

F4T® Controller

Setup and Operations

User's Guide



WATLOW[®]
Powered by Possibility



Registered Company

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Return Material Authorization (RMA)

1. Call Watlow Customer Service, (507) 454-5300, for a Return Material Authorization (RMA) number before returning any item for repair. If you do not know why the product failed, contact an Application Engineer or Product Manager. All RMA's require:
 - Ship-to address
 - Bill-to address
 - Contact name
 - Phone number
 - Method of return shipment
 - Your P.O. number
 - Detailed description of the problem
 - Any special instructions
 - Name and phone number of person returning the product.
2. Prior approval and an RMA number from the Customer Service Department is required when returning any product. Make sure the RMA number is on the outside of the carton and on all paperwork returned. Ship on a Freight Prepaid basis.
3. After we receive your return, we will examine it to verify the reason for the product failure. Unless otherwise agreed to in writing, Watlow's standard warranty provisions, which can be located at <https://www.watlow.com/terms>, will apply to any failed product.
4. In the event that the product is not subject to an applicable warranty, we will quote repair costs to you and request a purchase order from you prior to proceeding with the repair work.
5. Watlow reserves the right to charge for no trouble found (NTF) returns.

Technical Assistance

If you encounter a problem with your Watlow controller, review your configuration information to verify that your selections are consistent with your application: inputs, outputs, alarms, limits, etc. If the problem persists, you can get technical assistance from your local Watlow representative (see the Appendix in this User's Guide), by e-mailing your questions to wintechsupport@watlow.com or by dialing +1 (507) 494-5656 between 7 a.m. and 5 p.m., Central Standard Time (CST). Ask for an Applications Engineer. Please have the following information available when calling:

- Complete model number
- User's Guide
- All configuration information

Warranty

This product is warranted by Watlow for a period of 36 months in accordance with the terms and conditions set forth on Watlow's website which can be accessed at <https://www.watlow.com/terms>.

Table of Contents

Return Material Authorization (RMA)	2
Technical Assistance	2
Warranty	2
Table of Contents	3
Safety Instructions	6
Chapter 1: Overview	7
Available F4T® Literature and Resources	7
Your Comments are Appreciated	7
Document Overview and Purpose	7
A Conceptual View of the F4T® System	8
Inputs	9
Functions	9
Outputs	0
What is a Profile	10
Data Logging	10
Chapter 2: Composer® Software	11
Installing Composer® Software	11
Using Composer® Software	12
Overview Screen	14
Device Details	19
Configuring Pluggable Flex Modules	20
Configuring the Application using the Function Block Diagram	22
Personalizing the User Interface (UI) Using Composer®	29
Setting Up Data Log Files Using Composer®	29
Creating and Editing Profiles Using Composer®	36
Chapter 3: Using the F4T® Front Panel	44
Navigating and Understanding the User Interface (UI)	44
Front Panel Navigational Buttons	44
Understanding F4T® Menus	45
Multiple Languages	46
Event Driven Menus	47
Home Screen Described	48
Configuring Ethernet Communications	49
Default Ethernet Parameters and Settings	49
Personalizing the Home Screen Using the UI	50
Front Panel Usage From the Home Screen	52
Creating a Profile	52
Profile Actions From the Home Screen	53

Table of Contents (cont.)

Starting a Profile Using the Calendar	54
Changing Loop Operational Parameters	55
Using the Output Widget	55
Data Logging	56
Batch Processing Programming - Batch Menu	58
Export Data Log Report via USB Stick	62
Adding a Part Profile List using a PC	63
F4T® with the USB Mouse Feature	65
Transferring Data Log Files via the UI	66
Flashing the Controller Firmware	66
Email and Text Alerts	68
Step 1: Email Server Settings	69
Step 2: Send an Alert Test Message	70
Step 3: Defining Contacts	71
Step 4: Configuring Alerts	72
Chapter 4: Application Examples	77
Applications	77
Single Loop Control	77
Heat and Cool Control Loop	78
Process Alarm	80
Deviation Alarm	81
Safety Limit	82
Sensor Backup	83
Profile Ramp and Soak	84
Cascade Control	85
Compressor Control	87
Chapter 5: Function Block Reference	89
F4T® Functions Described	92
Alarm	93
Analog Outputs	100
Cascade	102
Compare	117
Control Loop	121
Counter	134
Current Input	137
Digital Input	139
Digital Inputs/Outputs (I/O)	140
Digital Outputs	143
Key	145

Table of Contents (cont.)

Limit	147
Limit Output	148
Linearization	148
Logic	154
Math	163
Profile	176
Process Value	182
Special Output	193
Temperature Input	198
Thermistor Input	201
Timer	204
Universal Input	210
Variable	221
Chapter 6: Communications	224
Communications	224
Watlow Supplied Software and HMI	224
Protocols Standard Bus	225
Introduction to Standard Commands for Programmable Instruments (SCPI)	226
SCPI Command List	226
Introduction to the Modbus Protocol	229
EtherNet/IP	232
EtherNet/IP Fundamentals	232
Setting up implicit data tables in Composer	233
Adding device to RSLogix 5000	235
Interpreting the data	237
Explicit Communications	240
EtherNet/IP Summary	241
Troubleshooting	242
Chapter 7: Appendix	243
F4T® Base Specifications	243
Declaration of Conformity	246
How to Reach Us	248

Safety Information

We use note, caution and warning symbols throughout this document to draw your attention to important operational and safety information.

A “NOTE” marks a short message to alert you to an important detail.

A “CAUTION” safety alert appears with information that is important for protecting your equipment and performance. Be especially careful to read and follow all cautions that apply to your application.

A “WARNING” safety alert appears with information that is important for protecting you, others and equipment from damage. Pay very close attention to all warnings that apply to your application.

The safety alert symbol, (an exclamation point in a triangle  precedes a general CAUTION or WARNING statement.

The electrical hazard symbol, (a lightning bolt in a triangle  precedes an electric shock hazard CAUTION or WARNING safety statement. Further explanations follow:

Symbol	Explanation
 CAUTION WARNING or  Electrical Shock Hazard	CAUTION: Warning or Electrical Hazard that needs further explanation than label on unit can provide. Consult QSG for further information. AVERTISSEMENT: mise en garde ou danger qui demande plus de précisions que l'information sur l'étiquette de l'unité. Consultez le manuel de l'utilisateur pour plus d'informations.
	Unit can be powered with either alternating current (ac) voltage or direct current (dc) voltage.
	ESD Sensitive product, use proper grounding and handling techniques when installing or servicing product.
	Do not throw in trash, use proper recycling techniques or consult manufacturer for proper disposal.
	Enclosure made of Polycarbonate material. Use proper recycling techniques or consult manufacturer for proper disposal.
	Unit is a Listed device per Underwriters Laboratories®. It has been evaluated to United States and Canadian requirements for Process Control Equipment. CSA 22.2#14, File 158031, UL 61010, File E185611 QUYX, QUYX7. See: www.ul.com
	Unit is compliant with European Union directives. See Declaration of Conformity for further details on Directives and Standards used for Compliance.
	Unit has been reviewed and approved by Factory Mutual as a Temperature Limit Device per FM Class 3545 standard. See: www.fmglobal.com
Symbol	Explanation
	Unit has been reviewed and approved by CSA International for use as Temperature Indicating-Regulating Equipment per CSA C22.2 No. 24. See: www.csa-international.org

1

Chapter 1: Overview

Available F4T® Literature and Resources

Document Title and Part Number	Description
F4T Installation and Troubleshooting User Guide, part number: 0600-0092-0000	Provides detailed specifications and information regarding mounting the F4T® base, flex module wiring and troubleshooting.
F4T Specification Sheet, part number: WIN-F4T®-0419	Describes F4T hardware options, features, benefits and technical specifications.
Watlow Application Guide	Comprehensive guide to understanding thermal principles, electrical noise, best practises for wiring industrial controls and much more.
Watlow Support Tools DVD, part number: 0601-0001-0000	Contains all product related user documents and software (Composer™), video tutorials, application notes and more.

To acquire one or more of these documents navigate to the Watlow website where you will have a choice to download free copies or purchase printed versions. Click on the link below to find your document of choice: <https://www.watlow.com/literature/index.cfm>

Your Comments are Appreciated

In an effort to continually improve our technical literature and ensuring that we are providing information that is useful to you, we would very much appreciate your comments and suggestions. Please send any comments you may have to the following email address:
TechlitComments@watlow.com

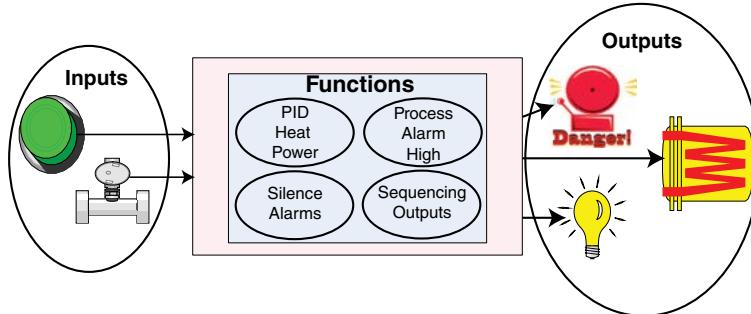
Document Overview and Purpose

This document looks deeper at the system configuration using Composer™ software and the F4T® function blocks and their associated connections. Common product usage is described and illustrated through application examples.

A Conceptual View of the F4T® System

The flexibility of the F4T® controller hardware and software (Composer™) allows for a large range of configurations. Composer software is a graphically based tool used to program the F4T® controller in its entirety. To learn more about installing and using Composer software see Chapter 2 of this document in the section titled "[Installing Composer Software](#)".

Acquiring a better understanding of the controller's overall functionality and capabilities while at the same time planning out how the controller can be used will deliver maximum effectiveness in your application.

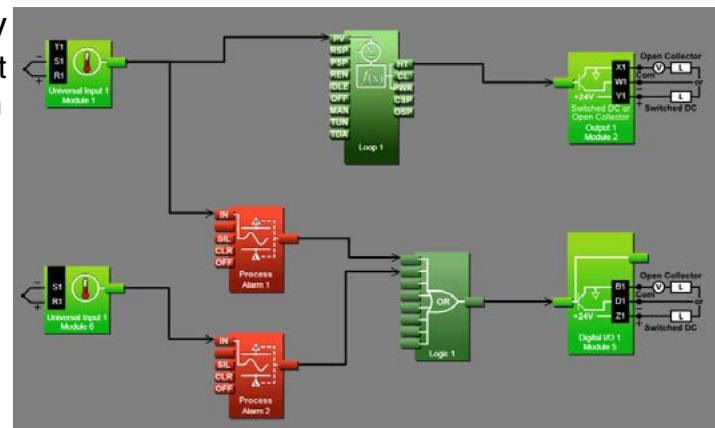


It is useful to think of the controller in three parts: inputs, functions and outputs. For the control itself, information flows from an input to a function to an output when the controller is properly configured. The F4T® system can carry out several functions at the same time; such as, monitoring and acting upon various inputs (temperature sensing devices, pressure transducers and digital inputs), PID control, monitoring for several different alarm situations and then driving output devices such as heaters, audible alarms, and lights. Each process needs to be thought out carefully and the controller's inputs, functions and outputs set up properly. As an example, the graphic below illustrates the Function Block Diagram as seen when using Composer software. The application requirements in this example are simple and defined below:

- Need two thermocouple inputs.
- Monitor both thermocouple inputs for high process alarms.
- Drive an output (alarm) device if either input is higher than expected.
- Use one thermocouple input to drive the PID loop (Heat output) with a switched DC output.

In the graphic below the following is true:

- Universal Input 1 is connected to the Process Value (PV) input of the control loop.
- When the control loop sees that the PV is less than the user defined set point it will drive the output to the load through its heat (HT) output.
- Two unique high process alarms are configured to monitor Universal Inputs 1 and 2.
- The logic function block (FB) is configured as an OR where its output will come on if either input comes on driving the real-world digital output (alarm) it's connected to.



Note:

In this configuration, the heat output of the control function would be uninterrupted if an alarm were to occur.

You will find more detailed information regarding the function blocks and how they work further on in this document.

Inputs

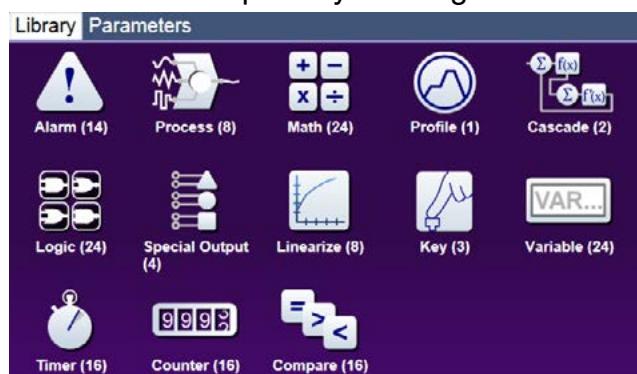
The inputs provide the information that any given programmed function can act upon. In a simple form, this information may come from an operator pushing a button, or as part of a more complex function it may represent a remote set point being received from another zone.

Each universal input can be configured for thermistors, thermocouples, or RTDs to read the process variable. They can also read mV/volts, current or resistance, enabling usage of various devices to read humidity, air pressure, operator inputs and other values. The settings associated to each analog input must be configured to match the device connected to that input.

Each digital input reads whether a device is on or off (voltage or resistance) and each system can be equipped with multiple digital I/O modules. Each I/O point must be configured to function as either an input or output.

Functions

Functions use input signals to calculate a value and/or performs an action. A function may be as simple as reading a digital input as on or off, or reading an analog value (temperature) to set an alarm state to on or off. As an example, a user could use sensor backup to avoid an unwanted shutdown if a failure with the primary sensing device should occur.



Keep in mind that a FB can be a purely internal function (i.e., control loop, alarm, logic, etc...), while they can also serve as a connection point between real-world devices

(i.e. thermocouple, heater etc...) and internal functions like a Universal Input connected to the Control Loop PV input. To have an effect outside of the controller, an output FB must be configured to respond to some other function. Functions and all associated dependencies would be configured using Composer software. To learn more about setting up function blocks see Chapter 2 of this document in the section titled "[Configuring the Application with the Function Block Diagram View](#)".

Outputs

Outputs respond to information provided by a function such as, heat power from the output of the control loop, driving a digital output based on a profile event, turn a light on or off, unlocking a furnace door or turning on a buzzer.

More than one output can be assigned to respond to any given function, i.e., more than one output device could be connected to the heat output of the control block. Another example (not shown), could use the (internal) output of the alarm function and connect it to any available real-world output to trigger a flashing light and another real-world output that might be connected to a siren.

What is a Profile

A profile is a set of instructions consisting of a sequence of steps. When a profile runs, the controller automatically executes its steps in sequence. The step type determines what action the controller performs. Steps can change temperatures and other process values gradually over time, maintain the temperatures and process values for specific periods, or repeat a sequence of steps numerous times. At each step the profile can activate or deactivate outputs that control other equipment. Also a step can have the controller wait for specific conditions before proceeding such as, waiting for a switch closure and/or a specific process value to be detected by a sensor.

Data Logging

Controllers equipped with this feature will have the letter [J, K, L or M] in the fifth character of its part number (see: F4T® Ordering Information). Logging can be enabled at any time and is intended to capture real-time data for a user selectable list of data points. With firmware revision 3.0 and above, several new features are available.

1. User can determine if logged files will be moved automatically and or manually.
2. Destination of the saved file can be directed to internal memory, USB thumb drive, TFTP server or a Samba shared drive.
3. Based on user choice, files can now be encrypted (filename.enc) for security purposes and or saved as comma separated values (filename.csv). Creating both file types allows viewing of the csv file while maintaining the integrity of the encrypted file.

To learn more about configuring these options see the section in this user's guide entitled [Setting Up Data Log Files Using Composer](#).

2

Chapter 2: Composer® Software

Controller Configuration and Setup

Installing Composer® Software

Locating the Software and System Requirements

Composer software is included on the "Watlow Support Tools" DVD which ships with the product. As an alternative, the software can also be downloaded at: <https://www.watlow.com/f4t>. In order to install and run this software successfully there are some baseline requirements for PC hardware and operating systems that must be observed. These requirements are listed below:

- 250 Megabytes or more of available hard disk drive space
- 300 Megabytes of available RAM
- Supported operating systems include: Windows® 7 / 8 / 8.1 / 10 (32 or 64 bit)
- Requires Microsoft® .NET Framework 4.0 (this installs automatically if not already on target machine)

Installing the Software

To install the software:

1. Double-click the Setup.exe.
2. Select the language of choice and click the **OK** to proceed.
3. Click the **Next** button to proceed.
4. After reading the Composer® software license agreement click the **I accept the terms in the License Agreement** radio button and then click on the **Next** button to proceed.
5. The next dialog box that will appear shows the default directory in which the software will be installed. The install location can be changed by clicking the **Browse** button and then point to the preferred location.
6. Click **Next** and then **Install**.
7. Clicking the **Finish** button will conclude the installation.

Note:

If experiencing difficulties installing or using Composer software, prior to contacting Watlow technical support, be prepared to send the user log file to the tech support team. This text file can be found here: C:\Users\username\AppData\Roaming\Watlow\Composer\Logs

The red text above will change to the user's Windows login name.

Using Composer® Software

Connecting the PC to the Controller (System) - Physical Connections

Physical connections (hardware and cabling) will vary depending on the controller in use.

1. To find instructions connecting an F4T® controller to a PC see: Chapter 3 of the F4T® Installation and Troubleshooting User's Guide.
2. To find instructions connecting a Rail Mount (RM) control to a PC see: Chapter 2 Install and Wire, of the RMC Module User's Guide

Starting Composer Software:

1. Click the **Start** button and then type composer.exe in the search box.

Composer Welcome Screen Orientation

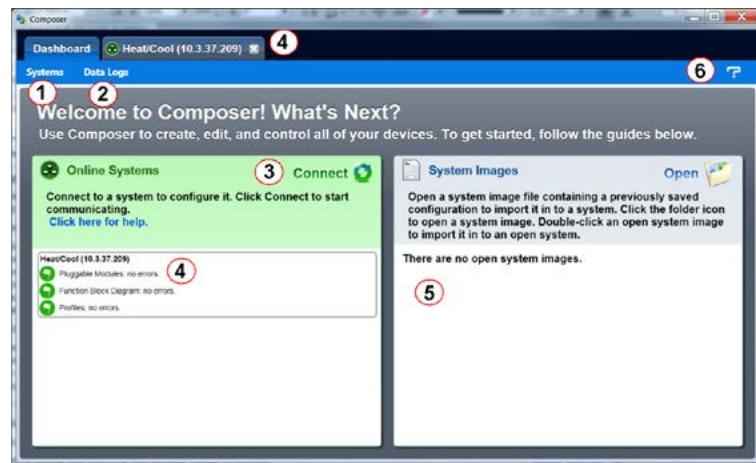
The graphic below illustrates and defines some points of interest as seen on the Composer Dashboard screen and describes the functionality, numbered correspondingly.

Dashboard (Systems)

- Displays options for online connections between PC and a controller or opening previously saved system image.

Data Logs Menu

- Decrypt Log File: allows for decryption of an encrypted data log file.
- View: displays the contents tents of a data logged file (enc or csv). Depending on files size this may take several minutes to open.



To decrypt an encrypted file follow the steps below:

1. If data logging has not yet been stopped do so now by pushing: **Main Menu -> Data Logging -> Stop** buttons.

Note:

When data logging is stopped, allow at a minimum, six minutes for closure of all files and movement of those files to the selected destination before attempting decryption.

2. Open up Composer software and click on **Data Logs** and then **Decrypt Log Files**.
3. Locate the encrypted files and open them one-by-one (click on one *.enc file and click **Open**), or by selecting more than one and click the **Open** button.

Note:

If logged file is sent to USB, the *.csv and the *.enc file are written directly to USB constantly. If the File Size Limit is set to 10MB or larger, the csv will continue to be written continuously while the encrypted portion (*.enc) is chunked into 7.5MB files, buffered internally and then written out as 7.5MB chunks. If the maximum file size is set to 10MB, there will be two *.enc files for each csv (7.5MB and 2.5MB). If File Size Limit is set to 15MB, there would be two 7.5MB *.enc files for each *.csv file.

Note:

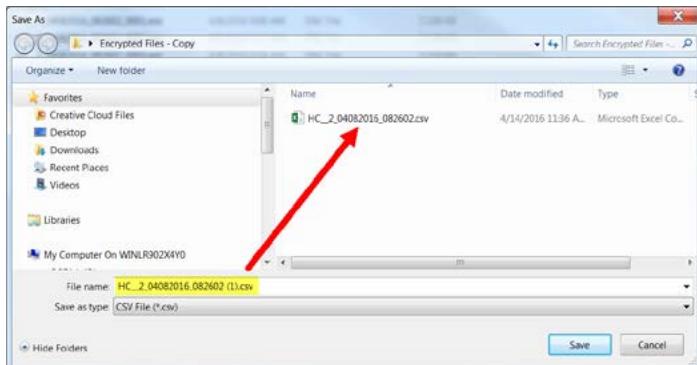
As noted above, if a csv file is greater than 10MB there will be more than one

encrypted file for the associated csv file. When decrypting these files, it is recommended that all encrypted files be selected in the decryption process. Each of the encrypted files will be concatenated into one csv file.

4. After selecting the desired encrypted files and then clicking **Open**, the window below will appear. Notice the filename of the original csv and the one suggested in the dialog box highlighted yellow below. The one within parentheses (1) is inserted to avoid overwriting the original csv file. You may name the file to your liking.

Note:

The largest file size allowed is 1GB. If decrypting a file of this size it could take up to 10 minutes to complete.



Connect to a System

- Opens a window showing all available communications ports.

Online Systems

- Displays all connected systems.

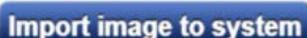
Open a System Image

- Opens a dialog box showing the default folder structure.



To import a system image follow the steps below:

1. Connect to the desired online system described above
2. Click **Open** to search storage device and find the desired system image
4. Double-click on the desired system image
5. Once the system image is opened click on the button below:



6. Select the system to be configured and click **continue**

Note:

Use caution when considering this option, once initiated, controller memory will be overwritten in its entirety and replaced with the new system image.

System Images

- Displays all opened system images.

Question Mark (?)

- Allows a user to do the following:
 - Update Settings, Change automatic software update settings
 - Check For Updates, Initiate an immediate check for software updates (internet connection is required)
 - Dashboard Help, Provides description and information pertaining to the Dashboard
 - About, Displays technical support contact information as well as the current versions of the installed software and installed modules.

Overview Screen

Topics discussed in this section follow:

[Connecting to an Online System](#): from the Dashboard connect to an online system.

[Overview Screen Orientation](#): visually identifies all devices connected to the system.

[System Menu](#): when clicked, a drop down submenu will appear.

[Device Menus](#): when clicked, a unique drop down submenu will appear for each device or controller on the system. The menus provide access to device specific screens.

[Global Settings](#): set temperature units and AC line frequency for the system (all controllers).

[Security](#): allows for multiple levels of password protection.

[Saving a System Image](#): save a system image to a storage device.

[Import System Image](#): restore a system image from a storage device to the controller.

The graphic below, shows the first displayed screen (System Overview) after connecting to a system.

Connecting to an Online System

To connect to a system:

1. On the Dashboard screen click Connect.
2. Select the communications port that the system is connected to and then click Continue.
3. Double-click on the desired online system.

To view the system overview:

1. On the Dashboard under Online Systems, double-click the desired system.

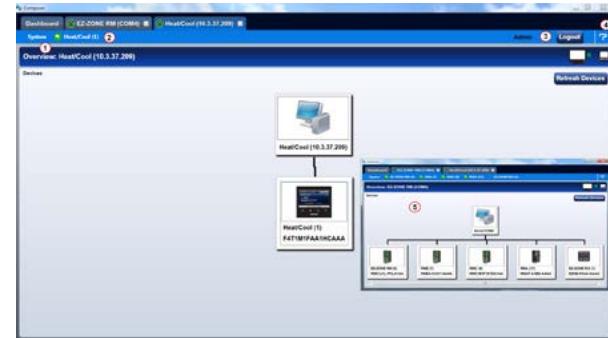
Overview Screen Orientation

The graphic below illustrates and defines some points of interest as seen in the system overview with each identified by a corresponding circled number. Further information for each can be found just below the orientation.

This screen can be accessed from within any Composer® view always rendering a visual display of all devices connected on the system while also providing navigation to and from each device.

System Menu

- Overview: displays the screen shown at the right.
- Save Image: saves a previously saved system image using the same name folder and the same destination folder.
- Save Image As: saves system image with a new name to the user specified folder.
- Import Image: select a previously saved system image to download to the device.
- Print: active when viewing the function block diagram. What's printed will be exactly what can be seen on the canvas. If all FBs are not visible, scale the canvas using the Navigator plus and minus buttons and then click the System tab and then Print.
- Global Settings: for use throughout the controller changes settings for Temperature units, AC Line Frequency, and Date and Time.
- Security: allows the administrator to determine and set security privileges to avoid unwanted changes.



Device Menus

- When clicked, a drop down submenu will appear allowing navigation to device level menus. Each device will have one of three flags displayed immediately to its left. Those flags are described in the following table.

Symbol	Menu Item	Description
	Pluggable Modules	All expected modules and no unexpected modules are present (F4T® only).
	Function Block Diagram	No signals have errors.
	Pluggable Modules	A module has been detected in a slot the controller expects to be empty (F4T® only).
	Function Block Diagram	At least one unexpected module has been detected, however, all expected modules are present.
	Profile Editor	One or more of the profiles were created for a different configuration and cannot be run (F4T® only).
	Pluggable Modules	At least one expected module is missing (F4T® only).

Security

- When enabled, displays current level of access with the ability to logout.

Question Mark (?)

- Provides help for each of the options mentioned above.

Inset Picture of Rail Mount (RM) modules connected as a system.

Global Settings

Each of the settings below will be used and applied throughout the controller.

- Temperature Units: will determine how the temperature is displayed (Fahrenheit or Celsius) on the front panel of the controller as well as throughout all configuration screens within Composer®.
- AC Line Frequency: set this to the line frequency of the power applied to loads such as heaters (50 Hz or 60 Hz) so that the current sensing and variable time-base features will work correctly.
- Date and Time: sets the date, time and time zone to the current computer settings or whatever the user enters.

Security

The security feature is used to protect the system's configuration and settings from unwanted changes. The Admin user sets what access other users have to the system's features. When security is enabled, a user must enter a password to gain access to protected features through the controller's user interface or Composer software.

There are three configurable user groups and an admin account:

- User: no password required, Admin sets feature access
- User with Password: requires a password, Admin sets feature access, is permitted to change the password for this user group.
- Maintenance User: requires a password, Admin sets feature access, is permitted to change the password for this user group.
- Admin: requires a password, has unlimited access to features, sets permissions and passwords for all user groups.

The Admin user can set permissions for each user group to allow full, read-only or no access to the following features:

- Home: controls access to controller's home screen.*
- Control Mode: controls access to setting the control mode, set points and PID parameters.
- Autotune: controls access to running the autotune feature.
- PID Settings: controls access to the PID settings.
- Profiles: controls access to creating and editing ramp and soak profiles.
- Global Settings: controls access to the system's global settings, temperature units, AC line frequency and real time clock setting.
- Network: controls access to communications settings.
- Operations: controls access to operational parameter settings.*
- Personalization: controls access to customizing the controller's home screen.
- Data Logging Setup: determines frequency of logging, location of saved files and other general information.
- File Transfer: allows a user to transfer files (Configuration, Profile and Data log) to/from the controller.

- Diagnostics and Troubleshooting: controls access to the device details and calibration.
- Setup: controls access to the pluggable module configuration and the function block diagram.

*This setting limits access to the controller's User Interface (UI) only, not via Composer®.



Note:

After making all of the desired security settings, ensure that the security enabled radio button (top left in the graphic above) is selected Enabled.

Note:

If the passwords have been misplaced or forgotten it will be necessary to contact the OEM or as a last resort [Watlow Technical Assistance](#).

Note:

Once security is applied to the controller, only the administrator (Admin) can reconfigure or remove the security.

Note:

When the system file is saved, any applied security will be saved with it.

Save Image

After clicking on save image as, the save button will become active (gray to white). This allows a user to make changes to the system image and simply save it to the same location using the same filename. Everything that will be saved is as listed below:

- Device Details
- Pluggable Modules (F4T® only)
- Function Block Diagram in its entirety
- System Security
- Profiles (F4T® with profile option only)
- Profile passwords (F4T® with profile option only)
- All parameters that can be read and written to

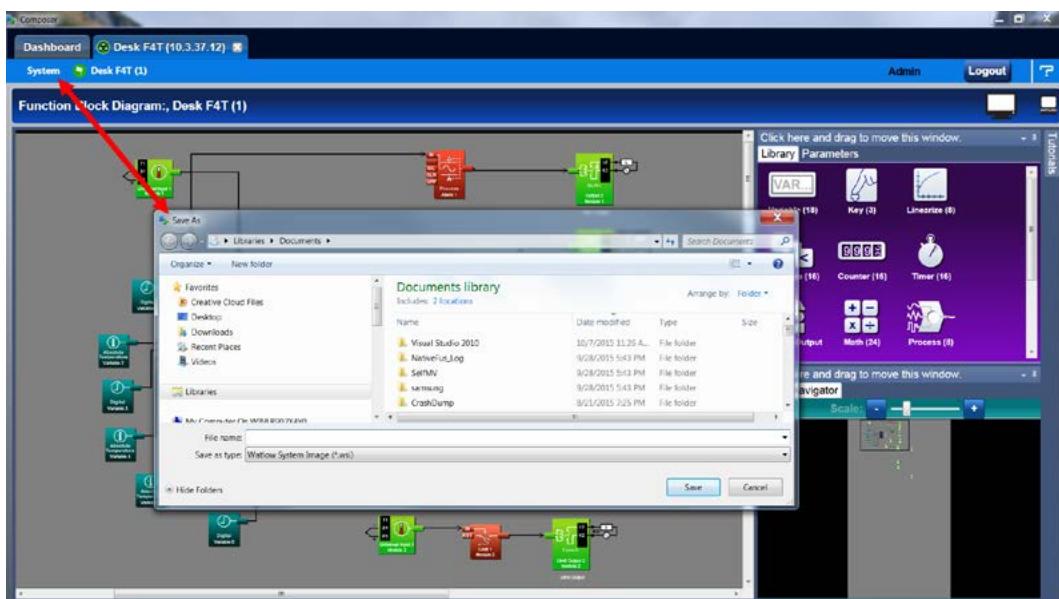
Save Image As

- Allows user to specify a name and storage location while saving everything in the list above.

Saving a System Image

To save a system image the first time:

- From any screen click on the System Menu tab to drop down a submenu.
- Click the **Save Image As** button.
- Use the save as dialog to select the destination folder for the image.
- Enter the desired filename.
- Click **Save**.



Note:

The system image filename will always have the extension wsi for Watlow System Image and cannot be changed.

Note:

The real-time clock values are not saved or imported.

Import Image

- Restore a system image from a storage device to the controller. The list below shows what is restored:
 - Device Details
 - Pluggable Modules (F4T® only)
 - Function Block Diagram in its entirety
 - System Security
 - Profiles (F4T® with profile option only)
 - Profile passwords (F4T® with profile option only)
 - All parameters that can be read and written to

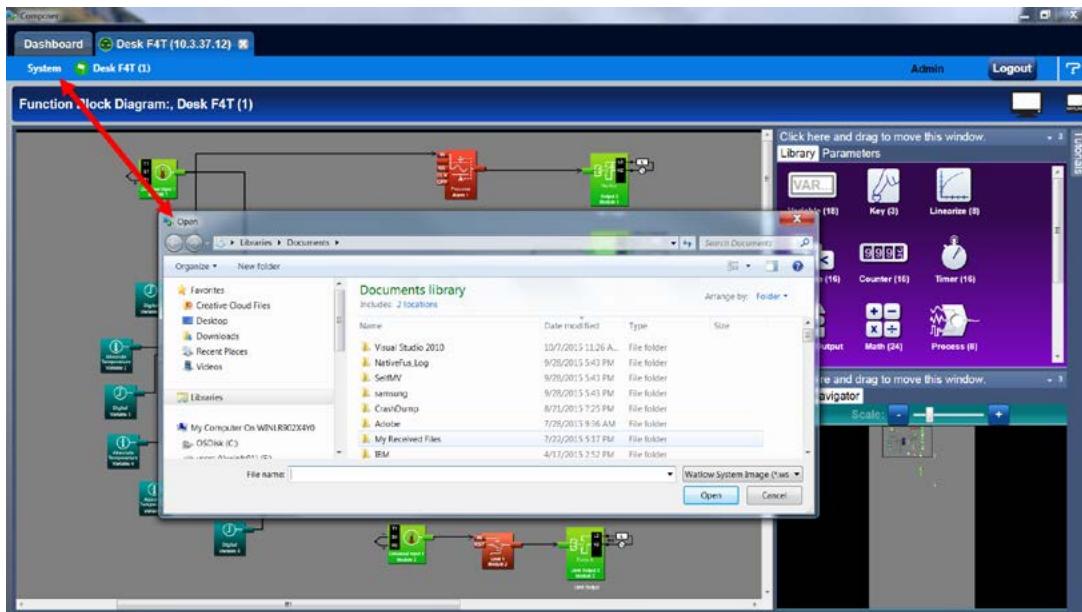
Importing a System Image

To import a system image:

1. From any screen click on the System menu tab to drop down a submenu.
2. Click the **Import Image** button.
2. Use the open dialog to select the folder location for the previously saved system image.
3. Double-click the desired filename or single-click the filename and then click the **Open** button.

Note:

Importing a system image will overwrite the controller in its entirety. Careful thought should be applied prior to importing.



Device Details

The Device Details allows a user to make changes to the system settings described below. Descriptions are numbered correspondingly in the graphic that follows.

Navigate to Device Details:

1. From any screen click on the Device menu tab to drop down a submenu.
2. Click the **Device Details** button.

Device Name - change the name (32 characters maximum) of the controller for easy identification.

Note:

This name will also be displayed in the upper left corner of the user interface.

Restore Settings From

- None: no action.
- Factory: allows a user to bring the controller back to the factory default state.



Configuring Pluggable Flex Modules

This controller can have up to six Flex Modules (FM) installed in the chassis. The presence of each FM must be confirmed and accepted using Composer® software. FMs can be fully configured as installed hardware or the user can type in a valid FM part number for late installation. For more detail regarding the module installation process, see the Installation and Troubleshooting User's Guide for the controller in use.

Note:

Typing in a valid part number without the presence of the module is intended for the sole purpose of building the FBD (connecting function blocks on the canvas). Errors may be generated and all outputs will be off until the module is inserted.

Topics discussed in this section follow:

Screen Orientation: detailed description of the Pluggable Module configuration screen and associated characteristics.

Symbols Related to Pluggable Modules: description of the symbols that may be displayed when using Composer software.

Configuring Flex Modules: configuration process described.

Entering FM Information Before Module Installation: detailed description of the why and how a user would do this prior to acquiring the module.

Note:

The graphic below represents a controller that first had its flex modules installed with the controller then being connected to a computer. Because of this scenario each slot appears with no expected modules. This screen and symbols that are displayed will look different using a different scenario.

Navigate to Pluggable Modules screen:

1. From any screen click on the Device Menu tab to drop down a submenu.
2. Click the Pluggable Modules button.

Pluggable Flex Modules - Screen Orientation

Module Slot - Location

- The blue box (on the right) and the slot highlight will move with the mouse to bring focus to the slot/module.

Use Detected Part Number

- Click this button to accept the module that the system sees as being present in the slot and displayed in the field identified as "Detected Part Number".

Set Expected To None



- Click on the X to tell the system there will be no module installed in this slot. Taking this action will turn the power off for this slot after the controller is reset.

Detect Modules

- The controller will shut off all outputs and initiate an evaluation of each slot to see if any modules are present.

Note:

In the graphic above, if a module were inserted in slot 3, clicking detect modules will turn the power on for the slot and report back with the module part number installed.

Finish

- Will cause the controller to restart and take the user to the Function Block Diagram.

Note:

There are some FM slot dependencies. If there is a question as to whether or not an FM is in an acceptable slot, refer to the Installation and Troubleshooting Guide for the controller in use.

Symbols Related to Pluggable Modules

As viewed from the Menu bar, the symbol that will be displayed to the left of the Pluggable Modules button will be of the most significance. The red exclamation will always take precedence.

Symbol	Description
	The expected module has been detected.
	No module has been detected in a slot the controller expects to be empty.
	A module has been detected in a slot the controller expects to be empty.
	The controller expects a module, but that module is missing or a different module has been detected.

Configuring Flex Modules

To accept the detected modules:

Note:

If modules were plugged in after powering up or resetting the controller, click on the **Detect Modules** button to restart the controller and detect all of the modules that are present.

- On the right side of the screen click the **Use Detected Part Number** button.
- Repeat step 1 for each slot to be configured.
- Click the **Finish** button to restart the controller and exit to the Function Block Editor.

Note:

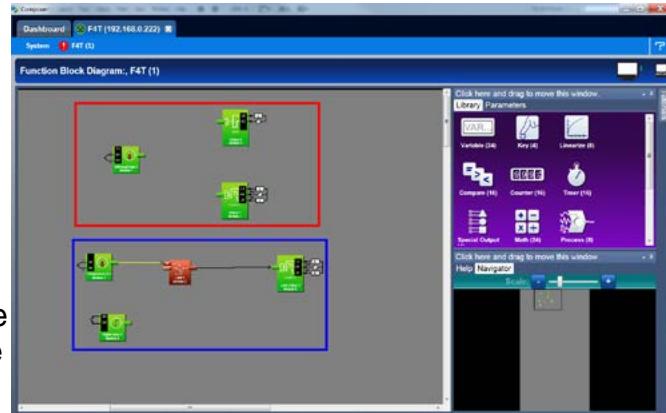
Exiting the pluggable modules screen after any changes are made will cause the controller to restart. A restart will stop all controller activities while turning off all outputs.

Entering Flex Module Information Prior to Installation

Function blocks associated with hardware will not be available until the hardware is expected to be present. Entering a part number for any slot (even though the module is not currently installed) allows the programmer access to the associated function blocks. As an example, if an FMMA-UEKA-AAAA is installed in slot one, the function blocks that would be available are shown in the red box. After entering a part number such as FMLA-YEBA-AAAA in slot 2, additional hardware dependent function blocks will appear as shown in the blue box.

Note:

When configuring modules as described above (not installed), the controller will not be able to control any outputs. All outputs will be off.



To configure the controller to expect a module that is not yet installed:

1. Select the desired slot and enter a valid part number in the Expected Part Number field.
2. On the keyboard, push the Enter key.
3. Click Finish when complete to restart the controller. After the restart process is complete the Function Block Diagram will appear.

Once the module is acquired, simply plug it into its assigned slot and click the Detect Modules button. After doing so, the controller will restart and a green flag  will be displayed for that slot number.

Configuring the Application using the Function Block Diagram

The Function Block Diagram (FBD) view is used to connect the real-world inputs and outputs to internal controller functions, such as alarms, control loops and ramp and soak profiling.

To enter the Function Block Diagram:

1. Click on the desired Device menu.
2. From the drop down menu click Function Block Diagram.

Topics discussed in this section follow:

[Screen Orientation](#): detailed description of the FBD screen and associated characteristics.

[Customizing the FBD Environment](#): change default canvas settings to user preference.

[Window Anchor Points](#): defines a new docking location.

[Getting Started](#): things a user will encounter on the canvas while building the application.

[Selecting and Placing FBs on the Canvas](#): describes where to find and then place selected FBs on the canvas.

[Moving FBs on the Canvas](#): describes how to move selected FBs on the canvas.

[Connecting FBs Together](#): describes how to make the application come to life by interconnecting FBs.

[Viewing Signal Values and Errors](#): describes how to view signal values and errors as they occur.

[Troubleshooting Signal Errors](#): suggestions in how to evaluate a signal error.

[Adjusting FB Behavior with Parameter Settings](#): change the functionality of a FB based on its parameter settings.

[Finding Help for FBs](#): describes how to acquire embedded help for each FB.

[Changing and Deleting Signals](#): making modifications to the program through new and revised FB connections.

[Removing FBs from the Canvas](#): describes how to delete FBs on the canvas.

[Using Auto Hide](#): maximize visibility of available screen space by hiding infrequently used windows.

[Floating a Window](#): move a window from its docked location to a user defined location.

[Docking a Window](#): describes how to create new or return to previous docking locations.

[Turning Floating Windows Off and On](#): describes how to enable and disable floating screens.

Function Block Diagram View - Screen Orientation

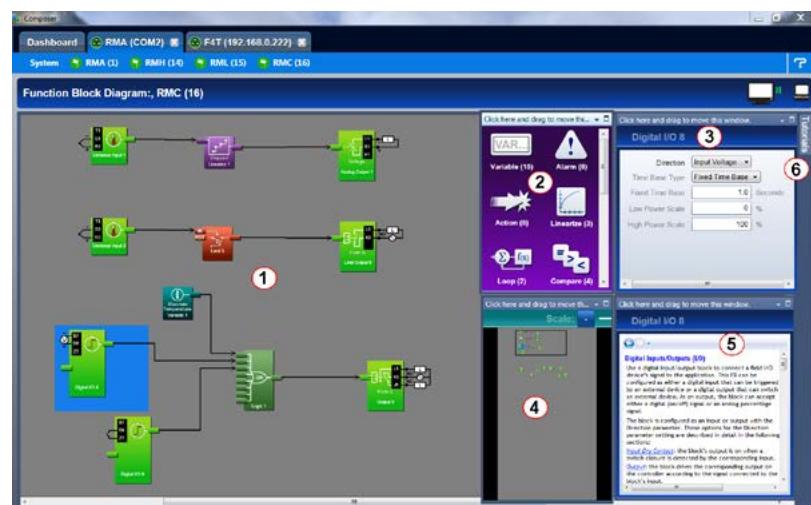
The FBD View has the following features, numbered correspondingly in the graphic below.

Function Block Diagram

- All FBs are placed and connected on the canvas.

Function Block Library

- Shows the available FBs for this controller. The number below each icon indicates how many FBs of that type remain available for use with this controller. As is displayed in this graphic, this window is movable and dockable.



Parameter List

- Used to view and set the FBs parameters customizing its behavior for the application. This window is movable and dockable.

Navigator

- Allows the user to adjust the view of the canvas. Drag the box to reposition the view.
- Use the slide bar or the min-plus and plus buttons to adjust the zoom level. This window is movable and dockable.

Help

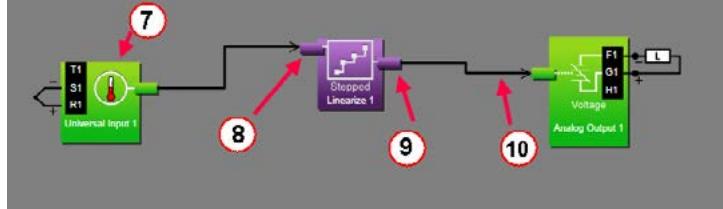
- To view detailed FB information click on any FB. This window is movable and dockable.

Tutorials

- Topic based video help files.

Function Blocks (FBs)

- Allows the user to customize the functionality of the controller for a specific application. Some FBs are interfaces to real-world I/O devices and some serve as the interface to internal functions such as, the compare, logic and math FBs.



Receiver

- The part of a FB to which a signal can be connected in order to supply data to the function.

Transmitter

- The part of a FB from which a signal can be connected in order to carry data to another FB.

Signal

- A line that represents the connection of data from one FB to another.

Customizing the Function Block Diagram Environment

The Parameter, Help, Library and Navigator windows can be moved from their default locations to allow a user to maximize the visibility of the FBD diagram. See the procedures below regarding how to float, hide and dock these windows.



Window Anchor Points

While dragging a window or a grouping of windows to a new docking location Anchor Points will appear on the screen. The anchor points in the graphic are numbered corresponding to their associated descriptions below:

- Drag the window here to add to the window group.
- Drag window here to dock above the window group.
- Drag window here to dock to the right of the window group.
- Drag window here to dock at the right of the screen.



Getting Started with the Function Block Diagram (FBD)

The basic steps for creating the function block diagram for any application are:

- Add the function blocks from the library to the canvas that are needed to interpret the signals from the physical inputs and set the physical outputs. Typically, these will include Loop, Alarm and Profile Engine function blocks.
- Connect the transmitters on the FBs that source data to the receivers on the FBs that need the data.
- Set each function block's parameters as needed for the application to perform as expected.

Detailed descriptions of each function block including all the function block's parameters can be accessed in the online help for the function block and in the User's Guide, chapter entitled Function Block Reference.

The FBs that represent the physical inputs and outputs from the controller and are associated with the flex modules that are expected in the configuration are always on the canvas. These FBs can only be removed by changing which modules are expected using the Pluggable Modules view.

Other FBs can be added to the canvas from the library. Some of these FBs such as Loop, Cascade, Alarm and Profile Engine perform sophisticated functions. See the Application Examples chapter in this User's Guide for more on these functions. Other function blocks such as Math and Logic perform fundamental functions that can be combined to add custom behaviors to the controller for specific applications.

The signals that carry data between function blocks normally appear as black lines in the diagram, but when the block that transmits the signal cannot determine what the correct value should be, the signal changes to yellow indicating the error. Each FB's response to errors received is explained in the description of the function block.

Warning:

Once an output FB receiver is connected to another block, the output on the flex module turns on according to the received signal. Do not connect outputs until it is safe to do so.

Notable facts about the FBD:

- How a FB responds to its inputs and drives its output is dependent on its parameter settings. Set the parameters for each function block as needed for the application.
- Signals cannot be moved after they are created; to change where a signal gets data or where it delivers it, delete the signal and create the desired connection.
- There are several ways to do many things. Try right-clicking to see options or short cuts.
- FBs from the library that have no signals connected are returned to the library when Composer® is closed.
- The location of dockable windows is not saved; windows return to their default locations when the system is closed.
- The selection of signal values displayed in the diagram is not saved; all signal value displays are turned off when the system is closed.

Hints:

- Click-and-drag any blank spot on the canvas to change the view.
- Use the scroll bars.
- Use the Navigator to reposition the view of the canvas and to zoom in or out.
- Use the mouse wheel to scroll the view. Hold the shift key to use the mouse wheel to pan. Hold the Control key to use the mouse wheel to zoom.

Selecting and Placing Function Blocks on the Canvas

To place a FB on the Canvas:

1. Find the desired FB within the library (using scroll bars if present).
2. Click-and-drag the FB to the canvas.

Moving Function Blocks

To move a FB on the Canvas:

- Click-and-drag the FB to the desired location on the canvas.

Hints:

- Click the main body of the FB not one of its transmitters or receivers. Clicking a transmitter or receiver begins to draw a signal rather than move the FB.
- The canvas will scroll if the mouse pointer is close to the edge but not outside the diagram window.
- To make a long move, click the block to select it, then zoom out to make it easier to move the block to the desired location.

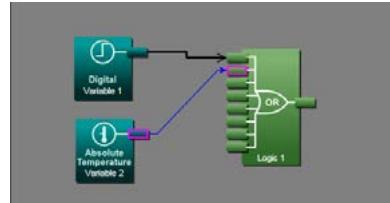
Connecting Function Blocks Together

To connect a transmitter to a receiver:

- Click and drag a signal from a FB's transmitter to a receiver on another FB.

Hint:

- This can also be accomplished in reverse, i.e., click and drag from a receiver to a transmitter.



Viewing Signal Values and Errors

To momentarily display a signal's value:

- Mouse over (point the mouse cursor at) the signal.

To display a signal's value continuously:

1. Right-click the signal.
2. Click Show/Hide Data

To cancel (turn off) the signal display:

1. Right-click the signal.
2. Click **Show/Hide Data**

Note:

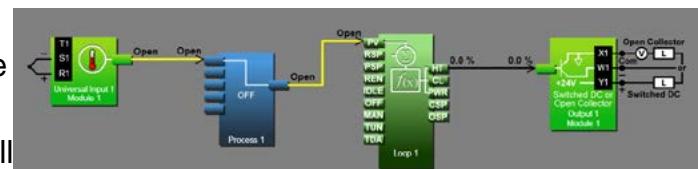
The values displayed are not in real-time.

Troubleshooting Signal Errors

While building the FB diagram, or during operation, there may be occasions when the signal from the transmitter of a FB is displayed yellow. This may reflect that the FB has encountered an error or some other anomaly has occurred. From the user perspective, an evaluation of the cause should be done to ensure that unexpected operation does not occur. Suggested steps to evaluate the cause of a yellow link are listed below:

To evaluate the cause of a yellow signal:

1. Trace the yellow signal back to the source (first occurrence of a yellow link) FB.
2. Place the mouse over the signal which will display the error.
3. In this particular example, the error is identified as an Open sensor.
4. Click on the selected FB and view the Help window.
5. Search ("Ctrl-F") the help file for the word "Open".
6. Once found, evaluate, make note or correct the cause of the problem.



If further assistance is needed review the associated product User's Guides or contact the Watlow Technical Support team (1-800-492-8569 or 1-507-494-5656).

Adjusting Function Block Behavior with Parameter Settings

To change a FB parameter:

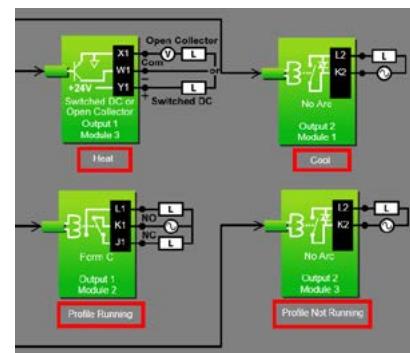
1. Double-click on the FB.
2. In the Parameters window locate and change the parameter.

Note:

If names are applied here, those names will appear on the FBD and if selected, the output view of the Personalization screen.

Select the content for each position on the output view:

	1: Heat	2: Cool Output
	3: Profile Disable	4: Manual On/Off
1 2 3 4		



Finding Help for Function Blocks

To locate the help topic for a FB on the Canvas:

- Click the FB and view the help window.

Hints:

- Many function blocks can be configured to perform one of several functions. For these FBs, the help topic has a section for each function. Locate and click the link for the desired function.

Changing and Deleting Signals

To delete a signal:

1. Click the signal to select it.
2. Press the **Delete** key on the keyboard.

Note:

To change where a signal connects, first delete it then make the desired connection.

Removing Function Blocks from the Canvas

To remove a FB from the Canvas:

1. Delete all signals connected to the FB.
 2. Click the FB to select it.
 3. Press the **Delete** key on the keyboard.
-

Using Auto Hide

To toggle the auto hide option for a window or a group of windows:

- Click the pin (auto hide) icon in the window's title bar.

To use a window that is hidden:

- Mouse over (point the mouse cursor at) the window name.

Floating Windows

To float a window or a group of windows:

- Click-and-drag the window's title bar to the desired location.

To separate a window from a group:

- Click-and-drag the window name to the desired location.
-

Docking Windows

To return a floating window or a group of windows to its previous docking location:

- Double-click the title bar.

To change where a window or a group of windows is docked:

1. Click-and-drag the window's title bar until the anchor points appear
2. Drag the window until the mouse pointer is at the desired anchor point.
3. Release the mouse.

Hint:

- Some anchor points dock the window at the sides of the FBD view and others dock or group the window with other windows.

Turn Floating Windows Off or On

To avoid the possibility of inadvertent window movement, this feature can be turned off.

To turn floating windows off:

- Right-click anywhere on the canvas and choose **Turn off float** in the pop-up menu.

To turn floating windows on:

- Right-click anywhere on the canvas and choose **Turn on float** in the pop-up menu.

Personalizing the User Interface (UI) Using Composer®

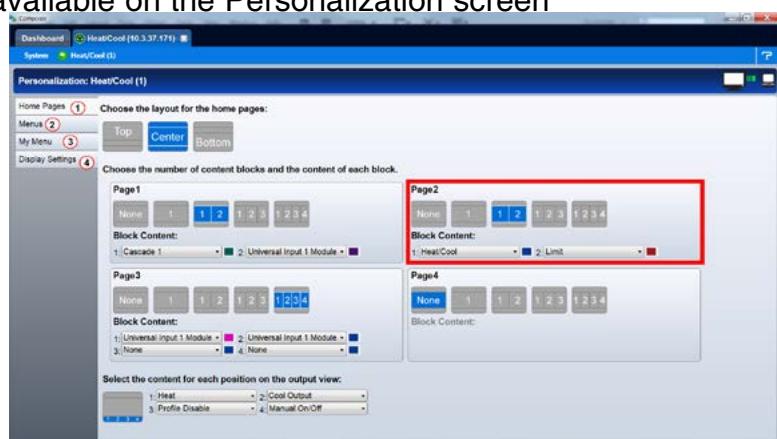
The home screen of the F4T® controller can be personalized to show multiple pages and multiple content blocks within each (4 maximum). Until personalized, the home screen will be blank. Features that are available on the Personalization screen are numbered corresponding to their associated descriptions below:

Home screen can be modified in accordance with installed hardware and named FBs on the FBD.

Modify user interface (UI) button colors.

Create a customized menu to be viewed on the UI.

Change the user interface screen brightness.



To personalize the home screen:

- From the device menu choose **Personalization** from the drop down menu.

Much, if not all of what is displayed on the home pages comes from the FBD. Therefore, it would make sense to first configure the FBD prior to personalizing the home screen.

The personalization settings shown above would produce a home page like the one below. Because it was the second page configured as shown above (red box), notice the arrow buttons on the right and left of screen capture below allowing navigation to page 1 and 3.



Setting Up Data Log Files Using Composer®

Data Logging can be enabled at any time and will log a user selectable list of data points. While data logging is enabled, the data log file is stored within either the USB device memory or internal memory. Once the file reaches a specified size (if being transferred automatically), it will be sent directly to one of three other destinations (USB, TFTP server or a Samba server). The file transfer can also be initiated manually at any time. The file transfer process from internal memory, whether completed automatically or manually, will move all log files from internal memory to the selected destination. To learn more about data logging see "Data Logging" in the Overview Section of this User Guide.

Note:

Data logging can also be enabled/configured through Modbus. There are specific Modbus registers for each of the parameters defined below.

Topics discussed in this section follow:

[Setup Data Logging](#): discusses required fields that must be set prior to starting data logging.

[Configuring a Samba Shared Folder](#): identifies and gives illustrations in defining the necessary user account and the shared folder.

[Configuring a TFTP Server](#): details required setup fields while illustrating steps to successfully move files from the F4T® to the TFTP destination.

Note:

Data logging is terminated when power is lost while the data log file itself will be maintained where it was captured.

Setup Data Logging

To setup data logging, follow the steps below:

1. Click on the **Device Menu** tab.
2. From the drop down menu click on **Data Logging**.
3. Select and add all of the desired **Data Points** for the data log file.

Note:

Selected data points will be used whenever data logging is enabled.

4. Click on the **Setup** button.
 - Logging Status: indicates whether or not recording is active or not.
 - File Name: any alphanumeric characters, 63 maximum.

Note:

When transferring files via TFTP, do not create a file on the server called "testfile".

Communications between the F4T® and the TFTP server is tested prior to starting a transfer using this filename while then verifying the response from the server.

- Log To: USB or Internal Memory.

Note:

When transferring files via TFTP or Samba, internal memory must be selected here.

Note:

There are many USB memory devices available. Watlow does not recommend using micro SD or SD card to USB adapters in the USB slots. Be aware that we have not tested all of the variations of USB memory devices but we have tested and validated those that are listed below:

- Lexar, Kingston, Toshiba and Verbatim

Note:

Supported USB file systems: FAT16 and FAT32.

Note:

Due to wear-leveling operations of flash memory devices (internal - F4T® and external - USB), there may be some gaps within the data logged file.

Note:

If logged file is sent to USB, the *.csv and the *.enc file are written directly to USB constantly. If the File Size Limit is set to 10MB or larger, the csv will continue to be written continuously while the encrypted portion (*.enc) is chunked into 7.5MB files, buffered internally and then written out as 7.5MB chunks. If the maximum file size is set to 10MB, there will be two *.enc files for each csv (7.5MB and 2.5MB). If File Size Limit is set to 15MB, there would be two 7.5MB *.enc files for each *.csv file.

