loop - State of the Autotune	Decimal
b1	Module 3 - Channel 1 - Value	Decimal
b2	Module 3 - Channel 2 - Value	Decimal
b3	Module 3 - Channel 3 - Value	Decimal
b4	Module 4 - Channel 1 - Value	Decimal
b5	Module 4 - Channel 2 - Value	Decimal
b6	Module 4 - Channel 3 - Value	Decimal
c1	Module 5 - Channel 1 - Value	Decimal
c2	Module 5 - Channel 2 - Value	Decimal
c3	Module 5 - Channel 3 - Value	Decimal
c4	Module 6 - Channel 1 - Value	Decimal
c5	Module 6 - Channel 2 - Value	Decimal
c6	Module 6 - Channel 3 - Value	Decimal
mA	Loop - Auto/Manual Mode	Decimal
o1	Std PV - Offset	Decimal
o2	Module 1 - Channel 1 - Offset	Decimal
pv	Analog Operator 1 - Select	Decimal
rE	Loop - Scheduler Remote Input	Decimal
td	Not supported in V4.0+, RTC support has been removed	Decimal
tm	Not supported in V4.0+, RTC support has been removed	Decimal
x4	Alarm 1 - Extended Status	Decimal
x5	Alarm 2 - Extended Status	Decimal
x6	Alarm 3 - Extended Status	Decimal
x7	Alarm 4 - Extended Status	Decimal
x8	Alarm 5 - Extended Status	Decimal
x9	Alarm 6 - Extended Status	Decimal
xa	Alarm 7 - Extended Status	Decimal
xb	Alarm 8 - Extended Status	Decimal
xc	Alarm 9 - Extended Status	Decimal
xd	Alarm 10 - Extended Status	Decimal
xe	Alarm 11 - Extended Status	Decimal
xf	Alarm 12 - Extended Status	Decimal
xg	Alarm 13 - Extended Status	Decimal
xh	Alarm 14 - Extended Status	Decimal
xi	Alarm 15 - Extended Status	Decimal
xj	Alarm 16 - Extended Status	Decimal
xk	Module 1 - Sensor Break	Decimal
xl	Module 2 - Sensor Break	Decimal
xm	Module 3 - Sensor Break	Decimal
xn	Module 4 - Sensor Break	Decimal
xo	Module 5 - Sensor Break	Decimal
xp	Module 6 - Sensor Break	Decimal
xq	Std PV - Sensor Break	Decimal
xr	Instrument - Diagnostics - Alarm Status Word 1	Decimal

Appendix - Technical Specification

General

Environmental performance

Temperature limits:	Operation: Storage:	0 to 50°C (32°F to 122°F) –10 to 70°C (14°F to 158°F)
Humidity limits:	Operation: Storage:	5% to 85% RH non condensing 5% to 95% RH non condensing
Front of panel sealing protection:		EN60529 IP65, UL50E Type 12 (equivalent to NEMA 12)
Rear of panel protection:		EN60529 IP10
Vibration:		2g peak, 10 to 150Hz
Altitude:		<2000 metres (6562 ft)
Atmospheres:		Not suitable for use in explosive or corrosive atmosphere*

Electromagnetic compatibility (EMC)

Emissions:		EN61326-1 Class B – Light Industrial/Laboratory Environment With Ethernet module fitted EN61326-1 Class A – Heavy Industrial Environment
Immunity:		EN61326-1 Industrial Environment

Electrical safety

		BS EN61010-1: 2010 and UL 61010-1: 2012 Pollution Degree 2 Insulation Category II

INSTALLATION CATEGORY II
The rated impulse voltage for equipment on nominal 230V ac mains is 2500V.

POLLUTION DEGREE 2
Normally, only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation shall be expected.