- Log Interval: defines the frequency in which the log will be written, 0.1 second to 60 minutes.
- File Type: Encrypted (filename.enc), comma separated values (filename.csv) or Both.
- File Size Limit: 20MB maximum when using internal memory, 1GB when using USB.
- Memory Full Action: when selected log to device is full, Overwrite or Stop.

Note:

Logging to USB allows for Stop only, when memory is full.

- Date Format: MM/DD/YYYY or DD/MM/YYYY.

Note:

Applies to each individual log entry alone, does not apply to filename.

- Time Format: 12 or 24 hour clock.

Note:

Applies to each individual log entry alone, does not apply to filename.

5. Click on the **File Transfer** button.

- Auto Transfer Type: None, TFTP, Samba or USB.

Note:

When automatic file transfer is enabled, the file as it's being created, will be buffered in internal memory. The file will be moved to its destination when it either reaches the maximum file size setting or the user stops data logging. If automatic transfer fails for any reason, data logging will continue and the files will be stored in internal memory until internal memory fills up. The setting for Memory Full Action (Overwrite or Stop) will then be implemented.

Note:

A user can initiate a file transfer manually at any time if one or more of the available destinations (USB, TFTP or Samba) have been configured.

- Samba User Name: Windows user account name with access to shared directory.

Note:

If using Asian fonts, you may need to create a Latin character set login for use with Samba transfers.

- Samba Password: Windows user account password.

Note:

If using Asian fonts, you may need to create a user, and password, using the Latin character set.

- Samba Path: shared directory path and name.

Note:

If using Asian fonts in the path name, please try using latin characters, or numbers as your folder name, and share name.

- Remote IP Address: the IP address of the remote computer.
- Remote Host Name: the name of the remote computer.
- Transfer Progress: when a transfer is initiated this will reflect its progress from 0% to 100%.

Note:

If an error were to occur, as described below, this value could exceed 100.

- Transfer Results, will return the enumerated values shown below:

Enumerated Value	Description	Possible Causes	Corrective Action
Blank	Nothing to report	<ul style="list-style-type: none"> Not configured, no activity. Transfer not initiated. 	- - - -
No Files to Transfer	No data log files in internal memory	<ul style="list-style-type: none"> Data logging has not yet been started. Files have already been moved from internal memory. 	- - - -
Transfer Complete	All data log files have been moved from internal memory	<ul style="list-style-type: none"> File transfer initiated and completed successfully. 	- - - -
Transferring Files	Data log files being moved from internal memory	<ul style="list-style-type: none"> File transfer initiated and in progress. 	- - - -
Server Down	Connectivity from client to server not present	<ul style="list-style-type: none"> Server not present. Server not configured or configured incorrectly. 	Samba <ul style="list-style-type: none"> Check and ensure user account info (name and password) is correct. Check and ensure that the shared folder name is correct and shared with the user account mentioned above. TFTP <ul style="list-style-type: none"> Ensure server is running and configured for read/write capability.
Need Host IP	IP address not present	<ul style="list-style-type: none"> No connectivity between PC and F4T®. Incorrect IP address entered. 	TFTP <ul style="list-style-type: none"> Verify a physical connection between PC and F4T®. Check the controller IP address from the F4T® front panel: push Main Menu > Settings > Network > Ethernet. Ping the F4T® to verify its presence on the network.
Need Host Name and IP	Missing host name or IP address	<ul style="list-style-type: none"> Not configured. Incorrect IP address or host name entered. 	Samba <ul style="list-style-type: none"> Ensure the computer name (Host) is correct. Click on the Windows Start button and type my computer in the search field. Verify IP address (see: Need IP Address above).
Error	File transfer did not occur successfully	<ul style="list-style-type: none"> TFTP server configuration not correct. 	TFTP <ul style="list-style-type: none"> Server not configured with overwrite capability, reconfigure server. Ensure server is not set for read only.
Check Directory Permissions, Host Name and IP Address		<ul style="list-style-type: none"> Not configured. Incorrect IP address or host name entered. Shared folder does not have correct permissions. 	Samba <ul style="list-style-type: none"> Ensure the shared folder name exists and that it is being shared with the user account (Samba User Name). Verify IP address (see: Need IP Address above). See the section entitled Configuring a Samba Shared Folder below.

Configuring a Samba Shared Folder

Samba, also known as Server Message Block (SMB)/Common Internet File System (CIFS), is fully supported by Windows File Sharing. Within this document, SMB/CIFS will be referred to as Samba.

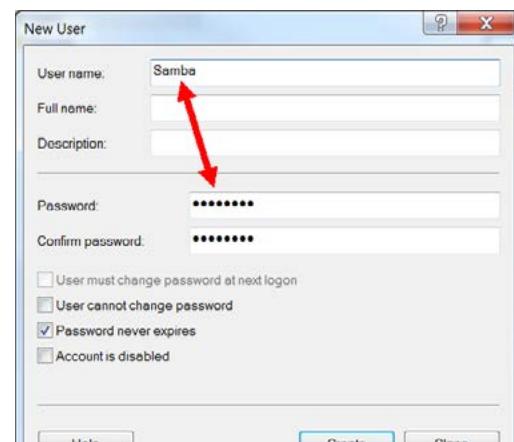
Samba, when in use, creates a directory on the F4T® device that maps to a shared directory on the user's PC. There are several ways that a Windows shared drive can be configured. With this in mind, one of those ways will be discussed and used for demonstration purposes below.

Note:

If a user account already exists with full Administrator rights, steps 1 through 12 can be skipped.

Setting up a Windows shared drive:

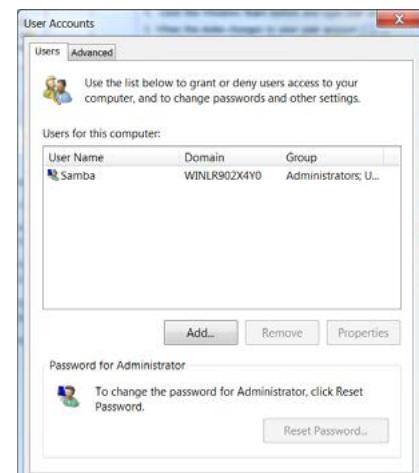
1. Click the Windows **Start** button and type user accounts in the search box.
2. When the Make changes to your user account window opens, click on **Manage User Accounts**.
3. When the User Accounts window opens, click on the **Advance** tab.
4. Under Advance user management, click on the **Advance** button.
5. Under the Name column right-click on **Users** and then **New User**.
6. In this example the new user will be identified as "Samba" and will be entered into the User name field as shown to the right.



Note:

To ensure that there will be no changes required regarding the password, check **Password never expires**.

7. Click on **Create** and then **Close**.
8. Click on the X (top right corner) to close the users window.
9. If not already open, navigate to Manage user accounts and click on it. Once there, the new user account should be visible as shown to the right.
10. Click the **OK** button.
11. Click on the X (top right corner) to close the User Account window.
12. Navigate to Windows Explorer and create a new folder.

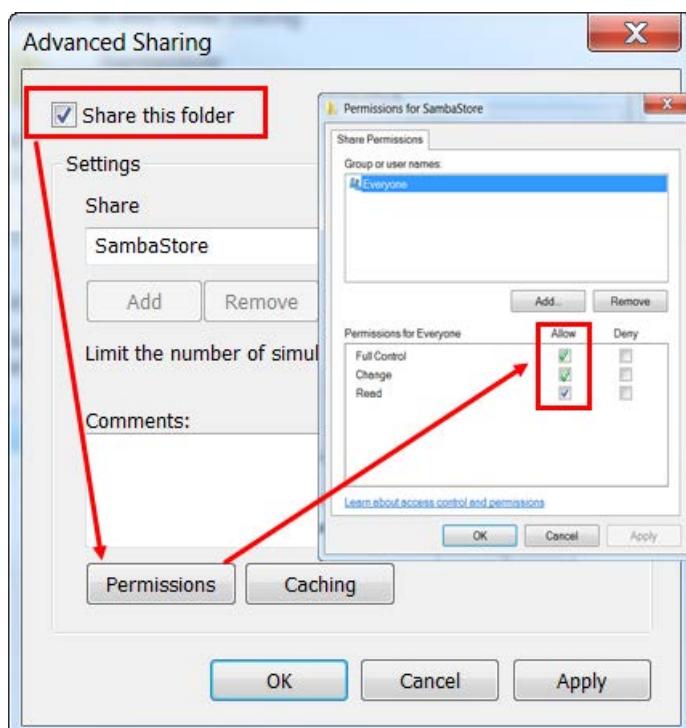


Note:

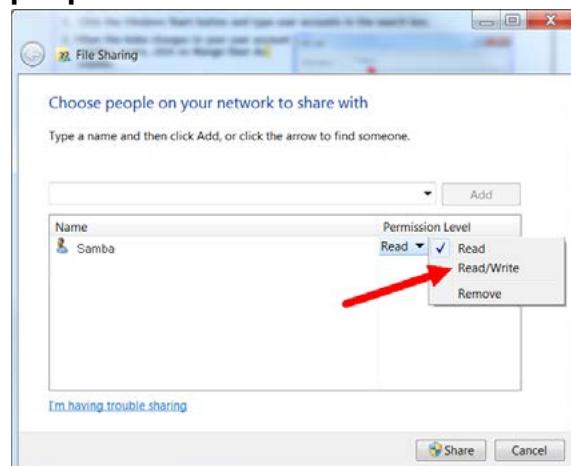
The name of the shared folder must not contain any slashes, or back-slashes.

Note:

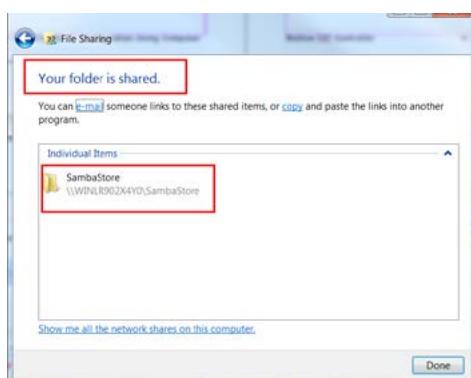
If the folder being created is a sub-folder off of the root directory, right click on the created folder > select **Properties** > **Sharing** > **Advanced Sharing** and check **Share this folder**. Doing this will allow the sub-folder path to be defined as if it were in the root directory of the selected domain. Lastly, click on **Permissions** and ensure that all boxes under Allow are checked as shown below.



13. Right-click on the folder created above and then mouse over Share with and click on **Specific People**.
14. Click on the drop down button and then **Find people**.
15. Enter the object name "Samba" and then click on the **Check Names** button.
16. Click the **OK** button.
17. Click on the drop down button and ensure the folder is set for Read/Write capabilities as shown below.



18. Click **Share**.
- The graphic below shows the folder as being shared.



After the user account has been identified or created and the shared folder has been setup it is time to configure the File Transfer function within the controller. The graphics below show all fields that must be filled in to do an automatic transfer of the data logged file to the shared folder identified in this example as SambaStore.

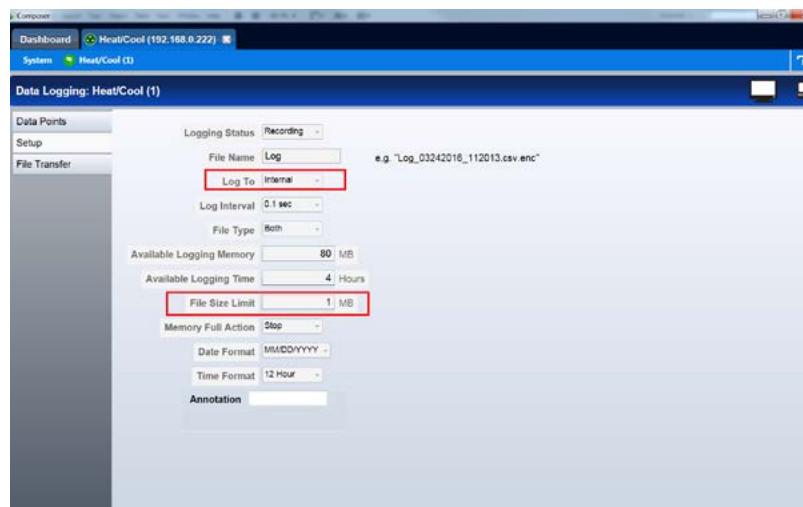
Note:

Transferring files via Samba may be accomplished by 2 methods; Auto-transfer, and a user initiated transfer. Once the automatic transfer is enabled this function will move the file to the remote computers shared folder whenever data logging is running and the set file size has been reached. The graphics that follow illustrate automatic transfer.

First, a couple of fields (parameters) within Setup must be addressed, identified in the red boxes below.

Log to - must be set to internal memory to automatically move the files to the shared folder.

File Size Limit - defines the maximum file size that will be moved to the shared drive.



Second, based on the example entries made above, the File Transfer fields need to be filled in accordingly.



After these screens have been populated as shown, data logged files, once they reach approximately 1MB in size, will be moved from internal memory to the shared folder (SambaStore).

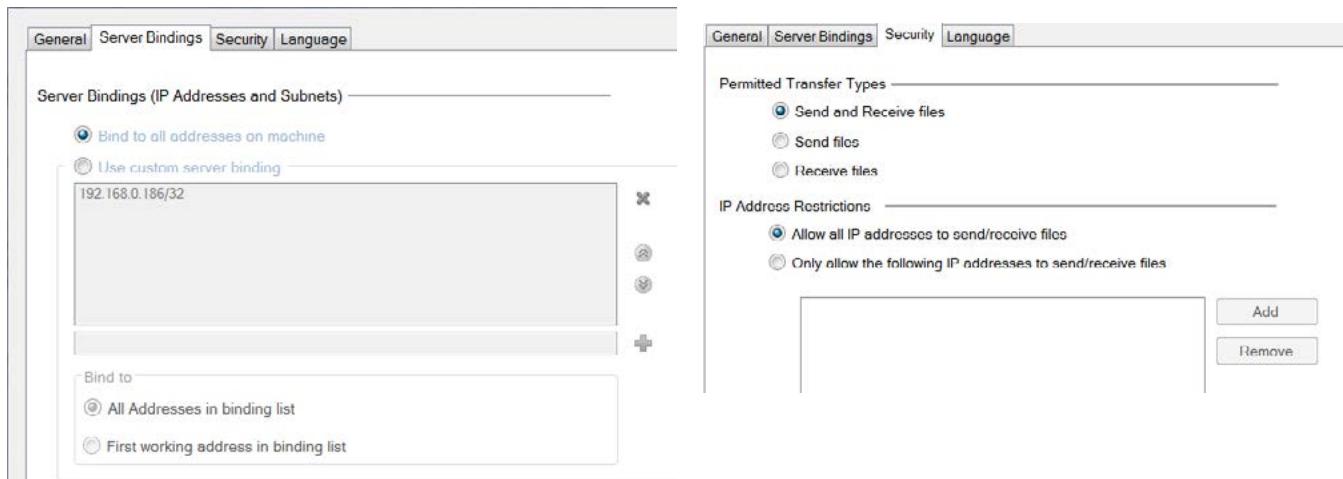
Configuring a Trivial File Transfer Protocol (TFTP) Server

In order to use the TFTP file transfer option, a TFTP server must be setup and running on your computer to service the TFTP transfers from the F4T®. The user will need to specify the IP address of the remote computer, and also the remote computer name.

TFTP requires no authentication and can transfer a file as large as 20MB to a remote host computer. There are many TFTP servers available and many can be downloaded off the internet free of charge. To enable a TFTP transfer, within Composer or via the UI, simply enter the IP address for the remote computer and ensure the TFTP server is running on the remote computer.

Configuring the TFTP Transfer:

- Because there are several TFTP servers available note that naming may be different. What is most important from the server standpoint is that the appropriate IP bindings are set while the security allows for read/write capability as shown below.



- Navigate back to the section entitled [Setup Data Logging](#) and follow the procedure to define what it is to be captured within the file. Within this same procedure (step 5), it will be important to define the IP address of the remote computer while also determining whether the file will be transferred manually or automatically.
- Start the TFTP server and then start data logging by pushing the following buttons on the F4T® front panel: **Main Menu > Data Logging > Start**

If the file does not seem to be transferring as expected check out the parameter identified above as [Transfer Results](#) and the table that follows it for some assistance.

Creating and Editing Profiles Using Composer®

This section describes the features of the Profile View and includes instructions for using it. To learn about profiles see "[What is a Profile](#)" in the Overview Section of this User Guide.

Note:

The Profile Engine function block must have one or more of its receivers (PV1 through PV4) connected prior to creating or editing profiles with this view. To learn more about how to set up the Profile Engine, see the [Profile Ramp and Soak](#) section in Chapter 4 Applications Examples and the [Profile](#) section in Chapter 5 in this User's Guide.

Profile View Orientation: describes the layout of the profile screens.

Profile Parameters: settings that apply to a profile.

Step Parameters: settings that apply to a step.

Opening the Profile View: displays the list of profiles in the device.

Creating Profiles: up to 40 profiles can be created.

Saving a profile: store profiles on the computer to make it easy to load them in other controllers or to restore one that was inadvertently changed or deleted from the controller.

Loading a Profile: loads a profile that was previously saved to the controller's memory.

Duplicating a Profile: is an easy way to create a new profile similar to one that was created previously.

Deleting a Profile: removes unneeded profiles from the controller memory freeing up space for new profiles.

Opening the Step Editor: displays the details of the step.

Adding Steps: up to 50 steps can be included within any given profile.

Inserting Steps: create a new step at a specific point in a profile.

Deleting Steps: remove a step from a profile.

Password Protect a Profile: avoid unwanted and inadvertent changes to a profile with password protection.

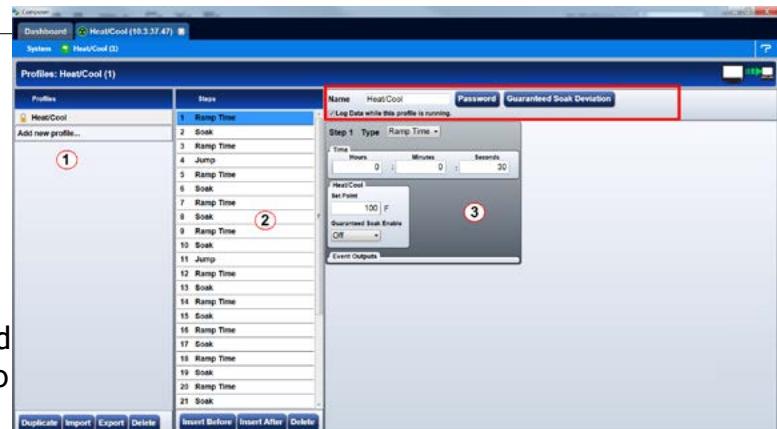
Changing or Removing a Password from a Profile: when password protection is no longer needed it can be easily removed.

Navigate to the Profile Editor:

1. From any screen click on the Device menu tab to drop down a submenu.
2. Click the **Profiles** button.

Profile View - Screen Orientation

The Profile View has the following features, numbered correspondingly in the graphic below.



Profile List

- Lists the profiles in the controller and indicates which have password protection (see lock symbol next to Oven 2).
- A user can use "Add new profile..." or use the buttons at the bottom to delete, duplicate, import and export profiles.

Step List

- Shows all currently existing steps for the selected profile (Oven 1).
- A user can use "Add new step..." or use the buttons at the bottom to delete or insert a step.

Step Detail

- Shows the current settings for the selected step while also allowing each to be modified.
- The user has the ability to give the profile a name, apply password protection and enable data logging for this profile while running (red box above).

Profile Parameters

The following settings apply to the entire profile.

Name

User-entered identifier for the profile. The name follows the profile when it is saved in a file or moved to another controller.

Note:

If data logging is enabled for the profile it is suggested that the profile name be limited to characters between A to Z, a to z or 0 to 9. The data log filename will replace any other characters with an underscore (_).

Password

User-set code that must be entered prior to editing a protected profile. A password may consist of up to ten characters, may include letters, numbers or symbols and is case sensitive.

Guaranteed Soak Deviation/Guaranteed Soak Values: Loop1 to Loop4

The amount by which the process value is allowed to differ from the loop's set point for steps with Guaranteed Soak Enable set to On. In such steps when the process value differs from the set point by more than this value, the step timer stops running until the process value is returns to within the band defined by the set point plus or minus this value.

Step Parameters

The following parameters set the behavior of a profile's steps. Only the parameters that apply to the selected step type appear in the step detail.

Step Type

Set the behavior of the step.

Options:

- Soak: maintains the each loop's set point constant for the step's Time.
- Ramp Time: adjusts each loop's set point gradually from the previous set point to the step's Set Point over the step's Time.
- Ramp Rate: adjusts each loop's set point at the user-set Rate of change until it reaches the step's Set Point.
- Wait For Process or Event: holds the profile until the specified conditions on the event inputs are met. When multiple conditions are specified, the profile will not proceed until all the conditions are satisfied at the same time.
- Instant Change: sets each loop's set point to the step's Set Point without ramping from the previous set point and holds that set point for the step's Time.
- Jump: repeats previous steps in the profile starting at the step set with Jump to Step for the Number of Times set. This option is not available for step 1. A value of zero entered for the Number of Times will create an infinite loop.
- End: sets what each loop and event output does when the profile ends.

Time: Hours Minutes Seconds

Set the duration of the step.

Note:

Step timing will be impacted if the a profile is running and the time settings are changed.

Ramp Rate

Set the speed at which the loop's set point is increased or decreased to the step's Set Point value.

Set Point

Set the value to which the loop's set point is changed by the step.

Guaranteed Soak Enable

Set On to prevent step time from elapsing whenever the loop's process value differs from its Set Point by more than Guaranteed Soak Value for the loop.

Options: On, Off

Event Input 1 to Event Input 4

Set the condition on each input for a Wait for Process or Event step.

Options:

- None: do not wait for this input.
- On: wait until a digital input is on or true.
- Off: wait until a digital input is off or false.
- Greater Than: wait until the process value is greater than the setting of the corresponding Input Value parameter.
- Less Than: wait until the process value is less than the setting of the corresponding Input Value parameter.

Input 1 Value to Input 4 Value

Set the process value against which the corresponding analog input condition is evaluated in a Wait for Process or Event step.

Jump To Step

Set the step at which the profile should begin to repeat steps.

Number of Times

Set the how many times the Jump Loop step repeats the previous profile steps.

Note:

Number of Times is the number of times the steps are repeated not including the time they are executed prior to reaching the Jump step. For example if step 5 of a six step profile is a Jump with Jump To Step set to 2 and Number of Times set to 1, when the profile is run starting at step 1 it executes steps as follows: 1, 2, 3, 4, 5, 2, 3, 4, 5, 6.

Event Outputs: Event Output 1 to 8 to Event Output 4

Set the state to which the profile sets each event output at the start of the step.

Options:

- On: the step sets the event output on or true.
- Off: the step sets the event output off or false.
- Unchanged: the step does not set the event output; it remains in whatever state was previously set.

End Action

Set what the control loop does after the profile is completed.

Options:

- User: the loop controls at the Set Point setting prior to execution of the profile.
- Off: the loop's control mode is set to Off.
- Hold: the loop's Set Point is set to the last value used in the profile.

Note:

To anticipate and plan for expected control action at the end of a profile, an End step should always be included as the last step in a profile. If not included within the profile, a parameter within the control or cascade loop called "Profile End Action" will determine which option above is active. End Action (if used within the profile), always takes precedence over Profile End Action.

Opening the Profile View

To view the profile listing:

1. From the device menu choose **Profiles**.
 2. Click **Profiles** to bring up the profile listing.
-

Creating Profiles

To create a new profile in the controller:

1. Click the **Add new profile..** button.
2. If desired, click in the **Name** field and change the profile's name.

Note:

The default name is New Profile. The user should give each profile a unique name. A profile name is limited to 20 characters

Saving a Profile to a Storage Device

To export a copy of a profile from the controller to a file:

1. Select the profile by clicking it in the profile list.
2. Click Export at the bottom of the profile list.
3. Use the Save As dialog to edit the name and select the desired location and click the **Save** button.

Hint:

- Export is an option on the profile pop-up menu.

Note:

A profile that has a password applied will be saved with the password.

Loading a Profile

To load a profile previously saved on the computer in to controller memory:

1. Click **Import**.
2. Use the open dialog to locate and select the desired profile file.
3. Click **Open**.

Duplicating a Profile

To duplicate a profile:

- Right-click the profile and click **Duplicate** in the pop-up menu.
Or
- Click the profile, then click the **Duplicate** at the bottom of the profile list.

Note:

The duplication process automatically appends the duplicated profile to the end of the profile list.

Note:

If a profile is locked with a password and duplicated, the duplicated profile is not password protected.

Note:

The name of the duplicate profile is the original profile's name with the words "Copy of" added to the beginning. The result may be truncated so as not to exceed 20 characters.

Deleting Profiles

To delete a profile:

- Right-click the profile, click **Delete** in the pop-up menu and then click **OK** to confirm.
Or
- Click the profile, click **Delete** button at the bottom of the profile list and then click **OK** to confirm.
Or
- Click the profile, press the **Delete** key on the computer keyboard and click **OK** to confirm.

Opening the Step Editor

To open the step editor:

- Click any step in the step list.

Adding Steps

To add a step to a profile:

- Right-click a step and choose **Insert Step After** or **Add Step to End** in the pop-up menu.
Or
- Click the **Add new step** button in the step list.

Hint:

- When clicking on "Add new step...", if a step is selected, a duplicate of the selected step is added, if no step is selected, a duplicate of the last step is added.

Inserting Steps

To insert a new step ahead of an existing step:

- Right-click the step and choose **Insert Step Before** in the pop-up menu.
Or
- Click the step and then click the **Insert Before** button at the bottom of the step list.

Deleting Steps

To delete a step:

- Right-click the step and choose **Delete Step** in the pop-up menu
 - Or
 - Click the step and then click the **Delete** button at the bottom of the step list
 - Or
 - Click the step and press the **Delete** key on the computer keyboard
-

Password Protect a Profile

To avoid inadvertent changes to a profile, apply password protection to it.

To set a password for a profile:

1. Click the **Password** button.
2. In the dialog box enter a password (10 characters maximum).
3. Re-enter the same password to verify it.
4. Click **OK**

Note:

A password protected profile requires the password be entered to edit but not to copy it or to delete it. If the profile is duplicated, the duplicate is not password protected.

Changing or Removing a Password from a Protected Profile

To change or remove a profile's password, the password must be known.

To change a profile's password:

1. Select the profile by clicking it in the profile list.
2. Enter the password and click OK.
3. Click the Password button.
4. Enter a new password (10 characters maximum).
5. Re-enter the same password to verify it.
6. Click OK.

To remove a profile's password:

1. Select the profile by clicking it in the profile list.
2. Enter the password and click OK.
3. Click the Password button.
4. Click the Remove button.

Enabling Data Logging Within a Profile

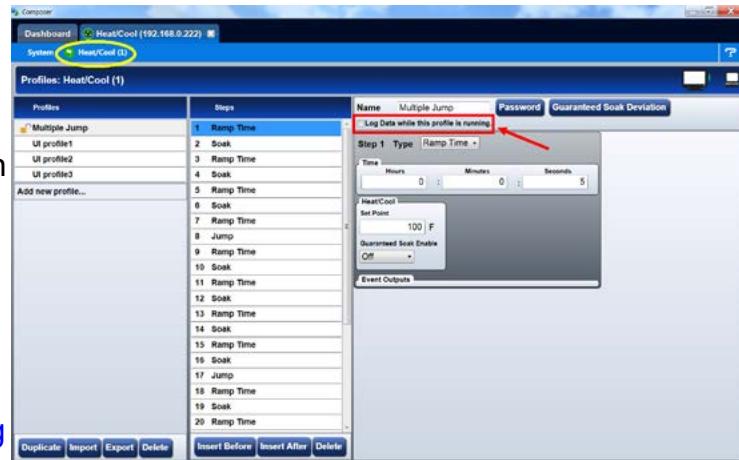
To enable data logging when running a profile: 5th character of the part number must be [J, K, L or M], while the 7th digit must be [D, E or F]. To learn more about data logging see "[Data Logging](#)" in the Overview Section of this User Guide.

To enable data logging within a profile:

1. Click on the **Device Name** (yellow circle) tab and then **Profiles**.
2. Click on the desired profile and then check the box next to "Log data while this profile is running" (red box).

Note:

All captured data points for the profile must first be configured within the Data Logging menu. See [Setting Up Data Log Files Using Composer](#).



3

Chapter 3: Using the F4T® Front Panel

Navigating and Understanding the User Interface (UI)

This chapter is designed to give the user a better understanding of the structure and navigation of the F4T® menus as viewed from the front panel.

Front Panel Navigational Buttons

When looking at the front panel of the F4T®, at the bottom of the display, four push buttons are displayed as icons shown below. The text in this graphic was placed there for clarity only and is not present on the front panel.



- Home: regardless of the screen currently in view, when pushed, will always return to the Home screen which displays the following:
 - Loop name: user designated (Chamber Temp, as shown above).
 - Control mode: (Auto, as shown above).
 - Process Value: input connected to the PV receiver of the loop function block.
 - Set Point: which represents the desired value to be maintained by the controller.
 - PWR: output power levels for heat and cool if both are configured.
 - Output Actions: allows a user to monitor the on/off status of user defined inputs or outputs.
- Menu: as shown below, will provide access to other settings and functions within the controller.



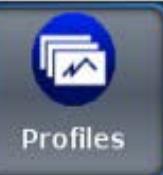
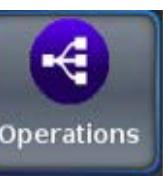
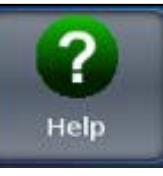
- Return: when pushed, this button will take the user back to the previous screen until the top level of either the home screen or the main menu are reached.
- Help: displays information about the controller such as: part number, software revision etc...

Note:

Depending on ordered options and configured features the Menu screen may have other buttons that are not visible. The red arrow above shows a scroll bar that will appear when this is the case. Swipe the screen upwards to view more.

Understanding F4T® Menus

The following section illustrates the structure of the F4T® menus at a high level. Press the Main Menu button below the display screen to access the menu buttons available.

Menu Item	Item Options	Menu Item	Item Options
	User-selected parameters		Import/Export Samba TFTP
	Options - Actions		Email Server Settings Contacts Alert Settings Send Test Message
	Control PID loops Profile Events Inputs/Outputs Alarms Limits Machine Controls		Location depends on security settings and installed hardware
	Settings for all Menu Items		Location depends on security settings and installed hardware
	Start Annotation - Logged Data Points Select Data Points - Setup - Data Log File Transfer		Calibration
	Actions		Home screen and menu personalization
	Batch Entry Batch Settings Batch File Transfer		About - Pluggable Modules - Installed Features Screenshot Enable/Disable

Multiple Languages

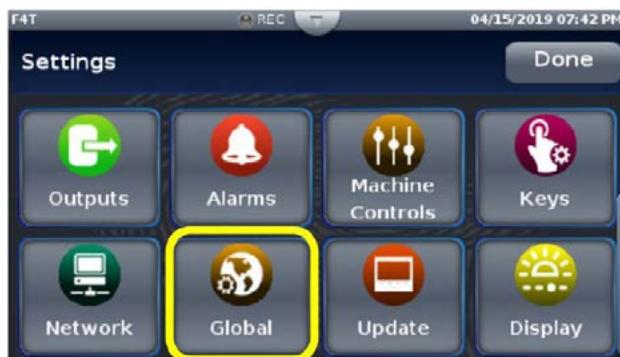
English, German, French, Italian, Spanish, Japanese, Korean and Chinese.

How to set the desired language:

Press the Menu button below the Main screen to access the Main Menu screen.



Press the Settings button on the Main Menu to access the Settings screen. Press the Global button to access the screen to make changes to the Global settings.



Select the desired language on the Global settings screen and then press the Done button to return to the Main Menu.

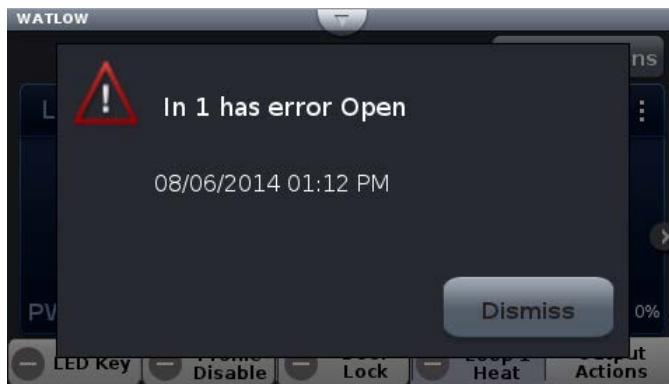


Event Driven Menus

During normal operation it is possible that an event can occur that will present the user with indications, pop-up windows and menu selections that are not shown above. As an example, if an alarm occurs the status bar (top of screen shot shown below) will indicate its existence by blinking yellow. If the user pushes the status bar down button to view the alarm message, and then pushes the alarm tab, menu options may appear (silence or clear) depending on the alarm settings. A representative alarm display is shown below.



As another example, if an input sensor opens, an error message will be displayed on the screen requiring user intervention. Once the error is acknowledged (Dismiss), the status bar will continue to blink red until the open sensor has been fixed. Once fixed, the status bar will return to its normal operational display as shown below.



Navigation Keys and Displays

After initially powering up the controller a white initialization screen will appear first. Once the startup process is complete the splash screen (shown below) will appear.



As described in the splash screen above...

After first time power-up, do the following:

1. Configure the controller using Composer software (see: [Configuring Pluggable Flex Modules](#))
2. Using the **Menu** button setup the Home screen (see: [Personalizing the Home Screen](#)).
3. If the above steps have already been completed simply push the **Done** button to go to the home screen.

The screen on the previous page will appear each time the controller power is cycled. If it is desired that the splash screen no longer appear, check the box "Don't show this again" (shown in red box for emphasis only).

Home Screen Described

The screen shot below shows a configured Home screen to include two content blocks (loops) and two or more pages (notice next page indicators). Any given page can have up to four content blocks configured.



1. Controller Status: indicates alarms and errors if they occur while also showing the current security level if enabled (see: [Security](#)) and the name (upper left corner) given by the user (see: [Device Details](#)). The button shown in the center of the status bar allows a user to view alarm and error messages when pushed.
2. Profile Status Bar: if profiles have been ordered and configured, provides visibility and information pertaining to running profiles as well as access to available profile actions (see: [Creating and Editing profiles](#)). This status bar can be relocated on the screen (see: [Personalizing the Home Screen](#)).
3. Vertical Ellipsis: displays current control mode while also providing access to other operational parameters such as the Closed Loop Set Point, Autotune, PID settings, etc... (see: [Control Mode](#)).
4. Next Page: if the controller has more than one control loop and the Home screen has been setup (Push Menu button to Personalization) to display multiple pages (loops), the left and right arrows on each side of the home screen provides navigation from one to the other.
5. Output Widget Bar: user configurable events, function keys or output status (on/off). This can be relocated on the screen (see: [Personalizing the Home Screen](#)).

Configuring Ethernet Communications

To change Ethernet parameters:

1. Push the **Menu**, **Settings** and **Network** buttons, in that order.
2. Push **Ethernet**.
3. Change desired settings.
4. Press the **Save** button to apply the changes to the settings.

For Ethernet connectivity options and step-by-step instructions on connecting the F4T® into an Ethernet network, see chapter 3 of the F4T® Installation and Troubleshooting User's Guide.

Default Ethernet Parameters and Settings

The bracketed settings below represent the defaults as delivered from the factory:

- IP Address Mode: **[DHCP]**, Fixed
 - DHCP: Dynamic Host Configuration Protocol, allows for dynamic distribution of network settings by a DHCP server.
 - Fixed: also referred to as a static IP address, is configured manually for a specified network.
- Actual IP Address: **[192.168.0.222]**
- Actual IP Subnet: **[255.255.255.0]**
 - Subnet: a method used to logically divide and isolate networks.

Note:

The Actual IP Address and Actual IP Subnet addresses shown above will be the default addresses if IP Address Mode is set for Fixed.

- Actual IP Gateway: **[0.0.0.0]**
 - Gateway: is a device used on the network to route messages with IP addresses that do not exist on the local network.
- MAC Address: xx:xx:xx:xx:xx:xx (Will be different and unique for each controller)
 - MAC address: is a manufacturer supplied address for the network interface card.
- IP Fixed Address Part 1 to 4
- IP Fixed Subnet Part 1 to 4
- Fixed IP Gateway Part 1 to 4
- Display Units: **[°F]** (Fahrenheit), °C (Celsius)
- Modbus® TCP Enable: **[Yes]**, No
 - EtherNet/IP Enable: **[Yes]**, No appears on select models
 - Modbus Display Units - applies to Modbus TCP and EtherNet/IP
 - Modbus is an industrially hardened field bus protocol used for communications from the controller to other devices on the network; only one connection via Modbus is allowed.
- Modbus Word Order: **[Low High]**, High Low
 - Modbus allows a user to select the word order of two 16-bit words in floating point values.
- Data Map: **[1]**, 2, 3
 - Data Map, the user can switch Modbus registers from the comprehensive listing of F4T registers to a limited set of the legacy F4 controller registers (1 = F4T, 2 = F4 non-cascade 3 = F4 cascade).

Personalizing the Home Screen Using the UI

Placement of objects on the home screen can be modified by the user.

Note:

Prior to personalizing the Home screen first configure pluggable modules and at least one control loop.

To personalize the Home screen, do the following:

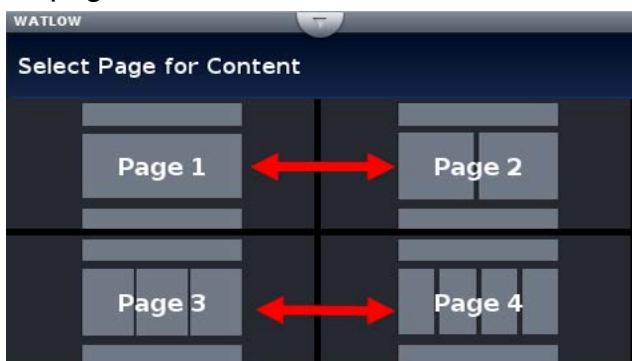
1. From any screen push the **Menu** button.
2. Push **Personalize**.
3. Push **Basic Personalization**.
4. Select the desired Home Layout by pushing **Main Top**, **Main Center** or **Main Bottom**.



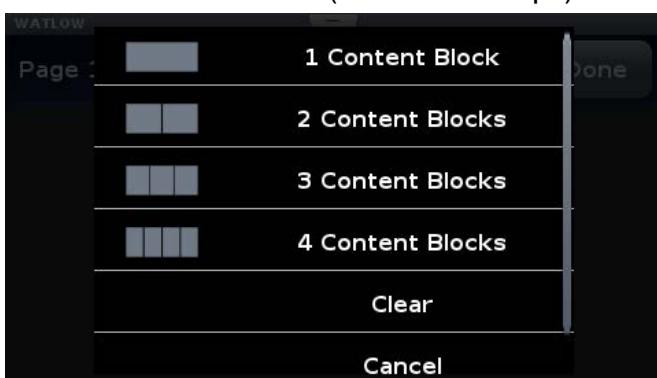
The red arrows were placed on this graphic for emphasis only and represent what the focus of this operation is; that being, defining the location of the profile status and the output widget bars. As shown above, the options include placing them on the bottom, split screen top and bottom or on the top.

5. Push each page (through 4) in which loop information will be displayed.

In the graphic that follows, each page has been configured to display from 1 to 4 loops on each page.



6. Define the content blocks (number of loops) that will be displayed on each page.

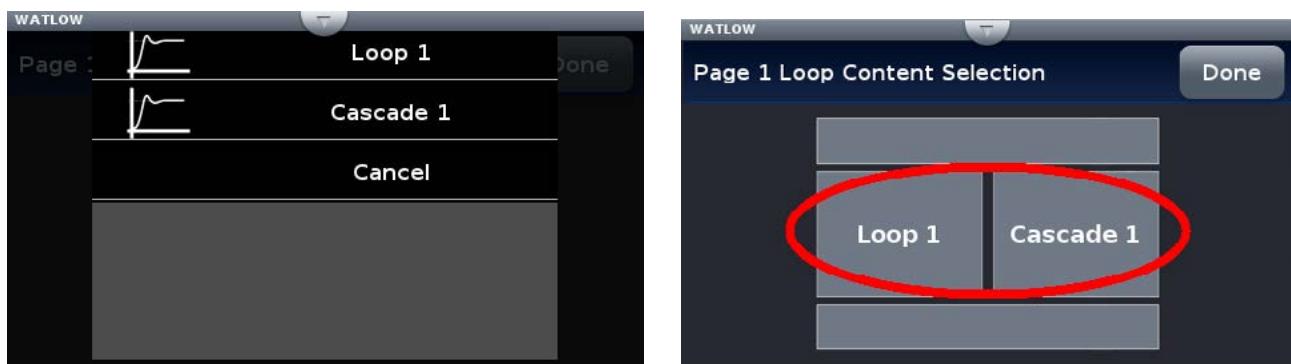


Redefining page 1 to display two loops (content blocks):

1. From any screen, push the **Menu** button.
2. Push **Personalize**.
3. Push **Basic Personalization**.
4. Select the desired Home Layout by pushing **Main Top**, **Main Center** or **Main Bottom**.
5. Push Page 1.
6. Select two content blocks.



7. Tap on each content block above selecting Loop 1 for the left and Cascade 1 for the right.



8. Push the Home screen button to see the result of this operation.



Front Panel Usage From the Home Screen

Creating a Profile

This section describes how to create a profile from the UI. Profiles can be created at any time and they can be created from the Home page via the "Profile Actions" button or through the Main Menu. To learn more about profiles see "[What is a Profile](#)" in the Overview Section of this User Guide.

To create a new profile in the controller via the Profile Actions button:

1. Push the **Profile Actions** button.
2. Push the **Create Profile** button.
 - Name, enter the desired profile name, 20 characters maximum.
 - Password, enter a profile password if desired, 10 characters maximum.
 - Log Data, select yes or no to log data.
 - Guaranteed Soak Deviation, The amount by which the process value is allowed to differ from the loop's set point for steps with Guaranteed Soak Enable set to On.
3. Push the **Options** button.
 - Create Steps, add steps to the profile.

Note:

As steps are added to the profile it may be necessary to swipe up on the screen to see the last configured step in the list.

- Cancel New Profile, removes the profile from the controller.
 - Close, closes the open window.
4. After all steps have been created push the **Options** button.
 - Done, exits the step editor and displays a listing of all profiles.
 - Run Profile, displays the Home screen and will then execute the selected profile.
 - View/Edit Details, displays the step editor for the selected profile while also allowing modifications to be made.
 - Cancel, returns the display to the step editor.

To create a new profile in the controller via the Main Menu button:

1. Push the **Main Menu** button.
2. Push the **Profiles** button.
3. Push the **Options** button.
 - Create Profile, adds a new profile to the end of the profile list.

Note:

As new profiles are added it may be necessary to swipe up on the screen to see the last profile in the list.

- View/Edit Profile Events, view and or modify the selected profile event output.
 - Import File, looks for a previously exported profile (profile filename.wpf) on a thumb drive inserted in to a USB port.
4. Push the **Create Profile** button.
 - Name, enter the desired profile name, 20 characters maximum.
 - Password, enter a profile password if desired, 10 characters maximum.
 - Log Data, select yes or no to log data.
 - Guaranteed Soak Deviation, The amount by which the process value is allowed to differ from the loop's set point for steps with Guaranteed Soak Enable set to On.

5. Push the **Options** button.

- Create Steps, add steps to the profile.

Note:

As steps are added to the profile it may be necessary to swipe up on the screen to see the last configured step in the list.

- Cancel New Profile, removes the profile from the controller.

- Close, closes the open window.

6. After all steps have been created push the **Options** button.

- Done, exits the step editor and displays a listing of all profiles.
- Run Profile, displays the Home screen and will then execute the selected profile.
- View/Edit Details, displays the step editor for the selected profile while also allowing modifications to be made.

- Cancel, returns the display to the step editor.

Profile Actions From the Home Screen

Controllers equipped with profiles will have a [D, E or F] in the seventh digit of its part number (see: [F4T® Ordering Information](#)). After programming the Profile FB in the Function Block Diagram a profile status bar will appear on the home screen after power-up. When the Profile Actions button is pushed, one of three pop-up windows (profile running, profile not running, profile paused) will appear; all three are described below:

Profile Running

Pause	> Suspends running the profile, profile can resume running at the same point.
Terminate	> Stop running a profile, profile cannot resume running, it must be started again.
View/Edit Profile Events	> View and edit profile events.
Create a Profile	> Create a new profile (see: Creating and Editing profiles).
Cancel	> Return to Home screen.

Profile Not Running

Run Last	> Starts the last executed profile.
Run Profile	> Brings up a list of profiles by name for selection.
View/Edit Profile Events	> View and edit profile events.
Create Profile	> Create a new profile (see: Creating and Editing profiles).
Go to Profiles	> Brings up a list of profiles by name for selection.
Clear Profile Status	> Removes the profile icon and step status (profile status bar).
Cancel	> Return to Home screen.

Profile Paused	
Resume	> Continue step execution where previously paused and with previous time remaining.
Terminate	> Cancels profile execution.
View/Edit Profile Events	> Create a new profile.
Create a Profile	> Create a new profile (see: Creating and Editing profiles).
Cancel	> Return to Home screen.

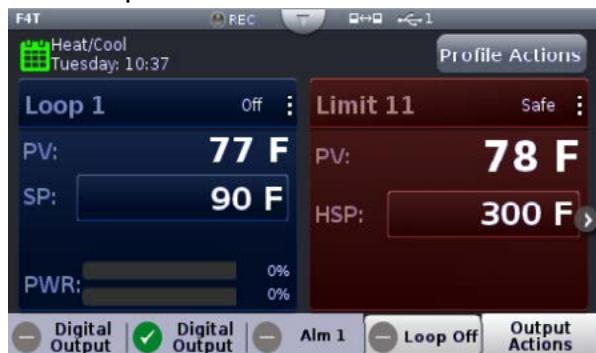
Starting a Profile Using the Calendar

A single Profile can be configured to start automatically based on a specific day and time.

To start a profile automatically follow the steps below:

1. Push the **Profile Actions** button.
2. Push the **Go to Profiles** button.
3. Push the **Actions** button for the desired profile.
4. Push the **Calendar Start** button.
5. Select and change the **Day of Week** and **Time** to the application requirements pushing the **Save** button for each when done.
6. Push the **Start** button (bottom right of screen) when complete and return to the home screen.

The graphic below now shows a calendar icon on the Profile Status bar with the day and time that the profile will start.



Note:

For further explanation regarding profiles, their operation and configuration see the section entitled "[Profile](#)" in Chapter 5 of this User's Guide.

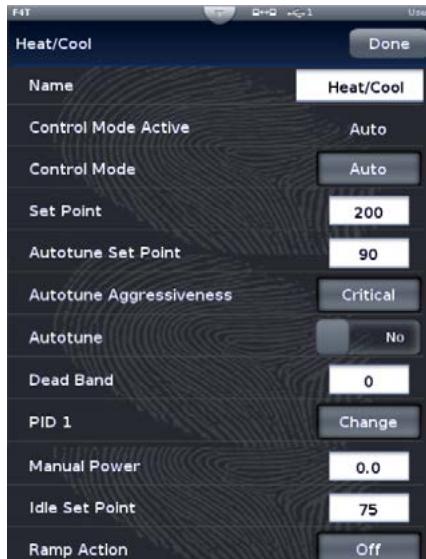
Changing Loop Operational Parameters

Pushing the vertical ellipsis or anywhere within the red box shown below will provide access to the loop name, control mode, PID settings and many other parameters.

Some of the available options accessible through this access point are shown below. Be aware



that what is visible and accessible here varies based on user settings. As an example, the F4T® can have up to 5 PID sets. The screen shot below shows access to one PID set.



Using the Output Widget

In the graphic below, the output widget it is located at the bottom of the screen within the red box. The buttons within the red box can be configured to display the status of an output, profile event or they can be used as inputs via a function key.



Configuring the Output Widget:

1. Push **Output Actions** (blue box above).

- View All Outputs, displays all connected outputs by their name (if given).
- Change View, defines widget location.
- Cancel, Returns to the Home screen.

2. Push the **Change View** button.



3. Push the desired position (**1 to 4**) and define its function.



4. Push the **Done** button when complete.

Data Logging

Note: To view a video about Data Logging go to www.watlow.com/F4T.

Data Logging can be enabled at any time and will log a user selectable list of data points. While data logging is enabled, the data log file is stored within either the USB device memory or internal memory. Once the file reaches a specified size (if being transferred automatically), it will be sent directly to one of three other destinations (USB, TFTP server or a Samba server). The file transfer can also be initiated manually at any time. The file transfer process from internal memory, whether completed automatically or manually, will move all log files from internal memory to the selected destination. To learn more about data logging see "Data Logging" in the Overview Section of this User Guide.

From the UI, there are two ways to setup and initiate data logging:

To setup and run data logging using the UI:

1. Press the **Menu** button.
2. Press the **Data Logging** button.
3. Press the **Select Data Points** button to select the data points to be captured in the log.
4. Press the **Done** button when complete.

5. Push the **Setup** button to define the following:

- Logging Status: indicates whether or not recording is active or not.
- File Name: any alphanumeric characters, 63 maximum.

Note:

A new dedicated file is created when data logging starts and the filename format will be "file name" "date stamp" "time stamp".csv or enc".

- Log To: USB or Internal Memory.
- Log Interval: defines the frequency in which the log will be written, 0.1 second to 60 minutes.
- File Type: Encrypted (*.enc), Comma Separated Values (*.csv) or Both.
- File Size Limit: 20MB when using TFTP or Samba, 1GB when using USB.
- Memory Full Action: when log to device defined above is full, Overwrite or Stop.

Note:

Logging to USB allows for Stop only, when memory is full.

- Date Format: MM/DD/YYYY or DD/MM/YYYY.
- Time Format: 12 or 24 hour clock.

6. Push the **Done** button when complete.

Note:

Although this completes the setup it may be desired to configure the file transfer function before starting data logging (see [Transferring Data Log Files on page 64](#)).

7. If desired push the **Annotation** button. Annotation allows for time specific entry of up to 32 alphanumeric characters to a specific entry (line) within the log file. The maximum speed at which annotation can be written to the log file is approximately once every 20 seconds. Once written to the file, the annotation field on the UI will be deleted where a new value can be entered and written again.

8. Push the **Start** button to begin data logging.

Note:

Data logging is terminated when power is lost, however, the file as it was prior to the loss of power will be retained.

To enable data logging when running a profile: 5th character of the part number must be [J, K, L or M], while the 7th digit must be [D, E or F].

1. From the Home screen push **Profile Actions** button.
2. Push **Go to Profiles** button.
3. Push the **Actions** button of the desired profile.
4. Push the **View/Edit Details**.
3. Push the **Log Data** button to indicate "Yes".

Note:

If data logging is already running when the profile starts with data logging enabled, the data log filename will remain as stated in the note above with the profile log data concatenated to the currently running data log file. If data logging is not running, a new dedicated data log file is created when the profile starts and ends when the profile stops. The filename format will be "Profile name" "date stamp" "time stamp".csv".

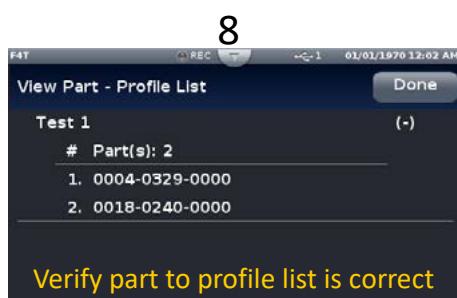
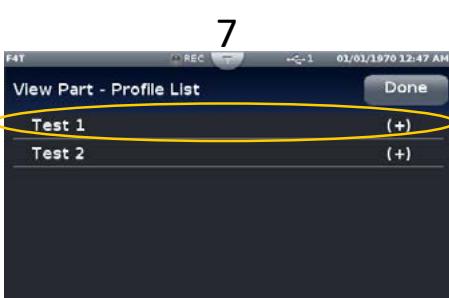
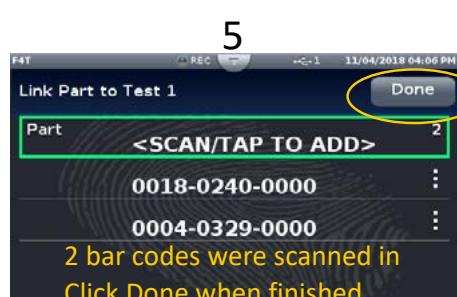
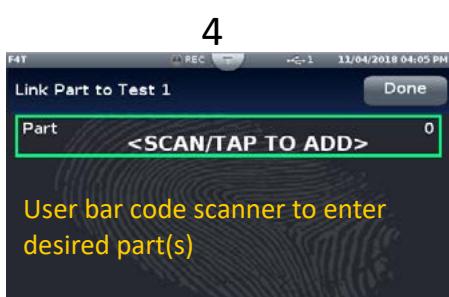
Batch Processing Programming - Batch Menu



Batch Processing Programming - 4 Simple "How To" Programming Steps

Step 1

- Admin. or Manager**
- Set up**
 - 1. **Create Part and Profile list** - Profiles automatically run based on parts being scanned in by operator
 - 2. **Set up Load Batch and Unload Batch fields** the end user will be prompted to scan for the job
- Line Operator**
- Daily Operations**
 - 3. **Batch Entry - Load:** Operator will scan in bar code fields being requested by controller
 - 4. **Batch Entry - Unload:** Operator will scan in bar code fields being requested by controller



Batch Processing Programming - 4 Simple "How To" Programming Steps (con't)

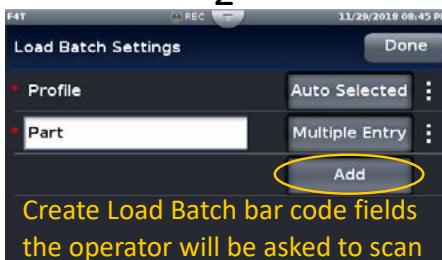
Step 2

- Admin. or Manager**
- Set up
 - 1. Create Part and Profile list
 - 2. Set up Load Batch and Unload Batch fields the end user will be prompted to scan for the job
- Line Operator**
- Daily Operations
 - 3. Batch Entry - Load: Operator will scan in bar code fields being requested by controller
 - 4. Batch Entry - Unload: Operator will scan in bar code fields being requested by controller

1



2



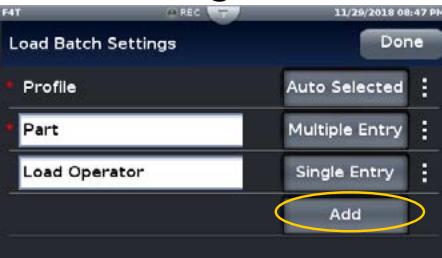
3



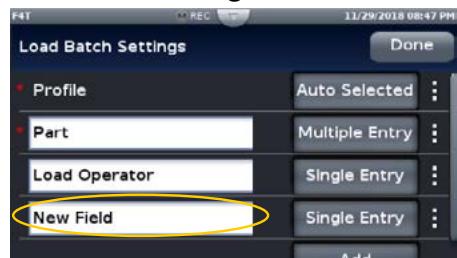
4



5



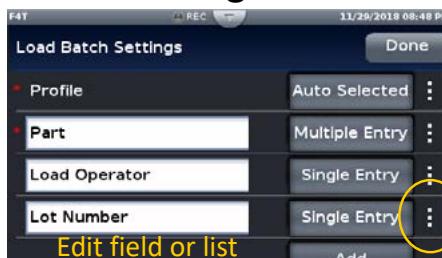
6



7



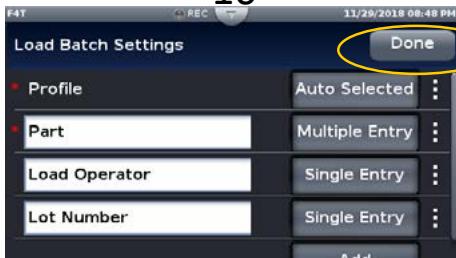
8



9



10



11



Up to 25 different custom named fields can be added

Set up of batch processing complete

Batch Processing Programming - 4 Simple "How To" Programming Steps (con't)

Step 3

- Admin. or Manager**
- Set up
 - 1. Create Part and Profile list
 - 2. Set up Load Batch and Unload Batch fields the end user will be prompted to scan for the job
- Line Operator**
- Daily Operations
 - 3. **Batch Entry - Load:** Operator will scan in bar code fields being requested by controller
 - 4. **Batch Entry - Unload:** Operator will scan in bar code fields being requested by controller

1

2

3

4

5

6

7

8

9

Using bar code scanner add part entries. Can also manually type in part entries by pressing green box and using pop-up keyboard

Part number not associated with selected profile.

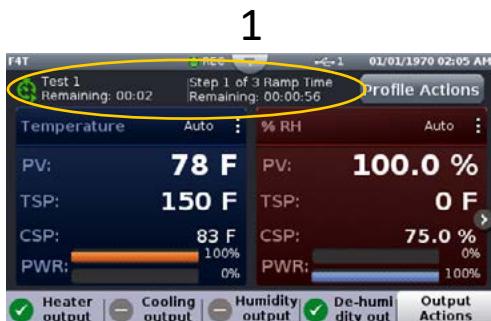
Part entry automatically set "Test 1" profile
Continue scanning remaining fields as green Box will advance with each scanned single entry

"Test 1" Profile and data logging both start automatically

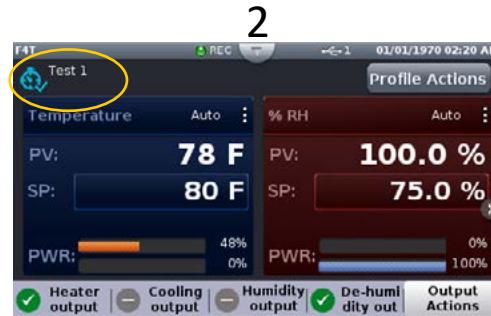
Batch Processing Programming - 4 Simple "How To" Programming Steps (con't)

Step 4

- Admin. or Manager**
- Set up
 - 1. Create Part and Profile list
 - 2. Set up Load Batch and Unload Batch fields the end user will be prompted to scan for the job
- Line Operator**
- Daily Operations
 - 3. Batch Entry - Load: Operator will scan in bar code fields being requested by controller
 - 4. Batch Entry - Unload: Operator will scan in bar code fields being requested by controller



"Test 1" Profile running



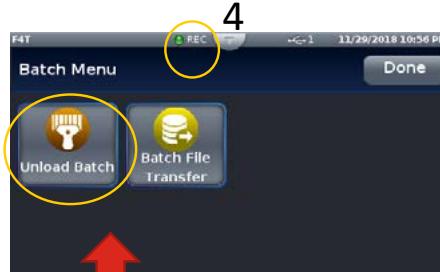
When profile completes F4T/D4T transitions from showing home screen to showing post batch entry screen



Scan requested data

A) If user presses home key and exits without completing task then Batch Mode Menu will show "Unload Batch" icon and data logging is still running

B) If operator scans "Unload Operator" bar code the controller will advance to screen 5



When user selects "Complete" confirming that all unload batch fields have been entered the F4T/D4T automatically returns back to home screen

Batch report data log file will now be automatically generated by F4T® /D4T controller.



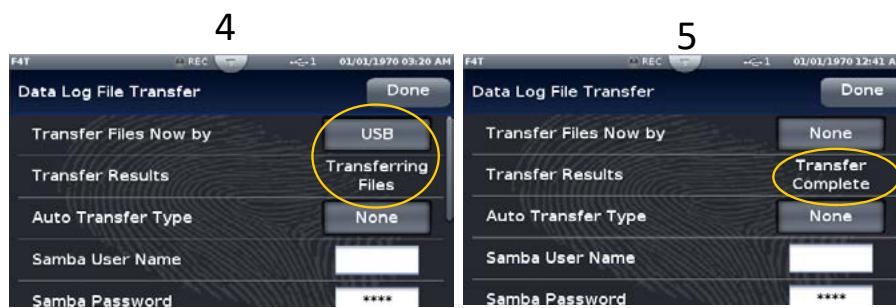
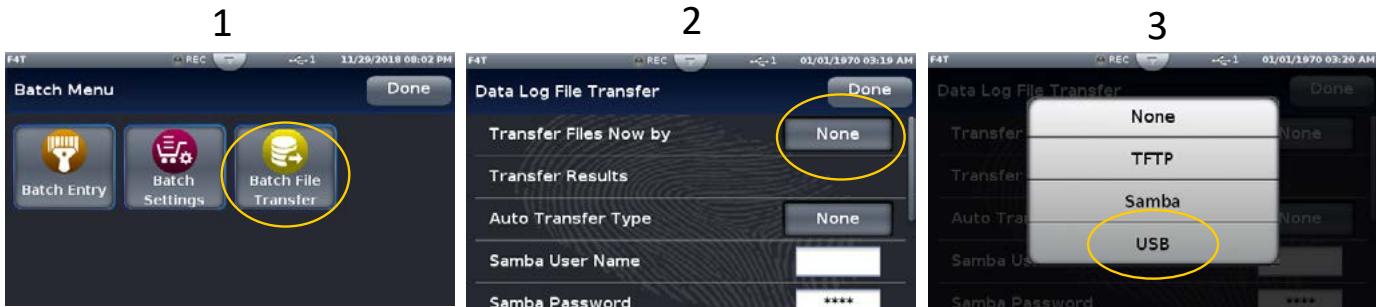
User (Kirk) scanned in their ID as the unloading operator



Export Data Log Report via USB Stick

Use existing "File Transfer" method to export data log file now formatted as a Batch Report (configuration, profiles, data log)

Scenario described below: Export via USB stick plugged into F4T®/D4T controller.



Microsoft Excel view of Batch Report (.CSV file format)

Transfer file on USB stick into a PC to view file

"Batch" Bar code data

Device Name: F4T
Profile (Auto Selected): Test 1
Part: 0004-0329-0000 10/07/2018 08:40 PM
0018-0240-0000 10/07/2018 08:40 PM
Lot No: W030131 10/07/2018 08:40 PM
Load Operator: Spock 10/07/2018 08:40 PM
Customer Name: Johns Auto 10/07/2018 08:40 PM
Unload Operator: Kirk 10/07/2018 08:41 PM

Thermal Data

Date (MDY)	Time	Temperature Heat Power (%)	Temperature PV (Deg F)	Temperature Set Point (Deg F)
10/7/2018	8:40:30 PM	100	81.189	88.068
10/7/2018	8:40:35 PM	100	81.191	97.243
10/7/2018	8:40:40 PM	100	81.184	108.712
10/7/2018	8:40:45 PM	100	81.188	120.181
10/7/2018	8:40:50 PM	100	81.199	131.65
10/7/2018	8:40:55 PM	100	81.205	143.119
10/7/2018	8:41:00 PM	100	81.186	150

Creating and viewing encrypted data files are also available.

Details covered in Watlow F4T® videos available on line.

Want to learn more:

- Data logging video: <https://www.youtube.com/watch?v=QC-dnzoKEXQ&t=0s&index=2&list=PLaQIQSMB2FG3K7m-mnhLubeh9W6bJcBZJ>
- Data log/batch report file transfer video: https://www.youtube.com/watch?v=Sg_eoNXQcus&index=3&list=PLaQIQSMB2FG3K7m-mnhLubeh9W6bJcBZJ

Adding a Part Profile List using a PC

Alternative to creating part-profile list via USB scanner

Can use readily available PC software for large part list entry into controllers



1. Export the “Part-Profile List” file from the F4T® onto a USB thumb drive



2. With USB stick plugged into PC, open ProfileToPart.json file on a PC using WordPad program (not Notepad)

3. Copy and paste sample data from WordPad into Excel

```
{  
    "Test 1": ["0004-0329-0000", "0018-0240-0000"],  
    "Test 2": ["0603-0092-0001", "0643-0041-15"]  
}
```

Profile 1 = Test 1

Part 1 = 0004-0329-0000

Part 2 = 0004-0240-0000

Adding "Part-Profile List" using a PC (con't)

4. Use Excel to enter additional part numbers

- Add more part numbers (column C)
- Add extra format type data for the json such as “ [] , type format data (columns A, B, D, E)
- Use concat function to merge columns A-E together
- Copy and past new part numbers back into WordPad program

Test 1:[“0004-0329-0000”, “0018-0240-0000”],

=concat(A5:E5)
use the =concat function to merge cells together necessary for json format

= add new part numbers (type, paste from another file, or create sequentially new additions by clicking on cell and copying down)
= add format necessary for json

=concat
= use concat function to merge or consolidate columns A-E for json file language compatibility

Copy and past formatted data back into WordPad. Save the file to a USB stick and import back into F4T

5. Copy the Excel data and paste unformatted text back into WordPad file

Syntax rules:

- Use “,” format between each part number
- Use [at the start and] at the end of each profile part number list
- Use { at the start and } at the end of each complete list

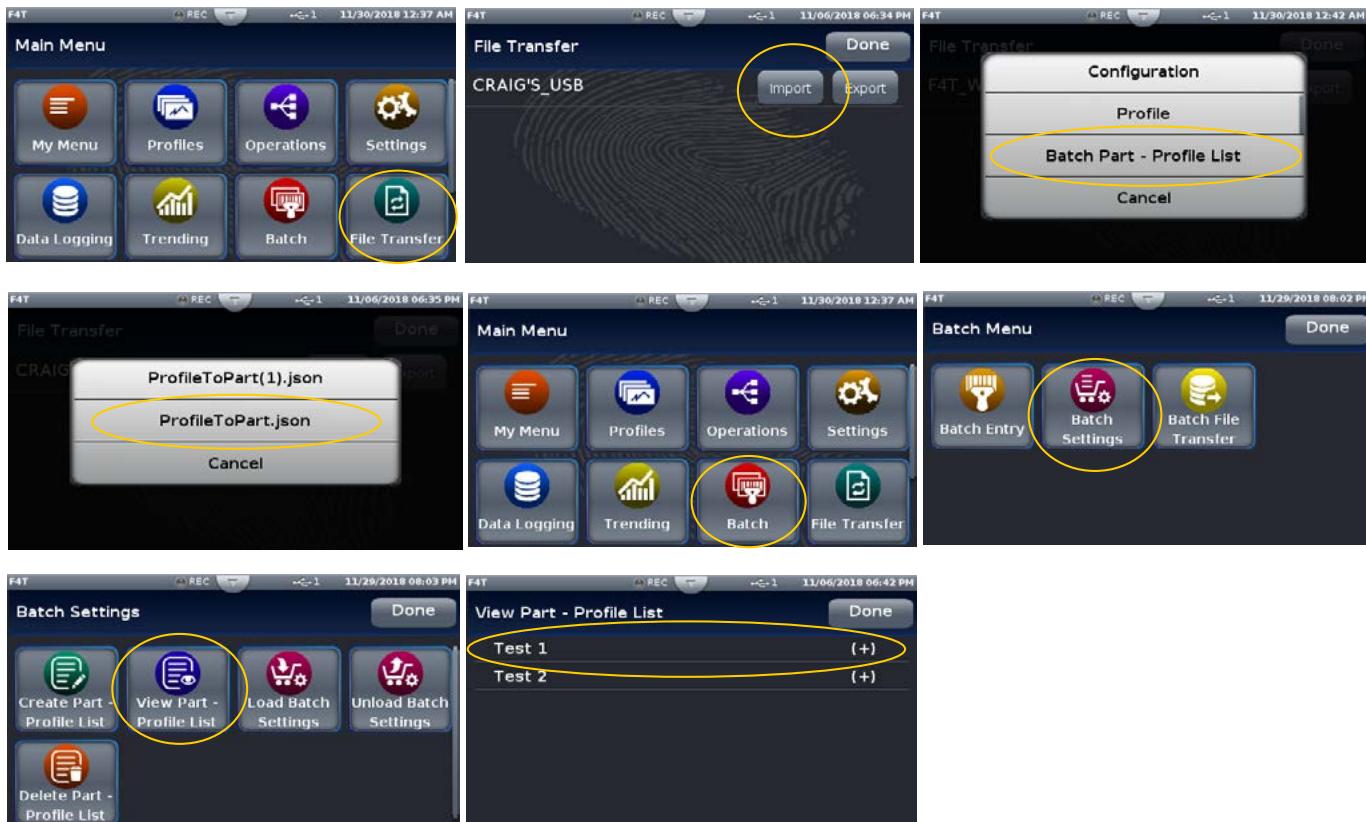
```
{  
    "Test 1": ["0004-0329-0000", "0018-0240-0000"],  
    "Test 2": ["0803-0092-0001", "0843-0041-150R"]  
}
```

```
{  
    "Test 1": ["0004-0329-0000", "0018-0240-0000", "0018-0240-0001",  
    "0018-0240-0002",  
    "0018-0240-0003",  
    "0018-0240-0004",  
    "0018-0240-0005",  
    "0018-0240-0006",  
    "0018-0240-0007"],  
    "Test 2": ["0803-0092-0001", "0843-0041-150R"]  
}
```

Adding "Part-Profile List" using a PC (con't)

6. Save the WordPad file to a USB thumb drive

7. Import "Part-Profile List" file back into the F4T® and verify list of parts listed to each profile



F4T® with the USB Mouse Feature



Use pop-up mouse pointer for point and click rather than finger touch for user interface



Typical USB wired mouse or wireless mouse with USB dongle pugged in the F4T USB port



Right click on mouse for pop-up of 4 front panel keys

Transferring Data Log Files via the UI

A user can transfer data log files manually or automatically.

Note:

All closed data log files are transferred. If a file is open during the logging process, that file will not transfer until closed.

To transfer files manually:

1. Push the **Menu** button.
2. Push the **File Transfer** button.



Note:

The graphic above may or may not look similar when viewed on your F4T®. To appear as shown, a USB thumb drive must be installed and both a TFTP and Samba server must be configured.

3. Push the **Export** button for the desired destination.

To transfer files automatically:

1. Push the **Menu** button.
2. Push the **Data Logging** button.
3. Push the **Data Log File Transfer** button.
4. Select Auto Transfer Type, **TFTP**, **Samba** or **USB**.

If TFTP or Samba is selected above, the server must be configured. For instructions on how to configure either or both, click on the server of choice: [TFTP](#) or [Samba](#)

Flashing the Controller Firmware

On occasion, the F4T® firmware may be updated. When flashing the firmware ensure that power to the controller is not disrupted and allow the process to proceed to completion. Once the process is complete, the controller will come back up with the same configuration (in its entirety) prior to flashing.

To flash the controller to the latest firmware version:

1. Copy the file "F4T®Update" to the root directory of a USB thumb drive.
2. Insert the USB thumb drive into either of the USB ports on the back of the F4T®.

Note:

Prior to initiating this process ensure that there is only one thumb drive connected.

3. Push the **Menu** button.
4. Push the **Settings** button.
5. Push the **Update** button.
6. Push the **Install Update** button.

Note:

After executing step 6 above, the three screen shots below will appear on screen as the flashing activity proceeds.

Copy files:



File Update:



File Update Complete:



When this last screen appears, it will remain on screen for approximately 15 seconds.

Note:

The controller will be restored to reflect the same state it was in when the flashing activity was started. For example, if the controller was in auto mode it will be returned to auto mode.

Email and Text Alerts

The Email/Text Alert feature provides a method to send an Email and/or an Email-to-SMS message (text message) to defined contacts when specified events occur. Up to 10 unique alerts can be configured. 10 Contacts can be predefined to receive alerts (with 2 addresses available per Contact).

When the specified conditions occur for any enabled Alert, the F4T® will automatically send an Alert message to each Recipient that has been selected within the respective Alert.

An Email or Text alert informs the recipient that an event has occurred for which they can be re-active or proactive in their response to the application. For example, a notification may be desired when a profile step has completed to allow the contact to begin preparing material for a future step in the process.

Alerts can be configured for:

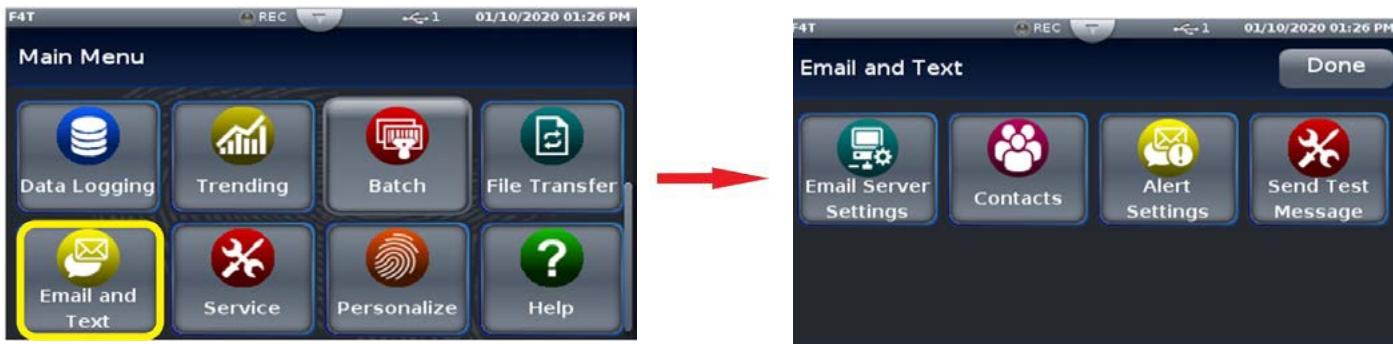
- Select profile conditions for Any profile or an Individual profile, including: Profile Started/Paused/Resumed/Ended, Profile Event Outputs becoming Active or Any/Individual Step Ends
- Alarm conditions
- Limit conditions
- When an analog input error has occurred

Note: The F4T® controller is only capable of sending Alerts when the following conditions are met:

- The F4T® is properly connected to a network via Ethernet
- The Email Server Settings are configured to allow the connection to an email server
- Email/Text Enabled is set to YES (in Email Server Settings)

Note: The timing and delivery of the Email and Text alerts is dependent on a variety of components for delivery. The failure of the internet connection, email server, power supply, or other components can prevent the delivery of the Alert. As a safety precaution, DO NOT rely on the delivery of an Alert for an event.

From the F4T® Main Menu, press the Email and Text button to access the Email and Text screen.



Step 1: Email Server Settings

You must enter the server settings to enable the F4T® controller to send alert messages. Press the Email Server Settings button to access the Server Settings screen.



Touch each field to edit the data for that field and enter the appropriate information. If you do not know the correct information for your email server, contact your system administrator for assistance.

The bracketed bold settings below represent the defaults as delivered from the factory:

- **Email/Text Enabled:** Yes, [No] Enables the Email Text feature.
 - Yes: Email/Text feature is enabled. Allows the F4T® to send Alerts when the Alert conditions are met.
 - No: Email/Text feature is not enabled. No Alerts will be sent.
- **Email Server:** [mail.company.com] Enter the name of the email server that will be used for sending email. Typical format is: mail.company.com. This information, along with the SSL/TLS, Port, Username & Password settings, must be configured properly, to allow the F4T® to send messages. Contact your system administrator for assistance.
- **Use SSL/TLS:** [Yes], No
 - Yes: use Secure Socket Layer (SSL) / Transport Security Layer (TLS) functionality.
 - No: SSL/TLS is not used.
- **Port:** [587] Enter the Port number used by the SMTP (email) server. Typically, the standard port number used would be the following:
 - Port **587** when Use SSL/TLS = **Yes**
 - Port **25** when Use SSL/TLS = **No**This may be different depending on your company's server settings. Contact your system administrator for assistance.
- **Username:** [user@example.com]
 - This must be a valid username that will be used to log in to your company's email server. This will be the sender email address when alerts are sent from the F4T®.
- **Password:** []
 - Enter the password, if required by your network, that corresponds to the Username entered above.

Press the Done button in the upper right corner to save the server settings and return to the Email and Text Main screen.

Step 2: Send an Alert Test Message

Send Test Message can be used as a diagnostic feature to determine if the Email Server Settings and network connection are configured properly to allow the F4T® to send Alert messages. No configuration of the Contacts or Alert Settings is required to use Send Test Message.



To: The Email address that the Test Message will be sent to.

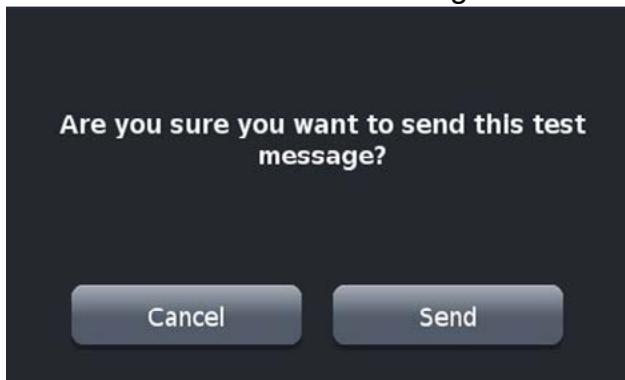
Subject: Subject line of the Test Message

Message: Body of the Test Message.

Note: The email will appear as if it comes from the email account that is used for the Username in Email Server Settings.

Enter the appropriate information in the fields and then press the Send button. When the confirmation screen is shown, press the Send button to send the test message or Cancel to dismiss without sending.

Note: The Send Test Message function will only work if the Email/Text Enabled field is set to YES in the Email Server Settings.



Step 3: Defining Contacts

Before alerts can be sent, you must define the people or contacts to which the messages will be sent. Press the Contacts button on the main Email and Text screen to access the Contacts screen.



You can define up to 10 contacts to receive alerts. Touch a Contact line to configure a contact for that number. The Contact Configuration screen is shown for the contact line that you selected. Note that the Address fields contain example text to show what type of address should be entered in the field.



Enter a name in the Name field to identify the contact. If this field is left blank, the default Contact # will be used. Enter an Email or Email-to-SMS address in the fields provided. Two address fields can be defined for each Contact.

To send the Alert as a text message to a recipient's phone, an Email-to-SMS address must be entered. The format of this address is specific to each recipient's cellular service provider. Contact the service provider for the proper format.

Some examples of formats for common cellular service providers are:

<u>Carrier</u>	<u>SMS gateway domain</u>
AT&T	10-digit number@txt.att.net
Sprint	10-digit number@messaging.sprintpcs.com
U.S. Cellular	10-digit number@email.uscc.net
Verizon	10-digit number@vtext.com

When the contact information has been entered, press the Done button in the upper right corner to save the contact information and return to the Email and Text Main screen.

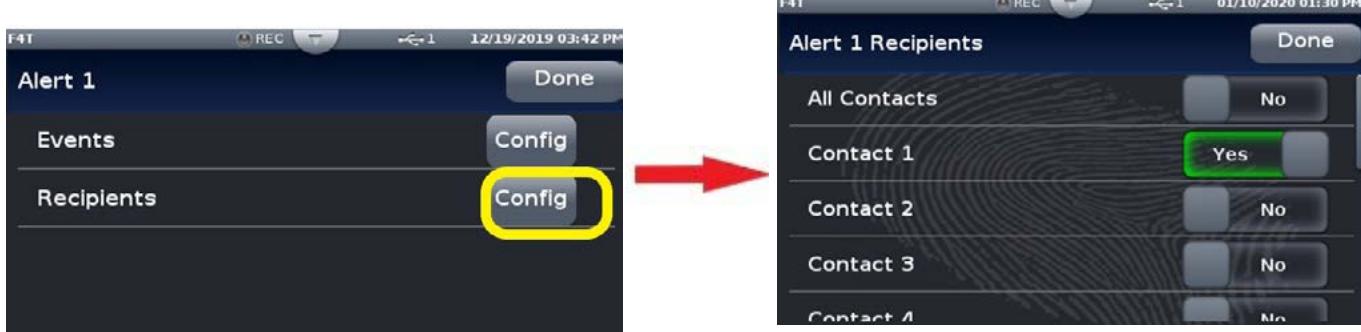
Step 4: Configuring Alerts

Once the Email Server Settings and Contacts have been defined, the Alerts can be configured. Press the Alerts Settings button on the main Email and Text screen to access the Alerts Settings screen.



Each Alert has a toggle switch on the alert definition line to turn the alert on and off. Slide the toggle switch to the desired position once the alert has been completely configured. To define an Alert, press the Config button beside an alert number to access the configuration screen for that alert.

Press the Config button on the Recipients line to define the Recipients that will receive this Alert. Set the toggle button to Yes next to any Contact to notify them of this Alert condition. If All Contacts is set to Yes, the Alert will be sent to All Contacts that have valid email addresses defined.



Press the Config button on the Events line to define the events that will trigger this alert to be sent. Press the Done button to return to the Alert configuration screen.

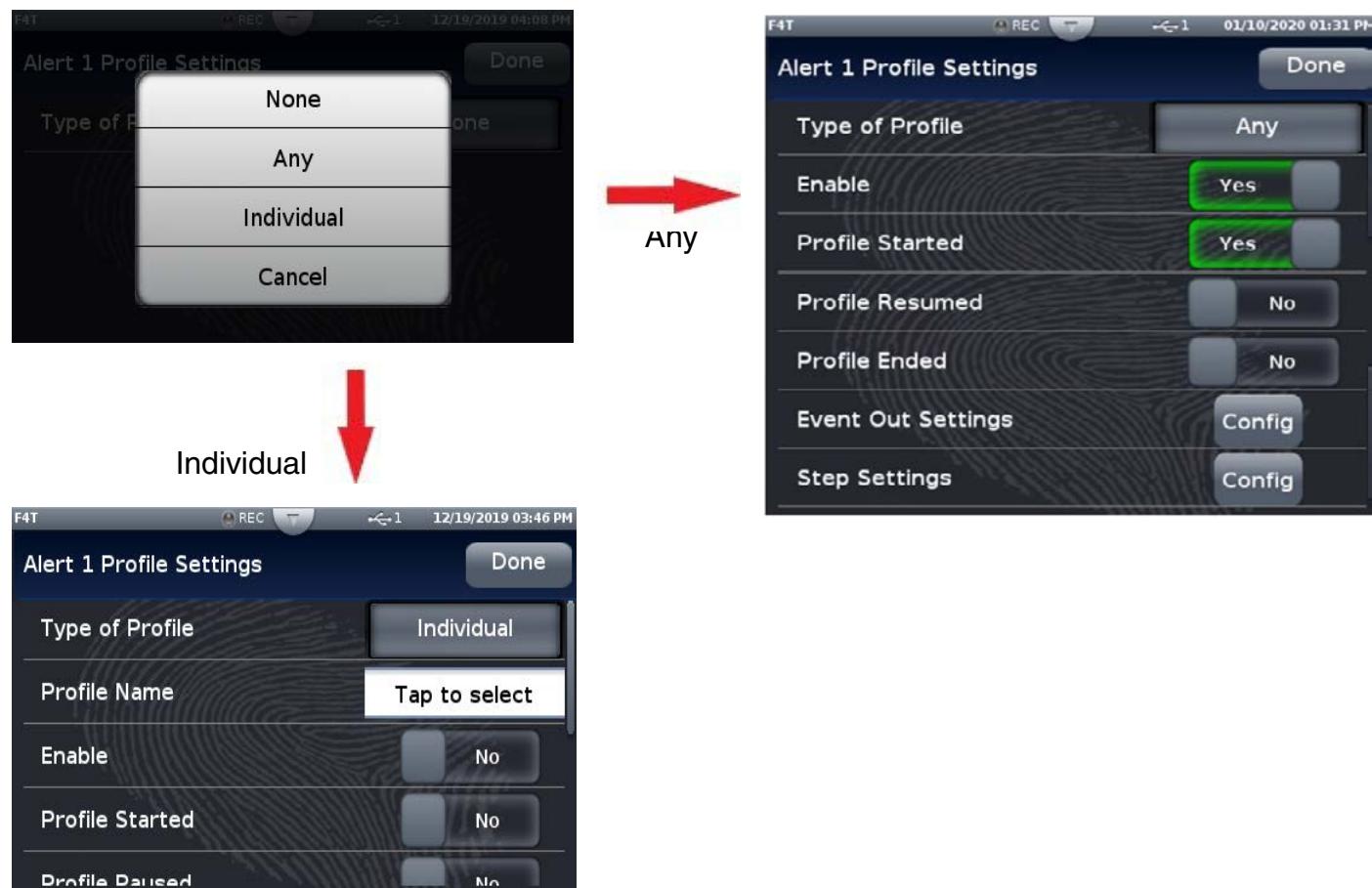


Alert Profiles Configuration

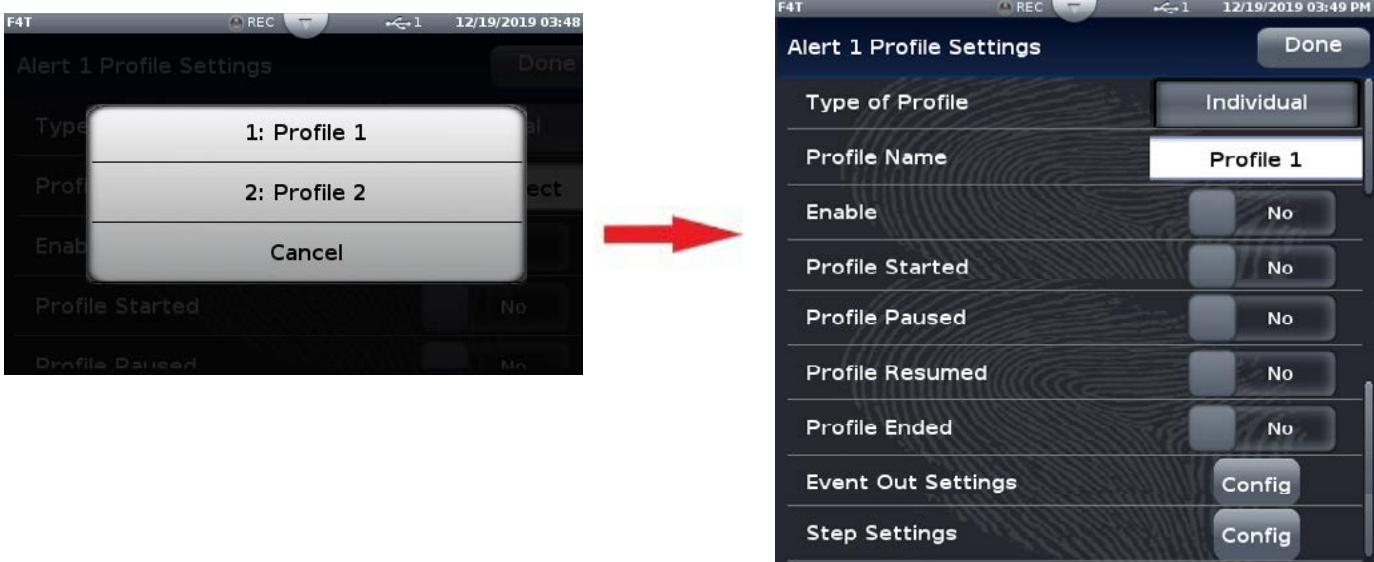
Alerts can be configured for select profile conditions for **Any** profile or an **Individual** profile, including: Profile Started/Paused/Resumed/Ended, Profile Event Outputs becoming Active or Any/Individual Step Ends. Press the Config button beside the Profile field on the Alert Events screen to access the Alert Profile Settings screen.



Press the button beside the Profile field to access the Profile Type choice box. Select the type of profile to access the appropriate screen.



If a specific Individual profile is selected, press the Tap to Select box. Select a profile from the box to access the Individual Profile configuration screen.



From either the individual or Any Alert Profile Settings screen, select the Event Out Settings or Step Settings configuration button to access the appropriate configuration screen.



Press the Done button on the screen when the alerts have been configured to return to the previous screen. Continue to press the done button to return to the Main screen.

Alarm Settings Configuration

Press the Alarms Config button on the Alert Events screen to access the Alert Alarms Settings screen. Select the appropriate settings and then press the Done button to return to the Alerts Event screen.



Limits Settings Configuration

Press the Limits Config button on the Alert Events screen to access the Alert Limits Settings screen. Select the appropriate settings and then press the Done button to return to the Alerts Event screen.



Analog Input Errors Settings Configuration

Press the Analog Input Errors Config button on the Alert Events screen to access the Alert Analog Input Errors Settings screen. Select the appropriate settings and then press the Done button to return to the Alerts Event screen.



4

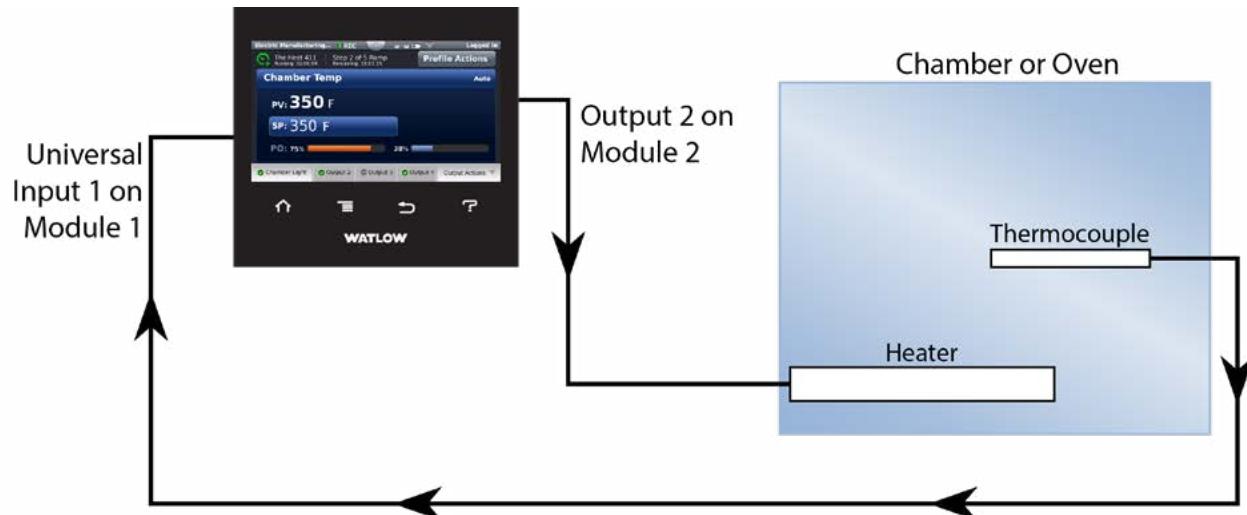
Chapter 4: Application Examples

Applications

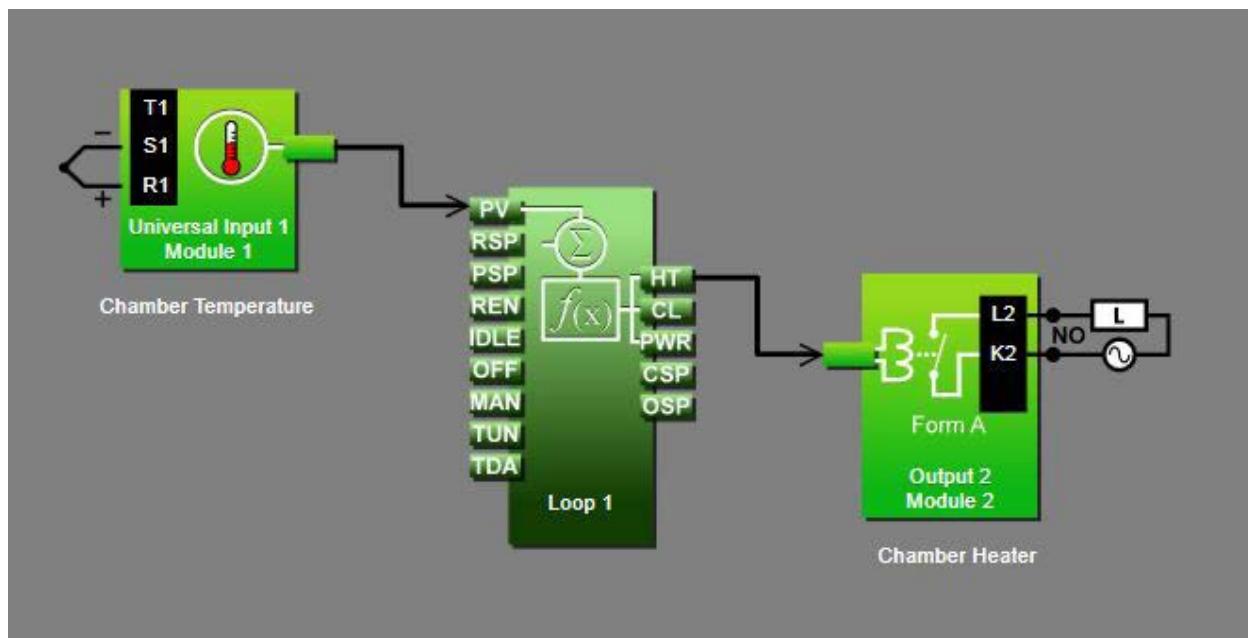
This chapter contains the basic instructions for configuring sample applications. Refer to Chapter 5 for detailed descriptions of the function blocks and parameters.

Single Loop Control

In this example, Universal Input 1 on module 1 measures the temperature of a chamber or oven with a thermocouple. Control Loop 1 takes its feedback directly from the universal input and signals output 2 on module 2 to switch the heater that heats the chamber or oven accordingly.



Function Block Diagram

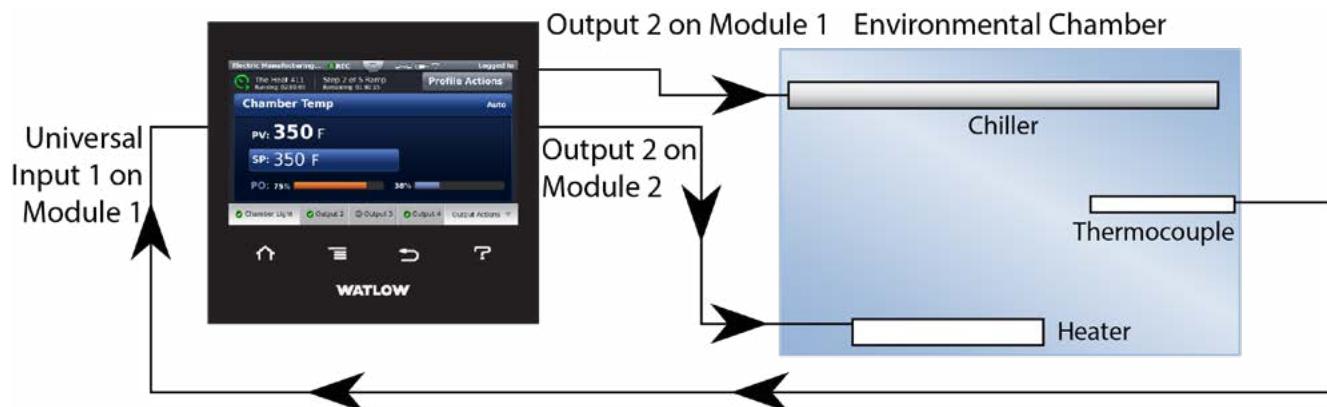


Application Tips:

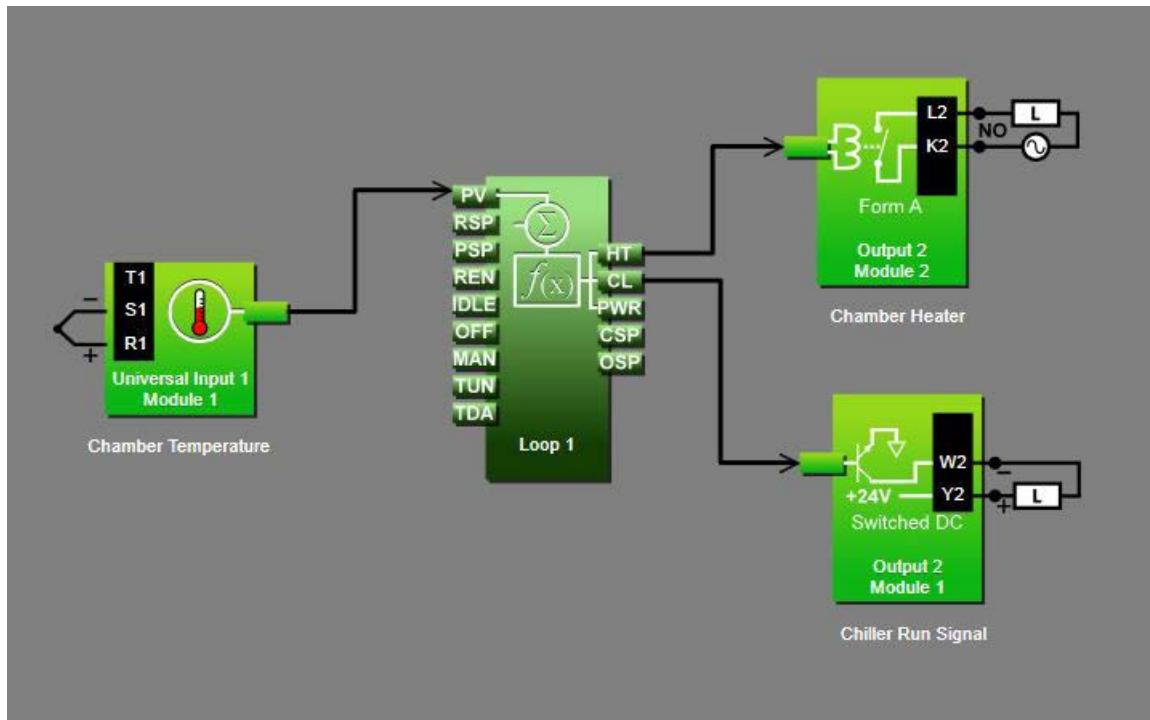
- Loop blocks are initially located in the library and can be dragged to the canvas.
- The signal from the universal input carries the process value to the PV receiver on the loop block where it is used as feedback to the control algorithm.
- The signal from HT on the loop to the output block controls the heater by signaling when the heater should be on for on-off control or how much it should be on with a 0 to 100% signal for PID control.
- Enter names for blocks where possible to make the application easier to understand.
- Make sure the input block's Sensor Type and other parameters are set correctly for your sensor.
- In the loop block set the Control Action and Heat Algorithm based on the type of load being controlled.
- If you use the PID algorithm, you'll need to tune the loop for your system. For more information on autotuning see the section entitled "[Autotune](#)" in Chapter 5.
- Depending on the type of output and the load it drives, you may be able to set Time Base Type in the output block to Variable Time Base to improve control stability. Don't use this setting with mechanical relays or switching devices or loads that are not purely resistive.

Heat and Cool Control Loop

In this example Universal Input 1 on module 1 measures the temperature of an environmental chamber with a thermocouple. Control Loop 1 takes its feedback directly from the universal input, and uses output 2 on module 2 to heat the chamber and output 2 on module 1 to cool the chamber as needed.



Function Block Diagram

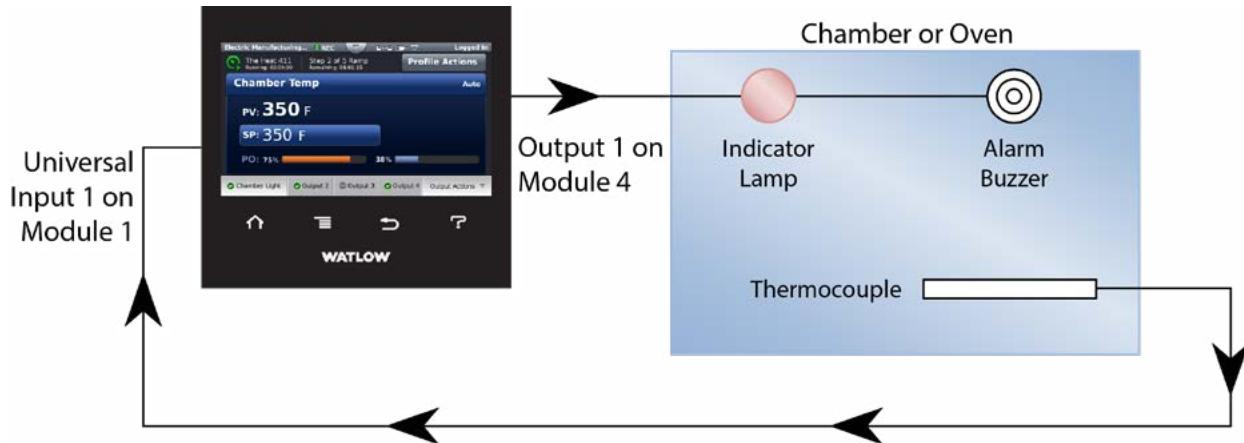


Application Tips:

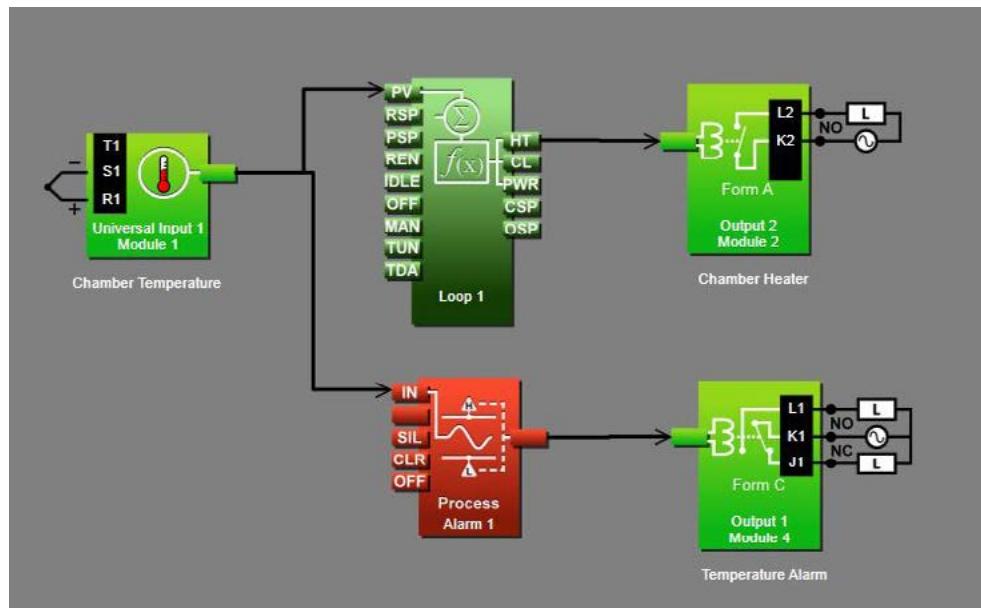
- Loop blocks are initially located in the library and can be dragged to the canvas.
- The signal from the universal input carries the process value to the PV receiver on the loop block where it is used as feedback to the control algorithm.
- The signal from HT on the loop to the output block controls the heater by signaling when the heater should be on for on-off control or how much it should be on with a 0 to 100% signal for PID control.
- The signal from CL on the loop to the output block controls cooling by signaling when the chiller should be on.
- Enter names for blocks where possible to make the application easier to understand.
- Make sure the input block's Sensor Type and other parameters are set correctly for your sensor.
- In the loop block set the Control Action, Heat Algorithm and Cool Algorithm based on the type of load being controlled.
- If you use the PID algorithm, you'll need to tune the loop for your system. For more information on autotuning see the section entitled "[Autotune](#)" in Chapter 5.
- Depending on the type of outputs and the loads they drives, you may be able to set Time Base Type in the output block to Variable Time Base to improve control stability. Don't use this setting with mechanical relays or switching devices or loads that are not purely resistive.

Process Alarm

In this example Universal Input 1 on module 1 measures the temperature of a chamber or oven with a thermocouple. Alarm 1 monitors the temperature from the universal input which is also used by the control loop as feedback for heat control. When the temperature goes outside the normal range defined by the user-adjustable, alarm set points, output 1 on module 4, a form C relay energizes an audible alarm and an indicator lamp to get the operator's attention.



Function Block Diagram



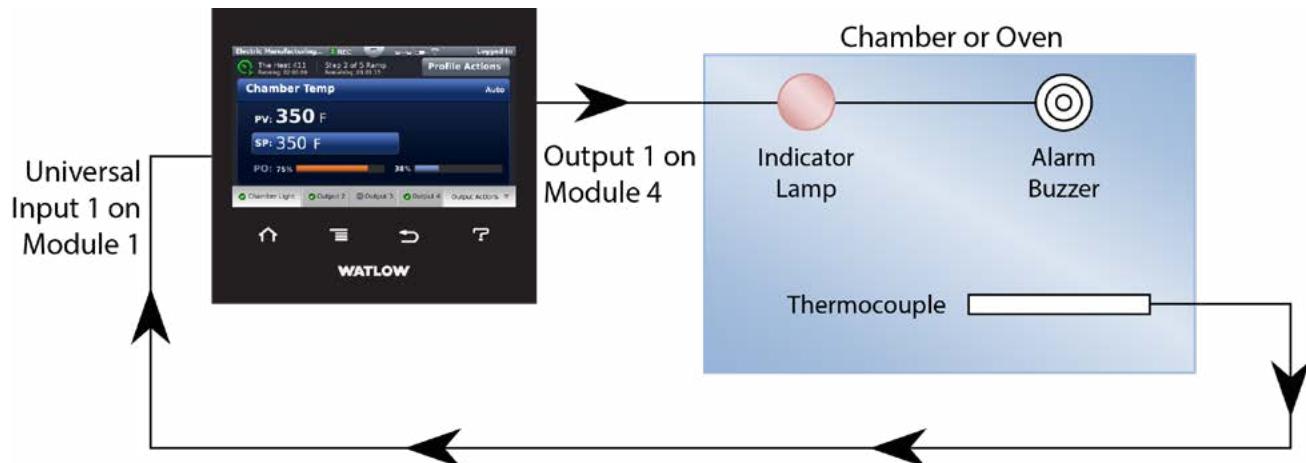
Application Tips:

- Alarm blocks are initially located in the library and can be dragged to the canvas.
- The signal from the universal input to IN on the alarm is the one the alarm monitors against the alarm set point.
- The signal from the alarm to the output indicates when the alarm has occurred. The alarm is indicated on the controller whether or not there is an output attached; the output on the alarm block is for use with additional logic in the application diagram or to drive external devices as is shown in this example.
- Enter names for blocks where possible to make the application easier to understand.
- The control loop is not necessary for the alarm; it is shown here just to make it clear that more than one function block can receive the analog input signal.

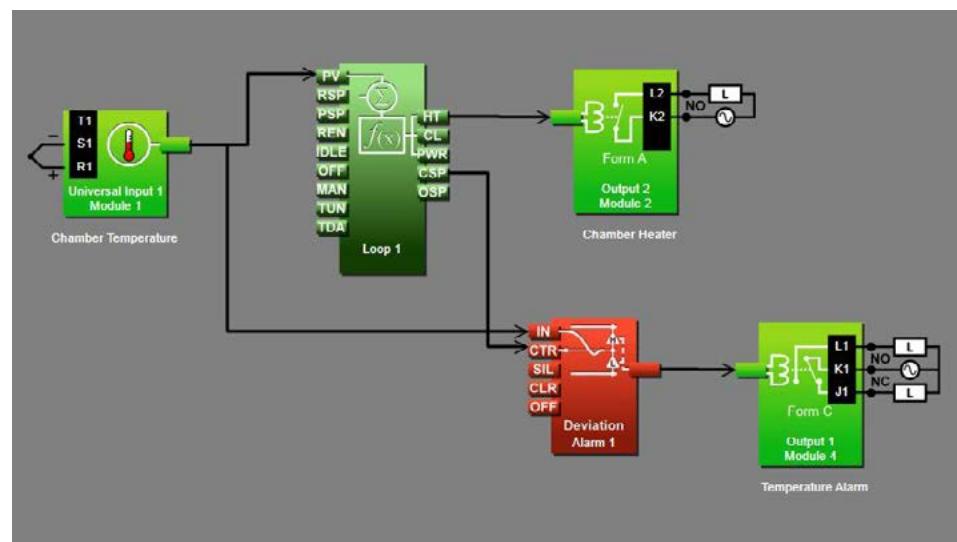
- Make sure the input block's Sensor Type and other parameters are set correctly for your sensor.
- By default the alarm's type setting is Off. Set it to Process Alarm.
- Set the alarm's Sides setting to High or Low if you want to monitor only for the process value going too high or too low, or set Sides to Both if you want the alarm to occur when the process value is either too high or too low.
- For more information on alarm parameters see the section entitled "Alarm" in Chapter 5.

Deviation Alarm

In this example Universal Input 1 on module 1 measures the temperature of a chamber or oven with a thermocouple. Alarm 1 monitors the temperature from the universal input which is also used by the control loop as feedback for heat control. When the temperature gets farther from set point than the user-adjustable, alarm set points, output 1 on module 4, a form C relay energizes an audible alarm and an indicator lamp to get the operator's attention.



Function Block Diagram

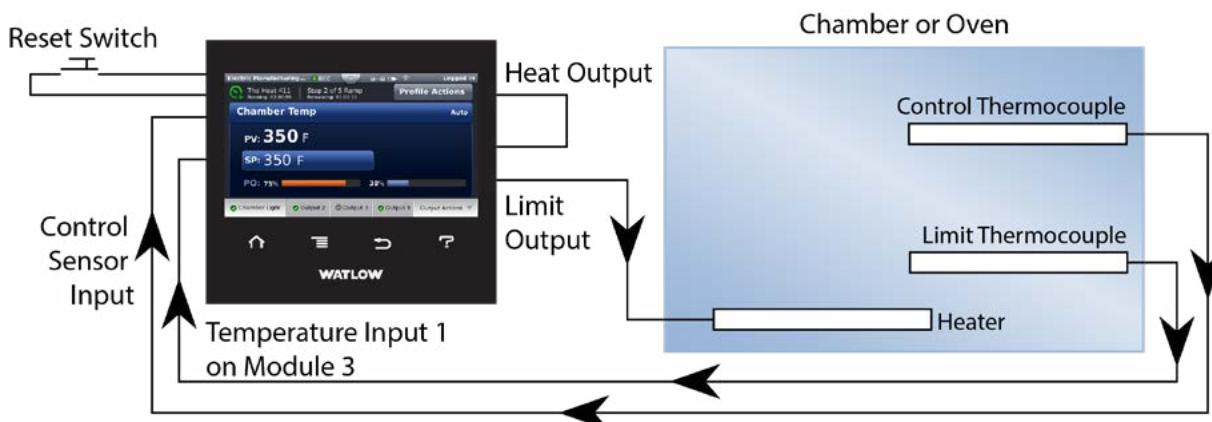


Application Tips:

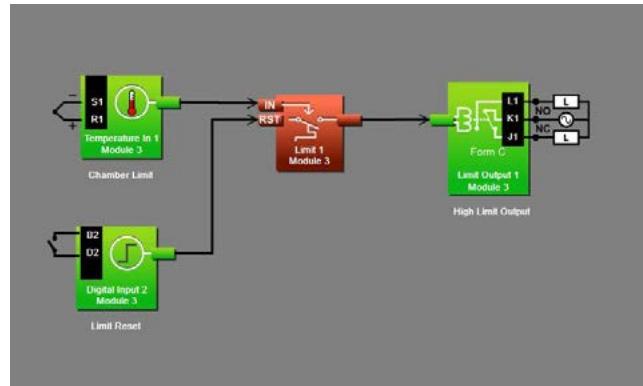
- Alarm blocks are initially located in the library and can be dragged to the canvas.
- The signal from the universal input to IN on the alarm is the one the alarm monitors against the alarm set point.
- The signal from CSP on the loop to CTR on the alarm transmits the loop's set point to the alarm so that the deviation alarms can be relative to the loop's set point.
- The signal from the alarm to the output indicates when the alarm has occurred. The alarm is indicated on the controller whether or not there is an output attached; the output on the alarm block is for use with additional logic in the application diagram or to drive external devices as is shown in this example.
- Enter names for blocks where possible to make the application easier to understand.
- A deviation alarm uses the signal received at CTR as the center of the deviation band. The high and low alarm set points are relative to that center value. In most deviation alarm applications users want the alarm deviation centered on a control loop's set point as shown in this example, but any analog signal could be used.
- Make sure the input block's Sensor Type and other parameters are set correctly for your sensor.
- By default the alarm's type setting is Off. Set it to Deviation Alarm.
- Set the alarm's Sides setting to High or Low if you want to monitor only for the process value going too high or too low, or set Sides to Both if you want the alarm to occur when the process value is either too high or too low.
- For more information on alarm parameters see the section entitled "[Alarm](#)" in Chapter 5.