Physical

Dimensions:	3508: 3504:	48W x 96H x 159Dmm 96W x 96H x 159Dmm
Weight:	3508: 3504:	400g 600g
Panel:	3508: 3504:	1/8 DIN mounting 45W x 92Hmm cut-out 1/4 DIN mounting 92W x 92Hmm cut-out
Panel depth:	Both:	148mm

Operator interface

Type:		STN LCD with backlight
Main PV display:	3508: 3504:	4 1/2 digits. green 5 digits, green
Message display:	3508: 3504:	8 character header and 3 lines of 10 characters 16 character header and 3 lines of 20 characters
Status beacons:		Units, outputs, alarms, program status, program events, active setpoint, manual, remote SP
Access levels:		3 operator plus config. Password protected

Power requirements

Supply voltage:		100 to 230V ac, ±15%, 48 to 62Hz, max 20W (3508 15W) 24V ac, –15%, 24V dc, –15%, +20% ±5% ripple voltage max 20W (3508 15W)
Interrupt protection:	Standard: Low voltage:	Holdup >10ms at 85V RMS supply voltage Holdup >10ms at 20.4V RMS supply voltage
Inrush current:	High Voltage:	(VH): 30A duration <100µS
	Low Voltage:	(VL): 15A duration <100µS

User page

Number:	8
Parameters:	64 total
Functions:	Text, conditional text, values, bar graph
Access level:	User selectable (level 1, 2 or 3)

Approvals and certification

Europe	CE (EN61326), RoHS (EN50581), REACH, WEEE
USA, Canada	UL, cUL
China	RoHS, CCC: Exempt (Product not listed in catalogue of products subject to China Compulsory Certification)
Global	When subject to the necessary field calibration, 3500 series controllers manufactured by Eurotherm are suitable for use in Nadcap applications in all furnace classes, defined in AMS2750E clause 3.3.1. Meets accuracy requirements of CQI-9

Communications

No of ports:	2 modules can be fitted
Slot allocation:	MODBUS RTU (H or J comms port) or I/O expander (J comms port only)

Serial communications option

Protocols:	MODBUS Client/Server Slot H only EI-Bisynch (818 style mnemonics) MODBUS Client/Server broadcast (1 parameter) Slot J only
Isolation:	264V ac, double insulated
Transmission standard:	EIA232, EIA485, CAN (DeviceNet)

Ethernet communications option: 10/100Base Tx (Dual port)

Protocol:	MODBUS TCP, MODBUS Client/Server (H comms only)
Isolation:	264V ac, double insulated
Transmission standard:	802.3
Features:	DHCP client, 4 simultaneous clients

Main process variable input

Calibration accuracy:	<±0.1% of reading ±1LSD (Note 1)
Sample rate:	9Hz (110ms)
Isolation:	264V ac double insulation from the PSU and communication
Input filter:	Off to 59.9s. Default 1.6s
Zero offset:	User adjustable over full ran
User calibration:	2-point gain & offset

Thermocouple

Range:	Uses 40mV and 80mV ranges dependent on type
Types:	K, J, N, R, S, B, L, T, C, PL2, custom download x 2
Resolution:	16 bits
Linearization accuracy:	<0.2% of reading
Cold junction compensation:	>40:1 rejection of ambient change External reference of 0°C, 45°C and 50°C (32°F, 113°F and 122°F)
Cold junction accuracy:	<±1°C at 25°C ambient

Resistance thermometer

Range:	0-400Ω (–200°C to +850°C)
Resistance thermometer types:	3-wire Pt100 DIN 43760
Resolution (°C):	<0.050°C with 1.6sec filter
Resolution:	16 bits
Linearity accuracy:	<±0.03% (best fit straight line)
Calibration accuracy:	<±0.310°C/°C, ±0.023% of measurement at 25°C

Drift with temperature:	<±0.010°C/°C, ±25ppm/C of measurement from 25°C
Common mode rejection:	<0.000085°C/V (maximum of 264V rms)
Series mode rejection:	<0.240°C/V (maximum of 280mV pk-pk)
Lead resistance:	0Ω to 22Ω, matched lead resistance
Input impedance:	100MΩ
Bulb current:	200µA

40mV Range

Range:	–40mV to +40mV
Resolution (µV):	<1.0µV with 1.6sec filter
Resolution:	16 bits
Linearity accuracy:	<0.003% (best fit straight line)
Calibration accuracy:	<±4.6µV, ±0.053% of measurement at 25°C (77°F)
Drift with temperature:	<±0.2µV/C, ±28ppm/C of measurement from 25°C (77°F)
Common mode rejection:	>175dB (maximum of 264V rms)
Series mode rejection:	>101dB (maximum of 280mV pk-pk)
Input leakage current:	±14nA
Input impedance:	100MΩ