Safety Limit

In this example one thermocouple measures the temperature of the chamber or oven providing feedback to a control loop that drives a heater with its heat output. A second thermocouple connected to Temperature Input 1 on module 3 also measures the temperature but provides its signal to the limit function. The limit controls a form A relay output that is energized when the temperature has not exceeded the safety limit setting and opens when the limit is exceeded. The control loop's output signal to the heater goes through the limit relay such that power to the heater is cut off when the temperature is above the limit. Also a momentary switch is connected to digital input 2 on module 3 so that the limit can be reset without using the controller interface.



Function Block Diagram

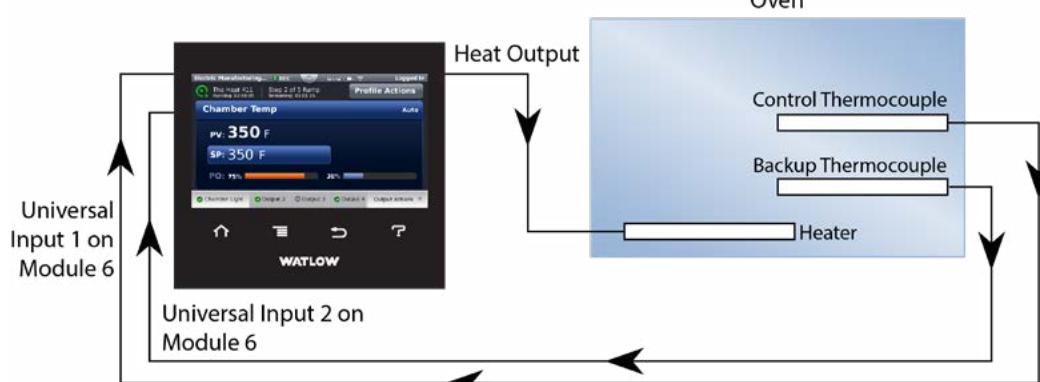


Application Tips:

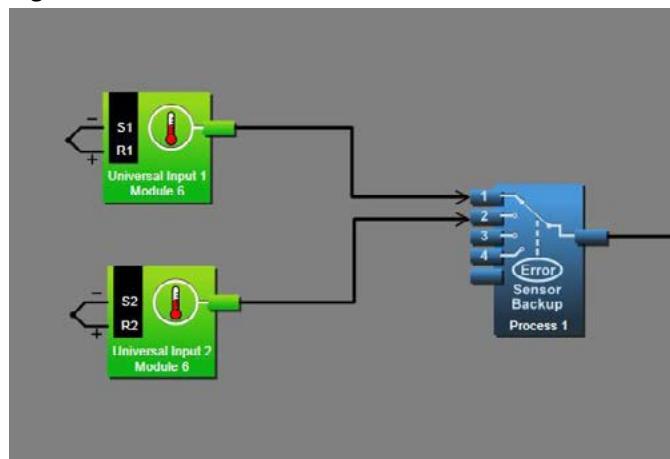
- Because the limit option is designed for safety, the limit block is automatically present on the diagram, and its input and output signals cannot be changed.
- The signal from the digital input to the RST on the limit block allows a momentary switch wired to that input to reset the limit alarm.
- The reset switch is optional. The limit can be reset using the controller's user interface. Note that it is not considered good practice to locate a reset switch in a location so remote from the equipment that the person resetting the limit cannot be sure it is safe to do so.
- Enter names for blocks where possible to make the application easier to understand.
- Make sure the temperature input block's Sensor Type and other parameters are set correctly for your sensor.
- By default the limit's Sides setting is Both. Set it to High or Low if you want to monitor only for the process value going too high or too low, or leave it set to Both if you want the limit to trip when the process value is either too high or too low.
- Set the limit's Low Set Point and/or High Set Point to the values at which you want to open the limit relay's contacts.
- Set the limit's Minimum Set Point and Maximum Set Point to the values above and below which you do not want an operator to set the limit's Low Set Point and High Set Point.

Sensor Backup

In this example there are two thermocouples measuring the temperature of an oven. Normally one provides feedback to a control loop that drives the heater. In the event the first thermocouple fails, the controller switches automatically to the second providing uninterrupted control.



Function Block Diagram

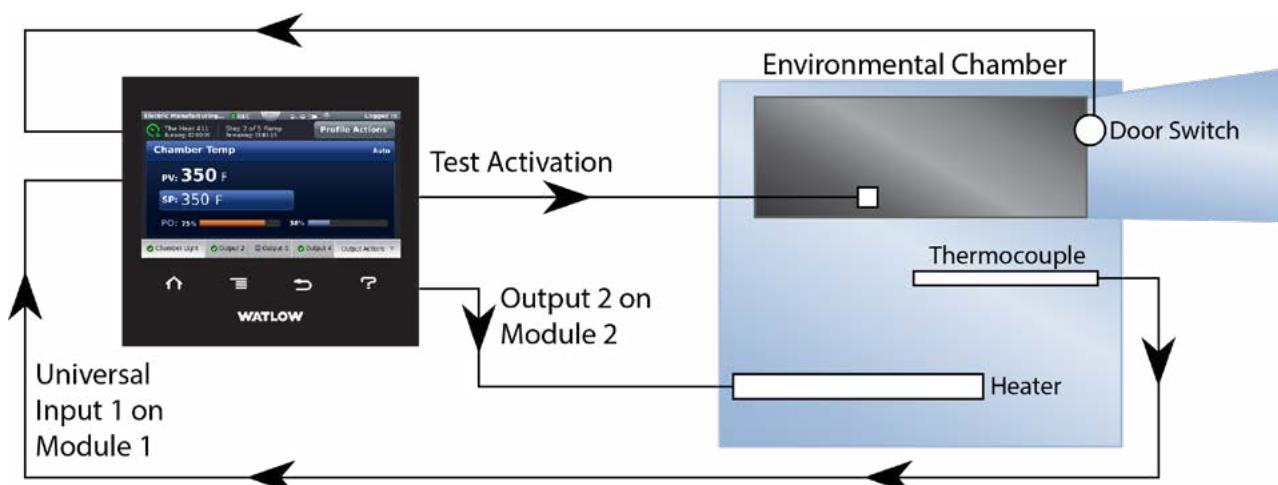


Application Tips:

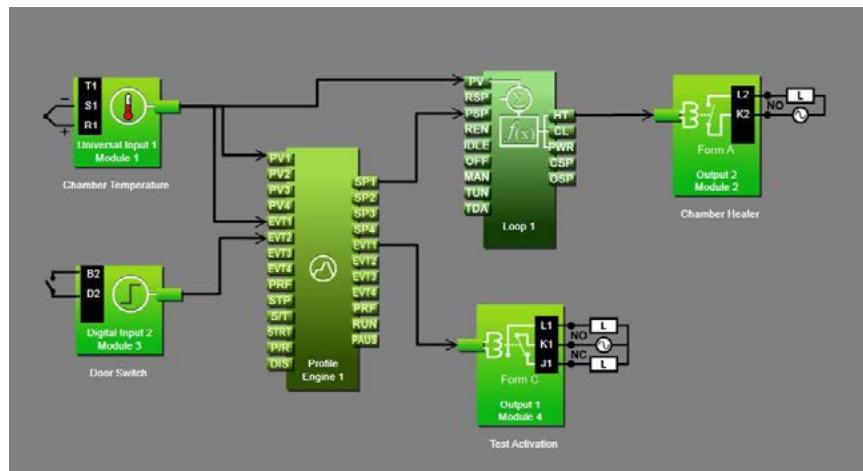
- Process blocks are initially located in the library and can be dragged to the canvas.
- You can connect up to four sensors to the Process block. The process block passes along the signal from the lowest number receiver that has no error on its sensor signal.
- The signal transmitted by the process block can be used by a control loop or any other function as if it was received directly from a universal input block.
- Make sure the input blocks' Sensor Type settings and other parameters are set correctly for your sensors.
- Set the Process block's Function to Sensor Backup.

Profile Ramp and Soak

In this example the temperature of an environmental chamber is measured by a thermocouple connected to Universal Input 1 on module 1 and controlled by a control loop with a heater connected to output 2 on module 2. The chamber also has a door switch so the profile can sense when the door is opened or closed and a test activation circuit to turn on parts that are being tested at specific profile steps.



Function Block Diagram

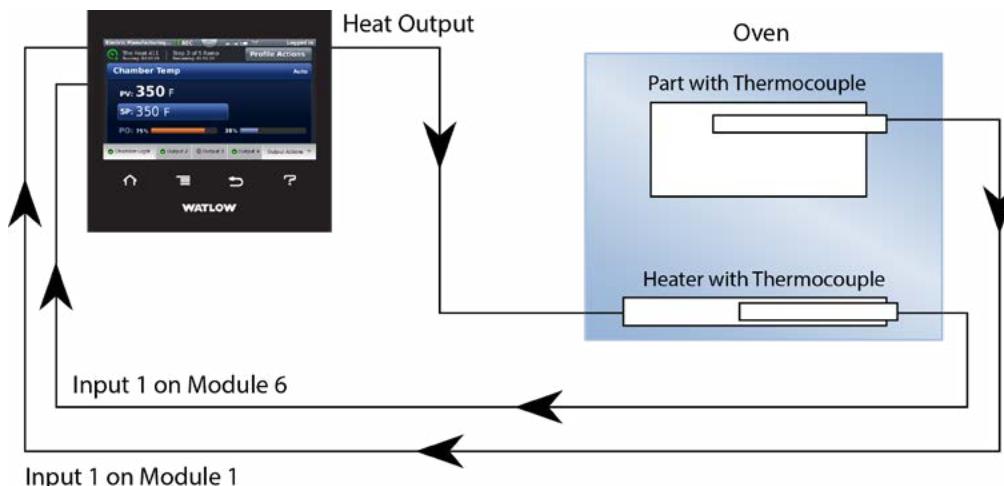


Application Tips:

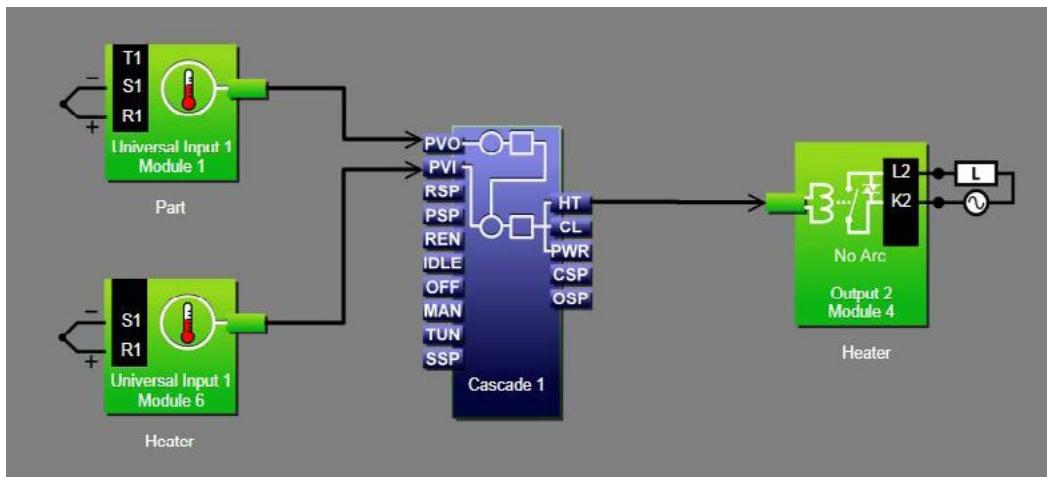
- The profile engine block is initially located in the library and can be dragged to the canvas.
- The signal from the input to PV1 on the profile engine lets the profile engine monitor the process value when guaranteed soak is used and to establish the initial set point when starting a profile.
- The signal from SP1 on the profile engine to PSP on the control loop allows the profile engine to control the loop's set point.
- If you want to be able to have a profile wait for a specific process value, connect the process value signal to the EVT1 receiver (left side of the profile engine).
- The door switch signal to EVT2 on the profile engine allows profiles to be programmed to wait for the door to be open or closed.
- The signal from the EVT1 transmitter (right side of the profile engine) to the test activation output allows the profile to enable an external circuit to power the parts under test at the appropriate times.
- Enter names for blocks where possible to make the application easier to understand.

Cascade Control

In this example a part is heated in an oven. The part takes a lot longer to heat up than the heater and oven, and it can be damaged if heated so quickly that the temperature on the surface is a lot higher than the interior temperature. To heat the part in the minimum amount of time while protecting it from excessive thermal stress, two temperature sensors are used and the controller is configured for cascade control.



Function Block Diagram

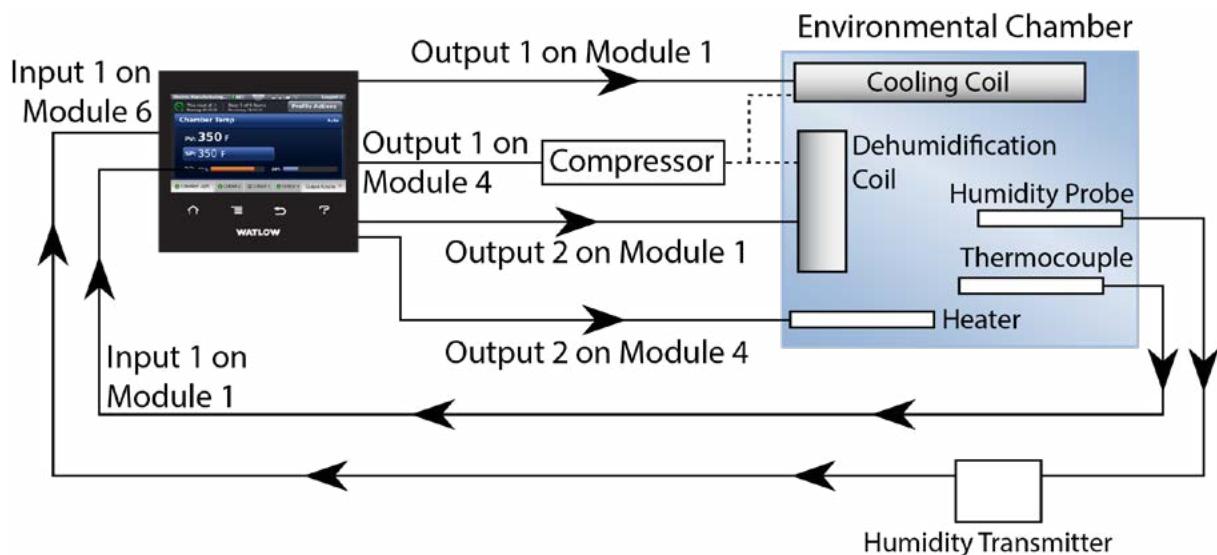


Application Tips:

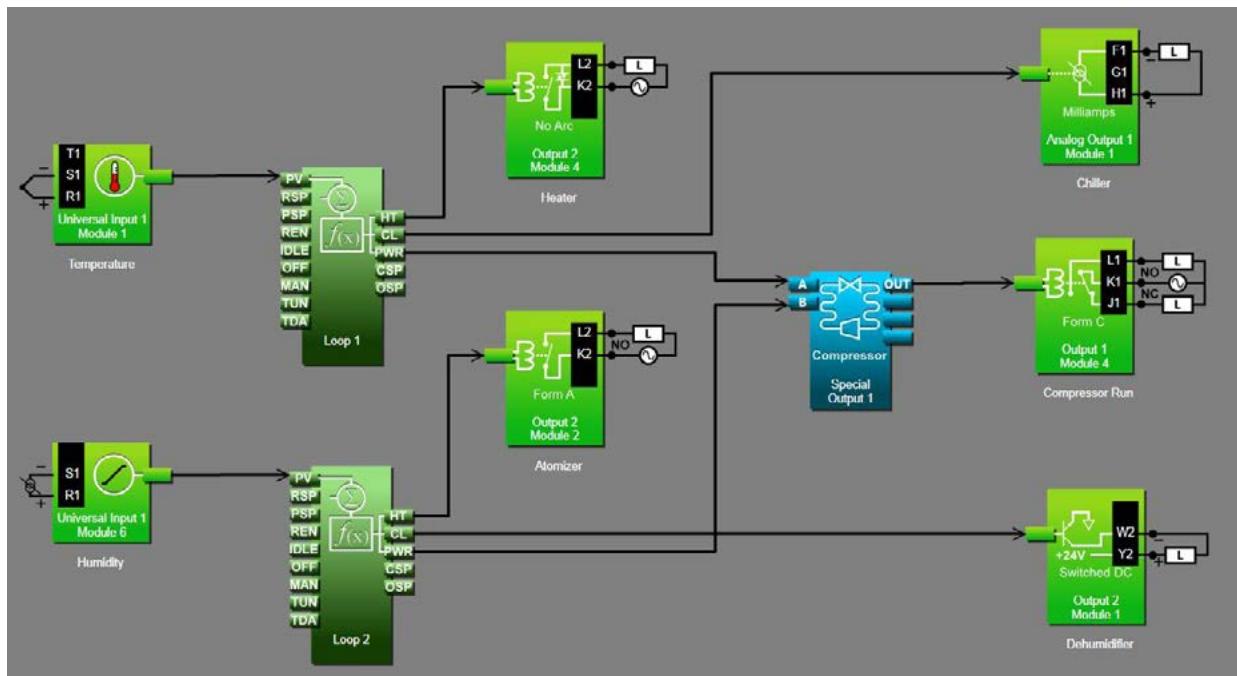
- The cascade block is initially located in the library and can be dragged to the canvas.
- The signal from the input for the part sensor to PVO on the cascade block lets the cascade algorithm know the temperature of the part being heated and is used to determine the set point for the heater.
- The signal from the input for the heater sensor to PVI on the cascade block is the feedback for the inner loop which controls the heater temperature.
- The signal from HT on the cascade block to the output controls the heater.
- Make sure the input blocks' Sensor Type settings and other parameters are set correctly for your sensors.
- Set the Cascade block's Function to Process.
- Set Range Low and Range High settings to limit the heater temperatures to which the part can be exposed. Setting Range Low to 50 and Range High to 210 means that when the temperature in the part is low, the heater set point will go as high as 210, but as the temperature inside the part increases, the heater set point drops.
- In this example Control Action is set to Heat, the Inner Loop Heat Algorithm is set to PID.
- The Inner loop PID settings were set by using the auto tune feature, but the outer loop PID settings were set manually for proportional only control with a proportional band of 20 so that the heater set point is proportional to how cool the part is.
- If the oven must heat parts to many different temperatures or must heat parts over a larger range of temperatures consider using the Deviation setting for the Cascade blocks' Function.
- For more information on cascade control parameters see the section entitled "[Cascade](#)" in Chapter 5.

Compressor Control

In this example the temperature and humidity of an environmental chamber are controlled by two loops. Loop 1 uses a heater to increase the temperature and a cooling coil to lower the temperature. Loop 2 uses a solenoid to control water flow to an atomizer to raise the humidity and a dehumidification coil to lower the humidity. The cooling and dehumidification coils share a compressor. To minimize wear on the compressor and use of electricity, the compressor is turned off and on by the controller's Special Output function block configured for compressor control.



Function Block Diagram



Application Tips:

- The special output block is initially located in the library and can be dragged to the canvas.
- The signals from the temperature and humidity loops' PWR transmitters to A and B on the special output block indicate the percent output power for each of the loops which allow it to determine when the temperature and/or humidity loops need or may soon need the compressor to be on.
- The signal from OUT on the special output block signals when to turn on the compressor.
- Enter names for blocks where possible to make the application easier to understand.
- Set the special output's function parameter to Compressor Control.
- Set the Minimum On Time and Minimum Off Time parameters long enough to protect the compressor from too much cycling, but short enough to allow the compressor to turn off between uses, for example 45 seconds for minimum on time and 15 seconds for minimum off time.
- Set Input A Turn On and Input B Turn On to the percent of power from the temperature and humidity loops at which you want the compressor to turn on so that it is ready when the loop needs cooling or dehumidification, for example 0%.
- Set Input A Turn Off and Input B Turn Off to the percent power at which you would be comfortable having the compressor turn off, for example 2% for temperature and 5% for humidity.
- Note the correct settings for the parameters above depend on the specific application hardware.
- For more information on compressor control parameters see the section entitled "[Compressor Control](#)" in Chapter 5.

5

Chapter 5: Function Block Reference

Function Block Reference

F4T® Functions Described	92
Alarm	93
Off	94
Process Alarm	94
Deviation Alarm	96
Analog Outputs	100
Cascade	102
Process	102
Deviation	103
Compare	117
Off	118
Greater Than	118
Less Than	118
Equal To	119
Not Equal To	119
Greater or Equal	120
Less or Equal	121
Control Loop	121
Counter	134
UP	134
Down	136
Current Input	137
Digital Input	139
Input Dry Contact	139
Input Voltage	140
Digital Inputs/Outputs (I/O)	140
Input Dry Contact	140
Output	141
Input Voltage	142
Digital Outputs	143
Solid-State Relay - Switched DC/Open Collector	143
Electromechanical and NO-ARC Relays	144
Key	145
Momentary	145
Toggle	145
On Pulse	145
Limit	147

Function Block Reference (cont.)

Limit Output	148
Linearization	148
Off	149
Interpolated	149
Stepped	151
Logic	154
Off	154
And	154
Nand	156
Equal To	157
Not Equal To	158
Or	159
Nor	160
Latch	161
RS Flip Flop	162
Math	163
Average	164
Switch Over	165
Process Scale	165
Deviation Scale	167
Differential	169
Ratio	169
Add	170
Multiply	170
Absolute Difference	171
Minimum	171
Maximum	172
Square Root	172
Sample and Hold	173
Pressure to Altitude	173
Dew Point	174
Profile	176
Process Value	182
Off	182
Sensor Backup	183
Average	184
Crossover	184
Wet Bulb / Dry Bulb	185
Switch Over	186
Differential	186
Ratio	187
Add	187
Multiply	188

Function Block Reference (cont.)

Absolute Difference	189
Minimum	189
Maximum	190
Square Root	190
Vaisala® RH Compensation	191
Pressure to Altitude	191
Special Output	193
Off	194
Compressor Control	194
Sequencer	197
Motorized Valve	198
Temperature Input	198
Resistance Temperature Device (RTD) 100 and 1000 Ohm	199
Thermocouple	200
Thermistor Input	201
Timer	204
Off	204
On Pulse	204
Delay	206
One Shot	207
Retentive	208
Universal Input	210
Millivolts/Volts	211
Off	213
Thermocouple	214
Millamps	215
Resistance Temperature Device (RTD) 100 and 1000 Ohm	217
1K Potentiometer	218
Variable	221
Analog	221
Digital	222

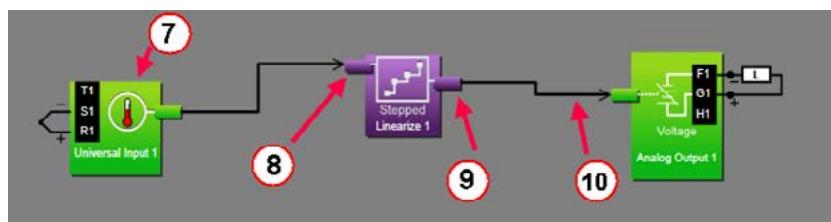
F4T® Functions Described

The controller is customized by connecting function blocks (FB) as needed for the application. A transmitter of one function is commonly connected to a receiver of another using Composer's function block diagram editor. The connections between blocks, referred to as signals, carry information from one function block to another.

Each signal carries three pieces of information:

1. Value

- The value is either analog (floating point numbers) or digital (on, off, true or false). Most function blocks expect a specific type of value to be received at each receiver and produce a specific type of value at each transmitter. Depending on the context, the value of a digital signal may be thought and spoken of in various terms. The table below lists the various terms that occur in the various contexts.



Analog Value	Digital Values	Logic	*Active Signal Parameter Settings
0%	Off	False	Low
100%	On	True	High

* When the state of a digital signal that triggers an action is configurable, the values are referred to as Active and Inactive and a parameter is provided for choosing which state triggers the action. As an example, if the TUN receiver in the graphic above is connected to a digital device, the Loop 1 parameter "Initiate Autotune Active Level" (High or Low) will determine when tuning occurs.

2. Units

- An analog signal can be in units of absolute or relative temperature (Celsius or Fahrenheit), percent power or relative humidity. Values may have no units or unspecified units, indicated as process. Digital signals have no units associated with them.

Units	Description
Absolute Temperature	The value is a temperature on the Celsius or Fahrenheit scale. For example, 33° F as an absolute temperature is one degree above the freezing point of water. An absolute temperature can be used as a set point or compared with other temperatures to determine which is hotter or colder
Relative Temperature	The value is a relative number of degrees, not an absolute temperature. For example, the difference between the two measured temperatures, 120° C and 100° C is 20 degrees, but it is not the temperature 20° C. A relative temperature is appropriate for use as a calibration offset or a deviation alarm set point
Relative Humidity	The value is a measurement of percent relative humidity (%RH)
Power	The value is a percentage with 100% representing full power and 0% representing no power
Process	The value is in units of measure other than degrees Fahrenheit, degrees Celsius or relative humidity
None	The value is a pure number without units

3. Error Status

- A signal's error status indicates whether or not the value can be relied on. A signal with no errors (error status is none), is displayed as a black line in Composer. When something is wrong such that a function block cannot determine an appropriate value to transmit, the signal is displayed as a yellow line in Composer. You can determine the specific error status by mousing over the signal in the diagram. The table below lists the possible errors that could be presented to the user. Any error status other than none is considered an error.

Error Status	Description
None	No error is detected.
Open	A sensor is broken or disconnected.
Shorted	A sensor has failed or is shorted.
Measurement Error	A measurement error has occurred.
Bad Calibration	The controller has not been calibrated.
Ambient Error	The ambient temperature is outside of the controller's operating range.
RTD Error	An RTD sensor error has occurred.
Fail	A measurement failure has occurred.
Not Sourced	The source FB is missing a required signal at one of its receivers.
Stale Data	Data sourced from another controller has become unavailable.
Math Error	A calculation has no defined result (such as divide by zero).

This chapter describes in detail each of the available functions as well as their associated parameters.

Note:

The addresses and other information required to read or set FB parameter values via a field bus protocol is located in the "Communications" section of the Appendix to this User's Guide.

Alarm

Use an alarm to monitor an analog signal and set an output when that signal goes above or below the user-set alarm conditions. This block is found in the Function Block Diagram editor's Library when working with a controller that offers the Alarm block. The number of these blocks available is shown within the parenthesis.

Use the Type parameter to set the block's behavior. These options for Type are described in detail in the following sections:

Off: no alarms occur. The block's output is off.

Process Alarm: monitors an analog signal for specified alarm conditions.

Deviation Alarm: monitors an analog signal for alarm conditions relative to another signal.

Off

When Type is set to Off, the output is off.

Process Alarm

A Process Alarm sets its output when the receiver (IN) rises above the High Set Point or drops below the Low Set Point. The alarm's behavior can be customized with Logic, Latching, Blocking, Silencing and Delay Time parameters.

Signals

Direction	Label	Type	Function
Receivers	IN	Analog	Monitored for alarm conditions
			Not used
	SIL	Digital	True silences the alarm (see Silencing)
	CLR	Digital	True clears the alarm if the condition that caused it no longer exists (See Latching)
	OFF	Digital	True makes the function act as if Alarm Type was set to off
Transmitter	- - - -	Digital	Indicates the alarm state (see Logic)

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Type

To monitor an analog signal for alarm conditions, set Type to Process Alarm.

Sides

Select whether the receiver (IN) is monitored for high, low or both high and low alarms.

Options:

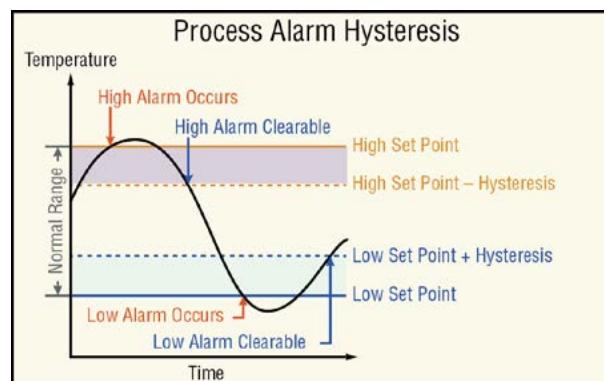
- Both: IN is monitored for high, low or both high and low alarms.
- High: IN is monitored for a high alarm only. The low alarm is not monitored.
- Low: IN is monitored for a low alarm only. The high alarm is not monitored.

Hysteresis

Set how far the process must return into the normal range before the alarm can be cleared. Hysteresis defines how far the signal must drop below the High Alarm Set Point before a high alarm can be cleared and how far the signal must rise above the Low Alarm Set Point before a low alarm can be cleared.

Range: 1 to 9,999 °F or units
2 to 5,555 °C

Silencing



Set whether or not the output can be returned to the non-alarm state (silenced) before the input returns to the normal range. Silencing an alarm returns the alarm's output to its inactive state without requiring the alarm state to be cleared. Once the alarm is silenced, the output remains inactive until the alarm is cleared and the alarm condition reoccurs.

Options:

- Yes: alarm can be silenced by connecting a digital signal to SIL or by using the Silence Alarm parameter
- No: alarm cannot be silenced. After an alarm occurs, the function's output returns to its non-alarm state only when the alarm is cleared

Latching

Select whether an alarm state is maintained (latched) or clears automatically when the process value returns to an acceptable level.

Options:

- Latching: alarm remains active until the condition that caused it no longer exists and the alarm is reset by the CLR receiver or the Clear Alarm parameter.
- Non-latching: alarm clears automatically once the condition that caused it no longer exists.

Blocking

Alarm blocking allows a system to warm-up after being powered up or to be adjusted without experiencing nuisance alarms. Set alarm blocking to prevent alarms before IN has first come within the normal operating range.

Options:

- Both: alarms are blocked when the controller powers up and deviation alarms are blocked when the loop's Set Point or the alarm's High Set Point or Low Set Point is changed.
- Off: alarms are not blocked.
- Set Point: deviation alarms are blocked when the loop's Set Point or the alarm's High Set Point or Low Set Point is changed.
- Startup: alarms are blocked when the controller powers up.

Display

Provides the ability to display alarm activity to the user interface (UI).

Options:

- On: when an alarm is active will cause the controller status bar on the UI to flash yellow.
- Off: when an alarm is active there will be no indication on the UI.

Logic

Set which state (on or off) of the alarm function's transmitter indicates there is an alarm.

Options:

- Close on Alarm: the alarm function's transmitter is off when there is no alarm and on when there is an alarm.
- Open on Alarm: the alarm function's transmitter is on when there is no alarm and off when there is an alarm.

Delay Time

Set a length of time, in seconds, that an alarm condition must be present before the alarm state and output are triggered. This setting determines the minimum time that the value at IN must be continuously above the High Set Point or below the Low Set Point before the alarm state and alarm function's output indicate an alarm. If the value at IN returns within the normal range before this time, no alarm occurs. This feature can be used to minimize nuisance alarms.

Range: 0 to 9,999 seconds

Low Set Point

Set the process value or temperature that triggers the low process alarm.

Range: -99,999 to 99,999

High Set Point

Set the process value or temperature that triggers the high process alarm.

Range: -99,999 to 99,999

Clear Alarm

Set this parameter to clear to reset the alarm state after correcting the condition that caused the alarm.

Options: Ignore, Clear

Silence Alarm

Set this parameter to silence alarms to deactivate the output after the alarm occurs.

Options: Ignore, Silence Alarms

Deviation Alarm

A Deviation Alarm's transmitter becomes active when the receiver (IN) rises above CTR (center) by more than the High Set Point or drops below CTR by more than the Low Set Point. The alarm conditions define a deviation window relative to CTR. CTR is typically connected to a control loop's set point so that when the control loop's set point changes, the deviation alarm window moves with it. The alarm's behavior can be further customized with Logic, Latching, Blocking, Silencing and Delay Time parameters.

Signals

Direction	Label	Type	Function
Receivers	IN	Analog	Monitored for alarm conditions
	CTR	Analog	Defines the center value relative to which the alarms are evaluated (typically a control loop's set point)
	SIL	Digital	On silences the alarm (see Silencing)
	CLR	Digital	On clears the alarm if the condition that caused it no longer exists (See Latching)
	OFF	Digital	On makes the function act as if Type was set to off
Transmitter	- - - -	Digital	Indicates the alarm state (see Logic)

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Type

To monitor an analog signal for alarm conditions relative to another signal, set Type to Deviation Alarm.

Sides

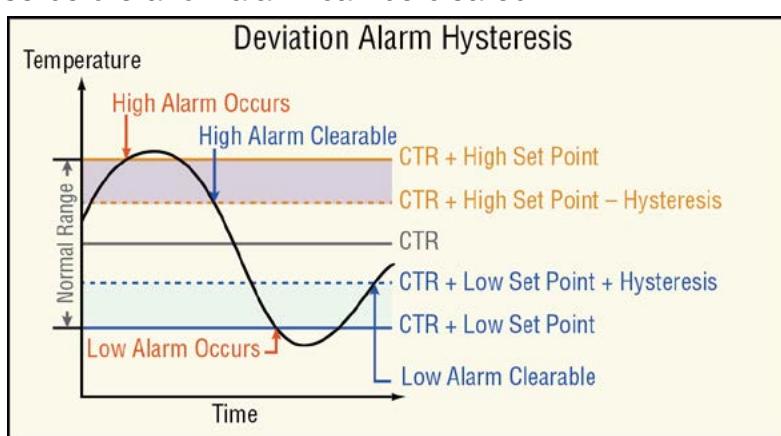
Select whether the receiver (IN) is monitored for high, low or both high and low alarms.

Options:

- Both: IN is monitored for high, low or both high and low alarms.
- High: IN is monitored for a high alarm only. The low alarm is not monitored.
- Low: IN is monitored for a low alarm only. The high alarm is not monitored.

Hysteresis

Set how far the process must return into the normal range before the alarm can be cleared. Hysteresis defines how far below the point at which a high alarm occurs the signal must drop before a high alarm can be cleared and how far above the point at which a low alarm occurs the signal must rise before a low alarm can be cleared.



Range: 1 to 9,999 °F or units

2 to 5,555 °C

Silencing

Set whether or not the output can be returned to the non-alarm state (silenced) before the input returns to the normal range. Silencing an alarm returns the alarm's output to its inactive state without requiring the alarm state to be cleared. Once the alarm is silenced, the output remains inactive until the alarm is cleared and the alarm condition reoccurs.

Options:

- Yes: alarm can be silenced by connecting a digital signal to SIL or by using the Silence Alarm parameter
- No: alarm cannot be silenced. After an alarm occurs, the function's output returns to its non-alarm state only when the alarm is cleared

Latching

Select whether an alarm state is maintained (latched) or clears automatically when the process value returns to an acceptable level.

Options:

- Latching: alarm remains active until the condition that caused it no longer exists and the alarm is reset by the CLR receiver or the Clear Alarm parameter.
- Non-latching: alarm clears automatically once the condition that caused it no longer exists.

Blocking

Alarm blocking allows a system to warm-up after being powered up or to be adjusted without experiencing nuisance alarms. Set alarm blocking to prevent alarms before IN has first come within the normal operating range.

Options:

- Both: alarms are blocked when the controller powers up and deviation alarms are blocked when the loop's Set Point or the alarm's High Set Point or Low Set Point is changed.
- Off: alarms are not blocked.
- Set Point: deviation alarms are blocked when the loop's Set Point, alarm's High Set Point or Low Set Point is changed.
- Startup: alarms are blocked when the controller powers up.

Display

Provides the ability to display alarm activity to the user interface (UI).

Options:

- On: when an alarm is active will cause the controller status bar on the UI to flash yellow.
- Off: when an alarm is active there will be no indication on the UI.

Logic

Set which state (on or off) of the alarm function's transmitter indicates there is an alarm.

Options:

- Close on Alarm: the alarm function's transmitter is off when there is no alarm and on when there is an alarm.
- Open on Alarm: the alarm function's transmitter is on when there is no alarm and off when there is an alarm.

Delay Time

Set a length of time, in seconds, that an alarm condition must be present before the alarm state and output are triggered. This setting determines the minimum time that the value at IN must be continuously above CTR by more than the high alarm set point or below CTR by more than the low alarm set point before the alarm state and alarm function's output indicate an alarm. If the value at IN returns within the normal range before this time, no alarm occurs. This feature can be used to minimize nuisance alarms.

Range: 0 to 9,999 seconds

Low Set Point

Set how far the value at IN must drop below CTR to trigger a low deviation alarm. The low deviation alarm occurs when the value at IN is below the center's value (CTR) plus this parameter's setting. A negative value for Low Set Point sets the alarm condition below the center and a positive value sets the alarm condition above the center.

Range: -99,999 to 99,999

High Set Point

Set how far the value at IN must rise above CTR to trigger a high deviation alarm. The high deviation alarm occurs when the value at IN is above the center's value (CTR) plus this parameter's setting. A negative value for High Set Point sets the alarm condition below the center and a positive value sets the alarm condition above the center.

Range: -99,999 to 99,999

Clear Alarm

Set this parameter to clear to reset the alarm state after correcting the condition that caused the alarm.

Options: Ignore, Clear

Silence Alarm

Set this parameter to silence alarms to deactivate the output after the alarm occurs.

Options: Ignore, Silence Alarms

Error Handling Rules

When the alarm's receiver (IN) has an error the alarm is triggered. The Alarm function never generates an error and the output's error status is always None.

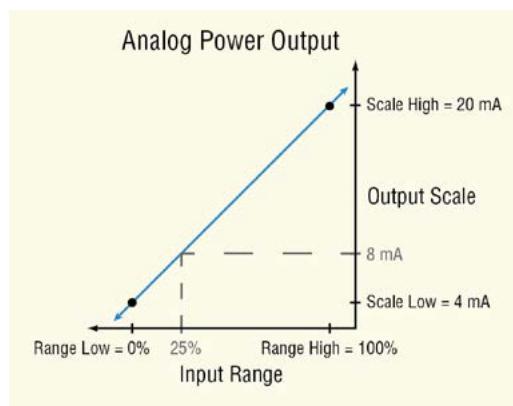
Error Condition	Result
Input has an error	The Alarm State indicates there is an error and the output is active.

Analog Outputs

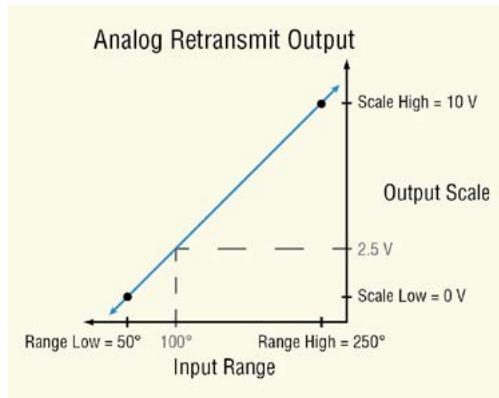
Use this block to operate an external device that takes an analog or process signal such as 4 to 20 mADC or 0 to 10 VDC.

These FBs are found on the canvas in the Function Block Diagram editor. The number of these FBs available depends on the number of flex modules with analog outputs installed in the controller.

These FBs can be used to operate a control element such as a proportional valve based on the output of a control loop or to retransmit a signal proportional to a process value or set point to another instrument such as a chart recorder. The illustrations below show examples of these two uses. For a power output to a 4 to 20 mADC output, the value received is scaled proportionally from the 0 to 100% input range to the 4 to 20 output scale. When the input is 25%, the output is 8 mA.



For a retransmit output to a 0 to 10 VDC output, the value received at input In is scaled proportionally from the 50 to 250° input range to the 0 to 10 output scale. When the input is 100°, the output is 2.5 VDC.



Note that the settings of the Range Low and Range High settings do not limit the physical output signal. The physical output is set according to the line defined by the range and scale parameters and is limited by the range of values input to the function and the electrical limitations of the hardware. If the input signal is limited to 0 to 100%, the Range Low is set to 0%, and the Range High is set to 100%, the output can be limited by setting the Scale Low and Scale High parameters to the desired minimum and maximum signal levels.

Signals

Direction	Label	Type	Function
Receiver	- - - -	Analog % or Digital	Drives the physical output associated with the block

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Output Type

Set whether the physical analog output supplies a voltage or current signal.

Options:

- Volts: the output supplies a voltage signal
- Milliamps: the output supplies a current signal

Scale Low

Set the desired value for the output in electrical units (mA DC or VDC) when the input to the block equals the Range Low setting. Scale Low and Range Low are the coordinates of a point on the line that relates the input to the scaled output.

Consult the hardware specifications for the signal range supported by the specific hardware.

Range: -100.0 to 100.0 mA DC (typically 0 mA DC or 4 mA DC)
-100.0 to 100.0 VDC (typically 0 VDC)

Scale High

Set the desired value for the output in electrical units (mA DC or VDC) when the input to the block equals the Range High setting. Scale High and Range High are the coordinates of a point on the line that relates the input to the scaled output.

Consult the hardware specifications for the signal range supported by the specific hardware.

Range: -100.0 to 100.0 mA DC (typically 20 mA DC)
-100.0 to 100.0 VDC (typically 1, 5, or 10 VDC)

Range Low

Set the value for the input to the block at which the Scale Low setting is the desired output value. When using the output to retransmit an analog signal, this is typically the low end of the range being retransmitted. When using the output for control, this is typically 0%.

Range: -99,999.000 to 99,999.000

Range High

Set the value for the input to the block at which the Scale High setting is the desired output value. When using the output to retransmit an analog signal, this is typically the high end of the range being retransmitted. When using the output for control, this is typically 100%.

Range: -99,999.000 to 99,999.000

Calibration Offset

Set an offset value for a process output.

Range: -1,999.000 to 9,999.000°F

-1,110.555 to 5,555.000°C

-99,999 to 99,999 units

Cascade

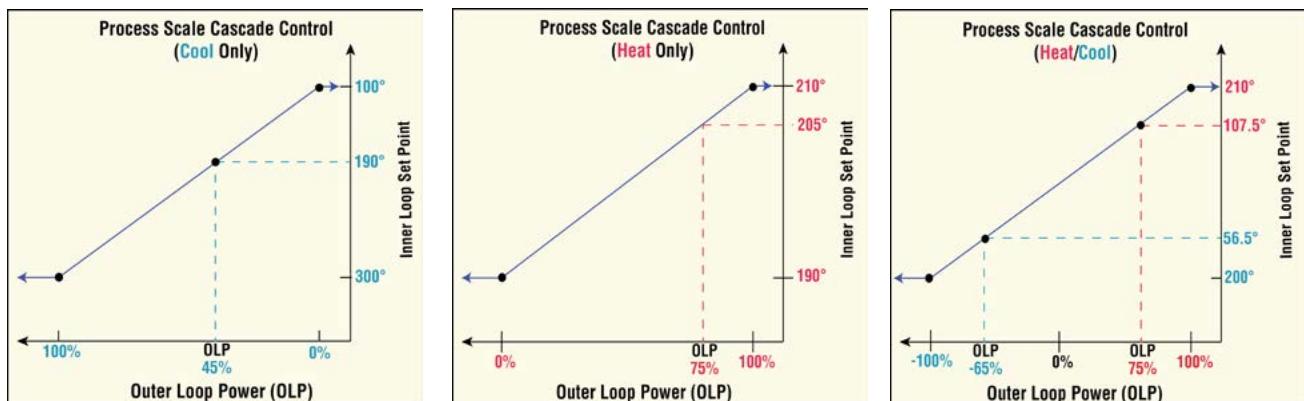
Cascade control can handle a difficult process with minimal overshoot, while reaching the set point quickly. Using cascade control minimizes the possibility of causing damage to system components and allows for over sizing heaters for optimal heat-up rates. Heater life is also extended by reducing thermal cycling of the heater. Systems with long lag times between the energy source (heater, steam, etc.) and the measured controlled variable are very difficult to control accurately and or efficiently with a single control loop. This is due primarily to a lot of energy build-up before a response is detected. When using single loop control, the likelihood of overshooting the set point is high, this overshoot can cause damage to the heater, product or heat transfer medium such as a heat transfer fluid.

This block is found in the Function Block Diagram editor's Library when working with a controller that offers cascade control. The number of these FBs available is shown within the parenthesis and is dependent on the controller part number.

When configuring the Cascade FB the user must select either Process or Deviation for the cascade Function setting.

Process

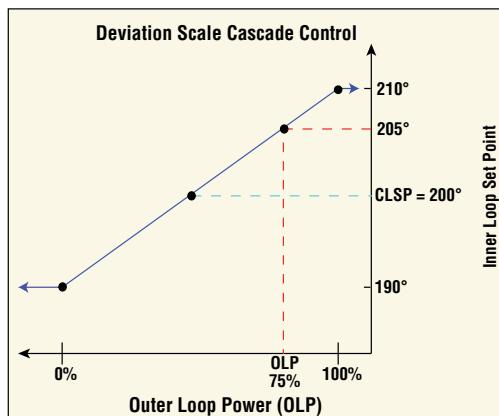
When process is selected, the outer loop will compare the outer process variable (PVO) to its set point. Based on the result of the comparison (error) the outer loop will generate a power level. This power level will be converted and scaled to serve as the set point for the inner loop. The range is defined by the user (y-axis) where the scaling (x-axis) is done automatically based on whether or not the control action is set for heat, cool or both. As an example, in the graph below for heat only, the user setting for Control Action would be heat with Range Low set to 190° and Range High set to 210°. In each graphic shown below, the solid line illustrates the proportional relationship between the scaling factors and the user defined range. The resultant inner loop set point is displayed (dashed lines) before any filtering or offset is applied.



Deviation

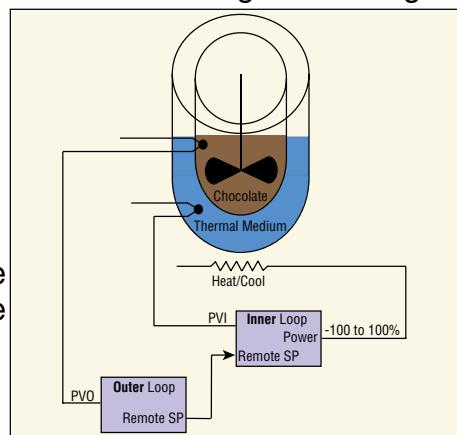
Deviation may be used instead of Process when it is desirable for the output range to be defined relative to a value that might change frequently or automatically. For cascade control, the outer loop will compare the outer process variable (PVO) to its set point. Based on the result of the comparison (error), the outer loop will generate a power level. This power level will be converted and scaled as an adjustment to the inner loop set point.

In the graphic below, the solid line illustrates the proportional relationship between the scaling factors and the user defined range adjustment (-10 to +10) with the resultant inner loop set point (dashed lines). Notice (in the graphic below) that with a user defined range of ± 10 , the inner loop set point will always be within the boundaries of 210° and 190° . When the outer loop calculates a power of 75% that will generate an inner loop set point of 205° .



The graphic below illustrates an application where deviation cascade control might be used. In many applications, like this one (chocolate production), the temperature of the controlled variable (chocolate) must be accurate and within specified tolerances. Assuming the melting point of the controlled variable is 94°F with settings for the deviation parameter set to ± 3 , the inner loop set point will remain between 91°F and 97°F . To control the process, two loops of control are required along with two inputs; shown in this example as the inner and outer loops with the inner process value (PVI) and the outer process value (PVO) respectively. The outer loop (PVO) monitors the controlled variable temperature, which is then compared to its CLSP. The result of the comparison, the error signal, is conditioned by the PID settings and the Range high/low settings. Ultimately, the outer loop produces a remote set point for the inner loop. The inner loop input (PVI) monitors the thermal medium, which is compared to the remote set point generated by the outer loop.

The result of the comparison, the error signal, is again conditioned by the PID settings in the cascade inner loop and it will then generate an output power level between -100% to +100%. If the power level is positive the heat will be on; if the power level is negative the cool will come on. Power from the energy sources are supplied by the outputs of choice, always connected to the inner loop.



Note:

When cascade control is disabled via the FB receiver named Simple Set Point (SSP), the input (PVO) and remote set point are virtually removed and the inner loop will now serve as a single loop PID controller.

The graph shown below illustrates a thermal system with a long lag time. Curve A represents a typical single loop control system with PID parameters that allow a maximum heat up rate. Too much energy is introduced and the set point is overshot. In most systems with long lag time, the process value may never settle out to an acceptable error. Curve C represents a single loop control system tuned to minimize overshoot. This results in unacceptable heat up rates, taking hours to reach the set point. Curve B shows a cascade system that limits the energy introduced into the system, allowing an optimal heat up rate with minimal overshoot.

Signals

Direction	Label	Type	Function
Receivers	PVO	Analog	Process value feedback for the outer loop.
	PVI	Analog	Process value feedback for the inner loop.
	RSP	Analog	Set point for the loop when REN is on. See: Remote Set Point Type
	PSP	Analog	Set point from the profile engine when profiling is used.
	REN	Digital	Active state causes loop to control to the Remote Set Point. See: Remote Set Point , Remote Set Point Type and Use Remote Set Point Active Level
	IDLE	Digital	Active state causes loop to control to the Idle Set Point. See: Use Idle Set Point Active Level
	OFF	Digital	Forces Control Mode to Off while active. See: Off Active Level
	MAN	Digital	Forces Control Mode to Manual while active. See: Manual Active Level
	TUN	Digital	Active state initiates autotuning. See: Initiate Autotune Active Level
	SSP	Digital	Active state switches the block from cascade to simple set point control. See: Simple Set Point (SSP) Enable and Disable Active Level

Transmitters	HT	Analog %	Heating needed: 0% is no heat and 100% is full heat.
	CL	Analog %	Cooling needed: 0% is no cooling and 100% is full cooling.
	PWR	Analog %	Heating or cooling needed: -100% is full cooling, 0% is no heating or cooling and 100% is full heating.
	SP	Analog	Set Point for use with Alarms or other blocks. Firmware release 3.0 and above renames CSP to SP.
	MP	Analog %	Manual Power for use with other blocks. Firmware release 3.0 and above renames OSP to MP.
	*Off	Digital	Reflects the current state of " Control Mode Active ": Off = On, Auto = Off, Manual = Off *Available in firmware release 3.0 and above.

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Function

Select to determine if cascade control will use process or deviation scale.

Options: Process, Deviation

Range Low

Set the minimum value for the cascade set point which will correspond to the lowest outer loop power.

Range: -99,999.000 to 99,999.000

Range High

Set the maximum value for the cascade set point which will correspond to the highest outer loop power.

Range: -99,999.000 to 99,999.000

Control Action

Select to determine if control action will be heat, cool or both.

Options:

- Off: transmitters HT, CL and PWR are turned off.
- Cool: (also referred to as direct) as the process increase the output increases.
- Heat: (also referred to as indirect) as the process increase the output decreases.
- Both: heat and cool transmitters will be driven by the Cascade FB.

Simple Set Point (SSP) Enable

When on, the cascade function will be disabled and this FB will serve as a single loop of control.

Options:

- Off: the Cascade function is active
- On: the cascade function will be disabled and this FB will serve as a single loop of control

Disable Active Level

Choose the signal value at the SSP receiver which causes the function block to perform simple set point control rather than cascade control.

Options:

- High: the block performs simple set point control when the signal is on
- Low: the block performs simple set point control when the signal is off

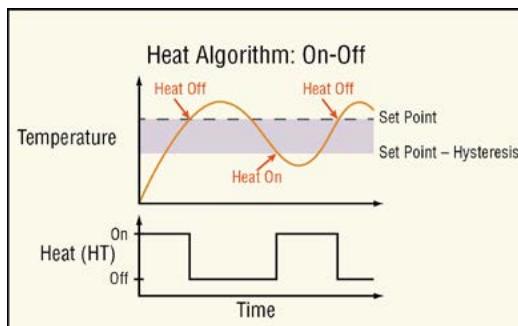
Inner Loop Heat Algorithm

Set the method the control loop uses to set heat (HT) and power (PWR) outputs. For a given application, on-off switches the output less frequently than PID, whereas PID maintains the process value with much less cycling around set point than on-off.

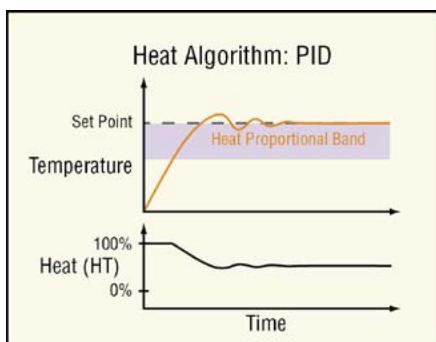
For applications other than temperature control, use the heat output when there is an indirect relationship between the input and the output, that is when the output should be increased as the input drops below set point.

Options:

- Off: no heat output is calculated or applied to HT or PWR
- On/Off: On-Off control sets the HT and PWR to (100%) on, or off (0%)



- PID: PID control sets the HT and PWR outputs to a value from 0% to 100%



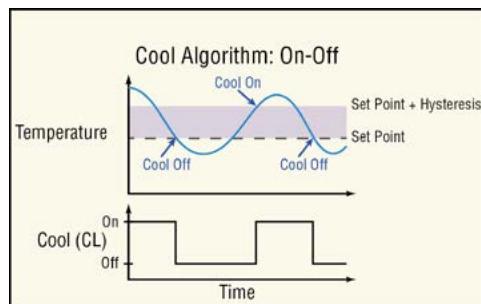
Inner Loop Cool Algorithm

Set the method the control loop uses to set cool (CL) and power (PWR) outputs. For a given application, on-off switches the output less frequently than PID, whereas PID maintains the process value with much less cycling around set point than on-off.

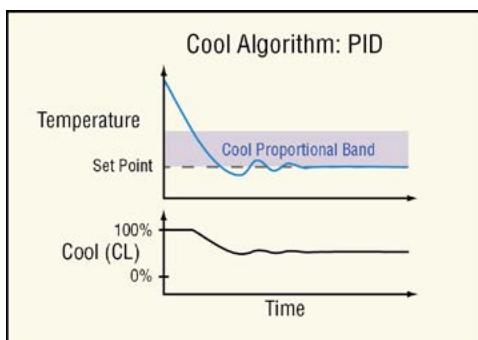
For applications other than temperature control, use the cool output when there is a direct relationship between the input and the output, that is when the output should be increased as the input rises above set point.

Options:

- Off: no cool output is calculated or applied to CL or PWR outputs
- On/Off: On-Off control sets the CL and PWR outputs on (100% for CL and -100% for PWR) or off (0%)

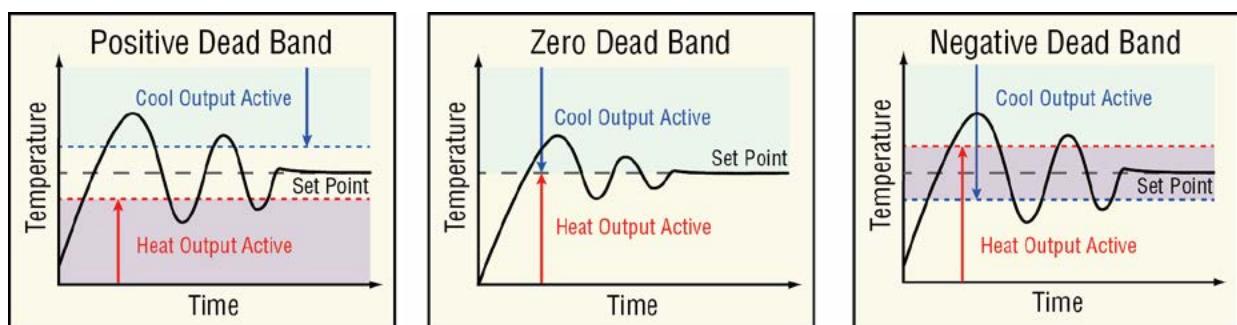


- PID: PID control sets the CL and PWR outputs to a value from no cooling 0% to full cooling (100% for CL and -100% for PWR)



Inner Loop Deadband

Set the offset between the set point and the heat and cool proportional bands. A positive deadband can reduce overshoot upon power up without changing the responsiveness of the system at other times and prevents heating and cooling outputs from being on at the same time. A negative deadband allows both the heat and cool outputs to be active around the set point which can be of benefit when a process must be controlled near the ambient temperature.



Range: -1,000.0 to 1,000.0 °F or units

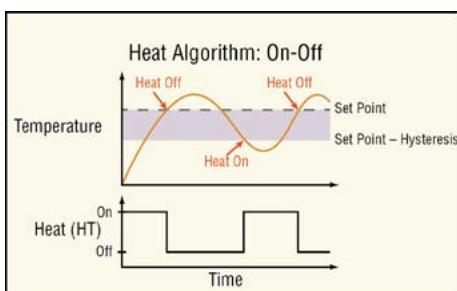
-555 to 555 °C

Inner Loop On/Off Heat Hysteresis

Set how far below set point the process value must drop before the heat output turns on. This parameter applies only when Heat Algorithm is set to On-Off.

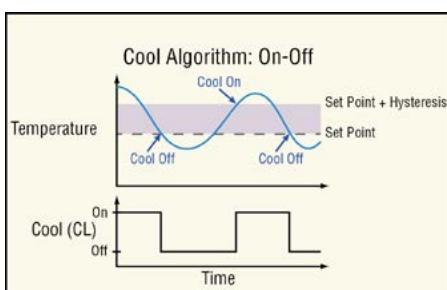
Range: 3 to 99,999 °F or units

1 to 55,555 °C



Inner Loop On/Off Cool Hysteresis

Set how far above set point the process value must rise before the cool output turns on. This parameter applies only when Cool Algorithm is set to On-Off.

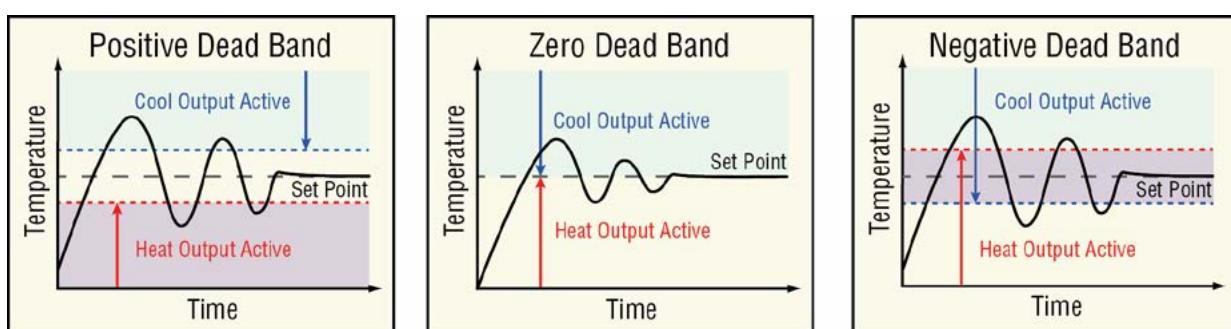


Range: 3 to 99,999 °F or units

1 to 55,555 °C

Outer Loop Deadband

Set the offset between the set point and the heat and cool proportional bands. A positive deadband can reduce overshoot upon power up without changing the responsiveness of the system at other times and prevents heating and cooling outputs from being on at the same time. A negative deadband allows both the heat and cool outputs to be active around the set point which can be of benefit when a process must be controlled near the ambient temperature.



Range: -1,000.0 to 1,000.0 °F or units

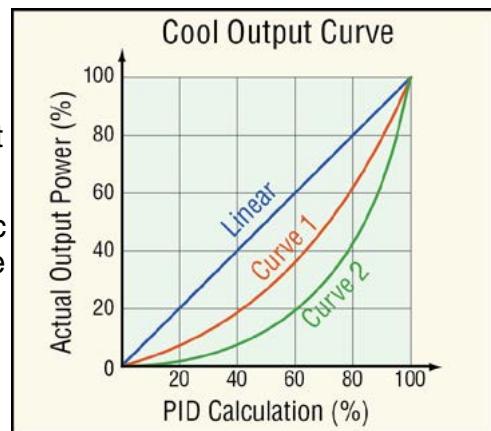
-555 to 555 °C

Cool Output Curve

Choose a cool output curve to set the responsiveness of the system. A nonlinear output curve may improve performance when the system's response is nonlinear. With the nonlinear curves, a given change in the PID calculation at the lower part of the output range yields a smaller change in the actual output level than a linear output provides.

This feature is used in applications such as cooling of plastic extruders where a small amount of water cooling has a large effect initially, but diminishing returns as water flow increases.

This parameter applies only when Cool Algorithm is set to PID.



Options:

- Off: the calculated PID value is applied linearly to the output.
- Non-linear Curve 1: somewhat non-linear response such as with oil coolant.
- Non-linear Curve 2: greater non-linear response such as with water coolant.

Profile End Action

Select what the cascade loop does when a profile ends without an End Step programmed within a profile. If a profile has an End Step, it will always take precedence over this setting.

Options:

- User: controls at the current Set Point setting prior to execution of the profile.
- Off: control mode set to off
- Hold: maintain the last set point within the profile

Auto-to-Manual Power

Choose how the Manual Power is set when the user switches Control Mode from auto to manual.

Options:

- Off: Manual Power is set to 0%.
- Bumpless Transfer: Manual Power is set equal to the last calculated value as long as the output was less than 75% and stable. Stable is defined as varying by no more than $\pm 5\%$ over the Integral setting or a minimum of 10 seconds. Otherwise, Manual Power is set to 0%
- Fixed Power: Manual Power is set equal to the Fixed Power setting
- User: uses the current Manual Power setting

Input Error Power

Select how the Open Loop Set Point is set when the loop's control mode switches from auto to manual due to an input error.

Options:

- Off: Manual Power is set to 0%
- Bumpless Transfer: Manual Power is set equal to the last calculated value as long as the output was less than 75% and stable. Stable is defined as varying by no more than $\pm 5\%$ over the Integral setting or a minimum of 10 seconds. Otherwise, Manual Power is set to 0%
- Fixed Power: Manual Power is set equal to the Fixed Power setting
- User: uses the current Manual Power setting

Fixed Power

Set the power level corresponding to the Fixed Power option for the Auto-to-Manual Power and Input Error Power parameters.

Range: Minimum Power to Maximum Power

Open Loop Detect Enable

Enable or disable the open-loop detect feature. When enabled, this feature monitors closed-loop control for the appropriate process value response to the output signal. If the loop does not respond as expected, the control mode is set to off.

Options:

- No: open loop detect is not enabled
- Yes: open loop detect is enabled

Open Loop Detect Time

Set a delay in seconds to the open loop error. If Open Loop Detect Enable is Yes and the process value deviates from the set point by the Open Loop Detect Deviation value for this amount of time, an open-loop error occurs and the control mode is set to off.

Range: 0 to 9,999 seconds

Open Loop Detect Deviation

Set the minimum difference between set point and process value that is considered excessive by the open loop detection feature. If the process deviates by this amount or more for the Open Loop Detect Time, an open loop error occurs and the control mode is set to off.

Range: -99,999 to 99,999 °F or units

-55,555 to 55,555 °C

Manual Active Level

Choose the signal value at the MAN receiver which switches the loop's Control Mode to Manual.

Options:

- High: the Control Mode is set to Manual when the signal is on
- Low: the Control Mode is set to Manual when the signal is off

Off Active Level

Choose the signal value at the OFF receiver which switches the loop's Control Mode to Off.

Options:

- High: the Control Mode is set to Off when the signal is on
- Low: the Control Mode is set to Off when the signal is off

PID Sets - Explained

This controller supports up to five heat/cool PID sets. This feature is extremely valuable if the characteristics of your thermal system vary over its operating range. All PID sets can be auto tuned or manually tuned and can also be configured to operate using any of the five sets based on crossover points of the set point or process value. When the process or set point value crosses the crossover point, the PID set designated for that region of the operating range is used to control the percent power being supplied to the load.

There is a -1° hysteresis for each crossover. A rising temperature will change PID sets at the crossover value. A falling temperature will change PID sets at the crossover value -1° .

Number of PID Sets.

Set the number of PID sets that will be available.

Range: 1 to 5

PID Set Crossover

Select what will trigger the crossover to another PID set.

Options: Process, Set Point

PID Set 1 to 2 Crossover

Set the value that will trigger a change (crossover point) from PID set 1 to set 2, relative to the selected source.

Range: -99,000 to 99,999

PID Set 2 to 3 Crossover

Set the value that will trigger a change (crossover point) from PID set 2 to set 3, relative to the selected source.

Range: -99,000 to 99,999

PID Set 3 to 4 Crossover

Set the value that will trigger a change (crossover point) from PID set 3 to set 4, relative to the selected source.

Range: -99,000 to 99,999

PID Set 4 to 5 Crossover

Set the value that will trigger a change (crossover point) from PID set 4 to set 5, relative to the selected source.

Range: -99,000 to 99,999

Heat Proportional Band Inner Loop [1 to 5]

Set the proportional relationship between heat power (%) and the process value (typically temperature). This setting determines how big a correction the proportional part of the PID control algorithm makes when the process value deviates from set point. A smaller proportional band yields a larger power adjustment for a given deviation from set point.

This parameter applies only when Heat Algorithm is set to PID. This parameter is set automatically by autotuning the loop.

Range: 1 to 99,999 °F or units

1 to 55,555 °C

Cool Proportional Band Inner [1 to 5]

Set the proportional relationship between cool power (%) and the process value (typically temperature). This setting determines how big a correction the proportional part of the PID control algorithm makes when the process value deviates from set point. A smaller proportional band yields a larger power adjustment for a given deviation from set point.

This parameter applies only when Cool Algorithm is set to PID. This parameter is set automatically by autotuning the loop.

Range: 3 to 99,999 °F or units

1 to 55,555 °C

Integral Inner Loop [1 to 5]

Set how aggressively the integral part of the PID algorithm acts. Integral acts to drive the process value to set point by steadily adjusting the output whenever the process value deviates from the set point. A smaller Integral setting yields a larger power adjustment for a given deviation from set point over a given time.

This parameter applies when either Heat Algorithm or Cool Algorithm or both are set to PID. This parameter is set automatically by autotuning the loop.

Range: 0 to 99,999 seconds per repeat

Derivative Inner Loop [1 to 5]

Set how aggressively the derivative part of the PID algorithm acts. Derivative acts to prevent the process value from changing too quickly. It can help minimize the effect of transient process disturbances, but too much derivative can make the process slow to adjust to changes. A greater Derivative setting yields a greater power adjustment for a given change.

This parameter applies when either Heat Algorithm or Cool Algorithm or both are set to PID. This parameter is set automatically by autotuning the loop.

Range: 0 to 99,999 seconds

Heat Proportional Band Outer Loop [1 to 5]

Set the proportional relationship between heat power (%) and the process value (typically temperature). This setting determines how big a correction the proportional part of the PID control algorithm makes when the process value deviates from set point. A smaller proportional band yields a larger power adjustment for a given deviation from set point.

This parameter applies only when Heat Algorithm is set to PID. This parameter is set automatically by autotuning the loop.

Range: 1 to 99,999 °F or units

1 to 55,555 °C

Cool Proportional Band Outer Loop [1 to 5]

Set the proportional relationship between cool power (%) and the process value (typically temperature). This setting determines how big a correction the proportional part of the PID control algorithm makes when the process value deviates from set point. A smaller proportional band yields a larger power adjustment for a given deviation from set point.

This parameter applies only when Cool Algorithm is set to PID. This parameter is set automatically by autotuning the loop.

Range: 3 to 99,999 °F or units

1 to 55,555 °C

Integral Outer Loop [1 to 5]

Set how aggressively the integral part of the PID algorithm acts. Integral acts to drive the process value to set point by steadily adjusting the output whenever the process value deviates from the set point. A smaller Integral setting yields a larger power adjustment for a given deviation from set point over a given time.

This parameter applies when either Heat Algorithm or Cool Algorithm or both are set to PID. This parameter is set automatically by autotuning the loop.

Range: 0 to 99,999 seconds per repeat

Derivative Outer Loop [1 to 5]

Set how aggressively the derivative part of the PID algorithm acts. Derivative acts to prevent the process value from changing too quickly. It can help minimize the effect of transient process disturbances, but too much derivative can make the process slow to adjust to changes. A larger Derivative setting yields a greater power adjustment for a given change.

This parameter applies when either Heat Algorithm or Cool Algorithm or both are set to PID. This parameter is set automatically by autotuning the loop.

Range: 0 to 99,999 seconds

Minimum Set Point

Set the low end of the range for the Set Point. The Set Point and Idle Set Point cannot be set below this value.

Range: -99,999 to 99,999 °F or units

-55,573 to 55,537 °C

Maximum Set Point

Set the high end of the range for the Set Point. The Set Point and Idle Set Point cannot be set above this value.

Range: -99,999 to 99,999 °F or units

-55,573 to 55,537 °C

Minimum Manual Power

Set the low end of the range for the Manual Power.

Range: -100 to 100.0%

Maximum Manual Power

Set the high end of the range for the Manual Power.

Range: -100.0 to 100.0%

Ramp Action

Choose the conditions under which the loop ramps its set point. When the set point ramps, it starts at the Process Value and changes gradually to the Set Point setting rather than abruptly changing values.

Options:

- Off: the loop controls to the Set Point immediately
- Startup: each time the controller is powered up, the loop ramps the set point. At all other times abrupt changes to the Set Point are allowed
- Set Point: upon powering up the Set Point immediately resumes its last value, but the loop ramps the set point each time the Set Point is changed
- Both: the loop ramps the set point each time the controller is powered up or the Set Point is changed

Ramp Scale

Choose the time units for the Ramp Rate parameter.

Options:

- Minutes
- Hours

Ramp Rate

Set how quickly the set point ramps. Set the time units for the rate with Ramp Scale.

Range: 0 to 99,999 °F or units / minute or hour
0 to 55,555 °C

Idle Set Point

Set a set point value that is triggered when an event signal to the IDLE receiver is active. See Use Idle Set Point Active Level below.

Range: Minimum Set Point to Maximum Set Point

Use Idle Set Point Active Level

Choose the signal value at the IDLE receiver which causes the loop to use the Idle Set Point.

Options:

- High: the idle set point is used when the signal is on
- Low: the idle set point is used when the signal is off

Remote Set Point

Choose whether or not the loop controls at the remote set point. The remote set point is received on the control loop's RSP input.

Options:

- No: the loop does not use the remote set point for control
- Yes: the loop uses the remote set point for control

Note:

Either the Remote Set Point parameter or the REN input can cause the remote set point to override the loop's set point.

Remote Set Point Type

Choose whether the remote set point received at input RSP overrides the Manual Power or the Set Point when the remote set point feature is enabled by either the Remote Set Point parameter or the REN input.

Options:

- Manual: the remote set point is in percent power where -100% is full cooling, 0% is no output and 100% is full heating and overrides the Manual Power when enabled
- Auto: the remote set point is in the units of the PV input and overrides the Set Point when enabled

Use Remote Set Point Active Level

Choose the signal value at the REN receiver which causes the loop to use the remote set point value received at RSP instead of the Set Point or Manual Power setting. See Remote Set Point Type.

Options:

- High: the remote set point is used when the signal is on
- Low: the remote set point is used when the signal is off

Set Point

Set the desired process value. When Control Mode is Auto, the loop adjusts its outputs to make the process value (input IN) equal to this setting.

Range: Minimum Set Point to Maximum Set Point

Manual Power

Set the desired output value for HT, CL and PWR outputs when Control Mode is Manual.

Range: Minimum Manual Power to Maximum Manual Power

Autotune Set Point

Set the percentage of the Set Point at which the loop autotunes. Because autotuning drives the process value above and below the set point, in some applications it may be necessary or preferable to autotune at a set point below or above the normal set point.

This parameter applies when either Heat Algorithm or Cool Algorithm or both are set to PID and autotuning is performed.

Range: 50.0 to 200.0%

Autotune Aggressiveness

Choose the desired responsiveness for PID control after autotuning. This parameter applies when either Heat Algorithm or Cool Algorithm or both are set to PID and autotuning is performed.

Options:

- Critical: balance a rapid response with minimal overshoot
- Over: bring the process value to the set point with minimal overshoot
- Under: bring the process value to the set point quickly tolerating overshoot

Autotune

When autotuning, the controller automatically selects the PID parameters for optimal control, based on the thermal response of the system. Five sets of PID values are available. Default PID values exist for all PID sets, although these values typically do not provide optimal control. PID values can be autotuned or adjusted manually.

When an autotune is started the current Set Point is used to calculate the tuning set point. The controller will disregard all set point changes until the tuning process is complete. For example, if the active set point is 200° and Autotune Set Point is set to 90 percent, the autotune function utilizes 180° for tuning.

Autotuning calculates the optimum heating and/or cooling PID parameter settings based on the system's response.

Autotuning can be enabled whether or not TUNE-TUNE+™ is enabled. The PID settings generated by the autotune will be used until the autotune feature is rerun, the PID values are manually adjusted or TRU-TUNE®+ is enabled. You should not autotune while a profile is running. If the autotune cannot be completed in 120 minutes, the autotune will time-out and the original settings will take effect. The temperature must cross the Autotune Set Point five times to complete the autotuning process. Once complete, the controller controls at the normal set point, using the new parameters.

To initiate an autotune, follow the steps below:

1. Determine and set the operational Set Point
2. Set the Autotune Set Point (a percentage of the Set Point)
3. Connect and activate a digital signal to TUN (appropriate active level is required)

If need be, there are settings provided to adjust the tuning procedure's aggressiveness. Use Autotune Aggressiveness. Select Under Damped to bring the process value to the set point quickly. Select Over Damped to bring the process value to the set point with minimal overshoot. Select Critical Damped to balance a rapid response with minimal overshoot.

Set to start or stop automatically tuning the control loop's PID parameters. This parameter applies when either Heat Algorithm or Cool Algorithm or both are set to PID.

Options:

- No: if already started, aborts the autotuning process.
- Yes: initiates the autotuning process.

Initiate Autotune Active Level

Choose the signal value at the TUN receiver which causes the loop to start autotuning.

Options:

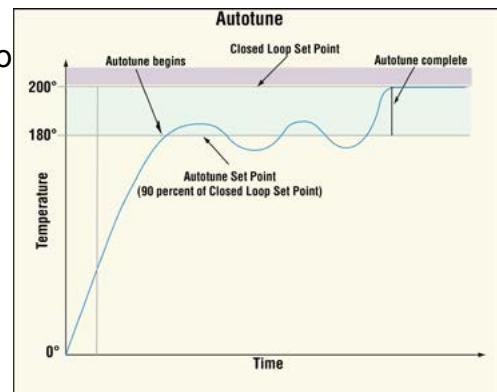
- High: the loop autotunes when the signal is on
- Low: the loop autotunes when the signal is off

Control Mode

Choose the method the cascade loop uses to set power outputs HT, CL and PWR.

Options:

- Off: power outputs are 0%
- Auto: closed-loop control, the loop adjusts the outputs automatically to make the Process Value equal to the Set Point
- Manual: open loop control, the loop's power outputs are set according to the Manual Power setting



Note:

When a PID loop's Control Mode is changed from Manual to Auto, the Manual Power is set equal to the integral value for a bumpless transition and normal PID action takes over to control to the Set Point.

Control Mode Active

Displays the current method the control loop is using to set power outputs HT, CL and PWR.

Options:

- Off: power outputs are 0%
- Auto: closed-loop control, the loop adjusts the outputs automatically to make the Process Value equal to the Set Point
- Manual: open-loop control, the loop's power outputs are set according to the Manual Power setting

Control Loop Error

Indicates the control loop's error status.

Options:

- None: no error
- Open Loop: the process value has not responded to the loop's outputs as expected according to the settings of the Open Loop Detect Deviation and Open Loop Detect Time parameters
- Reversed Sensor: the process value has responded to the loop's outputs by changing in the opposite direction expected, going down during heating or up during cooling

Clear Error

Set Clear Error to Clear to reset the Control Loop Error after correcting the condition that caused the problem.

Options: Ignore, Clear

Compare

Use a compare block to set an output based on comparing two analog signals.

This block is found in the Function Block Diagram editor's Library when working with a controller that offers the Compare block. The number of these blocks that are available is shown within the parenthesis.

Choose the type of comparison with the Function parameter. These options for the Function parameter are described in detail in the following sections:

Off: the block's output is off

Greater Than: the block's output is on when input A is greater than input B

Less Than: the block's output is on when input A is less than input B

Equal To: the block's output is on when the two inputs are equal

Not Equal To: the block's output is on when the two inputs are not equal to each other

Greater or Equal: the block's output is on when input A is greater than or equal input B

Less or Equal: the block's output is on when input A is less than or equal to input B

Off

When the Compare block's function is set to Off, the output (T/F) is off.

Greater Than

The output (T/F) is on when receiver A is greater than B.

Signals

Direction	Label	Type	Function
Receivers	A	Analog	Signal to be compared to B
	B	Analog	Signal to be compared to A
Transmitter	T/F	Digital	On when A is greater than B, otherwise off

Function

To test if A is greater than B, set Function to Greater Than.

Error Handling

When an error exists on any receiver, the function cannot definitively determine the result of the comparison and an error will be generated. Use Error Handling to select the output's value.

Options:

- True Good: output true (on) and no output error
- True Bad: output true (on) and output error
- False Good: output false (off) and no output error
- False Bad: output false (off) and output error

Less Than

The output (T/F) is on when receiver A is less than B.

Signals

Direction	Label	Type	Function
Receiver	A	Analog	Signal to be compared to B
	B	Analog	Signal to be compared to A
Transmitter	T/F	Digital	On when A is less than B, otherwise off

Function

To test if A is less than B, set Function to Less Than.

Error Handling

When an error exists on any receiver, the function cannot definitively determine the result of the comparison and an error will be generated. Use Error Handling to select the output's value and error status.

Options:

- True Good: outputs value is true (on) with no error
- True Bad: outputs value is true (on) and has an error
- False Good: outputs value is false (off) with no error
- False Bad: outputs value is false (off) and has an error

Equal To

The output (T/F) is on when receivers A and B are equal to each other. See Tolerance.

Signals

Direction	Label	Type	Function
Receiver	A	Analog	Signal to be compared to B
	B	Analog	Signal to be compared to A
Transmitter	T/F	Digital	On when A and B are equal and within tolerance, otherwise off

Function

To test if A and B are equal to each other, set Function to Equal To.

Tolerance

Use Tolerance to set how precisely A and B must match to be considered equal. For example, with Tolerance set to 2, the values 10 and 12 are considered equal, but 10 and 12.5 are not.

Range: 0 to 99,999

Error Handling

When an error exists on any receiver, the function cannot definitively determine the result of the comparison and an error will be generated. Use Error Handling to select the output's value and error status.

Options:

- True Good: outputs value is true (on) with no error
- True Bad: outputs value is true (on) and has an error
- False Good: outputs value is false (off) with no error
- False Bad: outputs value is false (off) and has an error

Not Equal To

The output (T/F) is on when receivers A and B are not equal to each other. See Tolerance.

Signals

Direction	Label	Type	Function
Receiver	A	Analog	Signal to be compared to B
	B	Analog	Signal to be compared to A
Transmitter	T/F	Digital	On when A and B are not equal and within tolerance, otherwise off

Function

To test if A and B are not equal to each other, set Function to Not Equal To.

Tolerance

Use Tolerance to set how precisely A and B must match to be considered equal. For example, with Tolerance set to 2, the values 10 and 12 are considered equal, but 10 and 12.5 are not.

Range: 0 to 99,999

Error Handling

When an error exists on any receiver, the function cannot definitively determine the result of the comparison and an error will be generated. Use Error Handling to select the output's value and error status.

Options:

- True Good: outputs value is true (on) with no error
- True Bad: outputs value is true (on) and has an error
- False Good: outputs value is false (off) with no error
- False Bad: outputs value is false (off) and has an error

Greater or Equal

The output (T/F) is on when receiver A is greater than or equal to B. See Tolerance.

Signals

Direction	Label	Type	Function
Receiver	A	Analog	Signal to be compared to B
	B	Analog	Signal to be compared to A
Transmitter	T/F	Digital	On when A is greater than or equal to B and within tolerance, otherwise off

Function

To test if A is greater than or equal to B, set Function to Greater or Equal.

Tolerance

Use Tolerance to set how precisely A and B must match to be considered equal. For example, with Tolerance set to 2, the values 10 and 12 are considered equal, but 10 and 12.5 are not.

Range: 0 to 99,999

Error Handling

When an error exists on any receiver, the function cannot definitively determine the result of the comparison and an error will be generated. Use Error Handling to select the output's value and error status.

Options:

- True Good: outputs value is true (on) with no error
- True Bad: outputs value is true (on) and has an error
- False Good: outputs value is false (off) with no error
- False Bad: outputs value is false (off) and has an error

Less or Equal

The output (T/F) is on when receiver A is less than or equal to B. See Tolerance below.

Signals

Direction	Label	Type	Function
Receiver	A	Analog	Signal to be compared to B
	B	Analog	Signal to be compared to A
Transmitter	T/F	Digital	On when A is less than or equal to B and within tolerance, otherwise off

Function

To test if A is less than or equal to B, set Function to Less or Equal.

Tolerance

Use Tolerance to set how precisely A and B must match to be considered equal. For example, with Tolerance set to 2, the values 10 and 12 are considered equal, but 10 and 12.5 are not.

Range: 0 to 99,999

Error Handling

When an error exists on any receiver the function cannot definitively determine the result of the comparison and an error will be generated. Use Error Handling to select the output's value and error status.

Options:

- True Good: outputs value is true (on) with no error
- True Bad: outputs value is true (on) and has an error
- False Good: outputs value is false (off) with no error
- False Bad: outputs value is false (off) and has an error

Compare Errors

Error Condition	Result
Either or both inputs are in an error state.	The output will be set according to the selections made for error handling described above.

Control Loop

Use a control loop to manipulate a temperature or other process value. This block is found in the Function Block Diagram editor's Library when working with a controller that offers one or more control loops. The number of these FBs available is shown within the parenthesis and is dependent on the controller part number.

This function reads its input, performs calculations and adjusts its outputs to maintain the desired, measured value at its input. A control loop can be configured for heating, cooling or both and can use PID or On-Off control.

Signals

Direction	Label	Type	Function
Receivers	PV	Analog	Process Value, feedback to the control loop.
	RSP	Analog	Set point for the loop when REN is on. See: Remote Set Point Type
	PSP	Analog	Set point from the profile engine when profiling is used
	REN	Digital	Active state causes loop to control to Remote Set Point. See: Remote Set Point , Remote Set Point Type and Use Remote Set Point Active Level
	IDLE	Digital	Active state causes loop to control to the Idle Set Point. See: Use Idle Set Point Active Level
	OFF	Digital	Forces Control Mode to Off while active. See: Off Active Level
	MAN	Digital	Forces Control Mode to Manual while active. See: Manual Active Level
	TUN	Digital	Active state initiates autotuning. See: Initiate Autotune Active Level
	TDA	Digital	Active state disables TRU-TUNE+ overriding the TRU-TUNE+ Enable setting. See: Disable TRU-TUNE+ Active Level
Transmitters	HT	Analog %	Heating needed: 0% is no heat and 100% is full heat.
	CL	Analog %	Cooling needed: 0% is no cooling and 100% is full cooling.
	PWR	Analog %	Heating or cooling needed: -100% is full cooling, 0% is no heating or cooling and 100% is full heating.
	SP	Analog	Set Point for use with Alarms or other blocks. Firmware release 3.0 and above renames CSP to SP.
	MP	Analog %	Manual Power for use with other blocks. Firmware release 3.0 and above renames OSP to MP.
	*Off	Digital	Reflects the current state of " Control Mode Active ": Off = On, Auto = Off, Manual = Off *Available in firmware release 3.0 and above.

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Control Action

Select to determine if control action will be heat, cool or both.

Options:

- Off: transmitters HT, CL and PWR are turned off.
- Cool: (also referred to as direct) as the process increase the output increases.
- Heat: (also referred to as indirect) as the process increase the output decreases.
- Both: heat and cool transmitters will be driven by the Cascade FB.

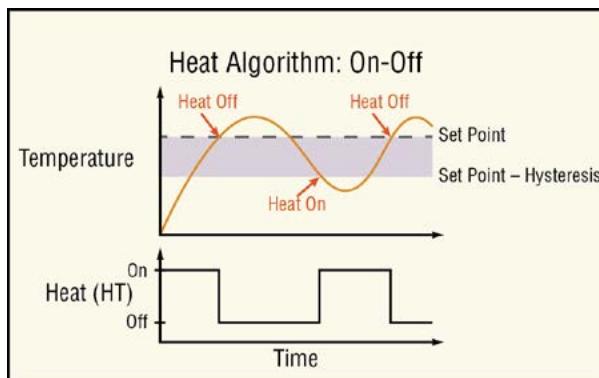
Heat Algorithm

Set the method the control loop uses to set heat (HT) and power (PWR) outputs. For a given application, on-off switches the output less frequently than PID, whereas PID maintains the process value with much less cycling around set point than on-off.

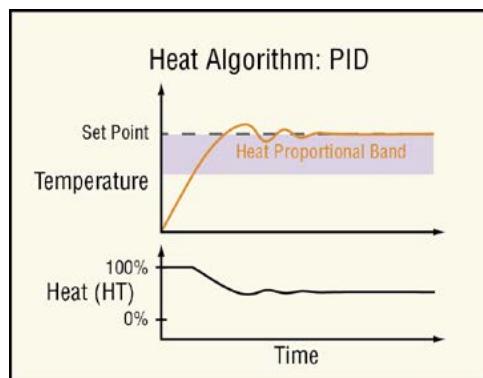
For applications other than temperature control, use the heat output when there is an indirect relationship between the input and the output, that is when the output should be increased as the input drops below set point.

Options:

- On/Off: On-Off control sets the HT and PWR to (100%) on, or off (0%)



- PID: PID control sets the HT and PWR outputs to a value from 0% to 100%



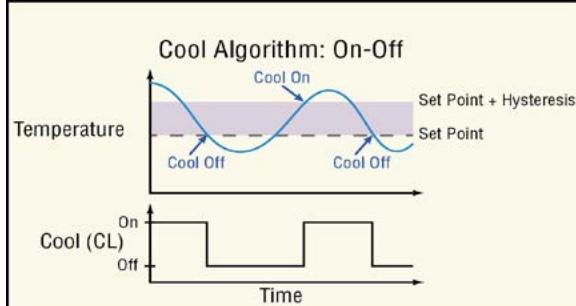
Cool Algorithm

Set the method the control loop uses to set cool (CL) and power (PWR) outputs. For a given application, on-off switches the output less frequently than PID, whereas PID maintains the process value with much less cycling around set point than on-off.

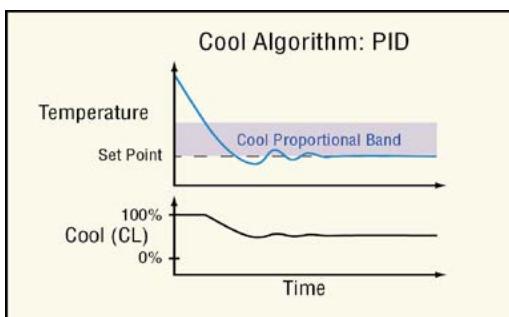
For applications other than temperature control, use the cool output when there is a direct relationship between the input and the output, that is when the output should be increased as the input rises above set point.

Options:

- On/Off: On-Off control sets the CL and PWR outputs on (100% for CL and -100% for PWR) or off (0%)

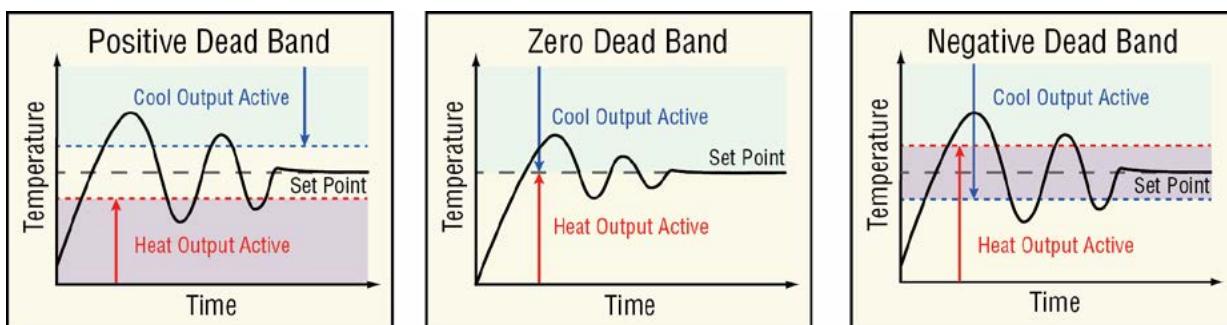


- PID: PID control sets the CL and PWR outputs to a value from no cooling 0% to full cooling (100% for CL and -100% for PWR)



Dead Band

Set the offset between the set point and the heat and cool proportional bands. A positive deadband can reduce overshoot upon power up without changing the responsiveness of the system at other times and also prevents heating and cooling outputs from being on at the same time. A negative deadband allows both the heat and cool outputs to be active around the set point which can be of benefit when a process must be controlled near the ambient temperature.

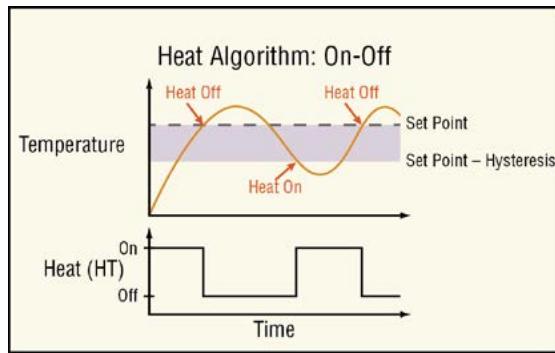


Range: -1,000.0 to 1,000.0 °F or units

-555 to 555 °C

On/Off Heat Hysteresis

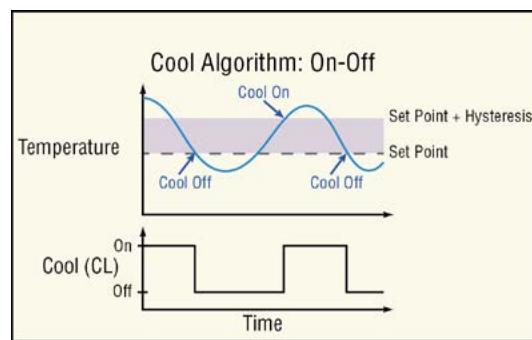
Set how far below set point the process value must drop before the heat output turns on. This parameter applies only when Heat Algorithm is set to On-Off.



Range: 3 to 99,999 °F or units
1 to 55,555 °C

On/Off Cool Hysteresis

Set how far above set point the process value must rise before the cool output turns on. This parameter applies only when Cool Algorithm is set to On-Off.



Range: 3 to 99,999 °F or units
1 to 55,555 °C

Peltier Delay

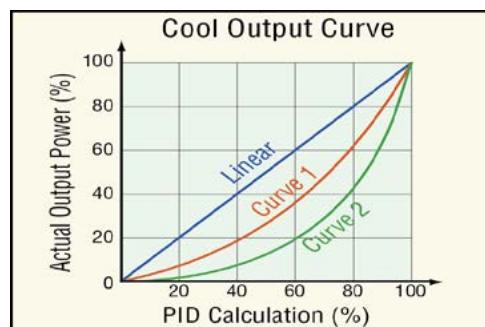
Set a delay for switching between heating and cooling. This applies to both heat and cool Algorithms set for PID control.

Range: 0.0 to 5.0 seconds

Cool Output Curve

Choose a cool output curve to set the responsiveness of the system. A nonlinear output curve may improve performance when the system's response is nonlinear. With the nonlinear curves, a given change in the PID calculation at the lower part of the output range yields a smaller change in the actual output level than a linear output provides.

This feature is used in applications such as cooling of plastic extruders where a small amount of water cooling has a large effect initially, but diminishing returns as water flow increases.



This parameter applies only when Cool Algorithm is set to PID.

Options:

- Off: the calculated PID value is applied linearly to the output
- Non-linear Curve 1: somewhat non-linear response such as with oil coolant
- Non-linear Curve 2: greater non-linear response such as with water coolant

Profile End Action

Select what the control loop does when a profile ends without an End Step programmed within the profile. If a profile has an End Step, it will always take precedence over this setting.

Options:

- User: controls at the current Set Point setting prior to execution of the profile.
- Off: control mode set to off
- Hold: maintain the last set point within the profile

Auto-to-Manual Power

Choose how the Manual Power is set when the user switches Control Mode from auto to manual.

Options:

- Off: Manual Power is set to 0%
- Bumpless Transfer: Manual Power is set equal to the last calculated value as long as the output was less than 75% and stable. Stable is defined as varying by no more than $\pm 5\%$ over the Integral setting or a minimum of 10 seconds. Otherwise, Manual Power is set to 0%
- Fixed Power: Manual Power is set equal to the Fixed Power setting
- User: uses the current Manual Power setting

Input Error Power

Select how the Manual Power is set when the loop's control mode switches from auto to manual due to an input error.

Options:

- Off: Manual Power is set to 0%
- Bumpless Transfer: Manual Power is set equal to the last calculated value as long as the output was less than 75% and stable. Stable is defined as varying by no more than $\pm 5\%$ over the Integral setting or a minimum of 10 seconds. Otherwise, Manual Power is set to 0%
- Fixed Power: Manual Power is set equal to the Fixed Power setting
- User: uses the current Manual Power setting

Fixed Power

Set the power level corresponding to the Fixed Power option for the Auto-to-Manual Power and Input Error Power parameters.

Range: Minimum Power to Maximum Power

Open Loop Detect Enable

Enable or disable the open-loop detect feature. When enabled, this feature monitors closed-loop control for the appropriate process value response to the output signal. If the loop does not respond as expected, the control mode is set to off.

Options:

- No: open loop detect is not enabled
- Yes: open loop detect is enabled

Open Loop Detect Time

Set a delay in seconds to the open loop error. If Open Loop Detect Enable is Yes and the process value deviates from the set point by the Open Loop Detect Deviation value for this amount of time, an open-loop error occurs and the control mode is set to off.

Range: 0 to 9,999 seconds

Open Loop Detect Deviation

Set the minimum difference between set point and process value that is considered excessive by the open loop detection feature. If the process deviates by this amount or more for the Open Loop Detect Time, an open loop error occurs and the control mode is set to off.

Range: -99,999 to 99,999 °F or units

-55,555 to 55,555 °C

Manual Active Level

Choose the signal value at the MAN receiver which switches the loop's Control Mode to Manual.

Options:

- High: the Control Mode is set to Manual when the signal is on
- Low: the Control Mode is set to Manual when the signal is off

Off Active Level

Choose the signal value at the OFF receiver which switches the loop's Control Mode to Off.

Options:

- High: the Control Mode is set to Off when the signal is on
- Low: the Control Mode is set to Off when the signal is off

PID Sets - Explained

This controller supports up to five heat/cool PID sets. This feature is extremely valuable if the characteristics of your thermal system vary over its operating range. All PID sets can be auto tuned or manually tuned and can also be configured to operate using any of the five sets based on crossover points of the set point or process value. When the process or set point value crosses the crossover point, the PID set designated for that region of the operating range is used to control the percent power being supplied to the load.

There is a -1° hysteresis for each crossover. A rising temperature will change PID sets at the crossover value. A falling temperature will change PID sets at the crossover value -1°.

Number of PID Sets.

Set the number of PID sets that will be available.

Range: 1 to 5

PID Set Crossover

Select what will trigger the crossover to another PID set.

Options: Process, Set Point

PID Set 1 to 2 Crossover

Set the value that will trigger a change (crossover point) from PID set 1 to set 2, relative to the selected source.

Range: -99,000 to 99,999

PID Set 2 to 3 Crossover

Set the value that will trigger a change (crossover point) from PID set 2 to set 3, relative to the selected source.

Range: -99,000 to 99,999

PID Set 3 to 4 Crossover

Set the value that will trigger a change (crossover point) from PID set 3 to set 4, relative to the selected source.

Range: -99,000 to 99,999

PID Set 4 to 5 Crossover

Set the value that will trigger a change (crossover point) from PID set 4 to set 5, relative to the selected source.

Range: -99,000 to 99,999

Heat Proportional Band [1 to 5]

Set the proportional relationship between heat power (%) and the process value (typically temperature). This setting determines how big a correction the proportional part of the PID control algorithm makes when the process value deviates from set point. A smaller proportional band yields a larger power adjustment for a given deviation from set point.

This parameter applies only when Heat Algorithm is set to PID. This parameter is set automatically by autotuning the loop and when TRU-TUNE+ is enabled.

Range: 1 to 99,999 °F or units

1 to 55,555 °C

Cool Proportional Band [1 to 5]

Set the proportional relationship between cool power (%) and the process value (typically temperature). This setting determines how big a correction the proportional part of the PID control algorithm makes when the process value deviates from set point. A smaller proportional band yields a larger power adjustment for a given deviation from set point.

This parameter applies only when Cool Algorithm is set to PID. This parameter is set automatically by autotuning the loop and when TRU-TUNE+ is enabled.

Range: 3 to 99,999 °F or units

1 to 55,555 °C

Integral [1 to 5]

Set how aggressively the integral part of the PID algorithm acts. Integral acts to drive the process value to set point by steadily adjusting the output whenever the process value deviates from the set point. A smaller Time Integral setting yields a larger power adjustment for a given deviation from set point over a given time.

This parameter applies when either Heat Algorithm or Cool Algorithm or both are set to PID. This parameter is set automatically by autotuning the loop and when TRU-TUNE+ is enabled.

Range: 0 to 99,999 seconds per repeat

Derivative [1 to 5]

Set how aggressively the derivative part of the PID algorithm acts. Derivative acts to prevent the process value from changing too quickly. It can help minimize the effect of transient process disturbances, but too much derivative can make the process slow to adjust to changes. A greater Time Derivative setting yields a greater power adjustment for a given change.

This parameter applies when either Heat Algorithm or Cool Algorithm or both are set to PID. This parameter is set automatically by autotuning the loop and when TRU-TUNE+ is enabled.

Range: 0 to 99,999 seconds

Minimum Set Point

Set the low end of the range for the Set Point. The Set Point and Idle Set Point cannot be set below this value.

Range: -99,999 to 99,999 °F or units

-55,573 to 55,537 °C

Maximum Set Point

Set the high end of the range for the Set Point. The Set Point and Idle Set Point cannot be set above this value.

Range: -99,999 to 99,999 °F or units

-55,573 to 55,537 °C

Minimum Manual Power

Set the low end of the range for the Manual Power.

Range: -100 to 100.0%

Maximum Manual Power

Set the high end of the range for the Manual Power. The Manual Power cannot be set outside of the ranges below.

Range: -100 to 100.0%

Ramp Action

Choose the conditions under which the loop ramps its set point. When the set point ramps, it starts at the Process Value and changes gradually to the Closed-Loop Set Point rather than abruptly changing values.

Options:

- Off: the loop controls to the Set Point immediately
- Startup: each time the controller is powered up, the loop ramps the set point. At all other times abrupt changes to the Set Point are allowed
- Set Point: upon powering up the Set Point immediately resumes its last value, but the loop ramps the set point each time the Set Point is changed
- Both: the loop ramps the set point each time the controller is powered up or the Set Point is changed

Ramp Scale

Choose the time units for the Ramp Rate parameter.

Options:

- Minutes
- Hours

Ramp Rate

Set how quickly the set point ramps. Set the time units for the rate with Ramp Scale.

Range: 0 to 99,999 °F or units / minute or hour

0 to 55,555 °C

Idle Set Point

Set a set point value that is triggered when an event signal to the IDLE receiver is active. See Use Idle Set Point Active Level below.

Range: Minimum Set Point to Maximum Set Point

Use Idle Set Point Active Level

Choose the signal value at the IDLE receiver which causes the loop to use the Idle Set Point.

Options:

- High: the idle set point is used when the signal is on
- Low: the idle set point is used when the signal is off

Remote Set Point

Choose whether or not the loop controls at the remote set point. The remote set point is received on the control loop's RSP input.

Options:

- No: the loop does not use the remote set point for control
- Yes: the loop uses the remote set point for control

Note:

Either the Remote Set Point parameter or the REN input can cause the remote set point to override the loop's set point.

Remote Set Point Type

Choose whether the remote set point received at input RSP overrides the Manual Power or the Set Point when the remote set point feature is enabled by either the Remote Set Point parameter or the REN input.

Options:

- Manual: the remote set point is in percent power where -100% is full cooling, 0% is no output and 100% is full heating and overrides the Manual Power when enabled
- Auto: the remote set point is in the units of the PV input and overrides the Set Point when enabled

Use Remote Set Point Active Level

Choose the signal value at the REN receiver which causes the loop to use the remote set point value received at RSP instead of the Set Point or Manual Power setting. See Remote Set Point Type above.

Options:

- High: the remote set point is used when the signal is on
- Low: the remote set point is used when the signal is off

Set Point

Set the desired process value. When Control Mode is auto, the loop adjusts its outputs to make the process value (input IN) equal to this setting.

Range: Minimum Set Point to Maximum Set Point

Manual Power

Set the desired output value for HT, CL and PWR outputs when Control Mode is Manual.

Range: Minimum Manual Power to Maximum Manual Power

Autotune Set Point

Set the percentage of the Set Point at which the loop autotunes. Because autotuning drives the process value above and below the set point, in some applications it may be necessary or preferable to autotune at a set point below or above the normal set point.

This parameter applies when either Heat Algorithm or Cool Algorithm or both are set to PID and autotuning is performed.

Range: 50.0 to 200.0%

Autotune Aggressiveness

Choose the desired responsiveness for PID control after autotuning. This parameter applies when either Heat Algorithm or Cool Algorithm or both are set to PID and autotuning is performed.

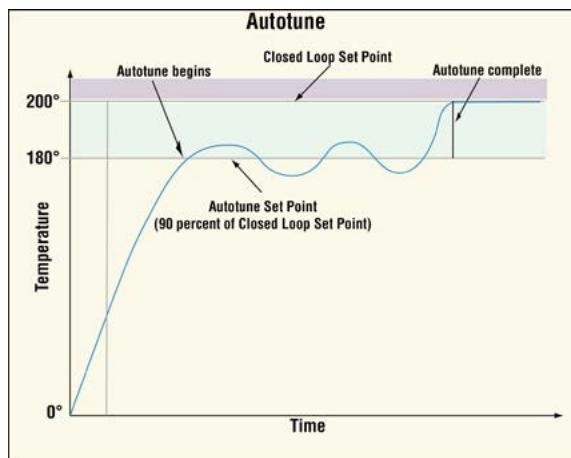
Options:

- Critical: balance a rapid response with minimal overshoot
- Over: bring the process value to the set point with minimal overshoot
- Under: bring the process value to the set point quickly tolerating overshoot

Autotune

When autotuning, the controller automatically selects the PID parameters for optimal control, based on the thermal response of the system. Five sets of PID values are available. Default PID values exist for all PID sets, although these values typically do not provide optimal control. PID values can be autotuned or adjusted manually.

When an autotune is started the current Set Point is used to calculate the tuning set point. The controller will disregard all set point changes until the tuning process is complete. For example, if the active set point is 200° and Autotune Set Point is set to 90 percent, the autotune function utilizes 180° for tuning.



Autotuning calculates the optimum heating and/or cooling PID parameter settings based on the system's response. Autotuning can be enabled whether or not TUNE-TUNE+™ is enabled. The PID settings generated by the autotune will be used until the autotune feature is rerun, the PID values are manually adjusted or TRU-TUNE®+ is enabled. You should not autotune while a profile is running. If the autotune cannot be completed in 60 minutes, the autotune will time-out and the original settings will take effect. The temperature must cross the Autotune Set Point five times to complete the autotuning process. Once complete, the controller controls at the normal set point, using the new parameters.

To initiate an autotune, follow the steps below:

1. Determine and set the operational Set Point
2. Set the Autotune Set Point (a percentage of the Set Point)
3. Connect and activate a digital signal to TUN (appropriate active level is required)

If need be, there are settings provided to adjust the tuning procedure's aggressiveness. Use Autotune Aggressiveness. Select Under Damped to bring the process value to the set point quickly. Select over damped to bring the process value to the set point with minimal overshoot. Select critical damped to balance a rapid response with minimal overshoot.

Set to start or stop automatically tuning the control loop's PID parameters. This parameter applies when either Heat Algorithm or Cool Algorithm or both are set to PID.

Options:

- No: if already started, aborts the autotuning process.
- Yes: initiates the autotuning process.

Initiate Autotune Active Level

Choose the signal value at the TUN receiver which causes the loop to start autotuning.

Options:

- High: the loop autotunes when the signal is on
- Low: the loop autotunes when the signal is off

TRU-TUNE®+ Enable

Enable or disable the TRU-TUNE+ adaptive tuning feature. This feature applies when either Heat Algorithm or Cool Algorithm or both are set to PID.

Over time the TRU-TUNE+ adaptive algorithm adjusts the PID control parameters (Heat Proportional Band, Cool Proportional Band, Integral and Derivative) automatically to optimize the control loop's responsiveness and stability.

Options:

- No: TRU-TUNE+ is off
- Yes: TRU-TUNE+ is on

TRU-TUNE+ Band

Set the range, centered on the set point, within which TRU-TUNE+ is in effect. This parameter applies when TRU-TUNE+ is enabled.

Use this function only if the controller is unable to adaptive tune automatically.

Range: 0 to 100

TRU-TUNE+ Gain

Set the desired responsiveness of the TRU-TUNE+ adaptive control algorithm. This parameter applies when TRU-TUNE+ is enabled.

The settings ranging from 1 (least aggressive response and least potential overshoot, lowest gain) to 6, (most aggressive response and most potential for overshoot, highest gain). The default setting, 3, is recommended for loops with thermocouple feedback and moderate response and overshoot potential.

Range: 1 to 6

Disable TRU-TUNE®+ Active Level

Choose the signal value at the TDA receiver which disables TRU-TUNE+.

Options:

- High: TRU-TUNE+ is disabled when the signal is on
- Low: TRU-TUNE+ is disabled when the signal is off

Control Mode

Choose the method the control loop uses to set power outputs HT, CL and PWR.

Options:

- Off: power outputs are 0%
- Auto: closed-loop control, the loop adjusts the outputs automatically to make the Process Value equal to the Set Point
- Manual: open-loop control, the loop's power outputs are set according to the Manual Power setting

Note:

When a PID loop's Control Mode is changed from Manual to Auto. The Manual Power is set equal to the integral value for a bumpless transition and normal PID action takes over to control to the Set Point.

Control Mode Active

Displays the current method the control loop is using to set power outputs HT, CL and PWR.

Options:

- Off: power outputs are 0%
- Auto: closed-loop control, the loop adjusts the outputs automatically to make the Process Value equal to the Set Point
- Manual: open-loop control, the loop's power outputs are set according to the Manual Power setting

Control Loop Error

Indicates the control loop's error status.

Options:

- None: no error
- Open Loop: the process value has not responded to the loop's outputs as expected according to the settings of the Open Loop Detect Deviation and Open Loop Detect Time parameters
- Reversed Sensor: the process value has responded to the loop's outputs by changing in the opposite direction expected, going down during heating or up during cooling

Clear Error

Set Clear Error to Clear to reset the Control Loop Error after correcting the condition that caused the problem.

Options: Ignore, Clear

Counter

Use a counter to set an output when a digital signal's state changes a given number of times. A counter can count up or down from the load value. Its output turns on when the count equals the target value. The output turns off and the count is set equal to the load value when the reset signal is received.

This block is found in the Function Block Diagram editor's Library when working with a controller that offers the Counter block. The number of these blocks that are available is shown within the parenthesis.

Choose whether the counter counts up or down with the Function parameter. These options for Function are described in detail in the following sections:

Up: Count is incremented by the CNT input.

Down: Count is decremented by the CNT input.

UP

This function counts up from the load value. The count is incremented by applying a signal to CNT. OUT turns on when the count equals the target value. OUT turns off and the count is set equal to the load value by RST (reset).

Signals

Direction	Label	Type	Function
Receivers	CNT	Digital	Increments the count
	RST	Digital	Resets the count to the load value
Transmitters	OUT	Digital	On when the count equals the target value

Function

To increment the count with CNT, set Function to Up.

Target Value

Set the count value at which OUT turns on.

Range: 0 to 9,999

Load Value

Set the value to which the Count parameter is set each time the controller is powered up and whenever the counter is reset by RST.

Range: 0 to 9,999

Latching

Select the behavior for the output when Count exceeds the Target Value.

Options:

- Yes: output is latched on once the count reaches the target value and turns off only when the counter is reset
- No: the output is on only when the count equals the target value. Additional counts cause the output to turn off

Count Active Level

Set which state changes at CNT are counted.

Options:

- Both: the count increments when CNT changes from on to off and when it changes from off to on
- High: the count increments only when CNT changes from off to on
- Low: the count increments only when CNT changes from on to off

Reset Active Level

Set which state change at RST sets Count equal to Load Value.

Options:

- High: off to on
- Low: on to off

Count

Indicates the current count.

Range: 0 to 9,999

Note:

The count is not retained through a power loss; it is set equal to the Load Value upon power up.

Note:

The count value rolls over at the ends of its range. If the count is incremented at 9,999 it indicates 0 and additional increments count up from there

Down

This function counts down from the load value. The count is decremented by applying a signal to CNT. OUT turns on when the count equals the target value. OUT turns off and the count is set equal to the load value by RST (reset).

Signals

Direction	Label	Type	Function
Receivers	CNT	Digital	Deccrements the count
	RST	Digital	Resets the count to the load value
Transmitters	OUT	Digital	On when the count equals the target value

Function

To decrement the count with the CNT, set Function to Down.

Target Value

Set the count value at which OUT turns on.

Range: 0 to 9,999

Load Value

Set the value to which the Count parameter is set each time the controller is powered up and whenever the counter is reset by RST.

Range: 0 to 9,999

Latching

Select the behavior for the output when Count exceeds the Target Value.

Options:

- Yes: output is latched on once the count reaches the target value and turns off only when the counter is reset
- No: the output is on only when the count equals the target value. Additional counts cause the output to turn off

Count Active Level

Set which state changes at CNT are counted.

Options:

- Both: the count decrements when CNT changes from on to off and when it changes from off to on
- High: the count decrements only when CNT changes from off to on
- Low: the count decrements only when CNT changes from on to off

Reset Active Level

Set which state change at RST sets Count equal to Load Value.

Options:

- High: off to on
- Low: on to off

Count

Indicates the current count.

Range: 0 to 9,999

Note:

The count is not retained through a power loss; it is set equal to the Load Value upon power up.

Note:

The count value rolls over at the ends of its range. If the count is incremented at 9,999 it indicates 0 and additional increments count up from there

Counter Errors

If the CNT input has an error, the count will not increment or decrement. If the RST input has an error, the count cannot be reset. An error on one input does not impact the operation of the other input and its associated function. Regardless of errors on the inputs, the value of the output is set according to the count and target values and the output never has an error. The counter function never generates or propagates an error.

Error Condition	Result
- CNT has an error - RST has no error	The count does not increment or decrement but can be reset.
- CNT has no error - RST has an error	The count increments or decrements normally but cannot be reset.
Both inputs have errors	The count does not increment or decrement and cannot be reset.

Current Input

This FB is found on the canvas of the FB diagram. The number of these FBs that are available depends on the number of flex modules with current inputs installed.

Accurate current sensing requires that the controller's global AC Line Frequency be set to the line frequency of current being measured and a current equal to or greater than 2 mA.