80mV Range

Range:	–80mV to +80mV
Resolution (µV):	<3.3µV with 1.6sec filter
Resolution:	16 bits
Linearity accuracy:	<0.003% (best fit straight line)
Calibration accuracy:	<±7.5µµV, ±0.052% of measurement at 25°C (77°F)
Drift with temperature:	<±0.2 V/°C, ±28ppm/C of measurement from 25°C
Common mode rejection:	>175dB (maximum of 264V rms)
Series mode rejection:	>101dB (maximum of 280mV pk-pk)
Input leakage current:	±14nA
Input impedance:	100MΩ

2V Range

Range:	–1.4V to +2.0V
Resolution (mV):	<90µV with 1.6sec filter
Resolution:	16 bits
Linearity accuracy:	<0.015% (best fit straight line)
Calibration accuracy:	<±420µµV, ±0.044% of measurement at 25°C (77°F)
Drift with temperature:	<±125 V/C, ±28ppm/C of measurement from 25°C (77°F)
Common mode rejection:	>155dB (maximum of 264Vrms)
Series mode rejection:	>101dB (maximum of 4.5V pk-pk)
Input leakage current:	±14nA
Input impedance:	100MΩ

10V Range

Range:	–3.0V to +10.0V
Resolution (mV):	<550µV with 1.6sec filter
Resolution:	16 bits
Linearity accuracy:	<0.007% of reading for zero source resistance. Add 0.003% for each 10Ω of source plus lead resistance
Calibration accuracy:	<±1.5mV, ±0.063% of measurement at 25°C (77°F)
Drift with temperature:	<±66µV/C, ±60ppm/C of measurement from 25°C (77°F)
Common mode rejection:	>145dB (maximum of 264V rms allowed)
Series mode rejection:	>92dB (maximum of 5V pk-pk allowed)
Input impedance	62.5kΩ to 667kΩ depending on input voltage

Notes: Calibration accuracy quoted over full ambient operating range and for all input linearization types

Digital IO (LA and LB)

Isolation:		Not isolated from each other. 264V ac double insulation from the PSU and communication

Input

Rating:	Voltage level:	Closed 0 to 7.3V dc Open 10.8 to 24V dc
	Contact closure:	Open >1200Ω Closed <480Ω
Functions:		Includes program control, alarm acknowledge, SP2 select, manual, keylock, RSP select, standby

Output

Rating:	18V dc >9mA <15mA
Functions:	Includes control outputs, alarms, events, status

AA Relay

Rating:	Min 1mA @ 1V dc, Max 2A @ 264V ac resistive 1,000,000 operations with external snubber
Isolation:	264Vac double insulation
Functions:	Includes control outputs, alarms, events, status

Input / Output modules

IO Modules:	3508:	3 modules can be fitted
	3504:	6 modules can be fitted
IO Expander:		20 Digital inputs, 20 relay outputs

Analogue input module

Calibration accuracy:	±0.2% of reading ±1LSD
Sample rate:	9Hz (110ms)
Isolation:	264V ac double insulation
Input filter:	Off to 59.9s. Default 1.6s
Zero offset:	User adjustable over full range
User calibration:	2-point gain & offset
Functions:	Includes process input, remote setpoint, power limit

Thermocouple

Range:	–100mV to +100mV
Types:	K, J, N, R, S, B, L, T, C, PL2, custom
Resolution (µV):	<3.3µV @ 1.6s filter time
Effective resolution:	15.9 bits
Linearization accuracy:	<0.2% of reading
Cold junction compensation:	>25:1 rejection of ambient change External reference of 0°C, 45°C and 50°C (32°F, 113°F and 122°F)
Cold junction accuracy:	<±1°C at 25°C ambient

Resistance thermometer

Range:	0-400Ω (–200°C to +850°C)
Resistance thermometer types:	3-wire Pt100 DIN 43760
Resolution (°C):	<±0.08°C with 1.6sec filter
Effective resolution:	13.7 bits
Linearity accuracy:	<0.033% (best fit straight line)
Calibration accuracy:	<±(0.4°C +0.15% of reading in °C)
Drift with temperature:	<±(0.015°C +0.005% of reading in °C) per °C
Common mode rejection:	<0.000085°C/V (maximum of 264V rms)
Series mode rejection:	<0.240°C/V (maximum of 280mV pk-pk)
Lead resistance:	0Ω to 22Ω, matched lead resistance
Bulb current:	300µA