Note:

If an alarm is configured to monitor current as its source, the low alarm will be effective only when the current level is equal to or greater than 2 mA. If there is no current present, the low alarm will not be activated.

Use a current input to detect current flow in a load such as a heater and indicate a problem if one were to occur, such as an open or short circuit.

Open and Shorted Load Circuit Detection

A Current Error can detect either an open or shorted load condition. A shorted condition would be present if the control is calling for 0% power while current is detected as flowing through the current transformer. Conversely, an open condition would be present when the control is calling for power with no current flow detected through the transformer.

A Heater Error is used to determine if the load current flow is within the specified limits as set by the user through the High Set Point and Low Set Point.

Signals

Direction	Label	Type	Function
Transmitter	CUR	Analog	The measured current value with scaling and offset applied when associated output is on.
	S&H	Analog	Samples and holds the last valid current reading, this transmitter will reset on a controller power cycle.

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Sides

Select which of the current set points trigger the heater error.

Options:

- Both: the measured current is monitored against both the High Set Point and Low Set Point
- High: the measured current is monitored against only the High Set Point
- Low: the measured current is monitored against only the Low Set Point
- Off: the current is not monitored for a heater error

High Set Point

Set the current value, in amperes that triggers a high heater error.

Range: -99,999 to 99,999

Low Set Point

Set the current value, in amperes that triggers a low heater error.

Range: -99,999 to 99,999

Indicate Reading

Select whether or not the RMS current is displayed.

Options: Yes, No

Input Scaling

Set the current transformer's high range, in amperes.

Range: 0 to 99,999

Heater Offset

Set a value to be added to the measured input value to calibrate the current reading.

Range: -99,999 to 99,999

Monitored Output

Set the number from the table below corresponding to the output that drives the heater or other device the current transformer is monitoring. This allows the current function to detect when the output is on and determine when current should or should not be flowing.

For example, if the current transformer is monitoring a heater driven by **Output 2, Module 4**, enter 32 for this setting.

Range: 1 to 56

	Output 1	Output 2	Output 3	Output 4	Output 5	Output 6
Module Slot 1	1	2	3	4	5	6
Module Slot 2	11	12	13	14	15	16
Module Slot 3	21	22	23	24	25	26
Module Slot 4	31	32	33	34	35	36
Module Slot 5	41	42	43	44	45	46
Module Slot 6	51	52	53	54	55	56

Load Current RMS, also known as CUR

The measured current value with scaling and offset applied when associated output is on.

Range: 0 to 9,999.00

Current Error

Indicates the load status.

Options:

- None: no error detected
- Shorted: current detected when the selected output is off
- Open: no current detected when the selected output is on

Heater Error

Indicates if load current flow is within the High and Low Set Points.

Options:

- None: no error detected
- High: the measured current has exceeded the value set for High Set Point
- Low: the measured current has dropped below the value set for Low Set Point

Digital Input

Use a digital input to integrate signals from field devices in to the application. The block is configured for the type of input signal with the Input Type parameter. These options for the Input Type parameter setting are described in detail below.

Input Dry Contact: the block's output is on when a switch closure is detected by the corresponding input on the flex module.

Input Voltage: the block's output is on when a sufficient voltage is detected by the corresponding input on the flex module.

Input Dry Contact

This FB is found on the canvas of the FB diagram. The number of these FBs that are available depends on the number of flex modules with a digital input configured as a dry contact.

Signals

Direction	Label	Type	Function
Transmitter	- - - -	Digital	Transmitter is inactive (off) when measured resistance is greater than 100KΩ and active (on) when less than 50Ω

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Input Type

To configure the input to detect a contact closure, set Input Type to Input Dry Contact.

Input Voltage

This FB is found on the canvas of the FB diagram. The number of these FBs that are available depends on the number of flex modules with a digital input configured to receive voltage.

Signals

Direction	Label	Type	Function
Transmitter	- - -	Digital	Transmitter is inactive (off) when measured voltage is less than 2V and active (on) when greater than 3V

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Input Type

To configure the input to detect a voltage level as a digital input, set Input Type to Input Voltage.

Digital Inputs/Outputs (I/O)

Use a digital input/output block to connect a field I/O device's signal to the application. This FB can be configured as either a digital input that can be triggered by an external device or a digital output that can switch an external device. As an output, the block can accept either a digital (on/off) signal or an analog percentage signal.

The block is configured as an input or output with the Direction parameter. These options for the Direction parameter setting are described in detail in the following sections:

[Input Dry Contact](#): the block's output is on when a switch closure is detected by the corresponding input on the flex module.

[Output](#): the block drives the corresponding output on the flex module according to the signal connected to the block's input.

[Input Voltage](#): the block's output is on when a sufficient voltage is detected by the corresponding input on the flex module.

Input Dry Contact

Use this function to integrate a signal from a switch or contact in a field I/O device into the application. For example, use a dry contact to detect the state of a door switch connected to a digital I/O point on the controller.

This FB is found on the canvas of the FB diagram. The number of these FBs that are available depends on the number of digital I/O flex modules installed and configured as dry contact inputs.

Signals

Direction	Label	Type	Function
Transmitter	- - -	Digital	Transmitter is inactive (off) when measured resistance is greater than 100KΩ and active (on) when less than 50Ω

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Direction

To configure the I/O point to detect a contact closure, set Direction to Input Dry Contact.

Output

Use this function to switch an external device. This FB is found on the canvas of the FB diagram. The number of these FBs that are available depends on the number of digital I/O flex modules installed and configured as outputs.

Signals

Direction	Label	Type	Function
Receiver	- - -	Analog (%) or Digital	Off or 0%: the output is off. Between 0% and 100%: the output switches according to the Time Base Type setting. On or 100%: the output is on.

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Direction

To configure the I/O point to drive the physical output, set Direction to Output.

Time Base Type

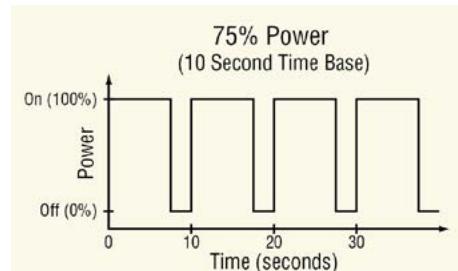
Choose the method used to operate the output when the input is an analog percentage. With either of the methods, the output switches off and on such that the average amount of time the output is on equals the desired percentage.

Note:

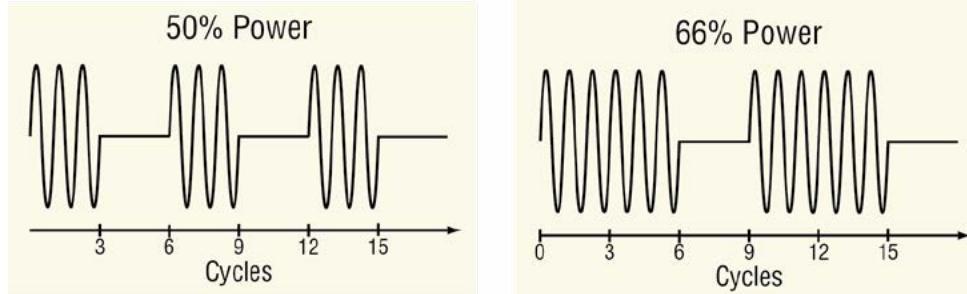
The type of field device connected to the output determines how frequently it can be switched.

Options:

- Fixed Time Base: the percent output power is converted to a duty cycle over the Fixed Time Base. For example, if the Fixed Time Base is ten seconds and 75% power is called for, the output turns on for 7.5 seconds and off for 2.5 seconds, and repeats as illustrated below. This is appropriate for mechanical relays.



- **Variable Time Base:** the output switches as often as every three ac line cycles. For example, when 66% power is called for, the output is on for six ac cycles and off for three, and when 50% power is called for, the output is on for three ac cycles and off for three. This method is appropriate for Solid-State Relays (SSR) or Silicon Controlled Rectifier (SCR) power controllers. Do not use a variable time base output to control electromechanical relays, mercury displacement relays, inductive loads or heaters with unusual resistance characteristics.



Fixed Time Base

Set the duration of one on-off cycle. This applies when the Time Base Type is set to Fixed Time Base.

Range: 0.1 to 60.0 seconds

Low Power Scale

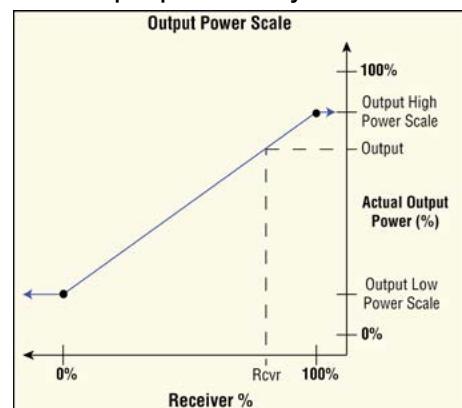
Set the minimum power level for the output. When the input equals 0% (off), the output is equal to the value set here. When the input equals 100% (on), the output is equal to the value set with High Power Scale. Values between 0% and 100% are scaled proportionally. See the illustration to the right.

Range: 0.0 to 100.0%

High Power Scale

Set the maximum power level for the output. When the input equals 100% (on), the output is equal to the value set here. When the input equals 0% (off), the output is equal to the value set with Output Low Power Scale. Values between 0% and 100% are scaled proportionally. See the illustration to the right.

Range: 0.0 to 100.0%



Input Voltage

Use this function to integrate a signal from a field I/O device that provides a high or low voltage signal indicating its state. This FB is found on the canvas of the FB diagram. The number of these FBs that are available depends on the number of digital I/O flex modules installed and configured as voltage inputs. **Signals**

Direction	Label	Type	Function
Transmitter	- - -	Digital	Transmitter is inactive (off) when measured voltage is less than 2V and active (on) when greater than 3V

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Direction

To configure the I/O point to detect a voltage level as a digital input, set Direction to Input Voltage.

Digital Outputs

Use a digital output block to drive an external device. Output blocks can accept either a digital (on/off) signal or an analog percentage signal. The following FBs are discussed in this section:

SSR and Switched DC/Open Collector: drive outputs on flex modules that are appropriate for loads that can be switched frequently.

Electromechanical and NO-ARC Relays: drive outputs on flex modules that are appropriate for loads that need not be switched frequently.

Solid-State Relay - Switched DC/Open Collector

These blocks are found on the canvas in the Function Block Diagram editor. The number of these blocks available depends on the number of solid state relays, switched DC outputs and open collector outputs on the flex modules installed in the controller.

Signals

Direction	Label	Type	Function
Receiver	- - -	Analog % or Digital	Off or 0%: the output is off. Between 0% and 100%: the output switches according to the Time Base Type setting. On or 100%: the output is on.

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Time Base Type

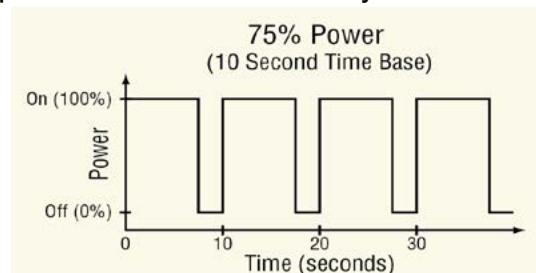
Choose the method used to operate the output when the input is an analog percentage. With either of the methods the output switches off and on such that the average amount of time the output is on equals the desired percentage.

Note:

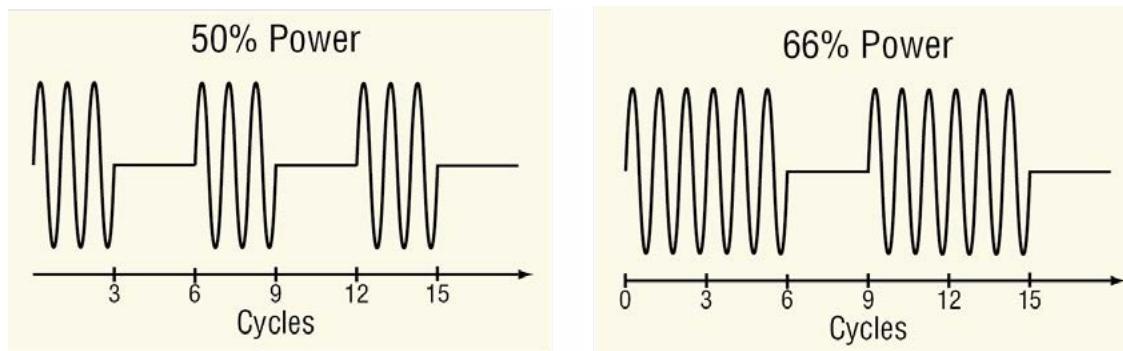
The type of field device connected to the output determines how frequently it can be switched.

Options:

- Fixed Time Base: the percent output power is converted to a duty cycle over the Fixed Time Base. For example, if the Fixed Time Base is ten seconds and 75% power is called for, the output turns on for 7.5 seconds and off for 2.5 seconds, and repeats as illustrated below. This is appropriate for mechanical relays.



- **Variable Time Base:** the output switches as often as every three ac line cycles. For example, when 66% power is called for, the output is on for six ac cycles and off for three, and when 50% power is called for, the output is on for three ac cycles and off for three. This method is appropriate for solid-state relays but not for electromechanical relays, mercury displacement relays, inductive loads or heaters with unusual resistance characteristics.



Fixed Time Base

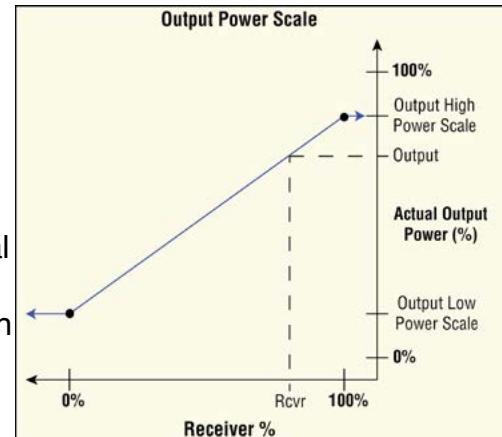
Set the duration of one on-off cycle. This applies when the Time Base Type is set to Fixed Time Base.

Range: 0.1 to 60.0 seconds

Low Power Scale

Set the minimum power level for the output. When the input equals 0% (off), the output is equal to the value set here. When the input equals 100% (on), the output is equal to the value set with High Power Scale. Values between 0% and 100% are scaled proportionally. See the illustration to the right.

Range: 0.0 to 100.0%



High Power Scale

Set the maximum power level for the output. When the input (Rcvr) is 100% (on), the output is equal to the value set here. When the input is 0% (off), the output is equal to the value set with Low Power Scale. Values between 0% and 100% are scaled proportionally.

Range: 0.0 to 100.0%

Electromechanical and NO-ARC Relays

Use this block to drive a digital output in the controller to switch an external device. These blocks are found on the canvas in the Function Block Diagram editor. The number of these blocks available depends on the number of electromechanical and NO-ARC relays on the flex modules installed in the controller.

Signals

Direction	Label	Type	Function
Receiver	-----	Analog % or Digital	Off or 0%: the output is off. Between 0% and 100%: the output switches according to the Fixed Time Base setting. On or 100%: the output is on.

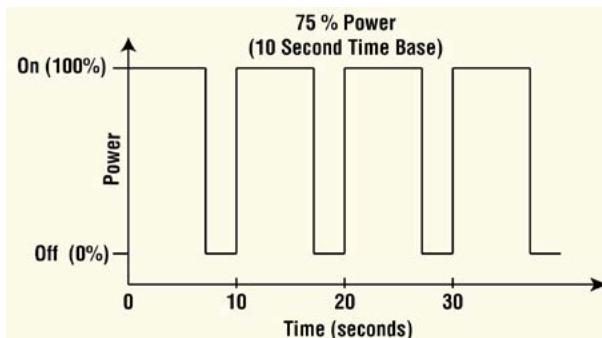
Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Fixed Time Base

Set the duration of one on-off cycle. A percent output power is converted to a duty cycle over the Fixed Time Base. For example, if the Fixed Time Base is ten seconds and 75% power is called for, the output turns on for 7.5 seconds and off for 2.5 seconds, and repeats as illustrated below. This is appropriate for mechanical relays.

Range: 5.0 to 60.0 seconds



Low Power Scale

Set the minimum power level for the output. When the input equals 0% (off), the output is equal to the value set here. When the input equals 100% (on), the output is equal to the value set with High Power Scale. Values between 0% and 100% are scaled proportionally. See the illustration below.

Range: 0.0 to 100.0%

High Power Scale

Set the maximum power level for the output. When the input is 100% (on), the output is equal to the value set here. When the input is 0% (off), the output is equal to the value set with Low Power Scale. Values between 0% and 100% are scaled proportionally.

Range: 0.0 to 100.0%

Key

Use a key to allow an output to be operated by a soft key on the controller user interface. When a key is connected to an output block, that output appears in the list of options for soft keys, for example on the output widget.

Choose how the key works with the Function parameter. These options for Function are described in detail in the following sections:

Momentary: the transmitted signal is on while the soft key is being pressed.

Toggle: the transmitted signal changes state each time the soft key is pressed.

On Pulse: the block transmits an on signal of a specified duration when it is pressed.

This function is found in the Function Block Diagram editor's Library.

The number of these blocks available to be added to the diagram is shown within the parenthesis.

Momentary

The transmitted signal is on while the soft key is being pressed.

Signals

Direction	Label	Type	Function
Transmitter	- - - -	Digital	On while the soft key is held and off while the soft key is not being pressed

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Function

To configure key to produce an on output only while it is held, set Function to Momentary.

Toggle

The transmitted signal changes state each time the soft key is pressed.

Signals

Direction	Label	Type	Function
Transmitter	- - - -	Digital	Initially off. Alternates between on and off with each press of the soft key.

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Function

To configure the key to change state each time the soft key is pressed, set Function to Toggle.

On Pulse

The transmitted signal is on for a user set period of time each time the soft key is pressed.

Signals

Direction	Label	Type	Function
Transmitter	- - - -	Digital	On for the specified duration after the soft key is pressed, otherwise off. Off when the pulse is canceled by a second key press.

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Function

To configure the key to produce a pulse of a specified duration when it is pressed, set Function to On Pulse.

Time

Set the length of time the output should remain on after the key is pressed.

Range: 0 to 99,999 seconds

Limit

Use a limit as a safety shutoff to disconnect the energy source from a system to prevent damage and injury in the event of a failure. A limit's output is on when the analog input indicates a safe value and off when the measured value is outside one of the user-set limit set points.

This block is found in the Function Block Diagram editor's workspace. The number of these blocks available depends on the number of flex modules with limits installed in the controller.

Signals

Direction	Label	Type	Function
Receivers	IN	Analog	Monitored for limit conditions.
	RST	Digital	Accepts a digital signal which clears the latched limit if the limit condition is cleared. Note: This link can only be connected to a Variable, a Function Key, a Digital Input or a Digital I/O point.
Transmitter	- - -	Digital	Supplies a digital signal that is on when the limit status is safe and off when the limit is tripped. This output has a fixed connection to the agency approved output hardware.

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Sides

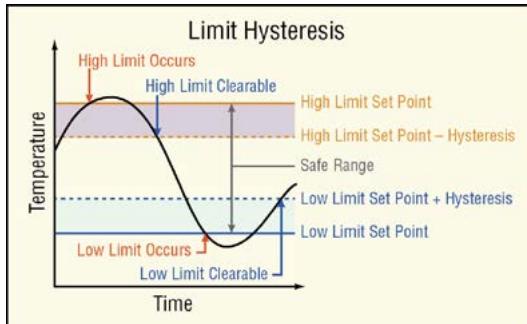
Select the conditions for which the input, IN is monitored.

Options:

- Both: the input is compared to both the High Limit Set Point and the Low Limit Set Point.
- High: the input is compared to the High Limit Set Point only; the low limit is not monitored.
- Low: the input is compared to the Low Limit Set Point only; the high limit is not monitored.

Hysteresis

Set how far the process must return into the normal operating range before the limit can be cleared. Hysteresis defines how far below the High Set Point the signal must drop before a high limit can be cleared and how far above the Low Set Point the signal must rise before a low limit can be cleared.



Range: 1 to 9,999 °F or units

2 to 5,555 °C

Minimum Set Point

Set the low end of the limit set point range. The Low Set Point cannot be set above this value.

Range: -99,999 to 99,999

Maximum Set Point

Set the high end of the limit set point range. The High Set Point cannot be set above this value.

Range: -99,999 to 99,999

High Limit Set Point

Set the process value that triggers the high limit.

Range: Minimum Set Point to Maximum Set Point

Low Limit Set Point

Set the process value that triggers the low limit.

Range: Minimum Set Point to Maximum Set Point

Clear Limit

Set this parameter to Clear to reset the limit and turn the limit output on after correcting the condition that caused the limit to trip.

Options: *Clear, No Change*

Limit Errors

Error Condition	Result
IN has an error	The Limit Status is Fail and the output is off with no error.

Limit Output

This block drives the output that is used to enable or disable the energy source associated with the limit sensor. It cannot be disconnected from the Limit block or connected to any other function.

These FBs are found on the canvas in the Function Block Diagram editor. The number of these FBs available depends on the number of flex modules with limits installed in the controller.

Signals

Direction	Label	Type	Function
Receiver	- - - -	Digital	Drives the physical output associated with the block

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Linearization

Use a linearize block to scale an analog signal according to a 10-point scaling curve and an offset. This block is found in the Function Block Diagram editor's Library when working with a controller that offers the Linearize block. Within the Library, the number of these blocks available is shown in parenthesis.

Choose the type of scaling curve with the Function parameter. These options for the Function parameter are described in detail in the following sections:

Off: The output is equal to the input plus the offset.

Interpolated: The output is equal to the scaled input plus the offset. The scaling curve is composed of line-segments connecting ten points. The output changes gradually as the input increases or decreases.

Stepped: The output is equal to the scaled input plus the offset. The scaling curve is composed of horizontal line segments extending from each point connected vertically to the subsequent point. The output is constant as the input increases until the input reaches the next step at which point the output changes abruptly to the new value.

Off

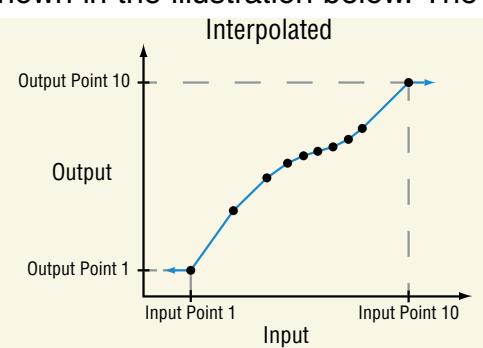
When the Linearize block's function is set to Off, the output is off.

Interpolated

The output is equal to the scaled input plus the offset. The scaling curve is composed of line-segments connecting the ten points in numerical order as shown in the illustration below. The output changes gradually as the input increases or decreases.

The points of the scaling curve must be in ascending order of the input value such that Input Point 1 is the lowest value to be scaled, Input Point 2 is the next higher value and so on. If fewer than ten points are required, set the

unused input points equal to the last point. For example, if the curve requires eight points, use points one to eight for the curve and set points nine and ten equal to point eight.



Signals

Direction	Label	Type	Function
Receiver	- - -	Analog	Signal to be scaled
Transmitter	- - -	Analog	Scaled signal with offset applied

Function

To scale the input according to a curve made up of interpolated line segments defined by ten points, set Function to Interpolate.

Units

Set the units of the output value.

Options:

- Source: the output has the same units as the signal connected to the top receiver.
- None: the output is a pure number without units.
- Absolute Temperature: the output is a temperature on the Celsius or Fahrenheit scale. For example, 33° F as an absolute temperature is one degree above the freezing point of water. An absolute temperature can be used as a set point or compared with other temperatures to determine which is hotter or colder.
- Relative Temperature: the output is a relative number of degrees, not an absolute temperature. For example, the difference between the two measured temperatures, 120° C and 100° C is 20 degrees, but it is not the temperature 20° C. A relative temperature is

appropriate for use as a calibration offset or a deviation alarm set point.

- Power: the output is a percentage with 100% representing full power and 0% representing no power.
- Process: the output is in units of measure other than degrees Fahrenheit, degrees Celsius or relative humidity.
- Relative Humidity: the output is a measurement of percent relative humidity (%RH).

Input Point 1

Set the minimum input value to be scaled. This value and all lesser values are scaled to Output Point 1.

Range: -99,999.000 to 99,999.000

Output Point 1

Set the value to which the input is scaled when the input is equal to or less than Input Point 1.

Range: -99,999.000 to 99,999.000

Input Point 2

Set the second lowest input value on the scaling curve. This value is scaled to Output Point 2.

Range: -99,999.000 to 99,999.000

Output Point 2

Set the value to which the input is scaled when the input is equal to Input Point 2.

Range: -99,999.000 to 99,999.000

Input Point 3

Set the third lowest input value on the scaling curve. This value is scaled to Output Point 3.

Range: -99,999.000 to 99,999.000

Output Point 3

Set the value to which the input is scaled when the input is equal to Input Point 3.

Range: -99,999.000 to 99,999.000

Input Point 4

Set the forth lowest input value on the scaling curve. This value is scaled to Output Point 4.

Range: -99,999.000 to 99,999.000

Output Point 4

Set the value to which the input is scaled when the input is equal to Input Point 4.

Range: -99,999.000 to 99,999.000

Input Point 5

Set the fifth lowest input value on the scaling curve. This value is scaled to Output Point 5.

Range: -99,999.000 to 99,999.000

Output Point 5

Set the value to which the input is scaled when the input is equal to Input Point 5.

Range: -99,999.000 to 99,999.000

Input Point 6

Set the sixth lowest input value on the scaling curve. This value is scaled to Output Point 6.

Range: -99,999.000 to 99,999.000

Output Point 6

Set the value to which the input is scaled when the input is equal to Input Point 6.

Range: -99,999.000 to 99,999.000

Input Point 7

Set the seventh lowest input value on the scaling curve. This value is scaled to Output Point 7.

Range: -99,999.000 to 99,999.000

Output Point 7

Set the value to which the input is scaled when the input is equal to Input Point 7.

Range: -99,999.000 to 99,999.000

Input Point 8

Set the eighth lowest input value on the scaling curve. This value is scaled to Output Point 8.

Range: -99,999.000 to 99,999.000

Output Point 8

Set the value to which the input is scaled when the input is equal to Input Point 8.

Range: -99,999.000 to 99,999.000

Input Point 9

Set the ninth lowest input value on the scaling curve. This value is scaled to Output Point 9.

Range: -99,999.000 to 99,999.000

Output Point 9

Set the value to which the input is scaled when the input is equal to Input Point 9.

Range: -99,999.000 to 99,999.000

Input Point 10

Set the tenth lowest input value on the scaling curve. This value is scaled to Output Point 10.

Range: -99,999.000 to 99,999.000

Output Point 10

Set the value to which the input is scaled when the input is equal to Input Point 10.

Range: -99,999.000 to 99,999.000

Offset

Set an adjustment to the final value, added after scaling.

Range: -99,999.000 to 99,999.000

Stepped

The output is equal to the scaled input plus the offset. The scaling curve is composed of horizontal segments extending from each point connected vertically to the subsequent point as shown in the illustration below. The output is constant as the input is increased until the input

reaches the next point where the output changes abruptly to the next value.

Signals

Direction	Label	Type	Function
Receiver	- - - -	Analog	Signal to be scaled
Transmitter	- - - -	Analog	Scaled signal with offset applied

Function

To scale the input values to up to ten specific values, set Function to Stepped.

Units

Set the units of the output value.

Options:

- Source: the output has the same units as the signal connected to the top receiver.
- None: the output is a pure number without units.
- Absolute Temperature: the output is a temperature on the Celsius or Fahrenheit scale. For example, 33° F as an absolute temperature is one degree above the freezing point of water. An absolute temperature can be used as a set point or compared with other temperatures to determine which is hotter or colder.
- Relative Temperature: the output is a relative number of degrees, not an absolute temperature. For example, the difference between the two measured temperatures, 120° C and 100° C is 20 degrees, but it is not the temperature 20° C. A relative temperature is appropriate for use as a calibration offset or a deviation alarm set point.
- Power: the output is a percentage with 100% representing full power and 0% representing no power.
- Process: the output is in units of measure other than degrees Fahrenheit, degrees Celsius or relative humidity.
- Relative Humidity: the output is a measurement of percent relative humidity (%RH).

Input Point 1

Set the minimum input value to be scaled. Input values less than Input Point 2 are scaled to Output Point 1.

Range: -99,999.000 to 99,999.000

Output Point 1

Set the value to which the input is scaled when the input is less than Input Point 2.

Range: -99,999.000 to 99,999.000

Input Point 2

Set the second lowest input value to be scaled. Input values equal to or greater than this, but less than Input Point 3 are scaled to Output Point 2.

Range: -99,999.000 to 99,999.000

Output Point 2

Set the value to which the input is scaled when the input is greater than or equal to Input Point

2 and less than Input Point 3.

Range: -99,999.000 to 99,999.000

Input Point 3

Set the third lowest input value to be scaled. Input values equal to or greater than this, but less than Input Point 4 are scaled to Output Point 3.

Range: -99,999.000 to 99,999.000

Output Point 3

Set the value to which the input is scaled when the input is greater than or equal to Input Point 3 and less than Input Point 4.

Range: -99,999.000 to 99,999.000

Input Point 4

Set the forth lowest input value to be scaled. Input values equal to or greater than this, but less than Input Point 5 are scaled to Output Point 4.

Range: -99,999.000 to 99,999.000

Output Point 4

Set the value to which the input is scaled when the input is greater than or equal to Input Point 4 and less than Input Point 5.

Range: -99,999.000 to 99,999.000

Input Point 5

Set the fifth lowest input value to be scaled. Input values equal to or greater than this, but less than Input Point 6 are scaled to Output Point 5.

Range: -99,999.000 to 99,999.000

Output Point 5

Set the value to which the input is scaled when the input is greater than or equal to Input Point 5 and less than Input Point 6.

Range: -99,999.000 to 99,999.000

Input Point 6

Set the sixth lowest input value to be scaled. Input values equal to or greater than this, but less than Input Point 7 are scaled to Output Point 6.

Range: -99,999.000 to 99,999.000

Output Point 6

Set the value to which the input is scaled when the input is greater than or equal to Input Point 6 and less than Input Point 7.

Range: -99,999.000 to 99,999.000

Input Point 7

Set the seventh lowest input value to be scaled. Input values equal to or greater than this, but less than Input Point 8 are scaled to Output Point 7.

Range: -99,999.000 to 99,999.000

Output Point 7

Set the value to which the input is scaled when the input is greater than or equal to Input Point

7 and less than Input Point 8.

Range: -99,999.000 to 99,999.000

Input Point 8

Set the eighth lowest input value to be scaled. Input values equal to or greater than this, but less than Input Point 9 are scaled to Output Point 8.

Range: -99,999.000 to 99,999.000

Output Point 8

Set the value to which the input is scaled when the input is greater than or equal to Input Point 8 and less than Input Point 9.

Range: -99,999.000 to 99,999.000

Input Point 9

Set the ninth lowest input value to be scaled. Input values equal to or greater than this, but less than Input Point 10 are scaled to Output Point 9.

Range: -99,999.000 to 99,999.000

Output Point 9

Set the value to which the input is scaled when the input is greater than or equal to Input Point 9 and less than Input Point 10.

Range: -99,999.000 to 99,999.000

Input Point 10

Set the tenth lowest input value to be scaled. Input values equal to or greater than this are scaled to Output Point 10.

Range: -99,999.000 to 99,999.000

Output Point 10

Set the value to which the input is scaled when the input is greater than or equal to Input Point 10.

Range: -99,999.000 to 99,999.000

Offset

Set an adjustment to the final value, added after scaling.

Range: -99,999.000 to 99,999.000

Linearization Errors

When the input has an error the signals connected to the output have the same error.

Error Condition	Result
Input has an error	The output propagates the same error.

Logic

Use a logic block to set an output based on one or more digital signals. The logic block performs logic operations on one or more inputs and sets its output based on the result.

This block is found in the Function Block Diagram editor's Library when working with a controller that offers the Logic block. Within the Library, the number of these blocks available is shown in parenthesis.

Choose the logic operation with the Function parameter. These options for the Function parameter are described in detail in the following sections:

Off: the output is false.

And: If any input is false, the output is false. If all inputs are true, the output is true.

Nand: if any input is false, the output is true. If all inputs are true, the output is false.

Equal To: if all the inputs are false or all the inputs are true, the output is true. Otherwise, the output is false.

Not Equal To: if all the inputs are false or all the inputs are true, the output is false. Otherwise, the output is true.

Or: if any input is true, the output is true. If all inputs are false, the output is false.

Nor: if any input is true, the output is false. If all inputs are false, the output is true.

Latch: when the HOLD input is false, the output follows the IN input. When HOLD is true, the output is held (latched) at the value it had when HOLD became true.

RS Flip Flop: one input sets the output true; the other sets it false.

Off

The output is false (off, 0%).

And

If any input is false (off, 0%), the output is false (off, 0%). If all inputs are true (on, 100%), the output is true (on, 100%).

Only connected inputs are considered by the logic operation; inputs that are not connected are ignored. The truth table at the right illustrates the outcomes for three inputs.

Inputs	Output
FFF	F
FFT	F
FTF	F
FTT	F
TFF	F
TFT	F
TTF	F
TTT	T

F = False (0%, off)
T = True (100%, on)

Signals

Direction	Label	Type	Function
Receivers	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
Transmitter	- - -	Digital	True when all the inputs are true, otherwise false

Function

To detect when all the inputs are true, set Function to And.

Error Handling

Use Error Handling to select the output's value and error status when the function cannot definitively determine the result.

Options:

- True Good: output's value is true (on) with no error
- True Bad: output's value is true (on) and has an error
- False Good: output's value is false (off) with no error
- False Bad: output's value is false (off) and has an error

Nand

If any input is false (off, 0%), the output is true (on, 100%). If all inputs are true (on, 100%), the output is false (off, 0%).

Only connected inputs are considered by the logic operation; inputs that are not connected are ignored. The truth table at the right illustrates the outcomes for three inputs.

Inputs	Output
FFF	T
FFT	T
FTF	T
FTT	T
TFF	T
TFT	T
TTF	T
TTT	F

F = False (0%, off)
T = True (100%, on)

Signals

Direction	Label	Type	Function
Receivers	- - - -	Digital	Input to logic function
	- - - -	Digital	Input to logic function
	- - - -	Digital	Input to logic function
	- - - -	Digital	Input to logic function
	- - - -	Digital	Input to logic function
	- - - -	Digital	Input to logic function
	- - - -	Digital	Input to logic function
	Transmitter	Digital	True when at least one of the inputs is false, otherwise false

Function

To detect when at least one inputs is false, set Function to Nand.

Error Handling

Use Error Handling to select the output's value and error status when the function cannot definitively determine the result.

Options:

- True Good: output's value is true (on) with no error

- True Bad: output's value is true (on) and has an error
- False Good: output's value is false (off) with no error
- False Bad: output's value is false (off) and has an error

Equal To

If all the inputs are false (off, 0%) or all the inputs are true (on, 100%), the output is true (on, 100%). Otherwise, the output is false (off, 0%).

Only connected inputs are considered by the logic operation; inputs that are not connected are ignored. The truth table at the right illustrates the outcomes for three inputs.

Inputs	Output
FFF	T
FFT	F
FTF	F
FTT	F
TFF	F
TFT	F
TF	F
TTT	T
F = False (0%, off)	
T = True (100%, on)	

Signals

Direction	Label	Type	Function
Receivers	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
Transmitter	- - -	Digital	True when each connected input has the same value, otherwise false

Function

To detect when all the inputs have the same value, set Function to Equal To.

Error Handling

Use Error Handling to select the output's value and error status when the function cannot definitively determine the result.

Options:

- True Good: output's value is true (on) with no error
- True Bad: output's value is true (on) and has an error

- False Good: output's value is false (off) with no error
- False Bad: output's value is false (off) and has an error

Not Equal To

If all the inputs are false (off, 0%) or all the inputs are true (on, 100%), the output is false (off, 0%). Otherwise, the output is true (on, 100%).

Only connected inputs are considered by the logic operation; inputs that are not connected are ignored. The truth table at the right illustrates the outcomes for three inputs.

Inputs	Output
FFF	F
FFT	T
FTF	T
FTT	T
TFF	T
TFT	T
TTF	T
TTT	F
F = False (0%, off)	
T = True (100%, on)	

Signals

Direction	Label	Type	Function
Receivers	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
Transmitter	- - -	Digital	True when not all of the inputs have the same value, otherwise false

Function

To detect when the inputs do not all have the same value, set Function to Not Equal To.

Error Handling

Use Error Handling to select the output's value and error status when the function cannot definitively determine the result.

Options:

- True Good: output's value is true (on) with no error
- True Bad: output's value is true (on) and has an error

- False Good: output's value is false (off) with no error
- False Bad: output's value is false (off) and has an error

Or

If any input is true (on, 100%), the output is true (on, 100%). If all inputs are false (off, 0%), the output is false (off, 0%).

Only connected inputs are considered by the logic operation; inputs that are not connected are ignored. The truth table at the right illustrates the outcomes for three inputs.

Inputs	Output
FFF	F
FFT	T
FTF	T
FTT	T
TFF	T
TFT	T
TTF	T
TTT	T
F = False (0%, off)	
T = True (100%, on)	

Signals

Direction	Label	Type	Function
Receivers	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
Transmitter	- - -	Digital	True when at least one of the inputs is true, otherwise false

Function

To detect when at least one of the inputs is true, set Function to Or.

Error Handling

Use Error Handling to select the output's value and error status when the function cannot definitively determine the result.

Options:

- True Good: output's value is true (on) with no error
- True Bad: output's value is true (on) and has an error
- False Good: output's value is false (off) with no error
- False Bad: output's value is false (off) and has an error

Nor

If any input is true (on, 100%), the output is false (off, 0%). If all the inputs are false (off, 0%), the output is true (on, 100%).

Only connected inputs are considered by the logic operation; inputs that are not connected are ignored. The truth table at the right illustrates the outcomes for three inputs.

Inputs	Output
FFF	T
FFT	F
FTF	F
FTT	F
TFF	F
TFT	F
TTF	F
TTT	F
F = False (0%, off)	
T = True (100%, on)	

Signals

Direction	Label	Type	Function
Receivers	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
	- - -	Digital	Input to logic function
Transmitter	- - -	Digital	True when all of the inputs are false, otherwise true

Function

To detect when all the inputs are false, set Function to Nor.

Error Handling

Use Error Handling to select the output's value and error status when the function cannot definitively determine the result.

Options:

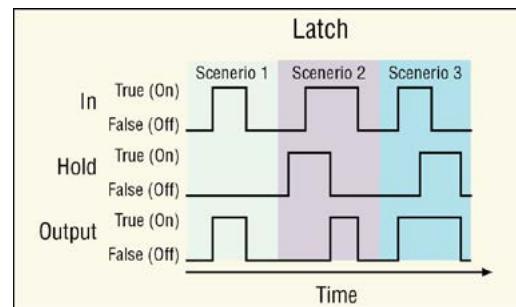
- True Good: output's value is true (on) with no error
- True Bad: output's value is true (on) and has an error
- False Good: output's value is false (off) with no error
- False Bad: output's value is false (off) and has an error

Latch

When the HOLD input is false (off, 0%), the output follows the IN input value. When HOLD is true (on, 100%), the output does not change; it is held (latched) at the value that was present at IN when HOLD became true (on, 100%).

To understand the Latch's behavior consider these scenarios illustrated in the timing diagram below:

1. When Hold is false, the output follows IN.
2. If IN becomes true after Hold become true, the output remains false until Hold becomes false.
3. If Hold becomes true after IN becomes true, the output remains true as long as Hold is true even after IN becomes false.



Signals

Direction	Label	Type	Function
Receivers	IN	Digital	The signal that sets the output
	Hold	Digital	The signal that holds the output
Transmitter	- - -	Digital	Follows the input (IN) when HOLD is false. Latches at the value of the input (IN) when HOLD becomes true.

Function

To have an output that follows the input when another input is false and holds the last value when the latching input becomes true, set Function to Latch.

Error Handling

Use Error Handling to select the output's value and error status when the function cannot definitively determine the result.

Options:

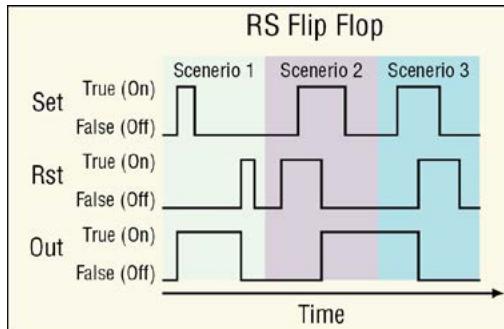
- True Good: output's value is true (on) with no error
- True Bad: output's value is true (on) and has an error
- False Good: output's value is false (off) with no error
- False Bad: output's value is false (off) and has an error

RS Flip Flop

True (on, 100%) at the Set input sets the output to true (on, 100%) unless the reset (Rst) input is true (on, 100%). Whenever Rst is true (on, 100%) the output is false (off, 0%).

To understand the RS Flip Flop's behavior consider these scenarios illustrated in the timing diagram below:

1. Set turns the output on, Rst turns it off.
2. If Rst is true when Set becomes true, the output remains off until Rst becomes false.
3. Set has no effect when the output is already on.



Signals

Direction	Label	Type	Function
Receivers	Set	Digital	Sets the output to true
	Rst	Digital	Sets the output to false, takes precedence over the Set input
Transmitter	- - -	Digital	True after being set by the Set input and false after being reset by Rst

Function

To have an output that is set to true by one input and reset to false by another input, set Function to RS Flip Flop.

Error Handling

Use Error Handling to select the output's value and error status when the function cannot definitively determine the result.

Options:

- True Good: output's value is true (on) with no error
- True Bad: output's value is true (on) and has an error
- False Good: output's value is false (off) with no error
- False Bad: output's value is false (off) and has an error

Logic Errors

When the input has an error the signals connected to the output have the same error.

Function	Error Condition	Result
Off	One or more inputs has an error	The output is false with no error
Latch	In has an error Hold is off with no error	The output's value and error follow the input.
	In has an error Hold is on with no error	The output's value and error are the same as the input was at the time the Hold signal turned on.
	Hold has an error	The output's value and error follow the input.
RS Flip Flop	SET input gets an error while the output is false	The output stays false with no error.
	SET input gets an error while the output is true	The output stays true with no error until the RST input resets the output to false.
	RST input gets an error while the output is false	The output stays false with no error until the SET input sets the output to true.
	RST input gets an error while the output is true	The output stays true with no error.
All Others	One or more inputs has an error	If there is enough information to determine the output, all errors are ignored. Otherwise, the output value and error are determined by the setting of the Error Handling parameter.

Math

Use a Math block to set an output based by performing the selected math function on up to four inputs. A filter and offset may be applied to the calculated value. A digital input enables or disables some of the math functions. This block is found in the Function Block Diagram editor's Library when working with a controller that offers the Math block. Within the Library, the number of these blocks available is shown in parenthesis.

Choose the math operation with the Function parameter. These options for the Function parameter are described in detail in the following sections:

Off: the output follows the filtered input plus the offset.

Average: calculates the average of up to four inputs.

Switch Over: selects one of two analog inputs with a digital input.

Process Scale: converts an input from its scale to another range.

Deviation Scale: adjusts an input by an amount proportional to another input.

Differential: subtracts one input from another.

Ratio: divides one input by another.

Add: sums up to four inputs.

Multiply: computes the product of up to four inputs.

Absolute Difference: calculates the absolute value of one input subtracted from another.

Minimum: outputs the lowest of up to four inputs.

Maximum: outputs the greatest of up to four inputs.

Square Root: calculates square root of an input.

Sample and Hold: freezes an analog signal with a digital input.

Pressure to Altitude: calculates the standard distance above sea level based on an atmospheric pressure.

Dew Point: calculates the temperature at which water vapor will condense based on the temperature and relative humidity of an environment.

Off

The output follows the top input. A filter and offset may be applied to the output value. The output has the units of the signal connected to the top input link.

Signals

Direction	Label	Type	Function
Receiver	- - - -	Analog	Value used for the output
Transmitter	- - - -	Digital	The filtered input plus the offset

Function

To filter and/or add an offset to a signal, set Function to Off.

Offset

Adjustment added to the input.

Range: -99,999.000 to 99,999

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Average

This function calculates the mean average of up to four inputs. Only inputs connected to a source are used in the calculation. A filter and offset may be applied to the calculated value. The output has the units of the signal connected to the top input link.

Signals

Direction	Label	Type	Function
Receivers	- - - -	Analog	Value to include in the average
	- - - -	Analog	Value to include in the average
	- - - -	Analog	Value to include in the average
	- - - -	Analog	Value to include in the average
Transmitter	- - - -	Analog	The filtered average of the inputs plus the offset

Function

To average the inputs, set Function to Average.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Switch Over

When SW is off, the output equals input 1. When SW is on, the output equals input 2. A filter and offset may be applied to the output. The output has the same units as the selected input.

Signals

Direction	Label	Type	Function
Receivers	1	Analog	Selected as the output when SW is off
	2	Analog	Selected as the output when SW is on
	SW	Digital	Off selects input 1, on selects input 2
Transmitter	- - -	Analog	The filtered value of the selected input plus the offset

Function

To select one of two analog inputs with a digital input, set Function to Switch Over.

Offset

Adjustment added to the selected value.

Range: -99,999.000 to 99,999

Filter

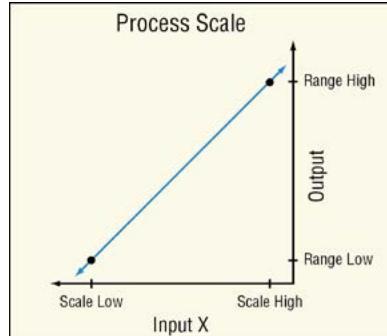
Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Process Scale

When SW is off, the output equals the filtered, scaled value of input X plus the offset. When SW is on, the output equals the filtered value of input B plus the offset.

Scaling converts input X proportionally from the input scale to the output range according to the line defined by the Scale Low, Scale High, Range Low and Range High settings as shown in the illustration.



The definition of the scaling line is very flexible. The input scale is not limited by the Scale Low and Scale High values and the range of the scaling calculation is not limited to values between Range Low and Range High. Input values are converted according to the line defined by the two points. Scale High need not be greater than Scale Low and Range High need not be greater than Range Low. A filter and offset may be applied to the calculated value.

Process Scale can be used, for example, to convert from one set of units to another or to convert a sensor signal to engineering units if the signal is linear with the value it represents.

Signals

Direction	Label	Type	Function
Receivers	X	Analog	Signal to scale when SW is off
	B	Analog	Signal used without scaling when SW is on
	SW	Digital	When off, the output is based on the scaled value of input X, when on the output is based on input B (not scaled)
Transmitter	- - -	Analog	The filtered result of the function plus the offset

Function

To convert an input from its scale to another range, set Function to Process Scale.

Scale Low

Set the value of input X at which the Range Low setting is the desired result of scaling. Scale Low and Range Low are the coordinates of a point on the line that relates input X to the scaled output.

Range: -99,999.000 to 99,999.000

Scale High

Set the value of input X at which the Range High setting is the desired result of scaling. Scale High and Range High are the coordinates of a point on the line that relates input X to the scaled output.

Range: -99,999.000 to 99,999.000

Units

Set the source units.

Options:

- Source: when SW is on, the output has the same units as input X. When SW is off, the output has the same units as input B.
- None: the output value is a pure number without units
- Absolute Temperature: the output value is a temperature value on the Celsius or Fahrenheit scale. For example, 33° F as an absolute temperature is one degree above the freezing point of water. An absolute temperature can be used as a set point or compared with other temperatures to determine which is hotter or colder.
- Relative Temperature: the output is a value is a relative number of degrees, not an absolute temperature. For example, the difference between the two measured temperatures, 120° C and 100° C is 20 degrees, but it is not the temperature 20° C. A relative temperature is appropriate for use as a calibration offset or a deviation alarm set point.
- Power: the output value is a percentage signal where 100% represents full power and 0% represents no power.
- Process: the output is in units of measure other than degrees Fahrenheit, degrees Celsius or relative humidity.
- Relative Humidity: the output is in percent relative humidity (%RH).

Range Low

Set the desired result of scaling at the point where input X equals the Scale Low setting. Scale Low and Range Low are the coordinates of a point on the line that relates input X to the scaled output.

Range: -99,999.000 to 99,999.000

Range High

Set the desired result of scaling at the point where input X equals the Scale High setting. Scale High and Range High are the coordinates of a point on the line that relates input X to the scaled output.

Range: -99,999.000 to 99,999.000

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

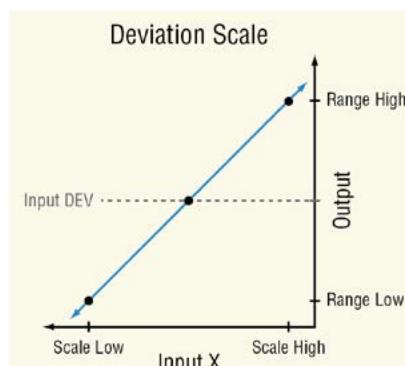
Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Deviation Scale

When SW is off, the output equals the filtered, scaled value of input X plus DEV plus the offset. When SW is on, the output equals the filtered value of DEV plus the offset.

Scaling converts input X proportionally from the input scale to the output range according to the line defined by the Scale Low, Scale High, Range Low and Range High settings as shown in the illustration.



The definition of the scaling line is very flexible. The input scale is not limited by the Scale Low and Scale High values and, the range of the scaling calculation is not limited to values between Range Low and Range High. Input values are converted according to the line defined by the two points. Scale High need not be greater than Scale Low, and Range High need not be greater than Range Low. A filter and offset may be applied to the calculated value. The output has the same units as input DEV.

Deviation Scale may be used instead of Process Scale when it is desirable for the output

range to be defined relative to a value that might change frequently or automatically.

Signals

Direction	Label	Type	Function
Receivers	X	Analog	Signal to scale when SW is off
	DEV	Analog	Signal added to the scaled value of X when SW is off, signal used without scaling when SW is on
	SW	Digital	When off, the output is based on DEV plus the scaled value of input X, when on the output is based on DEV (not scaled)
Transmitter	- - -	Analog	The filtered result of the function plus the offset

Function

To adjust an input by an amount proportional to another input, set Function to Deviation Scale.

Scale Low

Set the value of input X at which the Low Range setting plus the DEV value is the desired output. Scale Low and Range Low are the coordinates of a point on the line that relates input X to the adjustment added to input DEV to calculate the output.

Range: -99,999.000 to 99,999.000

Scale High

Set the value of input X at which the High Range setting plus the DEV value is the desired output. Scale High and Range High are the coordinates of a point on the line that relates input X to the adjustment added to input DEV to calculate the output.

Range: -99,999.000 to 99,999.000

Range Low

Set the adjustment be added to input DEV when input X equals the Scale Low setting. Scale Low and Range Low are the coordinates of a point on the line that relates input X to the adjustment added to input DEV to calculate the output.

Range: -99,999.000 to 99,999.000

Range High

Set the adjustment to be added to input DEV when input X equals the Scale High setting. Scale High and Range High are the coordinates of a point on the line that relates input X to the adjustment added to input DEV to calculate the output.

Range: -99,999.000 to 99,999.000

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to

increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Differential

This function calculates input X minus input Y. A filter and offset may be applied to the calculated value. The output has the units of input X.

Signals

Direction	Label	Type	Function
Receivers	X	Analog	Value from which Y is subtracted
	Y	Analog	Value subtracted from X
Transmitter	- - -	Analog	The filtered result of the calculation ($X - Y$) plus the offset

Function

To subtract one input from another, set Function to Differential.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Ratio

This function calculates the quotient: input X divided by input Y. A filter and offset may be applied to the calculated value. If both inputs have the same units, the output has no units, otherwise the output has the units of input X.

Signals

Direction	Label	Type	Function
Receivers	X	Analog	Value divided by Y (numerator)
	Y	Analog	Value by which X is divided (denominator)
Transmitter	- - -	Analog	The filtered result of the calculation ($X \div Y$) plus the offset

Function

To divide one input by another, set Function to Ratio.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to

increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Add

This function sums up to four inputs. Only inputs connected to a source are used in the calculation. A filter and offset may be applied to the calculated value. If any input is an absolute temperature, the output is also an absolute temperature; otherwise the output's units are those of the signal connected to the top input.

Signals

Direction	Label	Type	Function
Receivers	- - - -	Analog	Value to be summed
	- - - -	Analog	Value to be summed
	- - - -	Analog	Value to be summed
	- - - -	Analog	Value to be summed
Transmitter	- - - -	Analog	The filtered sum of the inputs plus the offset

Function

To sum up to four inputs, set Function to Add.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Multiply

This function multiplies up to four inputs. Only inputs connected to a source are used in the calculation. A filter and offset may be applied to the calculated value. If any input is an absolute temperature, the output is also an absolute temperature; otherwise the output's units are those of the signal connected to the top input.

Signals

Direction	Label	Type	Function
Receivers	- - - -	Analog	Value to be multiplied
	- - - -	Analog	Value to be multiplied
	- - - -	Analog	Value to be multiplied
	- - - -	Analog	Value to be multiplied
Transmitter	- - - -	Analog	The filtered product of the inputs plus the offset

Function

To compute the product of up to four inputs, set Function to Multiply.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Absolute Difference

This function calculates the absolute value of input X minus input Y. A filter and offset may be applied to the calculated value. The output has the units of input x.

Signals

Direction	Label	Type	Function
Receivers	X	Analog	Value from which Y is subtracted
	Y	Analog	Value subtracted from X
Transmitter	- - -	Analog	The filtered result of the absolute value of (X – Y) plus the offset

Function

To calculate the absolute value of one input subtracted from another, set Function to Absolute Difference

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Minimum

This function selects the minimum of up to four inputs. Only inputs connected to a source are considered. A filter and offset may be applied to the output. The output has the units of the signal with the minimum value.

Signals

Direction	Label	Type	Function
Receivers	- - -	Analog	Compared with other inputs
	- - -	Analog	Compared with other inputs
	- - -	Analog	Compared with other inputs
	- - -	Analog	Compared with other inputs
Transmitter	- - -	Analog	The filtered lowest value of the inputs plus the offset

Function

To output the lowest of up to four inputs, set Function to Minimum.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Maximum

This function selects the maximum of up to four inputs. Only inputs connected to a source are considered. A filter and offset may be applied to the output. The output has the units of the signal with the maximum value.

Signals

Direction	Label	Type	Function
Receivers	- - - -	Analog	Compared with other inputs
	- - - -	Analog	Compared with other inputs
	- - - -	Analog	Compared with other inputs
	- - - -	Analog	Compared with other inputs
Transmitter	- - - -	Analog	The filtered greatest value of the inputs plus the offset

Function

To output the greatest of up to four inputs, set Function to Maximum.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Square Root

This function calculates the square root of input X. A filter and offset may be applied to the calculated value. The output has the same units as X.

Signals

Direction	Label	Type	Function
Receiver	X	Analog	Value of which to find the square root
Transmitter	- - - -	Analog	The filtered square root of input X plus the offset

Function

To calculate the square root of an input, set Function to Square Root.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Sample and Hold

When the Hold input is off, the output follows the IN value. When Hold is on, the output stops changing; the output stays at the value it had at the time Hold turned on.

A filter and offset may be applied to the output value. Filtering holds when the Hold input is on. Changes to the offset are applied without filtering and are not affected by the Hold input. The output has the same units as the input (IN).

Signals

Direction	Label	Type	Function
Receivers	IN	Analog	Input to math function
	Hold	Digital	When off the output follows the input plus the offset. When on the output stops following the input and holds the input value present at the time hold turned on.
Transmitter	- - -	Analog	Filtered value of input (IN) plus the offset when HOLD is off. Holds the output once HOLD turns on.

Function

To freeze the analog signal with a digital input, set Function to Sample and Hold.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Pressure to Altitude

This function determines the altitude based on the atmospheric pressure. A filter and offset may be applied to the calculated value. The output has the units selected with the Altitude Units parameter.

The calculation is based on the International Standard Atmosphere 1976 and is accurate from

sea level to 90,000 feet. It can be used beyond this range in both directions, but with loss of accuracy. The standard is based on an altitude of 0 feet (sea level) pressure of 14.6967 PSI and a temperature of 59 °F.

Signals

Direction	Label	Type	Function
Receiver	- - - -	Analog	Pressure (See Pressure Units parameter)
Transmitter	- - - -	Analog	The calculated altitude plus the offset (See Altitude Units parameter).

Function

To calculate the standard distance above sea level based on an atmospheric pressure, set Function to Pressure to Altitude.

Pressure Units

Set the units of pressure input.

Options: PSI, mbar, Torr, Pascal, Atmosphere

Altitude Units

Set the units for the altitude output.

Options: Feet, Kilofeet

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Dew Point

This function calculates the dew point based on temperature and relative humidity. A filter and offset may be applied to the calculated value. The output is an absolute temperature.

Signals

Direction	Label	Type	Function
Receivers	T	Analog	Temperature measurement
	RH	Analog	Relative humidity measurement
Transmitter	- - - -	Analog	Filtered calculated dew point plus the offset

Function

To calculate the temperature at which water vapor will condense based on the temperature and relative humidity of an environment, set Function to Dew Point.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Math Errors

Inputs that are not connected are ignored. Otherwise error behavior is specific to the Function setting.

Function	Error Condition	Result
Off	Any or none	The output value and error follow the first input
Average	One or more, but not all inputs have errors	The output value is the average of the inputs that have no errors and the output has no error.
	All inputs have errors	The output has the last good value and has an error.
Switch Over	When SW has no error	The output's value and error follow the input selected by the digital input.
	When SW has an error	The output value and error follow input 1.
Deviation Scale	X or DEV or both have errors	The output is equal to the offset and has an error.
	SW has an error	The function considers the switch to be off.
Process Scale	X has an error	The output is equal to the offset and has an error.
	SW has an error	The function considers the switch to be off.
Differential	X or Y or both have errors	The output is equal to the offset and has an error.
Ratio	X or Y or both have errors	The output is equal to the offset and has an error.
	Y equals zero	The output is equal to the offset and has an error.
Add	Any or all inputs have errors	The output is equal to the offset and has an error.
Multiply	Any or all inputs have errors	The output is equal to the offset and has an error.
Absolute Difference	X or Y or both have errors	The output is equal to the offset and has an error.

Maximum	One or more, but not all inputs have errors	The output value is the maximum of the inputs with no errors and the output has no error.
	All inputs have errors	The output's value and error follow the first input.
Minimum	One or more, but not all inputs have errors	The output value is the minimum of the inputs with no errors and the output has no error.
	All inputs have errors	The output's value and error follow the first input.
Math Errors (cont.)		
Function	Error Condition	Result
Square Root	X has an error	The output is equal to the offset and has an error.
	X is less than zero	The output is equal to the offset and has an error.
Sample and Hold	IN has an error HOLD is off	The output's value and error follow IN.
	IN has an error HOLD is on with no error	The output value and error status are the same as IN at the time HOLD turned on.
	HOLD has an error	The output's value and error follow IN.
Pressure to Altitude	X has an error	The output's value is calculated as usual and has an error.
Dew Point	T, RH or both have errors	The output is equal to the offset and has an error.

Profile

Use this block to configure how the profile features interact with control loops, physical inputs and outputs and other application blocks. This block is found in the Function Block Diagram editor's Library when working with a controller that offers the Profile block. The number of these blocks available is shown within the parenthesis.

Profiling is a feature that allows users to create time-based programs that, when run, change control loop set points and output states automatically over time. The profile engine links the controller's profiling feature with the inputs, outputs and other controller functions. It provides a way to integrate the use of profiles with the application as a whole.

Note:

After receivers PV1 - PV4 and EVT1 - EVT4 of the profile engine have been configured and profiles have been created, any changes to those inputs will invalidate the existing profiles.

This is due to the fact that all input units (temperature, relative humidity, process, etc.) must be compatible with the running profile. The profile invalidation will be graphically displayed in the profile editor with a yellow exclamation symbol . Changes are allowed to the Profile Engine configuration for any of the other Inputs (PRF, STP, S/T, STRT, P/R, DIS) or any of the outputs on the right side of the block without affecting the currently existing profiles.

Note:

To learn more about using Modbus® to define which profile will run, within the Appendix, see the section entitled "[Using Modbus to Determine Profile Selection](#)".

Signals

Direction	Label	Type	Function
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Receivers	PV1	Analog	Process Value for the loop that uses SP1
	PV2	Analog	Process Value for the loop that uses SP2
	PV3	Analog	Process Value for the loop that uses SP3
	PV4	Analog	Process Value for the loop that uses SP4
	EVT1	Digital or Analog	Event Input 1 monitored by Wait For steps or Event steps
	EVT2	Digital or Analog	Event Input 2 monitored by Wait For steps or Event steps
	EVT3	Digital or Analog	Event Input 3 monitored by Wait For steps or Event steps
	EVT4	Digital or Analog	Event Input 4 monitored by Wait For steps or Event steps
	PRF	Analog	The profile number to run
	STP	Analog	The step number at which to start running the profile
	S/T	Digital	Active state transition starts the profile, inactive terminates it. See Start / Stop Active Level
	STRT	Digital	Active state transition starts the profile. See Start Active Level
	P/R	Digital	Active state transition pauses the profile. See Pause / Resume Active Level
	DIS	Digital	When on, disables the profile engine. See Enable/Disable Profile
Direction	Label	Type	Function

Transmitters	SP1	Analog	Set point driven by the profile for use by a control loop
	SP2	Analog	Set point driven by the profile for use by a control loop
	SP3	Analog	Set point driven by the profile for use by a control loop
	SP4	Analog	Set point driven by the profile for use by a control loop
	EVT1	Digital	Event Output 1 set by the profile to drive an output or other feature
	EVT2	Digital	Event Output 2 set by the profile to drive an output or other feature
	EVT3	Digital	Event Output 3 set by the profile to drive an output or other feature
	EVT4	Digital	Event Output 4 set by the profile to drive an output or other feature
	EVT5	Digital	Event Output 5 set by the profile to drive an output or other feature
	EVT6	Digital	Event Output 6 set by the profile to drive an output or other feature
	EVT7	Digital	Event Output 7 set by the profile to drive an output or other feature
	EVT8	Digital	Event Output 8 set by the profile to drive an output or other feature
	PRF	Analog	The number of the profile that is running
	RUN	Digital	On indicates the profile is running
	PAUS	Digital	On indicates the profile is paused

Power Out Minutes

Set the minutes portion of the power failure recovery time limit for profiles. If power is lost while a profile is running, and power is restored within the time limit, the profile resumes where it left off.

Range: 0 to 59

Power Out Hours

Set the hours portion of the power failure recovery time limit for profiles. If power is lost while a profile is running, and power is restored within the time limit, the profile resumes where it left off.

Range: 0 to 99

Minutes

Set the minutes portion of the time of day for the calendar start feature. This feature starts the specified profile at the time and day specified with the Minutes, Hours and Day of Week parameters.

Range: 0 to 59

Hours

Set the hours portion of the time of day for the calendar start feature. This feature starts the specified profile at the time and day specified with the Minutes, Hours and Day of Week parameters.

Range: 0 to 23

Day of Week

Set the day of the week for the calendar start feature. This feature starts the specified profile at the time and day specified with the Minutes, Hours and Day of Week parameters.

Options:

- Sunday
- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday

Start / Stop Active Level

Choose the signal value at the S/T receiver which causes the profile to start.

Options:

- High: on starts the profile (receiver requires an off to on transition)
- Low: off starts the profile (receiver requires an on to off transition)

Start Active Level

Choose the signal value at the STRT receiver which causes the profile to start.

Options:

- High: the profile starts when the signal is on
- Low: the profile starts when the signal is off

Pause / Resume Active Level

Choose the signal value at the P/R receiver which pauses the profile.

Options:

- High: the profile pauses when the signal is on and continues when the signal is off
- Low: the profile pauses when the signal is off and continues when the signal is on

Enable/Disable Profile

Connect the DIS receiver to a digital device to enable or disable the profile engine.

Options:

- On: the profile engine is disabled while the signal is on and is enabled while the signal is off
- Off: the profile engine is disabled while the signal is off and is enabled while the signal is on

Event 1

Indicates the state of event 1 and allows the output to be forced when the profile engine is not running a profile.

Options:

- Off: the event is off
- On: the event is on

Name

Set the name to display for event 1 in the controller user interface and in the profile editor.

Options:

- Any alphanumeric character (20 maximum)

Event 2

Indicates the state of event 2 and allows the output to be forced when the profile engine is not running a profile.

Options:

- Off: the event is off
- On: the event is on

Name

Set the name to display for event 2 in the controller user interface and in the profile editor.

Options:

- Any alphanumeric character (20 maximum)

Event 3

Indicates the state of event 3 and allows the output to be forced when the profile engine is not running a profile.

Options:

- Off: the event is off
- On: the event is on

Name

Set the name to display for event 3 in the controller user interface and in the profile editor.

Options:

- Any alphanumeric character (20 maximum)

Event 4

Indicates the state of event 4 and allows the output to be forced when the profile engine is not running a profile.

Options:

- Off: the event is off
- On: the event is on

Name

Set the name to display for event 4 in the controller user interface and in the profile editor.

Options:

- Any alphanumeric character (20 maximum)

Event 5

Indicates the state of event 5 and allows the output to be forced when the profile engine is not running a profile.

Options:

- Off: the event is off
- On: the event is on

Name

Set the name to display for event 5 in the controller user interface and in the profile editor.

Options:

- Any alphanumeric character (20 maximum)

Event 6

Indicates the state of event 6 and allows the output to be forced when the profile engine is not running a profile.

Options:

- Off: the event is off
- On: the event is on

Name

Set the name to display for event 6 in the controller user interface and in the profile editor.

Options:

- Any alphanumeric character (20 maximum)

Event 7

Indicates the state of event 7 and allows the output to be forced when the profile engine is not running a profile.

Options:

- Off: the event is off
- On: the event is on

Name

Set the name to display for event 7 in the controller user interface and in the profile editor.

Options:

- Any alphanumeric character (20 maximum)

Event 8

Indicates the state of event 8 and allows the output to be forced when the profile engine is not running a profile.

Options:

- Off: the event is off
- On: the event is on

Name

Set the name to display for event 8 in the controller user interface and in the profile editor.

Options:

- Any alphanumeric character (20 maximum)

Process Value

Use this block to produce a conditioned analog signal based on up to four analog signals and one digital signal. A filter and offset may be applied to the function's output. This block is found in the Function Block Diagram editor's Library. Within the Library, the number of these blocks available is shown in parenthesis and that number is determined by the controller part number. The type of conditioning performed by the process block depends on the setting of the Function parameter. These options for the Function parameter are described in detail in the following sections:

Off: the output follows the filtered input plus the offset.

Sensor Backup: automatically switches to the next of up to three alternate inputs when a sensor fails.

Average: calculates the average of up to four inputs.

Crossover: gradually transitions from one input to another over a user-defined range.

Wet Bulb / Dry Bulb: calculates relative humidity based on two temperature measurements.

Switch Over: selects one of two analog inputs with a digital input.

Differential: subtracts one input from another.

Ratio: divides one input by another.

Add: sums up to four inputs.

Multiply: computes the product of up to four inputs.

Absolute Difference: calculates the absolute value of one input subtracted from another.

Minimum: outputs the lowest of up to four inputs.

Maximum: outputs the greatest of up to four inputs.

Square Root: calculates square root of an input.

Vaisala® RH Compensation: calculates the relative humidity based on the input from an uncompensated relative humidity sensor and a temperature measurement.

Pressure to Altitude: calculates the standard distance above sea level based on an atmospheric pressure.

Off

The output follows the top input. A filter and offset may be applied to the output value. The output has the units of the signal connected to the top input link.

Signals

Direction	Label	Type	Function
Receiver	- - - -	Analog	Value used for the output
Transmitter	- - - -	Analog	The filtered input plus the offset

Function

To filter and/or add an offset to a signal, set Function to Off.

Offset

Adjustment added to the input.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Sensor Backup

This function passes the first input that has no error as the output. The inputs are considered as backups in numerical order. If input 1 has no error the output follows input 1. If input 1 has an error and input 2 does not, the output follows input 2 and so on. Only inputs connected to a source are considered as backups. A filter and offset may be applied to the output. The output has the same units as the selected input.

Signals

Direction	Label	Type	Function
Receivers	1	Analog	Primary input
	2	Analog	First backup
	3	Analog	Second backup
	4	Analog	Third backup
Transmitter	- - -	Analog	The first input that has no error, filtered, plus the offset

Function

To automatically switch to the next of up to three alternate inputs when a sensor fails, set Function to Sensor Backup.

Offset

Adjustment added to the output.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Average

This function calculates the mean average of up to four inputs. Only inputs connected to a source are used in the calculation. A filter and offset may be applied to the calculated value. The output has the units of the signal connected to the top input link.

Signals

Direction	Label	Type	Function
Receivers	- - -	Analog	Value to include in the average
	- - -	Analog	Value to include in the average
	- - -	Analog	Value to include in the average
	- - -	Analog	Value to include in the average
Transmitter	- - -	Analog	The filtered average of the inputs plus the offset

Function

To average the inputs, set Function to Average.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

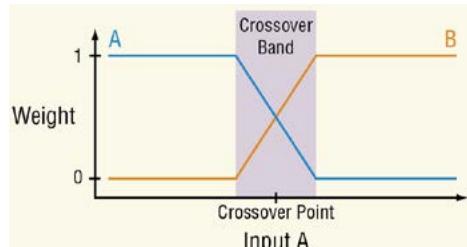
Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Crossover

The output of this function follows input A at the low end of the range, and, over a user-defined band as the input increases, the output gradually transitions to follow input B. A filter and offset may be applied to the calculated value. The output has the same units as input A.

The diagram below illustrates how the weighting of inputs A and B in determining the output changes over the input range. At the low end of the range only A is considered. As the value of A increases into the crossover band, A becomes less significant and B becomes more significant to the output until at the crossover point, the inputs are weighted equally, and the output is the average of A and B. At the high end of the range only B is considered.



Signals

Direction	Label	Type	Function
Receivers	A	Analog	The input for the low end of the range
	B	Analog	The input for the high end of the range

Transmitter	- - -	Analog	<p>When A is below the crossover band the output is the filtered value of A plus the offset.</p> <p>When A is in the crossover band the output is the filtered weighted average of the inputs plus the offset.</p> <p>When A is above the crossover band, the output is the filtered value of B plus the offset.</p>
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Function

To gradually transition from one input to another over a user-defined range, set Function to Crossover.

Crossover Point

Set the middle of the band over which the function transitions between inputs A and B.

Range: -99,999.000 to 99,999.000 seconds

Crossover Band

Set the width of the transition between input A and B.

Range: -99,999.000 to 99,999.000 seconds

Offset

Adjustment added to the output.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Wet Bulb / Dry Bulb

This function calculates the relative humidity of an environment based on two measured temperatures: the air temperature (dry bulb) and the temperature reached by evaporative cooling (wet bulb). A filter and offset may be applied to the calculated value. The output is in percent relative humidity.

This method for determining relative humidity applies in the temperature range 10 to 350°F (-12°C to 177°C).

Signals

Direction	Label	Type	Function
Receivers	DRY	Analog	The dry temperature measurement
	WET	Analog	The wet temperature measurement
Transmitter	- - -	Analog	The filtered relative humidity plus the offset

Function

To calculate relative humidity based on wet and dry temperature measurements, set Function to Wet Bulb / Dry Bulb.

Barometric Pressure

Set the atmospheric pressure in pounds per square inch (psi) of the environment for which the humidity is calculated.

Range: 10.0 to 16.0 psi

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Switch Over

When SW is off, the output equals input 1. When SW is on, the output equals input 2. A filter and offset may be applied to the output. The output has the same units as the selected input.

Signals

Direction	Label	Type	Function
Receivers	DRY	Analog	Selected as the output when SW is off
	WET	Analog	Selected as the output when SW is on
	SW	Digital	Off selects input 1, on selects input 2
Transmitter	- - -	Analog	The filtered value of the selected input plus the offset

Function

To select one of two analog inputs with a digital input, set Function to Switch Over.

Offset

Adjustment added to the selected value.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Differential

This function calculates input X minus input Y. A filter and offset may be applied to the calculated value. The output has the units of input X.

Signals

Direction	Label	Type	Function
Receivers	X	Analog	Value from which Y is subtracted
	Y	Analog	Value subtracted from X
Transmitter	- - -	Analog	The filtered result of the calculation ($X - Y$) plus the offset

Function

To subtract one input from another, set Function to Differential.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Ratio

This function calculates the quotient, input X divided by input Y. A filter and offset may be applied to the calculated value. If both inputs have the same units, the output has no units, otherwise the output has the units of input X.

Signals

Direction	Label	Type	Function
Receivers	X	Analog	Value divided by Y (numerator)
	Y	Analog	Value by which X is divided (denominator)
Transmitter	- - -	Analog	The filtered result of the calculation ($X \div Y$) plus the offset

Function

To divide one input by another, set Function to Ratio.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Add

This function sums up to four inputs. Only inputs connected to a source are used in the calculation. A filter and offset may be applied to the calculated value. If any input is an absolute temperature, the output is also an absolute temperature; otherwise the output's units are those

of the signal connected to the top input.

Signals

Direction	Label	Type	Function
Receivers	- - - -	Analog	Value to be summed
	- - - -	Analog	Value to be summed
	- - - -	Analog	Value to be summed
	- - - -	Analog	Value to be summed
Transmitter	- - - -	Analog	The filtered sum of the inputs plus the offset

Function

To sum up to four inputs, set Function to Add.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Multiply

This function multiplies up to four inputs. Only inputs connected to a source are used in the calculation. A filter and offset may be applied to the calculated value. If any input is an absolute temperature, the output is also an absolute temperature; otherwise the output's units are those of the signal connected to the top input.

Signals

Direction	Label	Type	Function
Receivers	- - - -	Analog	Value to be multiplied
	- - - -	Analog	Value to be multiplied
	- - - -	Analog	Value to be multiplied
	- - - -	Analog	Value to be multiplied
Transmitter	- - - -	Analog	The filtered product of the inputs plus the offset

Function

To compute the product of up to four inputs, set Function to Multiply.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Absolute Difference

This function calculates the absolute value of input X minus input Y. A filter and offset may be applied to the calculated value. The output has the units of input x.

Signals

Direction	Label	Type	Function
Receivers	X	Analog	Value from which Y is subtracted
	Y	Analog	Value subtracted from X
Transmitter	- - - -	Analog	The filtered result of the absolute value of (X – Y) plus the offset

Function

To calculate the absolute value of one input subtracted from another, set Function to Absolute Difference.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Minimum

This function selects the minimum of up to four inputs. Only inputs connected to a source are considered. A filter and offset may be applied to the output. The output has the units of the signal with the minimum value.

Signals

Direction	Label	Type	Function
Receivers	- - - -	Analog	Compared with the other inputs
	- - - -	Analog	Compared with the other inputs
	- - - -	Analog	Compared with the other inputs
	- - - -	Analog	Compared with the other inputs
Transmitter	- - - -	Analog	The filtered lowest value of the inputs plus the offset

Function

To output the lowest of up to four inputs, set Function to Minimum.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Maximum

This function selects the maximum of up to four inputs. Only inputs connected to a source are considered. A filter and offset may be applied to the output. The output has the units of the signal with the maximum value.

Signals

Direction	Label	Type	Function
Receivers	- - - -	Analog	Compared with the other inputs
	- - - -	Analog	Compared with the other inputs
	- - - -	Analog	Compared with the other inputs
	- - - -	Analog	Compared with the other inputs
Transmitter	- - - -	Analog	The filtered greatest value of the inputs plus the offset

Function

To output the greatest of up to four inputs, set Function to Minimum.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Square Root

This function calculates the square root of input X. A filter and offset may be applied to the calculated value. The output has the same units as X.

Signals

Direction	Label	Type	Function
Receiver	X	Analog	Value of which to find the square root
Transmitter	- - -	Analog	The filtered square root of input X plus the offset

Function

To calculate the square root of an input, set Function to Square Root.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Vaisala® RH Compensation

This function calculates the relative humidity of an environment based on the input from an uncompensated relative humidity sensor and a temperature measurement. A filter and offset may be applied to the calculated value. The output is in percent relative humidity.

Signals

Direction	Label	Type	Function
Receivers	~RH	Analog	Uncompensated humidity measurement
	T	Analog	Temperature measurement
Transmitter	- - -	Analog %	Filtered calculated relative humidity plus the offset

Function

To calculate the relative humidity based on the input from an uncompensated relative humidity sensor and a temperature measurement, set Function to Vaisala RH Compensation.

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Pressure to Altitude

This function determines the altitude based on the atmospheric pressure. A filter and offset may be applied to the calculated value. The output has the units selected with the Altitude Units parameter.

The calculation is based on the International Standard Atmosphere 1976 and is accurate from sea level to 90,000 feet. It can be used beyond this range in both directions, but with loss of accuracy. The standard is based on an altitude of 0 feet (sea level) pressure of 14.6967 PSI and a temperature of 59 °F.

Signals

Direction	Label	Type	Function
Receiver	- - -	Analog	Pressure (See Pressure Units parameter)
Transmitter	- - -	Analog	The calculated altitude plus the offset (See Altitude Units parameter)

Function

To calculate the standard distance above sea level based on an atmospheric pressure, set Function to Pressure to Altitude.

Pressure Units

Set the units of the pressure input.

Options: PSI, mbar, Torr, Pascal, Atmosphere

Altitude Units

Set the units for the altitude output.

Options: Feet, Kilofeet

Offset

Adjustment added to the result of the calculation.

Range: -99,999.000 to 99,999.000

Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the function's response.

Range: 0.0 to 60.0 seconds

Process Errors

Inputs that are not connected are ignored. Otherwise error behavior is specific to the Function setting.

Function	Error Condition	Result
Off	Any or none	The output value and error follow the first input.
Sensor Backup	One or more, but not all inputs have errors	The output's value follows the first input without an error.
	All inputs have errors	The output value and error follow the first input.
Average	One or more, but not all inputs have errors	The output value is the average of the inputs that have no errors and the output has no error.
	All inputs have errors	The output has the last good value and has an error.

Crossover	A or B has an error but not both	The output is equal to the error free input plus the offset
	A and B both have errors	The output's value and error follow input A.
Wet Bulb Dry Bulb	DRY or WET or both have errors	RH has an error
Switch Over	When SW has no error	The output's value and error follow the input selected by the digital input.
	When SW has an error	The output value and error follow input 1.
Differential	X or Y or both have errors	The output is equal to the offset and has an error.
Ratio	X or Y or both have errors	The output is equal to the offset and has an error.
	Y equals zero	The output is equal to the offset and has an error.
Add	Any or all inputs have errors	The output is equal to the offset and has an error.
Multiply	Any or all inputs have errors	The output is equal to the offset and has an error.
Absolute Difference	X or Y or both have errors	The output is equal to the offset and has an error.
Maximum	One or more, but not all inputs have errors	The output value is the maximum of the inputs with no errors and the output has no error.
	All inputs have errors	The output's value and error follow the first input.
Minimum	One or more, but not all inputs have errors	The output value is the minimum of the inputs with no errors and the output has no error.
	All inputs have errors	The output's value and error follow the first input.
Square Root	X has an error	The output is equal to the offset and has an error.
	X is less than zero	The output is equal to the offset and has an error.
Viasala	%RH or T or both have errors	%RH has an error
Pressure to Altitude	X has an error	The output's value is calculated as usual and has an error.

Special Output

Use this block to operate outputs for one of these applications: operating mechanical compressors, controlling a motorized valve or sequencing multiple output devices to switch

large power loads. This FB is found in the Function Block Diagram editor's Library. Within the Library, the number of these blocks available is shown in parenthesis and that number is determined by the controller part number.

Choose the algorithm with the Function parameter. These options for the Function parameter are described in detail in the following sections:

Off: the first output follows the input all others are off.

Compressor Control: operates a compressor to meet demands for cooling or dehumidification from one or two control loops while protecting it from excessive cycling.

Sequencer: operates a proportional power control and up to three on-off power controls as if they were a single, larger, proportional controller.

Motorized Valve: operates a proportional valve without position feedback.

Off

The first output follows the input, all others are off.

Compressor Control

This function coordinates the demands of one or two control loops for a single compressor and eliminates short cycling of the compressor. For example, when a compressor is used for controlling an environment, a control loop may adjust a bypass valve proportionally to the amount of cooling needed and another loop may adjust a valve proportionally for dehumidification. Both require the compressor to be on, but to save power and extend the life of the compressor, it is desirable for the compressor to be off when it is not needed. The output from this function turns the compressor on in anticipation of its use by either loop and turns it off when it is not needed. The need for the compressor is anticipated by monitoring the power outputs from the two loops (Input A for one loop and Input B for the second loop, if used).

The diagram below illustrates how the compressor control functions for a single heat/cool loop.

Compressor Settings:

Input A Turn On = -2%

Input A Turn Off = 2%

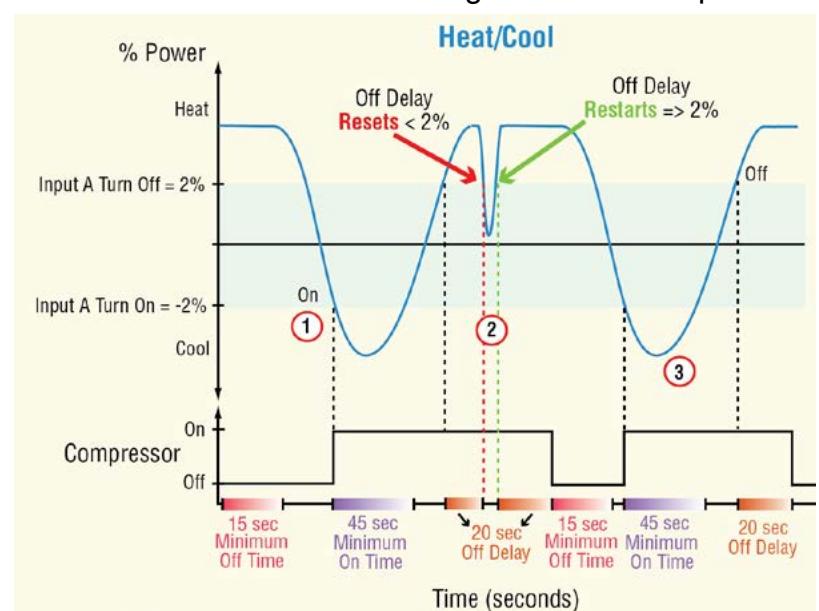
Minimum Off Time = 15 (sec)

Minimum On Time = 45 (sec)

Off Delay = 20 (sec)

Compressor Operation (Graphic Explained):

1. In this example, the power signal from the temperature loop is connected to Input A of the FB. When the power signal drops below its Turn On setting (-2%) and the Minimum Off Time (15 sec) has been satisfied, the output to the compressor turns on immediately and will remain on until the Minimum On Time is satisfied (45 sec).



2. When the power level rises above 2% (Turn Off), the output to the compressor remains on until

the Off Delay is satisfied. Note that in this example the power level momentarily drops below the 2% turn off, therefore the Off Delay is reset prior to reaching 20 seconds. As soon as the power level rises to 2%, the Off Delay again starts; after 20 seconds the output shuts off.

- When the power signal drops below its Turn On setting (-2%) and the Minimum Off Time (15 sec) has been satisfied, the output to the compressor turns on immediately and will remain on until the Minimum On Time is satisfied (45 sec). As soon as the power level rises to 2%, the Off Delay again starts shutting the compressor off after 20 seconds.

The diagram below illustrates how the compressor control functions while coordinating the demands from two control loops.

Compressor Settings:

Input A Turn On = 0%

Input B Turn On = -5%

Input A Turn Off = 2%

Input B Turn Off = 5%

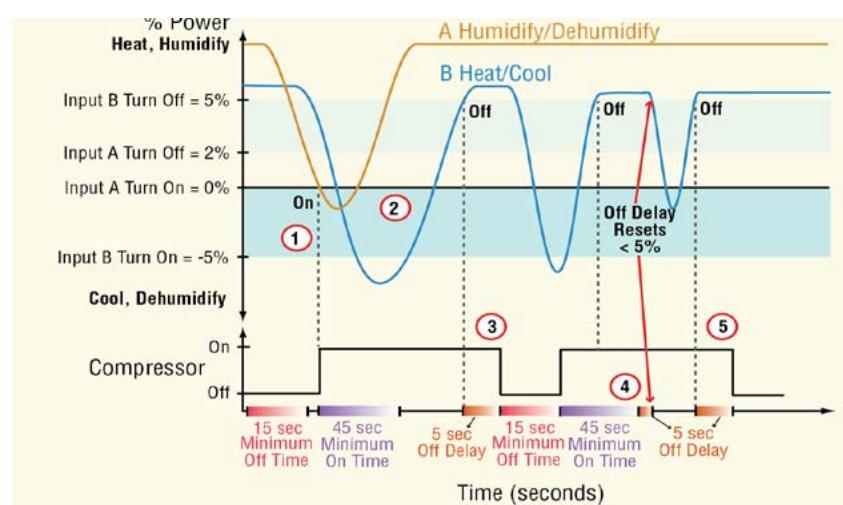
Minimum On Time = 45 (sec)

Minimum Off Time = 15 (sec)

Off Delay = 5 (sec)

Compressor Operation

(Graphic Explained):



- In this example, the power signal from the humidity loop is connected to Input A and the power signal from the temperature loop is connected to Input B. When the humidity signal (A) drops below its Turn On setting (0%) and the Minimum Off Time has been satisfied, the output to the compressor turns on immediately.
- When the temperature signal (B) drops below its Turn On setting (-5%), the compressor is already on. When the humidify/dehumidify loop (A) rises above its Turn Off (2%) the When Input B rises above 5% (Turn Off), the output to the compressor remains on for an additional 5 seconds (Off Delay) to give the power signals time to stabilize. Notice that after the 5 second delay expires the output shuts off.
- When Input B again drops below -5% (Turn On), the compressor turns on only after the Minimum Off Time is met to minimize wear on the compressor. Again, Input B is calling for the compressor to go off when it rises above 5%. In this case, the output will remain on until the Minimum On Time of 45 seconds is satisfied plus the Off Delay (5 seconds). In the event that Inputs A or B falls below their respective turn off percentages while the Off Delay is active, the Off Delay timer will reset as shown in the graphic above.
- Once Input B rises above 5% the Off Delay timer is activated. When that time has been satisfied the compressor goes off.

Signals

Direction	Label	Type	Function
Receivers	A	Analog %	Power output from one control loop that requires the compressor
	B	Analog %	Power output from a second control loop that requires the compressor
Transmitter	OUT	Digital	On indicates the compressor should be running

Function

To operate a compressor to meet demands for one or two control loops while protecting it from excessive cycling, set Function to Compressor Control.

Input A Turn On

Set the value of the signal at receiver A that indicates demand for the compressor to turn on. When A drops to or below this value and the Minimum Off Time condition has been met, the function turns on the output to the compressor.

Range: -100.0 to 100.0%

Input A Turn Off

Set the value of the signal at receiver A that indicates there is no demand for the compressor to be on. When A rises to or above this value and the Minimum On Time condition has been met, the function turns off the output to the compressor.

Range: -100.0 to 100.0%

Input B Turn On

Set the value of the signal at receiver B that indicates demand for the compressor to turn on. When B drops to or below this value and the Minimum Off Time condition has been met, the function turns on the output to the compressor.

Range: -100.0 to 100.0%

Input B Turn Off

Set the value of the signal at receiver B that indicates there is no demand for the compressor to be on. When B rises to or above this value and the Minimum On Time condition has been met, the function turns off the output to the compressor.

Range: -100.0 to 100.0%

Minimum On Time

Set the minimum amount of time the compressor must be on before it can be turned off again.

Range: 0 to 9,999 seconds

Minimum Off Time

Set the minimum amount of time the compressor is kept off before it can be turned on again.

Range: 0 to 9,999 seconds

Off Delay

Set an amount of time the output signal remains on after the Minimum On Time is satisfied and the signals at A and B indicate the compressor is no longer needed. This prevents the compressor from turning off prematurely due to a transient condition such as opening a door.

Range: 0 to 9,999 seconds

Note:

During the Off Delay, if either channel's power signal drops below its turn off setting, the compressor stays on and the Off Delay timer is reset. The timer starts again when A and B are each above their Turn Off levels.

Time Delay

Set how long the compressor remains on while 0% power is received from the control loops. This feature turns the compressor off when the power from the control loops is 0% for longer than the Time Delay setting. Use the Time Delay to distinguish between the case where the power is 0% because the loop is turned off, and the case where the power is 0% for a short time when a loop switches from heating to cooling. To ensure the compressor stays on when needed, but turns off when the control loops are off, set the Time Delay longer than the time the loop outputs are at 0% in normal operation. If two loops are connected to the Special Output function block, the Time Delay feature looks for both loops to output 0%. When the Time Delay is set to 0, this feature is disabled.

Range: 0 to 9,999 seconds

Sequencer

This function coordinates a proportional output and up to three on-off outputs so that a large amount of power may be controlled proportionally without the expense of a proportional power control large enough to handle all the power at once.

The sequencer function takes a single input power signal and splits it up into four output signals. Each output controls a portion of the total output power. The primary output, often referred to as the vernier output, operates a proportional power controller. The proportional power controller must control the largest portion of the output. The other outputs are contactors or other on-off power switches.

Signals

Direction	Label	Type	Function
Receiver	- - - -	Analog %	Demand for power (0 to 100%)
Transmitters	1	Analog %	Proportional output
	2	Digital	On-off output
	3	Digital	On-off output
	4	Digital	On-off output

Function

To operate a proportional power control and up to three on-off power controls as if they were a single, larger, proportional controller, set Function to Sequencer.

Output 1 Size

Set the proportion of the total power that is controlled by the proportional (vernier) output. This must greater than each of the other three (Output 2 Size, Output 3 Size and Output 4 Size).

Range: 0 to 99,999

Output 2 Size

Set the proportion of the total power that is switched by on-off output 2.

Range: 0 to 99,999

Output 3 Size

Set the proportion of the total power that is switched by on-off output 3.

Range: 0 to 99,999

Output 4 Size

Set the proportion of the total power that is switched by on-off output 4.

Range: 0 to 99,999

Time Delay

Set minimum amount of time to wait between turning on one on-off output and the next. This is used to avoid power surges.

Range: 0 to 9,999 seconds

Output Order

Choose the method by which outputs 2, 3 and 4 are sequenced.

Options:

- Linear: turns the on-off outputs on in the same order every time
- Progressive: rotates the order to balance usage and wear on contactors and heaters

Motorized Valve

This function controls the position of a proportional valve without using position feedback. When power is applied to the controller, the valve is driven closed.

Signals

Direction	Label	Type	Function
Receiver	IN	Analog %	Desired position of the valve where 0% is fully closed and 100% is fully open
Transmitters	CLS	Digital	On to drive the valve closed
	OPN	Digital	On to drive the valve open

Function

To operate a proportional valve without position feedback, set Function to Motorized Valve.

Valve Travel Time

Set this to the time the valve takes to travel between fully closed and fully open.

Range: 10 to 9,999 seconds

Dead Band

Set the minimum amount for a single adjustment to the valve position. This is set as percentage of the full range of motion (closed to open). Small values allow finer adjustments, but can wear the valve more quickly. Large values reduce the frequency of adjustments and so reduce wear on the mechanism, but also reduce the accuracy.

Range: 1.0 to 100.0%

Temperature Input

Configure and use this input to condition a temperature measurement made with a thermocouple or RTD. The Temperature Input block scales the signal to an absolute temperature with no other configuration required.

Resistance Temperature Device (RTD) 100 and 1000 Ohm

Use this block to condition a temperature measurement made with an RTD. This FB is found on the canvas of the FB diagram. The number of these FBs that are available depends on the number of installed flex modules with temperature inputs.

The module number shown on the block is the number of the controller's slot that houses the flex module with the temperature input. The Temperature In number indicates the specific input on the flex module.

Signals

Direction	Label	Type	Function
Transmitter	- - -	Analog	The measured temperature with filter and offset applied

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Sensor Type

Select the device used to measure temperature.

Options: *RTD 100 Ohm, RTD 1000 Ohm*

Display Precision

Set how many decimal places are displayed for the process value and associated parameters such as set points.

Options: Whole, Tenths, Hundredths, Thousandths

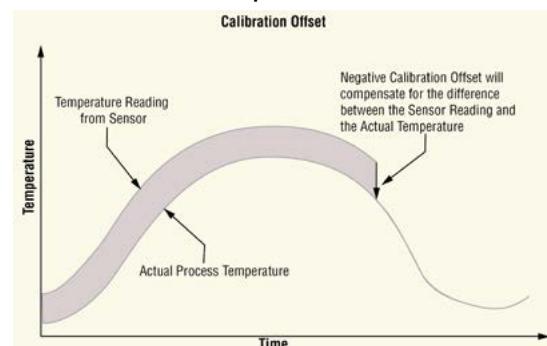
Calibration Offset

Set a value to add to the measured input value to compensate for sensor placement, lead wire resistance or other factors that cause the input to vary from the actual process value

Range: -99,999.000 to 99,999.000°F or units
-55,555.000 to 55,555.000°C

Filter

Set the amount of filtering to apply to the input. Filtering



smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the input's response.

Range: 0.0 to 60.0 second

Input Error Latching

Set whether an input error persists until it is cleared or clears automatically when the sensor signal returns to a normal level.

Options:

- Off: error clears automatically once the input returns to normal
- On: error remains active until the input returns to normal and the error is cleared by the Clear Error parameter

Clear Error

Set this parameter to Clear to reset the input error after correcting the condition that caused it.

Options: Ignore, Clear

Thermocouple

Use this block to condition a temperature measurement made with a thermocouple. This FB is found on the canvas of the FB diagram. The number of these FBs that are available depends on the number of installed flex modules with temperature inputs.

The module number shown on the block is the number of the controller's slot that houses the flex module with the temperature input. The Temperature In number indicates the specific input on the flex module.

Signals

Direction	Label	Type	Function
Transmitter	- - -	Analog	Supplies scaled, absolute temperature \pm the offset as a connection to another FB.

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Sensor Type

Select the device used to measure temperature.

Options: Thermocouple

TC Linearization

Select the Thermocouple type.

Range: B, K, C, N, D, R, E, S, F, T, J

Display Precision

Set how many decimal places are displayed for the process value and associated parameters such as set points.

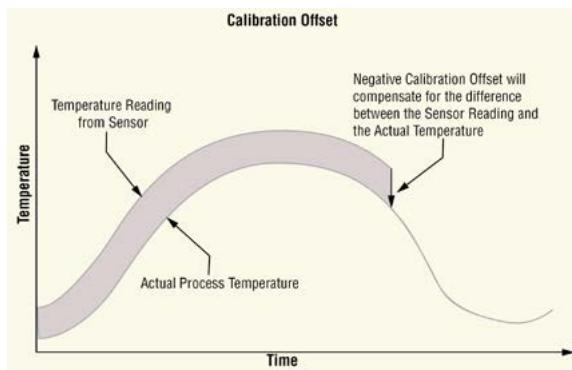
Options: Whole, Tenths, Hundredths, Thousandths

Calibration Offset

Set a value to add to the measured input value to compensate for sensor placement, lead wire resistance or other factors that cause the input to vary from the actual process value

Range: -99,999.000 to 99,999.000°F or units

-55,555.000 to 55,555.000°C



Filter

Set the amount of filtering to apply to the input. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the input's response.

Range: 0.0 to 60.0 second

Input Error Latching

Set whether an input error persists until it is cleared or clears automatically when the sensor signal returns to a normal level.

Options:

- Off: error clears automatically once the input returns to normal
- On: error remains active until the input returns to normal and the error is cleared by the Clear Latch parameter

Clear Error

Set this parameter to Clear to reset the input error after correcting the condition that caused it.

Options: Ignore, Clear

Temperature Input Errors

Error Status	Description
None	No error is detected.
Open	A sensor is broken or disconnected.
Shorted	A sensor has failed or is shorted.
Measurement Error	A measurement error has occurred.
Bad Calibration	The controller has not been calibrated.
Ambient Error	The ambient temperature is outside of the controller's operating range.
RTD Error	An RTD sensor error has occurred.
Fail	A measurement failure has occurred.

Not Sourced	An input signal is not connected to a function block's output.
Stale Data	Data sourced from another controller has become unavailable.
Math Error	A calculation has no defined result (such as divide by zero).

Thermistor Input

Use this block to condition a temperature measurement made with a thermistor. This FB is found on the canvas of the FB diagram. The number of these FBs that are available depends on the number of installed flex modules with thermistor inputs.

The module number shown on the block is the number of the controller's slot that houses the flex Module with the thermistor input. The Thermistor Input number indicates the specific input on the flex module.

Signals

Direction	Label	Type	Function
Transmitter	- - - -	Analog	The measured temperature with filter and offset applied

This function includes three curves pre-programmed for use with popular sensors selectable with the Thermistor Curve parameter. See the table. It also can be user-configured for other sensors by entering the Steinhart-Hart coefficients for the thermistor.

Thermistor Curve Setting	Resistance @ 25°C	Alpha Technics	Measurement Specialties (BetaTHERM)	YSI
Curve A	2,252 Ω	Curve A	2.2K3A	004
Curve B	10,000 Ω	Curve A	10K3A	016
Curve C	10,000 Ω	Curve C	10K4A	006
Custom	Use Steinhart-Hart equation coefficients (A, B and C) from thermistor manufacturer corresponding to the terms of the Steinhart-Hart equation:			
	$\frac{1}{T} = A + B\ln(R) + C(\ln(R))^3$			

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Thermistor Curve

Set the curve for the thermistor used.

Options: Custom, Curve A, Curve B, Curve C

Coefficient A

Enter the custom resistance coefficient for the thermistor.

Range: -3.400000E039 to 3.400000E038

Coefficient B

Enter the custom resistance coefficient for the thermistor.

Range: -3.400000E039 to 3.400000E038

Coefficient C

Enter the custom resistance coefficient for the thermistor.

Range: -3.400000E039 to 3.400000E038

Resistance Range

Set the maximum resistance to be measured by the thermistor input. Higher settings yield a wider range with less precision.

Range: 5K, 10K, 20K, 40K

Display Precision

Set how many decimal places are displayed for the process value and associated parameters such as set points.

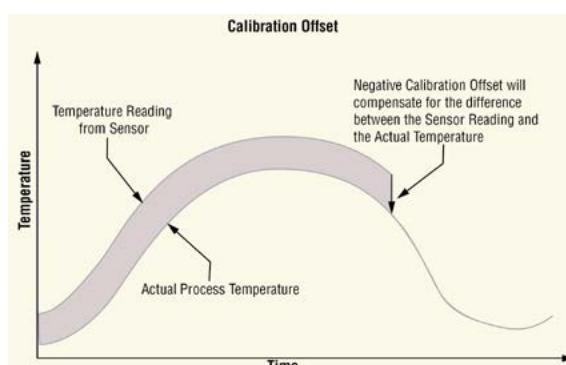
Options: Whole, Tenths, Hundredths, Thousandths

Calibration Offset

Set a value to add to the measured input value to compensate for sensor placement, lead wire resistance or other factors that cause the input to vary from the actual process value

Range: -99,999.000 to 99,999.000°F or units

-55,555.000 to 55,555.000°C



Filter

Set the amount of filtering to apply. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the input's response.

Range: 0.0 to 60.0 seconds

Input Error Latching

Set whether an input error persists until it is cleared or clears automatically when the sensor signal returns to a normal level.

Options:

- Off: error clears automatically once the input returns to normal.
- On: error remains active until the input returns to normal and the error is cleared by the Clear Error parameter.

Clear Error

Set this parameter to Clear to reset the input error after correcting the condition that caused it.

Options: Ignore, Clear

Thermistor Input Errors

Error Status	Description
None	No error is detected.
Open	A sensor is broken or disconnected.
Shorted	A sensor has failed or is shorted.
Measurement Error	A measurement error has occurred.
Bad Calibration	The controller has not been calibrated.
Ambient Error	The ambient temperature is outside of the controller's operating range.
Fail	A measurement failure has occurred.
Not Sourced	An input signal is not connected to a function block's output.
Stale Data	Data sourced from another controller has become unavailable.
Math Error	A calculation has no defined result (such as divide by zero).

Timer

Use a timer when applications require timed control of outputs or a delay to an output for a specific length of time. This block is found in the Function Block Diagram editor's Library when working with a controller that offers the Timer block.

The number of these blocks available to be added to the diagram is shown within the parenthesis.

Choose the type of timer with the Function parameter. These options for the Function parameter are described in detail in the following sections:

Off: disables the timer and holds the output in its inactive state.

On Pulse: sets the output for a specified time.

Delay: switches the output a specified time after the input changes states.

One Shot: triggers the output by setting the time, timer counts down while the input is active, output is active until time runs out.

Retentive: measures how long the input is active and triggers the output when the cumulative time reaches a specified duration

Off

When the Timer block's function is set to Off, the transmitter is in its inactive state. See Transmitter Active Level.

Signals

Direction	Label	Type	Function
Transmitter	- - -	Digital	In the state selected with the Transmitter Active Level parameter

Function

To disable the timer and hold the output in its inactive state, set Function to Off.

Transmitter Active Level

Choose the output's active state. When Function is set to Off, the output is in the inactive state, the opposite of the state selected here.

Options:

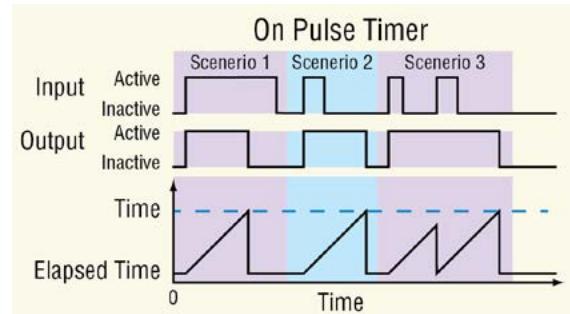
- High: the timer's output is off while the timer is disabled.
- Low: the timer's output is on while the timer is disabled.

On Pulse

This function produces an output pulse of a constant duration. This can be used as a minimum on time for devices that do not tolerate excessive cycling.

To understand the timer's behavior, consider these scenarios illustrated in the timing diagram below:

1. When input changes to its active state, the function sets the output to its active state and begins accumulating the elapsed time. Once the elapsed time reaches the value set for the Time parameter, the output returns to its inactive state and the elapsed time resets to zero.
2. The input need not stay active for the output to remain active for the specified time.
3. However, while the timer is running, if the input becomes inactive and then active again, the pulse length is increased.



Note:

The active and inactive states are user configurable with the parameters described below. Therefore, the description of the timer's behavior for its inputs and outputs refers to the active and inactive states for each rather than on or off. For example, if the input's active state is set to High, the timer starts running (becomes active) when the input changes from low (off) to high (on). However, if the input's active state is set to Low, the timer starts running (becomes active) when the input changes from high (on) to low (off).

Signals

Direction	Label	Type	Function
Receiver	- - - -	Digital	Run signal for the timer. The output becomes active and the timer starts when this input becomes active.
Transmitter	- - - -	Digital	The output becomes active and the timer starts when the input becomes active. The output becomes inactive when specified time has elapsed.

Function

To set the output for a specified time, set Function to On Pulse.

Time

Set how long the output is held in its active state once the timer is triggered by the input.

Range: 0 to 99,999.000

Run Active Level

Set which state change at RUN sets the output to its active state and starts the timer.

Options:

- High: off to on
- Low: on to off

Transmitter Active Level

Set the state in which the output is held while the timer is running.

Options:

- High: On
- Low: Off

Elapsed Time

Indicates the amount of time since the timer was triggered while the timer is running. When the timer is not running, Elapsed Time reads zero.

Range: 0 to 99,999.000

Note:

The elapsed time is not retained through a power loss; it is set to zero upon power up.

Delay

The output follows the input, but only after the input is present for at least the specified time. This can be used to keep short input pulses from propagating through to logic or an output. It can also be used to trigger a secondary action following a primary action and a specific time delay, such as, turning on successive output devices. The timer can be configured as an on-delay or off-delay by setting the Active State and Active Level parameters appropriately.

To understand the timer's behavior, consider these scenarios illustrated in the timing diagram below:

1. When the input changes to its active state, the elapsed time begins to increment. Once the elapsed time reaches the value set for the Time parameter, the output changes to its active state and the elapsed time holds. When the input changes back to its inactive state, the output returns to its inactive state and the elapsed time resets to zero.
2. If the input is active for less than the Time setting, the output never becomes active.

Note:

The active and inactive states are user configurable with the parameters described below. Therefore, the description of the timer's behavior for its inputs and outputs refers to the active and inactive states for each rather than on or off. For example, if the input's active state is set to High, the timer starts running (becomes active) when the input changes from low (off) to high (on). However, if the input's active state is set to Low, the timer starts running (becomes active) when the input changes from high (on) to low (off).

Signals

Direction	Label	Type	Function
Receiver	-----	Digital	Run signal for the timer. The timer starts when this input becomes active.

Transmitter	- - -	Digital	Becomes active once the specified time has elapsed and becomes inactive again when the input becomes inactive.
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Function

To switch the output a specified time after the input changes states, set Function to Delay.

Time

Set how long the input must be continuously active before the output becomes active.

Range: 0 to 99,999.000

Run Active Level

Set which state change at RUN starts the timer. This is the state change that is delayed.

Options:

- High: off to on
- Low: on to off

Transmitter Active Level

Set the state of the output that indicates the input has been active for at least the specified time.

Options:

- High: On
- Low: Off

Elapsed Time

Indicates the amount of time since the input became active up to the value set with the Time parameter, then holds at that value until the input becomes inactive. When the input becomes inactive, Elapsed Time is reset to zero.

Range: 0 to 99,999.000

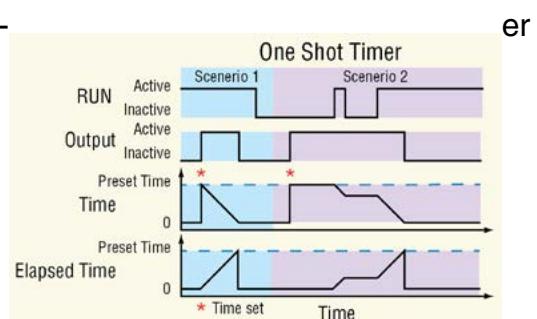
Note:

The elapsed time is not retained through a power loss; it is set to zero upon power up.

One Shot

The One Shot timer behaves like an analog oven timer. The user sets the time and the timer counts down to zero without retaining the original time (hence the name one-shot). The output is active whenever the time is greater than zero, and the timer counts down while the input is active until the time reaches zero. This can be used in applications where the user may set a different time each time the process runs.

To understand the timer's behavior, consider these scenarios illustrated in the timing diagram below:



- If the input is active when the time is set by the user, the output becomes active and the timer starts counting down immediately. The Time parameter counts down and Elapsed Time counts up until Time reaches zero and Elapsed Time reaches the value initially set for Time by the user. Once the time has elapsed, the output becomes inactive and the Elapsed Time resets to zero.
- If the input is not active when the user sets the time, the output becomes active, but the timer does not run. When the input becomes active, the output remains active until the timer counts down to zero. If the input becomes inactive at any point while the timer is running, the output remains active and the Time and Elapsed Time hold until the input becomes active again at which point the timer resumes running.

Note:

The active and inactive states are user configurable with the parameters described below. Therefore, the description of the timer's behavior for its inputs and outputs refers to the active and inactive states for each rather than on or off. For example, if the input's active state is set to High, the timer starts running (becomes active) when the input changes from low (off) to high (on). However, if the input's active state is set to Low, the timer starts running (becomes active) when the input changes from high (on) to low (off).

Signals

Direction	Label	Type	Function
Receiver	RUN	Digital	Run signal for the timer. The timer runs when this input is active and holds when this input is inactive.
Transmitter	- - -	Digital	Active whenever the time is greater than zero

Note:

The elapsed time is not retained through a power loss; it is set to zero upon power up.

Function

To trigger the output by setting the time, to have the timer count down while the input is active, and have the output active until the time runs out, set Function to One Shot.

Time

Set the amount of time to count down. While the input is active this parameter counts down until it reaches zero. The output is active whenever this parameter is greater than zero.

Range: 0 to 99,999.000

Run Active Level

Set in which state at RUN the timer counts down.

Options:

- High: on
- Low: off

Note:

The time is not retained through a power loss; it is set to zero upon power up.

Transmitter Active Level

Set the state of the output that indicates the timer is running or holding with a Time setting greater than zero.

Options:

- High: On

- Low: Off

Elapsed Time

Indicates how long the timer has been running not including holding time. The value holds whenever the input is inactive. The elapsed time resets to zero once the Time parameter has counted down to zero.

Range: 0 to 99,999.000

Retentive

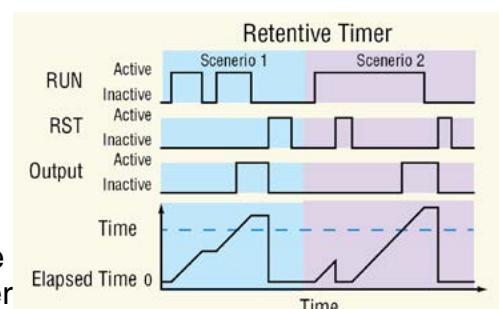
A retentive timer is used to keep track of how much cumulative time the input has been active. For example, it can be used to time how long an alarm is on over the course of a day. The output can be used to trigger an event if the elapsed time is considered excessive.

To understand the timer's behavior consider these scenarios illustrated in the timing diagram below

1. While the RUN input is active, the elapsed time counts up. Whenever RUN is inactive, the elapsed time holds. When the elapsed time reaches the specified time, the output becomes active and remains active until the timer is reset. When the RST input becomes active, the output becomes inactive and the elapsed time is reset to zero.
2. If RST becomes active while the timer is running, the timer stops and the elapsed time is reset to zero.

Note:

The elapsed time increments whenever the input is active and the reset is not, even if it exceeds the Time parameter setting.



Note:

The active and inactive states are user configurable with the parameters described below. Therefore, the description of the timer's behavior for its inputs and outputs refers to the active and inactive states for each rather than on or off. For example, if the input's active state is set to High, the timer starts running (becomes active) when the input changes from low (off to high (on)). However, if the input's active state is set to Low, the timer starts running (becomes active) when the input changes from high (on) to low (off).

Signals

Direction	Label	Type	Function
Receivers	RUN	Digital	Run signal. As long as RST is inactive, the timer runs when this input is active and holds when this input is inactive.
	RST	Digital	Reset signal. The output becomes inactive and the elapsed time is reset to zero when this input becomes active.
Transmitter	- - -	Digital	Active whenever the elapsed time is greater than the specified time. Once on, the output remains on until the timer is reset.

Function

To measure how long the input is active and trigger the output when the cumulative time reaches a specified duration, set Function to Retentive.

Time

Set the cumulative amount of time the input must be active before the output becomes active.

Range: 0 to 30,000.0

Run Active Level

Set in which state at RUN the timer counts up.

Options:

- High: off
- Low: on

Reset Active Level

Set which state change at RST resets the timer.

Options:

- High: off to on
- Low: on to off

Transmitter Active Level

Set the state of the ouput that indicates the elapsed time is greater than or equal to the Time setting.

Options:

- High: On
- Low: Off

Elapsed Time

Indicates the cumulative time the input has been active since the timer was last reset.

Range: 0 to 30,000.0

Note:

The elapsed time is not retained through a power loss; it is set to zero upon power up.

Universal Input

Use this block to condition a temperature measurement made with a thermocouple or RTD or another analog process signal. Refer to the sections below for descriptions of the Universal Input and each sensor type it supports:

[About the Universal Input](#): overview of this block.

[Scaling Voltage and Current Inputs to Process Units](#): overview and example of linear scaling of process inputs.

[Millivolts](#): use this sensor type to measure and condition and scale a voltage input.