100mV Range

Range:	–100mV to +100mV

Resolution (µV):	<3.3µV with 1.6s filter time
Effective resolution:	15.9 bits
Linearity accuracy:	<0.033% (best fit straight line)
Calibration accuracy:	<±10µµV, ± 0.2% of measurement at 25°C
Drift with temperature:	<±0.2 V + 0.004% of reading per °C
Common mode rejection:	>146dB (maximum of 264V rms)
Series mode rejection:	>90dB (maximum of 280mV pk-pk)
Input leakage current:	<1nA
Input impedance:	>100M

2V Range

Range:	–0.2V to +2.0V
Resolution (µV):	30uV with 1.6s filter time
Effective resolution:	16.2 bits
Linearity accuracy:	<0.033% (best fit straight line)
Calibration accuracy:	<±2mV + 0.2% of reading
Drift with temperature:	<±0.1mV + 0.004% of reading per °C
Common mode rejection:	>155dB (maximum of 264Vrms)
Series mode rejection:	>101dB (maximum of 4.5V pk-pk)
Input leakage current:	<10nA
Input impedance:	>100M

10V Range

Range:	–3.0V to +10.0V
Resolution (µV):	<200µV with 1.6sec filter
Effective resolution:	15.4 bits
Linearity accuracy:	<0.033% (best fit straight line)
Calibration accuracy:	<±0.1mV + 0.02% of reading per °C
Drift with temperature:	<± 0.1mV + 0.02% of reading per °C
Common mode rejection:	>145dB (maximum of 264V rms)
Series mode rejection:	>92dB (maximum of 5V pk-pk)
Input impedance:	>69kΩ

Potentiometer input	
Type:	Single channel
Resistance:	100Ω to 15kΩ
Excitation:	0.5V dc supplied by module
Isolation:	264V ac double insulation
Functions:	Includes valve position and remote setpoint

Analogue control output	
Type:	Single channel
Rating:	0-20mA <600Ω 0-10V dc >500Ω
Accuracy:	<±2.5%
Resolution:	10 bits
Isolation:	264V ac double insulation

Analogue retransmission output	
Type:	Single channel
Rating:	0-20mA <600Ω 0-10V dc >500Ω
Accuracy:	<±0.5%
Resolution:	11 bits
Isolation:	264V ac double insulation

Dual 4-20mA OP/24V dc TxPSU	
Type:	Dual channel
Rating Output:	4-20mA dc, <1KΩ

TxPSU:	24V dc, 22mA
Isolation:	264V ac double insulation between channels
Functions:	Either channel can be control output or TxPSU
Accuracy:	<±1%
Resolution:	11 bits

Logic input modules

Module types:		Triple contact closure, triple logic level
Isolation:		No channel isolation. 264V ac double insulation from other modules and system
Rating:	Voltage level:	Open –3 to 5V dc @ <-0.4mA Closed 10.8 to 30V dc @ 2.5mA
	Contact closure:	Open >28kΩ Closed <100Ω
Functions:		Includes program control, alarm acknowledge, SP2 select, manual, keylock, RSP select, standby

Logic output modules

Module types:	Single channel, triple channel
Isolation:	No channel isolation. 264V ac double insulation from other modules and system
Rating Single:	12V dc >20mA <29mA
Triple:	12V dc >9mA <12mA
Functions:	Includes control outputs, alarms, events, status

Relay modules

Module types:	Single channel Form A, Single channel Form C, dual channel Form A
Isolation:	264V ac double insulation
Rating:	Min 100mA @ 12V dc, Max 2A @ 264V ac resistive Min 400,000 (max load) operations with external snubber
Functions:	Includes control outputs, alarms, events, status

Triac modules

Module types:	Single channel, dual channel
Isolation:	264V ac double insulation
Rating:	<0.75A @ 264V ac resistive
Functions:	Includes control outputs, alarms, events, status

Transmitter PSU module

Type:	Single channel
Isolation:	264V ac double insulation
Rating:	24V dc @ 20mA

Transducer PSU module

Type:	Single channel
Isolation:	264V ac double insulation
Bridge voltage:	Software selectable 5V dc or 10V dc
Bridge resistance:	300Ω to 15kΩ
Internal shunt resistor:	30.1Ω @0.25%, used for calibration of 350Ω bridge at 80%

I/O Expander

Type:	20 I/O:	4 Form C relays, 6 Form A relays, 10 logic inputs
	40 I/O:	4 Form C relays, 16 Form A relays, 20 logic inputs
Isolation:		264V ac double insulation between channels
Ratings:	Relay:	Min 100mA @ 12V dc, Max 2A @ 264V ac resistive
	Logic Input:	Open -3 to 5V dc @ <–0.4mA Closed 10.8 to 30V dc @ 2.5mA
Communications:		Using EX comms module in comms slot J

Software features

Control

Number of loops:	2
Loop update:	110ms
Control types:	PID, OnOff, VP, Dual VP
Cooling types:	Linear, fan, oil, water
Modes:	Auto, manual, forced manual, control inhibit
Overshoot inhibition:	High and low cutbacks
Number of PID sets:	3, selectable on PV, SP, OP, On Demand, program segment and remote input
Control options:	Supply voltage compensation, feedforward, output tracking, OP power limiting, SBR safe output
Setpoint options:	Remote SP with trim, SP rate limit, 2nd Setpoint, tracking modes

Setpoint programmer

Program function:	50 programs, max 500 segments
Program names:	User defined up to 16 characters
No of profile channels:	2 (1 if single loop)
Operation:	Full or partially synchronised
Events:	8 per channel (8 when fully synchronised) 1 timed event, 1 PV event
Segment types:	Rate, dwell, time, call, goback and wait
Digital inputs:	Run, Hold, Reset, RunHold,RunReset, Adv Seg, Skip Seg
Servo action:	Process value, setpoint
Power failure modes:	Continue, ramp, reset
Other functions:	Guaranteed soak, holdback, segment user values, wait inputs, PV hot start

Process/Digital Alarms

Number:	16
Type:	Abs Hi, Abs Lo, Dev Hi, Dev Lo, Dev Band, Dig Hi, Dig Lo, Pos Edge, Neg Edge, Edge and Abs Hi/Lo
Latching:	None, Auto, manual, event
Other features:	Delay, inhibit, blocking, display message, 3 priority levels

Zirconia

Number:	1
Functions:	Carbon potential, dewpoint, %O2 LogO2, probe mV
Supported probes:	Barber Colman, Drayton, MMICarbon, AACC, Accucarb, SSI, MacDhui, BoschO2, BoschCarbon
Gas reference:	Internal or remote analogue input
Probe diagnostics:	Clean recovery time, impedance measurement
Probe burn-off:	Automatic or manual
Other features:	Sooting alarm with tolerance setting, PV

Humidity

Number:	1
Functions:	Relative humidity, dewpoint
Measurement:	Psychrometric (wet & dry) inputs
Atmosphere compensation:	Internal or remote analogue input
Other features:	Psychrometric constant adjust

Recipes

Number:	8
Parameters:	40 per recipe
Length of name:	8 Characters
Selection:	HMI, comms, strategy

Transducer calibration

Number:	2
Type:	Shunt, load cell, comparision
Other features:	Autotare

Communication tables

Number:	250
Function:	MODBUS remapping (indirection)
Data formats:	Integer, IEEE (full resolution)

Application blocks

Soft wiring:	Orderable options of 30, 60, 120, 250 or 360
User values:	16 as standard, 40 with 360 wires, real numbers with decimal point
2 IP maths:	24 as standard, 32 with 360 wires. add, subtract, multiply, divide, absolute difference, max, min, hot swap, sample and hold, power, square root, Log, Ln, exponential, switch
2 IP logic:	24 as standard, 40 with 360 wires AND, OR, XOR, latch, equal, not equal, greater than, less than, greater than or equal to, less
8 IP logic:	2 as standard, 4 with 360 wires AND, OR, XOR
8 IP multiplexor:	4 as standard, 8 with 360 wires 8 sets of 8 values selected by input parameter
8 IP multiple IP:	2 as standard, 4 with 360 wires average, min, max sum
BCD Input:	2 blocks, 2 Decades
Input monitor:	2 blocks, max, min, time above threshold
32 point linearization:	2 as standard, 8 with 360 wires, 32-point linearization fit
Polynomial fit:	2 blocks, characterisation by Poly Fit table
Switchover:	1 block, smooth transition between 2 values
Timer blocks:	4 blocks, OnPulse, OnDelay, OneShot, MinOn Time
Counter blocks:	2 blocks, Up or down, directional flag
Totaliser blocks:	2 blocks, alarm at threshold value

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Published July, 2024

HA033837ENG Issue 3

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