[Off](#): when set to off, the FB will be in error (Not Sourced) and the control loop (if connected) will be held at 0% power output.

[Thermocouple](#): use this sensor type to condition a temperature measurement made with a thermocouple.

[Volts](#): use this sensor type to measure, condition and scale a voltage input.

[Millamps](#): use this sensor type to measure, condition and scale a current input.

[RTD 100 Ohm](#): use this sensor type to condition a temperature measurement made with an RTD.

RTD 1,000 Ohm: use this sensor type to condition a temperature measurement made with an RTD.

1K Potentiometer: use this sensor type to measure and scale a resistance input.

Universal Input Errors: this section describes the errors that may occur on the signal supplied by the Universal Input function block.

About the Universal Input

The Universal Input block scales the electrical signal received by the analog input hardware to a process value that can be used by other blocks such as a control loop or alarm. If the signal is from a thermocouple or RTD, once the Sensor Type, TC Linearization and RTD Leads parameters are set, the block scales the signal to an absolute temperature with no other configuration required.

Note:

Flex Modules can be ordered as Mixed I/O or High Density (HD) I/O. When HD modules are in use, the pinouts on the card are slightly different than Mixed I/O modules. Pinouts and the associated graphics are displayed for both.

Note:

Although the functionality and parameters for any given sensor type does not change with the selected Units, the graphic does. In the following descriptions, the associated graphics for the sensor type will be displayed for the selected units.

Scaling Voltage and Current Inputs to Process Units

If the signal is from a device that outputs a voltage or current proportional to the process value, set the Sensor Type, Units, Scale Low, Scale High, Range Low and Range High parameters to present the process value in the appropriate units. Scale Low and Range Low are the coordinates of one point and Scale High and Range High are the coordinates of another point defining the line relating the electrical signal to the conditioned process value produced by this block. See the figure below.

For example, a flow meter is connected to the universal input. The flow meter provides a current signal proportional to flow where 4 mA indicates 0 gallons per minute (gpm) and 20 mA indicates 10 gpm.

With the scaling parameters set as listed below, when the universal input receives an 8 mA signal, the output of the block is 2.5 (gpm).

Sensor Type: Milliamps

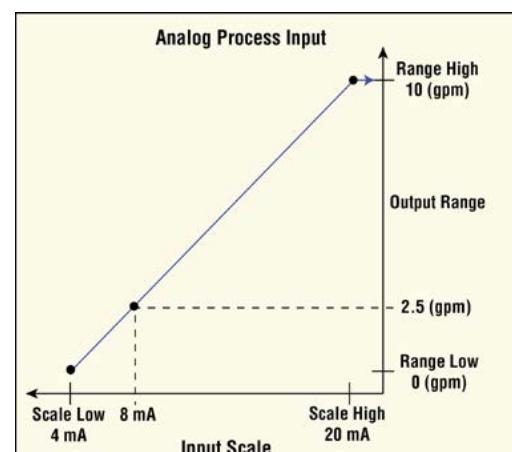
Units: Process

Scale Low: 4 mA

Scale High: 20 mA

Range Low: 0 (gpm)

Range High: 10 (gpm)



Millivolts/Volts

These FBs are found on the canvas of the FB diagram. The number of these FBs that are available depends on the number of flex modules with Universal Inputs installed and configured for voltage (millivolts or voltage).

The module number shown on the FB is the number of the controller's slot that houses the flex module with the Universal Input. The Universal Input number indicates the specific input on the flex module.

Signals

Direction	Label	Type	Function
Transmitter	- - - -	Analog	The scaled electrical signal or process value with filter and offset applied

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Sensor Type

To detect and condition a voltage for use with other FBs, set Sensor Type to Millivolts or Volts.

Units

Set the units for the function's output.

Options:

- Power: the output is a percentage with 100% representing full power and 0% representing no power.
- Process: the output is in units of measure other than degrees Fahrenheit, degrees Celsius or relative humidity.
- Relative Humidity: the output is a measurement of percent relative humidity (%RH).
- Absolute Temperature: the output is a temperature on the Celsius or Fahrenheit scale.

Scale Low

Set the electrical signal level at which the Range Low setting is the desired indicated process value. Scale Low and Range Low are the coordinates of a point on the line that relates the electrical signal to the conditioned process value produced by this block. Consult the hardware specifications for the signal range supported by the specific hardware.

Use to set the minimum value of the process range in electrical units.

Range: -100.0 to 1000.0 VDC

-100.0 to 1000.0 mVDC

Scale High

Set the electrical signal level at which the Range High setting is the desired indicated process value. Scale High and Range High are the coordinates of a point on the line that relates the electrical signal to the conditioned process value produced by this block. Consult the hardware specifications for the signal range supported by the specific hardware.

Use to set maximum value of the process range in electrical units.

Range: -100.0 to 1000.0 VDC

-100.0 to 1000.0 mVDC

Range Low

Set the process value to be indicated when the electrical signal is equal to the Scale Low setting. Scale Low and Range Low are the coordinates of a point on the line that relates the electrical signal to the conditioned process value produced by this block.

Use to set the minimum value in process units.

Range: -99,999.000 to 99,999.000°F or units
-55,555 to 55,555°C

Range High

Set the process value to be indicated when the electrical signal is equal to the Scale High setting. Scale High and Range High are the coordinates of a point on the line that relates the electrical signal to the conditioned process value produced by this block.

Use to set the maximum value in process units.

Range: -99,999.000 to 99,999.000°F or units
-55,555 to 55,555°C

Process Error Enable

Set this parameter to enable low scale input error detection and response. Process inputs do not have intrinsic open/short detection. To enable detection of process errors set this parameter to Low.

Options: Off, Low

Process Error Low Value

When Process Error Enable is set to Low, set the minimum electrical signal level that is considered a good measurement. If the signal level to the hardware drops below this value, an error will be triggered.

Range: -100.0 to 1000.0 VDC
-100.0 to 1000.0 mVDC

Display Precision

Set how many decimal places are displayed for the process value and associated parameters such as set points.

Options: Whole, Tenths, Hundredths, Thousandths

Calibration Offset

Set a value to add to the measured input value to compensate for sensor placement, lead wire resistance or other factors that cause the input to vary from the actual process value.

Range: -99,999.000 to 99,999.000°F or units
-55,555 to 55,555°C

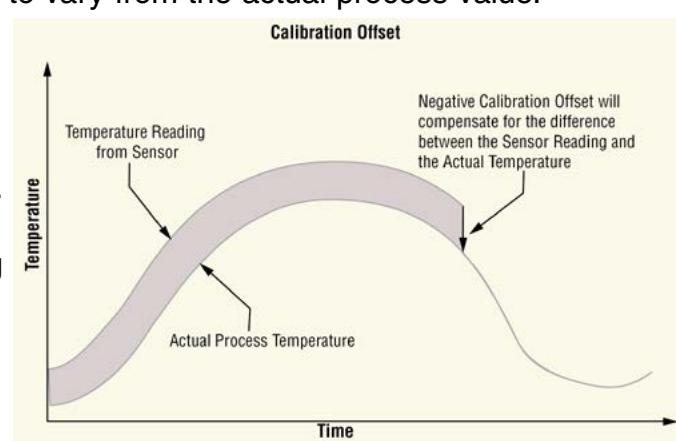
Filter

Set the amount of filtering to apply to the input. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the input's response.

Range: 0.0 to 60.0 seconds

Input Error Latching

Set whether an input error persists until it is cleared or clears automatically when the sensor signal returns to a normal level.



Options:

- Off: error clears automatically once the input returns to normal.
- On: error remains active until the input returns to normal and the error is cleared by the Clear Error parameter.

Clear Error

Set this parameter to Clear to reset the input error after correcting the condition that caused it.

Options: Ignore, Clear

Off

When the Universal Input FB is set to Off, the output will have an indeterminate value.

Signals

Direction	Label	Type	Function
Transmitter	- - - -	Analog	No output when off.

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Sensor Type

To turn an input off, set Sensor Type to Off.

Thermocouple

This FB is found on the canvas of the FB diagram. The number of these FBs that are available depends on the number of flex modules with universal inputs installed and configured as a thermocouple.

The module number shown on the block is the number of the controller's slot that houses the flex module with the universal input. The Universal Input number indicates the specific input on the flex module.

Signals

Direction	Label	Type	Function
Transmitter	- - - -	Analog	Supplies scaled, absolute temperature \pm the offset as a connection to another FB.

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Sensor Type

To detect and condition a temperature measurement set Sensor Type to Thermocouple.

TC Linearization

Select the Thermocouple type.

Options: B, K, C, N, D, R, E, S, F, T, J

Display Precision

Set how many decimal places are displayed for the process value and associated parameters such as set points.

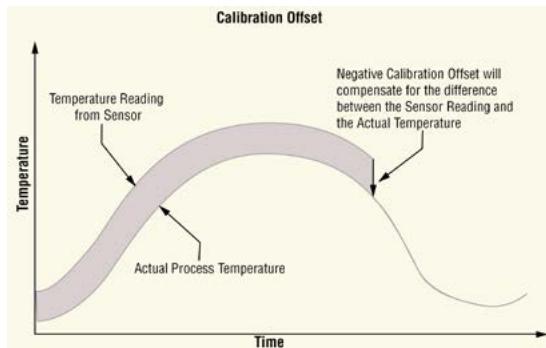
Options: Whole, Tenths, Hundredths, Thousandths

Calibration Offset

Set a value to add to the measured input value to compensate for sensor placement, lead wire resistance or other factors that cause the input to vary from the actual process value

Range: -99,999.000 to 99,999.000°F or units

-55,555 to 55,555°C



Filter

Set the amount of filtering to apply to the input.

Filtering smooths signal

fluctuations. Increase the time to increase filtering.

Excessive filtering slows the input's response.

Range: 0.0 to 60.0 second

Input Error Latching

Set whether an input error persists until it is cleared or clears automatically when the sensor signal returns to a normal level.

Options:

- Off: error clears automatically once the input returns to normal.
- On: error remains active until the input returns to normal and the error is cleared by the Clear Error parameter.

Clear Error

Set this parameter to Clear to reset the input error after correcting the condition that caused it.

Options: Ignore, Clear

Millamps

These FBs are found on the canvas of the FB diagram. The number of these FBs that are available depends on the number of flex modules with Universal Inputs installed and configured for millamps.

The module number shown on the FB is the number of the controller's slot that houses the flex module with the Universal Input. The Universal Input number indicates the specific input on the flex module.

Signals

Direction	Label	Type	Function
Transmitter	- - - -	Analog	The scaled electrical signal or process value with filter and offset applied

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Sensor Type

To detect and condition a input current for use with other FBs, set Sensor Type to Millamps.

Units

Set the units for the function's output.

Options:

- Power: the output is a percentage with 100% representing full power and 0% representing no power.
- Process: the output is in units of measure other than degrees Fahrenheit, degrees Celsius or relative humidity.
- Relative Humidity: the output is a measurement of percent relative humidity (%RH).
- Absolute Temperature: the output is a temperature on the Celsius or Fahrenheit scale.

Scale Low

Set the electrical signal level at which the Range Low setting is the desired indicated process value. Scale Low and Range Low are the coordinates of a point on the line that relates the electrical signal to the conditioned process value produced by this block. Consult the hardware specifications for the signal range supported by the specific hardware.

Use to set the minimum value of the process range in electrical units.

Range: -100.0 to 1000.0 VDC
-100.0 to 1000.0 mVDC

Scale High

Set the electrical signal level at which the Range High setting is the desired indicated process value. Scale High and Range High are the coordinates of a point on the line that relates the electrical signal to the conditioned process value produced by this block. Consult the hardware specifications for the signal range supported by the specific hardware.

Use to set maximum value of the process range in electrical units.

Range: -100.0 to 1000.0 VDC
-100.0 to 1000.0 mVDC

Range Low

Set the process value to be indicated when the electrical signal is equal to the Scale Low setting. Scale Low and Range Low are the coordinates of a point on the line that relates the electrical signal to the conditioned process value produced by this block.

Use to set the minimum value in process units.

Range: -99,999.000 to 99,999.000°F or units
-55,555 to 55,555°C

Range High

Set the process value to be indicated when the electrical signal is equal to the Scale High setting. Scale High and Range High are the coordinates of a point on the line that relates the electrical signal to the conditioned process value produced by this block.

Use to set the maximum value in process units.

Range: -99,999.000 to 99,999.000°F or units
-55,555 to 55,555°C

Process Error Enable

Set this parameter to enable low scale input error detection and response. Process inputs do not have intrinsic open/short detection. To enable detection of process errors set this parameter to Low.

Options: Off, Low

Process Error Low Value

When Process Error Enable is set to Low, set the minimum electrical signal level that is considered a good measurement. If the signal level to the hardware drops below this value, an error will be triggered.

Range: -100.0 to 1000.0 VDC
-100.0 to 1000.0 mVDC

Display Precision

Set how many decimal places are displayed for the process value and associated parameters such as set points.

Options: Whole, Tenths, Hundredths, Thousandths

Calibration Offset

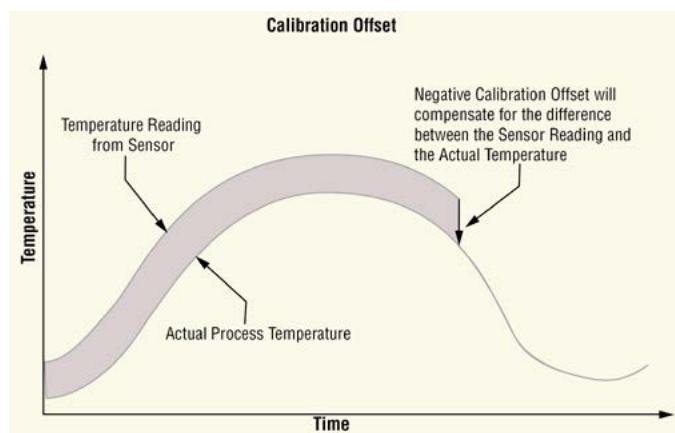
Set a value to add to the measured input value to compensate for sensor placement, lead wire resistance or other factors that cause the input to vary from the actual process value.

Range: -99,999.000 to 99,999.000°F or units
-55,555 to 55,555°C

Filter

Set the amount of filtering to apply to the input. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the input's response.

Range: 0.0 to 60.0 seconds



Input Error Latching

Set whether an input error persists until it is cleared or clears automatically when the sensor signal returns to a normal level.

Options:

- Off: error clears automatically once the input returns to normal.
- On: error remains active until the input returns to normal and the error is cleared by the Clear Error parameter.

Clear Error

Set this parameter to Clear to reset the input error after correcting the condition that caused it.

Options: Ignore, Clear

Resistance Temperature Device (RTD) 100 and 1000 Ohm

Use this block to condition a temperature measurement made with an RTD. This FB is found

on the canvas of the FB diagram. The number of these FBs that are available depends on the number of flex modules with Universal Inputs installed and configured as an RTD with two or three wires.

The module number shown on the block is the number of the controller's slot that houses the flex module with the universal input. The Universal Input number indicates the specific input on the flex module.

Signals

Direction	Label	Type	Function
Transmitter	- - -	Analog	Supplies scaled, absolute temperature \pm the offset as a connection to another FB.

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Sensor Type

Select the input device.

Options: RTD 100 Ohm, RTD 1000 Ohm

RTD Leads

Set the number of sensor leads connected to the flex module.

Options: 2, 3

Display Precision

Set how many decimal places are displayed for the process value and associated parameters such as set points.

Options: Whole, Tenths, Hundredths, Thousandths

Calibration Offset

Set a value to add to the measured input value to compensate for sensor placement, lead wire resistance or other factors that cause the input to vary from the actual process value

Range: -99,999.000 to 99,999.000°F or units

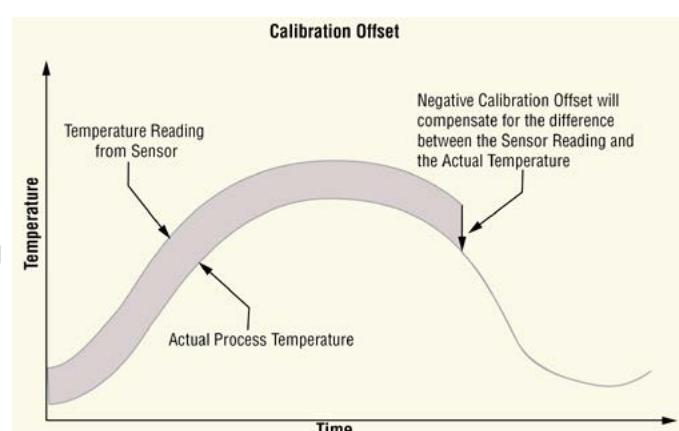
-55,555 to 55,555°C

Filter

Set the amount of filtering to apply to the input.

Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the input's response.

Range: 0.0 to 60.0 second



Input Error Latching

Set whether an input error persists until it is cleared or clears automatically when the sensor signal returns to a normal level.

Options:

- Off: error clears automatically once the input returns to normal.
- On: error remains active until the input returns to normal and the error is cleared by the Clear Error parameter.

Clear Error

Set this parameter to Clear to reset the input error after correcting the condition that caused it.

Options: Ignore, Clear

1K Potentiometer

Use this sensor type to measure and scale a resistance input. These FBs are found on the canvas of the FB diagram. The number of these FBs that are available depends on the number of flex modules with universal inputs installed and configured for a potentiometer input.

The module number shown on the block is the number of the controller's slot that houses the flex module with the universal input. The Universal Input number indicates the specific input on the flex module.

Signals

Direction	Label	Type	Function
Transmitter	- - -	Analog	Supplies scaled process value \pm the offset as a connection to another FB.

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Sensor Type

To detect and condition a resistance signal for use with other FBs, set Sensor Type to Potentiometer.

Units

Set the units for the function's output.

Options:

- Power: the output is a percentage with 100% representing full power and 0% representing no power.
- Process: the output is in units of measure other than degrees Fahrenheit, degrees Celsius or relative humidity.
- Relative Humidity: the output is a measurement of percent relative humidity (%RH).
- Absolute Temperature: the output is a temperature on the Celsius or Fahrenheit scale.

Scale Low

Set the electrical signal level at which the Range Low setting is the desired indicated process value. Scale Low and Range Low are the coordinates of a point on the line that relates the electrical signal to the conditioned process value produced by this block. Consult the hardware specifications for the signal range supported by the specific hardware.

Use to set the minimum value of the process range in electrical units.

Range: -100.0 to 1000.0 VDC
-100.0 to 1000.0 mVDC

Scale High

Set the electrical signal level at which the Range High setting is the desired indicated process value. Scale High and Range High are the coordinates of a point on the line that relates the electrical signal to the conditioned process value produced by this block. Consult the hardware

specifications for the signal range supported by the specific hardware.

Use to set maximum value of the process range in electrical units.

Range: -100.0 to 1000.0 VDC

-100.0 to 1000.0 mVDC

Range Low

Set the process value to be indicated when the electrical signal is equal to the Scale Low setting. Scale Low and Range Low are the coordinates of a point on the line that relates the electrical signal to the conditioned process value produced by this block.

Use to set the minimum value in process units.

Range: -99,999.000 to 99,999.000°F or units

-55,555 to 55,555°C

Range High

Set the process value to be indicated when the electrical signal is equal to the Scale High setting. Scale High and Range High are the coordinates of a point on the line that relates the electrical signal to the conditioned process value produced by this block.

Use to set the maximum value in process units.

Range: -99,999.000 to 99,999.000°F or units

-55,555 to 55,555°C

Process Error Enable

Set this parameter to enable low scale input error detection and response. Process inputs do not have intrinsic open/short detection. To enable detection of process errors set this parameter to Low.

Options: Off, Low

Process Error Low Value

When Process Error Enable is set to Low, set the minimum electrical signal level that is considered a good measurement. If the signal level to the hardware drops below this value, an error will be triggered.

Range: -100.0 to 1000.0 VDC

-100.0 to 1000.0 mVDC

Display Precision

Set how many decimal places are displayed for the process value and associated parameters such as set points.

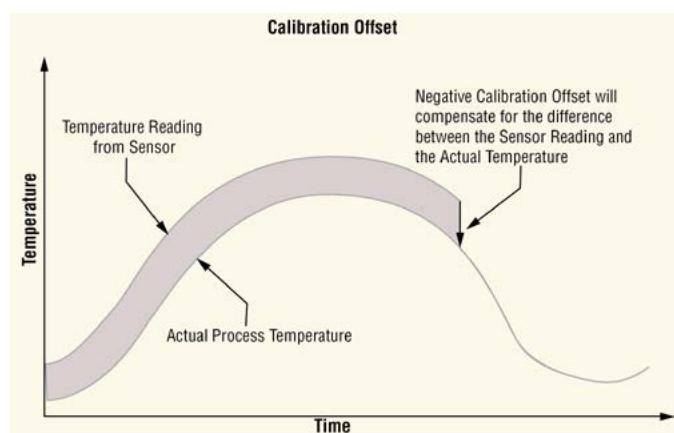
Options: Whole, Tenths, Hundredths,
Thousands

Calibration Offset

Set a value to add to the measured input value to compensate for sensor placement, lead wire resistance or other factors that cause the input to vary from the actual process value.

Range: -99,999.000 to 99,999.000°F or units

-55,555 to 55,555°C



Filter

Set the amount of filtering to apply to the input. Filtering smooths signal fluctuations. Increase the time to increase filtering. Excessive filtering slows the input's response.

Range: 0.0 to 60.0 seconds

Input Error Latching

Set whether an input error persists until it is cleared or clears automatically when the sensor signal returns to a normal level.

Options:

- Off: error clears automatically once the input returns to normal.
- On: error remains active until the input returns to normal and the error is cleared by the Clear Error parameter.

Clear Error

Set this parameter to Clear to reset the input error after correcting the condition that caused it.

Options: Ignore, Clear

Universal Input Errors

Error Status	Description
None	No error is detected.
Open	A sensor is broken or disconnected.
Shorted	A sensor has failed or is shorted.
Measurement Error	A measurement error has occurred.
Bad Calibration	The controller has not been calibrated.
Ambient Error	The ambient temperature is outside of the controller's operating range.
RTD Error	An RTD sensor error has occurred.
Fail	A measurement failure has occurred.
Not Sourced	An input signal is not connected to a function block's output.
Stale Data	Data sourced from another controller has become unavailable.

Variable

Use a variable to allow a user to set and modify an analog or digital signal value that is an input to another block. This block is found in the Function Block Diagram editor's Library when working with a controller that offers the Variable block. The number of these blocks available to be added to the diagram is shown within the parenthesis.

Choose the type of variable with the Data Type parameter. These options for the Data Type parameter are described in detail in the following sections:

[Analog](#): variable holds a user-set, analog value for use as an input to another block.

[Digital](#): variable holds a user-set, digital or Boolean state for use as an input to another block.

Analog

- Power: Use this function to integrate a user-set, power level or percentage in to the application. When the Data Type is Analog and Units is Power, the Variable function appears as shown at the left.

Note:

When used as the input to the control loop FB, a profile will run in manual mode. When the profile is not running, the control loop will run in the user defined mode.

- **Process:** Use this function to integrate a user-set, analog value that has units other than degrees C or degrees F or is a pure number in to the application. When the Data Type is Analog and Units is None or Process, the Variable function appears as shown at the left.
- **Relative Humidity:** Use this function to integrate a user-set, relative humidity in to the application. When the Data Type is Analog and Units is Relative Humidity, the Variable function appears as shown at the left.
- **Absolute Temperature:** Use this function to integrate a user-set, absolute temperature in to the application. When the Data Type is Analog and Units is Absolute Temperature, the Variable function appears as shown at the left. See Units below for more information on when to use relative temperature vs. absolute temperature.
- **Relative Temperature:** Use this function to integrate a user-set, relative temperature in to the application. When the Data Type is Analog and Units is Relative Temperature, the Variable function appears as shown at the left. See Units below for more information on when to use relative temperature vs. absolute temperature.

Signals

Direction	Label	Type	Function
Transmitter	- - -	Analog	The value set by the user with the Analog parameter in the units specified with the Units parameter

Name

Uniquely identify this FB using up to 20 alphanumeric characters.

Data Type

To configure the variable to hold a user-set, analog value, set Data Type to Analog.

Units

Set the units of the function's output.

Options:

- **None:** the output is a pure number without units.
- **Power:** the output is a percentage with 100% representing full power, 0% representing no power and, for some uses, -100% representing full cooling.
- **Process:** the output is in units of measure other than degrees Fahrenheit, degrees Celsius or relative humidity.
- **Relative Humidity:** the output is in percent relative humidity (%RH).
- **Absolute Temperature:** the output is a temperature on the Celsius or Fahrenheit scale. For example, 33°F as an absolute temperature is one degree above the freezing point of water. An absolute temperature can be used as a set point or compared with other temperatures to determine which is hotter or colder.
- **Relative Temperature:** the output is a relative number of degrees, not an absolute temperature. For example, the difference between the two measured temperatures,

6

Chapter 6: Communications

Communications

The F4T® controller supports several communication protocols using two different interfaces. Protocols supported are Watlow Standard Bus on port 44819, Standard Commands for Programmable Instruments (SCPI) on port 5025, Modbus® TCP on port 502, optionally Modbus® RTU, and optionally EtherNet/IP implicit messaging on port 2222 and explicit messaging on port 44818. Interfaces supported are Ethernet and optionally serial connection via EIA-232 and EIA-485.

In addition, SAMBA drive transfers on port 445, TFTP file transfers on port 69 and email/text alerts are supported on the Ethernet specified port. These protocols are not detailed in this section. The protocols are located on the web page <https://www.watlow.com/f4t> > "Related Documentation" > "Software & Demos" > "F4T Register List for communication protocols and LabView".

The two USB-A ports are used for insertion of memory devices, bar code scanner or keyboard. Memory devices are used to update the controller firmware, store log files, transfer configuration files or to connect a USB bar code scanner for batch processes. The port will support a USB keyboard. The MINI-USB-B port is not utilized.

Utilizing one of the protocols on an interface allows multiple programs to be selected to either configure the controller for installation or used to interface to the controller for day-to-day activities such as operation, data logging, email notification, text messaging to a cell phone or batch process data entry.

Note that a PC firewall must allow specified ports to pass for Ethernet connections to be established.

Watlow Supplied Software and HMI

Watlow offers various options for interfacing with the F4T.

Composer is software provided free to graphically configure the controller via a Windows based PC. Using Standard Bus protocol over the Ethernet connection provides auto discovery of connections, hardware and functionality of the connected F4T. Simply ensure the PC and F4T are on the configured to the same logical network, connected and powered. Then run Composer to auto detect the controller connected. Follow included built-in help and training videos to quickly learn the configuration process. See <https://www.watlow.com/products/controllers/software/composer-software> to download Composer for installation. Ensure you have administrative rights on the PC for complete installation.

SpecView is easy-to-use Supervisory Control and Data Acquisition (SCADA) software for Watlow controllers, including the F4T with INTUITION® process controller, ASPYRE® Power Controller and EZ-ZONE® controllers, as well as third-party products. Watlow's single point of support for hardware, software and application needs ensures knowledgeable and prompt responses to questions or concerns.

This competitively priced package includes field-proven features, many suggested by loyal users. Built-in support and auto-detect for Watlow controllers make setup quick and simple. SpecView from Watlow is ideal for industrial applications with support for barcode readers and touch-screen operation.

To try before purchasing, download the SpecView demo.

See <https://www.watlow.com/products/controllers/software/specview-scada-software>

LabVIEW™ instrument driver software package, created with LabVIEW™, simplifies development of applications such as test software. These instrument drivers include software functions called LabVIEW™ Virtual Instruments (VIs) that are used with LabVIEW™ to communicate with Watlow products.

This National Instruments' LabVIEW™ software communicates with Watlow's F4T controller, D4T data logger, and the EZ-ZONE® suite of controller products via the standard bus communications protocol that is included with these products.

The LabVIEW™ instrument driver software is available as a free download. The driver allows users to create applications in the National Instruments program allowing complete access to all registers within the F4T via the Ethernet connection.

See <https://www.watlow.com/products/controllers/software/labview-driver-software> for obtaining the driver. If using a NI Modbus driver, either the Ethernet or serial interface may be utilized. Silver Series EM is a rugged, touchscreen operator interface terminal (OIT). Available in three sizes (4.3,7 and 10-inch diagonal display sizes), the OIT's feature serial and Ethernet communications with multiple controllers, e-mail messaging, universal serial bus (USB host), data logging, flexible password security and multiple languages. The small bezel size and two-inch depth make mounting in tight spots easy.

The Silver Series EM programming software, EZwarePlus, is easy to use and features a large variety of built-in screen objects that makes it powerful. When creating screens, the user can call upon extensive graphics libraries, import custom graphics and add numeric displays, entry fields, analog meters, bar graphs and trend graphs with just a few mouse clicks. Screen objects are highly customizable, and the user can create libraries of their own objects for repeat use. The online simulator, Ethernet and USB support make testing and downloading fast. The EZwarePlus screen editor is part of the EZwarePlus software suite and is available as a FREE download on <https://www.watlow.com>.

The Silver Series may interface to the F4T using Modbus® TCP or Modbus® RTU.

See <https://www.watlow.com/products/controllers/operator-interfaces/silver-series-em> for more detail.

Program the desired registers to access on the HMI by adding a value of 1 to the Modbus relative address and entering the appropriate data type. Create custom screens and graphics to suit your personality.

Protocols

Standard Bus

The Watlow Standard Bus protocol is a proprietary protocol. It may be used to configure the F4T controller with Watlow Composer or communicate to a LabVIEW written program utilizing a LabVIEW™ driver supplied by Watlow. Watlow has implemented this protocol only over Ethernet port 44819.

Each F4T parameter setting has a unique parameter id to reference the data tag. The parameter id is needed in LabVIEW™ whereas Composer self discovers each parameter and replaces the id with an English name.

To get a listing of the parameter ids, see <https://www.watlow.com/f4t> > "Related Documentation" > "Software & Demos" > "F4T Register List for communication protocols and LabView". > LabVIEW tab > Parameter ID column on the spreadsheet.

Standard Commands for Programmable Instruments (SCPI)

SCPI commands are ASCII text strings with a wide array of defined SCPI commands. Watlow implements a subset of the commands. Although the SCPI protocol can be deployed over multiple physical layers, Watlow has implemented this protocol only over Ethernet port 5025.

Capital letters shown in command list are required while those in lower case are optional. Replace the # symbol with a number such as CLOOP# becomes CLOOP2 to reference control loop 2. Commands are either to read or write to a parameter.

To get a current listing of SCPI commands, see <https://www.watlow.com/f4t> > "Related Documentation" > "Software & Demos" > "F4T Register List for communication protocols and LabView". > SCPI tab on the spreadsheet.

Example commands >

:SOURCE:CLOOP1:PVALUE?	Read control loop 1 process value
:SOURCE:CLOOP1:SPOINT?	Read control loop 1 set point
:SOURCE:CLOOP1:SPOINT 75	Write control loop 1 set point to 75
:SOURCE:CLOOP1:RTIME?	Read control loop 1 ramp time
:SOURCE:CLOOP1:RTIME 15	Write control loop 1 ramp time
:SOURCE:CLOOP1:RSCALE MINUTES	Write control loop 1 ramp time units to MINUTES
:SOURCE:CLOOP1:RSCALE HOURS	Write control loop 1 ramp time units to HOURS
:SOURCE:CLOOP1:RRATEVALUE?	Read control loop 1 ramp rate value

Command List

The available SCPI commands are shown below:

*IDN?

Read Identification

Commands to support control loops

:SOURce:CLOOp#:PVALue?	Read control loop # process value
:SOURce:CLOOp#:SPOint?	Read control loop # set point
:SOURce:CLOOp#:SPOint <value>	Write control loop # set point
:SOURce:CLOOp#:RTIMe?	Read control loop # ramp time
:SOURce:CLOOp#:RTIMe<numeric value>	Write control loop # ramp time
:SOURce:CLOOp#:RSCALe MINutes	Write control loop # ramp time to MINUTES
:SOURce:CLOOp#:RSCALe HOURS	Write control loop # ramp time to HOURS
:SOURce:CLOOp#:RRATe?	Read control loop # step ramp rate
:SOURce:CLOOp#:RRATe<numericvalue>	Write control loop # ramp rate
:SOURce:CLOOp#:RACTion OFF	Write control loop # ramping action to OFF
SOURce:CLOOp#:RACTion STArtup	Write control loop # ramp action to STARTUP
:SOURce:CLOOp#:RACTion SETPoint	Write control loop # ramp action to SET POINT
:SOURce:CLOOp#:RACTion BOTH	Write control loop # ramp action to BOTH
:SOURce:CLOOp#:ERRor?	Read control loop # input error
:SOURce:CLOOp#:IDLE?	Read control loop # idle set point
:SOURce:CLOOp#:IDLE <numeric value>	Write control loop # idle setpoint

Commands to support cascade loops

:SOURce:CAScade#:SPOint?	Read cascade # setpoint
:SOURce:CAScade#:SPOint<numeric value>	Write cascade # setpoint
:SOURce:CAScade#:OUTer:PVALue?	Read cascade # outer loop process value
:SOURce:CAScade#:OUTer:ERRor?	Read cascade # outer loop input error
:SOURce:CAScade#:INNer:PVALue?	Read cascade # inner loop process value
:SOURce:CAScade#:INNer:ERRor?	Read cascade # inner loop input error
:SOURce:CAScade#:OUTer:SPOint?	Read cascade # outer loop set point

:SOURce:CASEcade#:INNer:SPOint?	Read cascade # inner loop set point
:SOURce:CASEcade#:FUNCTION?	Read cascade # loop function
:SOURce:CASEcade#:FUNCTION PROCESS	Write cascade # function to PROCESS
:SOURce:CASEcade#:FUNCTION DEVIATION	Write cascade # function to DEVIATION
:SOURce:CASEcade#:RANGE:LOW?	Read cascade # range low
:SOURce:CASEcade#:RANGE:LOW <numericvalue>	Write cascade # range low
:SOURce:CASEcade#:RANGE:HIGH?	Read cascade # range high
:SOURce:CASEcade#:RANGE:HIGH <numericvalue>	Write cascade # range high
:SOURce:CASEcade#:CONTrol?	Read cascade # control mode
:SOURce:CASEcade#:CONTrol OFF	Write cascade # mode to OFF
:SOURce:CASEcade#:CONTrol COOL	Write cascade # mode to COOL
:SOURce:CASEcade#:CONTrol HEAT	Write cascade # mode to HEAT
:SOURce:CASEcade#:CONTrol BOTH	Write cascade # mode to BOTH
:SOURce:CASEcade#:SSPoint:CONTrol?	Read cascade # simple set point control
:SOURce:CASEcade#:SSPoint:CONTrol OFF	Write cascade # simple set point control to OFF
:SOURce:CASEcade#:SSPoint:CONTrol ON	Write cascade # simple set point control to ON

Commands for process value measurements

:UNIT:TEMPerature?	
:UNIT:TEMPerature C	Write communications units to °C
:UNIT:TEMPerature F	Write communications units to °F
:UNIT:TEMPerature:DISPLAY?	Read displayed temperature units
:UNIT:TEMPerature:DISPLAY C	Write display units to °C
:UNIT:TEMPerature:DISPLAY F	Write display units to °F

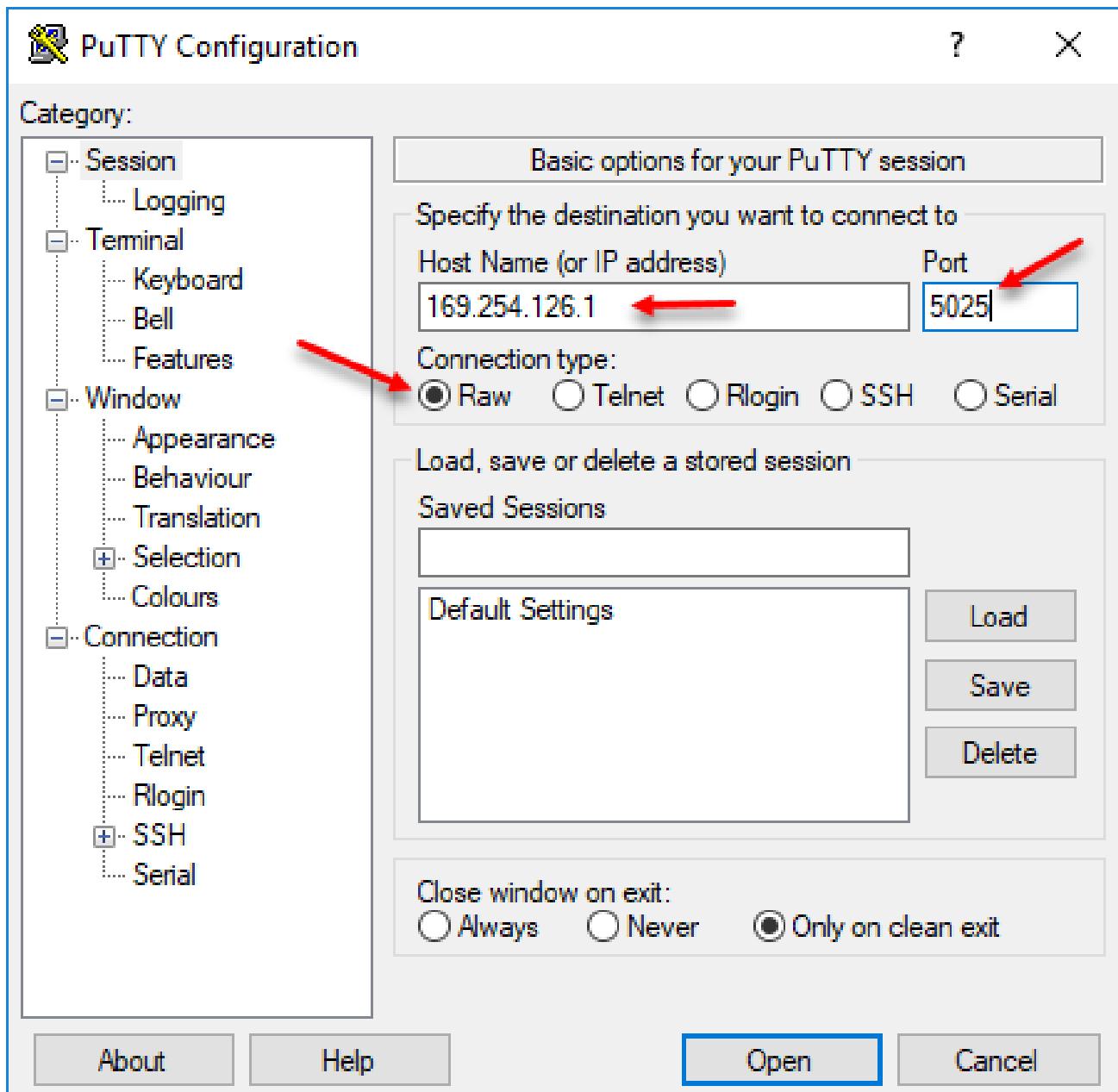
Commands to support profiles and outputs

:OUTPut#:NAME?	Read event output # name
:OUTPut#:STATe?	Read event output # state
:OUTPut#:STATe OFF	Write event output # to OFF
:OUTPut#:STATe ON	Write event output # to ON
:PROGram:SElected:NUMBER <numeric value>	Write current profile number
:PROGram:SElected:NAME?	Read current profile name
:PROGram:SElected:STEP <numeric value>	Write current profile step
:PROGram:SElected:STATe STArt	Start current profile
:PROGram:SElected:STATe PAUsE	Pause current profile
:PROGram:SElected:STATe RESume	Resume current profile
:PROGram:SElected:STATe STOP	Terminate current profile
:PROGram[:SElected]:NUMBER?	Read active profile number
:PROGram[:SElected]:STATe?	Read profile state
:PROGram[:SElected]:SPOint#?	Read current profile set point
:PROGram[:SElected]:STEP?	Read current profile step number
:PROGram[:SElected]:STEP:TYPE?	Read current profile step type
:PROGram[:SElected]:STEP:TIME:ELApsed?	Read current profile step time elapsed
:PROGram[:SElected]:STEP:TIME:REMain?	Read current profile step time remain

Commands to provide access to soft key values

:KEY#[STATe]?	Read key # state
:KEY#[STATe] ON	Write key # state to ON
:KEY#[STATe] OFF	Set key # state to OFF
:KEY#:NAME?	Read key # name

Use an open source program such as PuTTY available for free from <https://www.putty.org/> to test the SCPI commands. Enter IP address of F4T ensuring both PC and F4T are on configured for the same logical network. Enter port 5025 and select Raw for connection type.



Then enter the SCPI command followed by <Enter>.

The screenshot shows the PuTTY terminal window titled "169.254.126.1 - PuTTY". The command "*IDN?" was entered, and the response is: "Watlow Electric", "F4T1M1FAA1ACAAA", 1126, "4.06". The window has standard minimize, maximize, and close buttons at the top right.

Modbus TCP or Modbus RTU

Introduction to the Modbus Protocol

Gould Modicon, now called AEG Schneider, first created the protocol Modbus used in process control systems. This protocol works on the principle of packet exchanges. The packet contains the address of the controller to receive the information, a command field that says what is to be done with the information, and several fields of data. The Modbus specification is now maintained as open source. See <https://www.modbus.org/> for more details.

Each F4T® parameter has a unique zero based Modbus relative address.

Modbus TCP uses the Ethernet port 502 and Modbus RTU uses a serial port located in slot 6 of the F4T. The F4T is a server device which never initiates Modbus transactions. All registers are holding registers which require function code 0x03 for reads and function code 0x10 for multi-writes. There is no support for bit function codes.

All Modbus registers are 16-bits and are listed in the table as zero based relative addresses (actual) and one based absolute addresses for client devices which program in absolute addressing. The difference between zero based relative registers and one based absolute registers is 400,001.

Many F4T parameters are contained within two 16-bit registers or 32 bits (IEEE float, signed 32 bit), notice that only one (low order) of the two registers is listed. By default, the low order word contains the two low bytes of the 32-bit parameter. Parameters having data type as floating-point number is represented by two consecutive registers (low order bytes) and (high order bytes). The Modbus specification does not dictate which register should be high or low order, therefore F4T® provides the user the ability to swap this order. Floating point or real data type values allow a wide range of values with high precision to be defined.

The other data type most used is called enumerated. Enumerated means a value represents a choice such as 62=OFF and 63=ON. Enumerated data types fit into one Modbus 16-bit register and therefore require only 16-bits of memory.

Note:

To making an easy transition from the legacy F4 to the F4T controller using Modbus, a special set of the most commonly used F4 registers were created. Notice that there are three tables of Modbus registers, they are unique sets of registers (not interchangeable) and the user must select one set when implementing Modbus.

- Map 1 = F4T registers (default, recommended for new applications)
- Map 2 & 3 = Limited set of F4 compatible registers

To change the Modbus mapping using the F4T® front panel:

1. From any screen, push the **Menu** button
2. Push the **Settings** button and then the **Network** button
3. Select the **Ethernet** or **Serial** communications channel
4. Scroll the screen down to find Data Map and select 1 or 2.

To get a listing of the Modbus register, see see <https://www.watlow.com/f4t> > "Related Documentation" > "Software & Demos" > "F4T Register List for communication protocols and LabView". > Modbus Map 1 tab > Reference column Relative Address on the spreadsheet.

To get a listing of legacy F4S/D or F4P compatible registers, see <https://www.watlow.com/f4t> > "Related Documentation" > "Software & Demos" > "F4T Register List for communication protocols and LabView". > Modbus Map 2 tab > Reference column Relative Address on the spreadsheet or Modbus Map 3 for cascade control applications.

Diagnostic software for testing Modbus communications may be obtained from the Watlow web site.

See <https://www.watlow.com/-/media/documents/software-and-demos/modbustcptest130.ashx> for Ethernet connected program or <https://www.watlow.com/-/media/documents/software-and-demos/modbustest130.ashx> for a serial connected program.

Additional sample packet information is available at <http://www.watlow.com/f4t> > "Related Documentation" > "Software & Demos" > "F4T Register List for communication protocols and LabView".

Enabling Data Logging Using Modbus

To enable data logging when using the Modbus communications protocol:

1. Load Modbus register 18888 (Profile Active File Number) with the desired profile number (1 to 40).
2. Load Modbus register 19038 "Log Data" with 106 (yes).
3. Write Modbus registers to the controller.

Or

Manually enabling data logging (outside of a profile)

1. Think about and modify the following Modbus registers if need be:
 - Memory Full Action, Modbus register 42350 [**Stop or Overwrite**]
 - File Size Limit, Modbus register 42372 [**20 MB or 1/4 of the available memory if internal memory is used. 1GB if USB memory is used and then the 1/4 value might apply.**]
 - Log Interval, Modbus register 42388 [0.1, 0.2, 0.5, 1, 2, 5, 10, 15 and 30 seconds, 1, 2, 5, 10, 15, 30 and 60 minutes]
2. Load Modbus register 42386 "Log Action" with 1782 [**start**].
3. Write Modbus registers to the controller.

Using Modbus to Determine Profile Selection

It is important to know that when creating profiles an index is assigned to each in the order in which they were created. When defining which profile to run through Modbus it is most important to understand how the indexing works.

The actual number of profiles within a controller and the index for each can be easily identified through 41 unique Modbus registers beginning at 48000 (Profile List Count) and a unique List Member for each profile. If the list of profiles is created once without deletion of any of those profiles, the List Member Modbus register for any given index will not change. However, if any profiles are deleted after original creation, the List Members and index values for those following the deletion point will be modified (shifted up in the profile listing).

In the example that follows, 6 profiles have been created with given names shown to the left and the associated Modbus registers (Profile List Member) displayed with index values to the right. With the profile listing as shown below, Modbus register 48000 (Profile List Count) would be equal to 6.

Profile Listing As Originally Created	
Profile Listing (as viewed in controller)	Profile List Member - Modbus Registers
Heat Only	48002 = 1
Heat/Cool	48004 = 2
Blk Furnace	48006 = 3
Part Chamber	48008 = 4
Part Cool Down	48010 = 5
Roaster	48012 = 6

To load and run "Part Cool Down" above, the value of 5 would be written to Modbus register 16558 (Start Profile) while then writing 1782 (start) to register 16562 (Profile Action Request).

If the profile listing were modified where Profile 3 is deleted, note the changes in the table below for the profile listing and associated Profile List Member - Modbus registers.

Profile Listing After Changes	
Profile Listing (as viewed in controller)	Profile List Member - Modbus Registers
Heat Only	48002 = 1
Heat/Cool	48004 = 2
Part Chamber	48006 = 4
Part Cool Down	48008 = 5
Bean Roaster	48010 = 6

Note that all of the profiles following the deletion point were shifted up (name and index value) and Modbus register 48000 (Profile List Count) would now be equal to 5. Notice that for the same profile mentioned above (Part Cool Down) the index did not change but it was moved from List Member 5 to 4 where index 3 no longer exists.

EtherNet/IP

EtherNet/IP Fundamentals

Common Industrial Protocol (CIP) is used to collect data, configure, and control the F4T®. Digit 9 of the F4T base model must contain the number 3 for the option to be available. Example: F4Txxxxx3xxxxxx. Modbus TCP must be disabled to use implicit messaging.

CIP is an open protocol at the application layer fully managed by the Open DeviceNet Vendors Association ([ODVA](https://www.odva.org), <https://www.odva.org>). EtherNet/IP is a network communication standard capable of handling large amounts of data at speeds of 10 Mbps or 100 Mbps, and at up to 1,500 bytes per packet. It makes use of standard off-the-shelf Ethernet chip sets and the currently installed physical media (hardware connections). Reading or writing when using CIP is accomplished via explicit and/or implicit communications. Explicit communications are usually executed via a message instruction within the PLC but there are other ways to do this as well outside of the focus of this document.

The Requested Packet Interval (RPI) setting in the PLC determines how quickly the assembly information (I/O) is to be refreshed. When communicating implicitly, the Client (PLC) controls the cyclic timing (I/O updates) via the RPI setting. The RPI setting should be set at 100 mS or more. The PLC will open port 44818 to make a connection.

For implicit communications (real time I/O messaging) using a PLC, configure the F4T assembly size into the I/O structure of the PLC. The assembly structures can be changed to selected tags of your choice and quantities between 0 to 124 inputs to F4T from the PLC outputs and 0 to 124 outputs from F4T to PLC inputs.

NOTE: The maximum number of implicit input/output members using EtherNet/IP is 124. These are fully configurable using Watlow Composer.

For explicit communications (information/configuration messaging), you'll need to use specific addressing information. Explicit message connection can be thought of as a client/server relationship. EtherNet/IP requires the Class, Instance and Attribute.

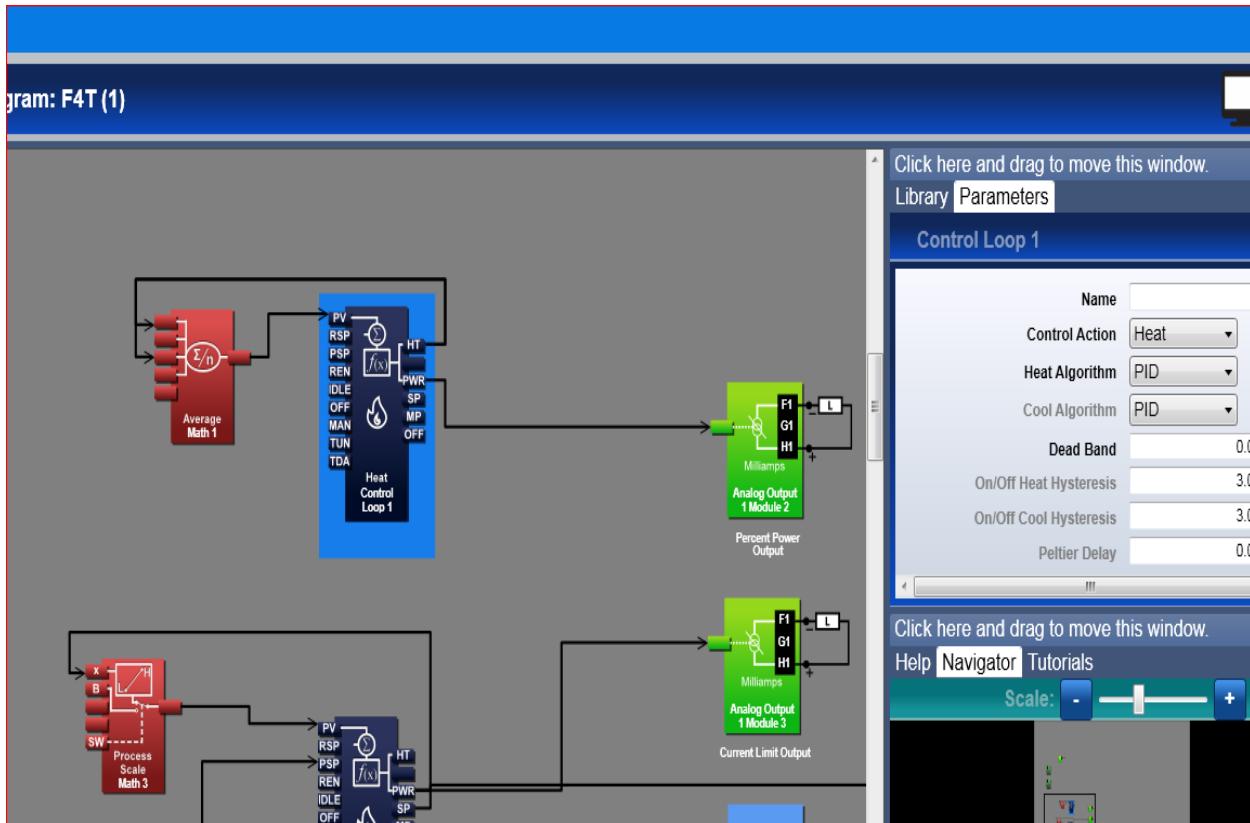
see <https://www.watlow.com/f4t> > "Related Documentation" > "Software & Demos" > "F4T Register List for communication protocols and LabView". > EtherNet IP tab > Reference the following columns:

- Class ID (1 to 255)
- Instance ID (0 to 255)
- Attribute ID (1 to 255)

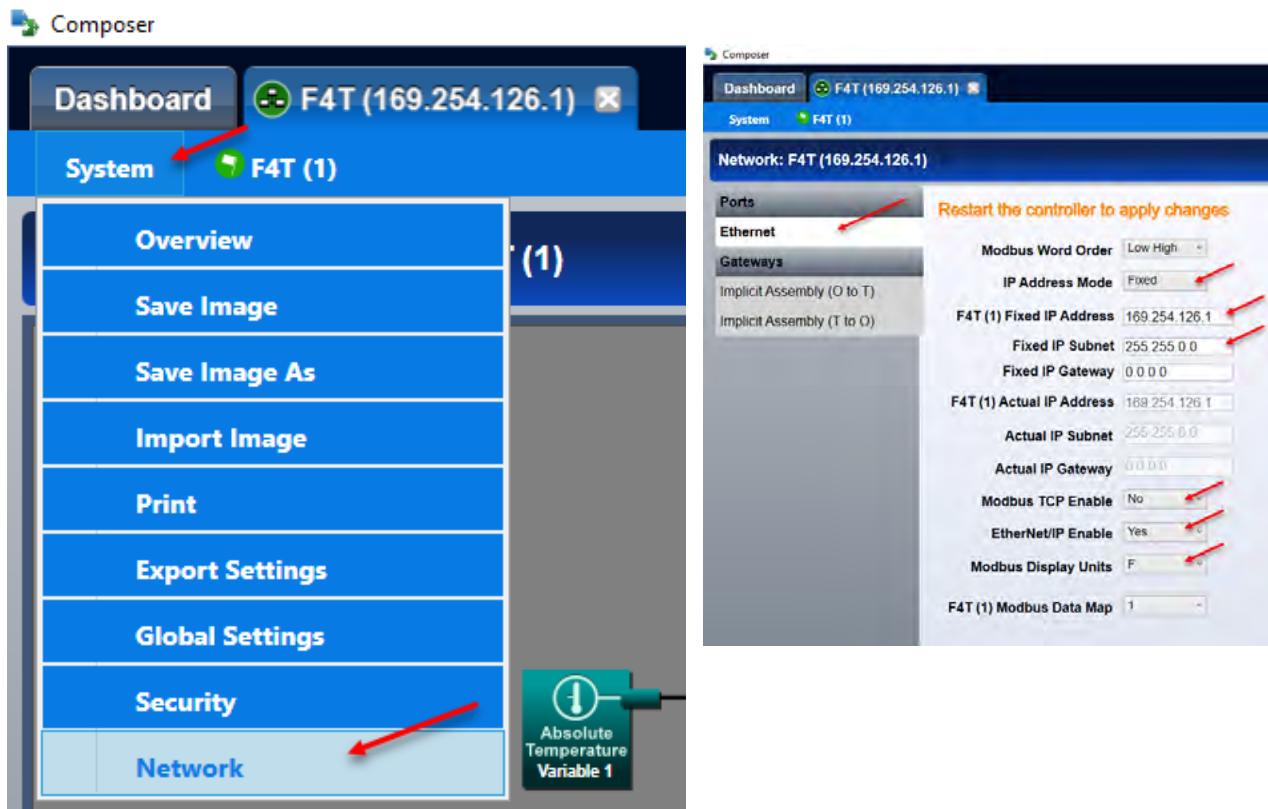
The F4T does not support connected explicit messages but fully supports unconnected explicit messaging.

Setting up implicit data tables in Composer:

1. Before setting up Ethernet IP, configure the controller. It may be helpful to name the function blocks so they are easier to reference when setting up values to transmit in the F4T.



2. Navigate to System, Network view.
3. Select Ethernet, Define IP Address Mode. If Fixed, enter Fixed IP Address and Fixed IP Subnet. Ensure the actual IP Address is what is desired for the Ethernet/IP. You may have to remove and reapply power to the F4T for the values to update. Ensure Modbus TCP Enable is set to No and Ethernet/IP Enable is set to Yes. The Modbus Display Units apply to both EtherNet/IP and Modbus TCP. Set as desired for the temperature units being transferred between PLC and F4T independent of the display of F4T.



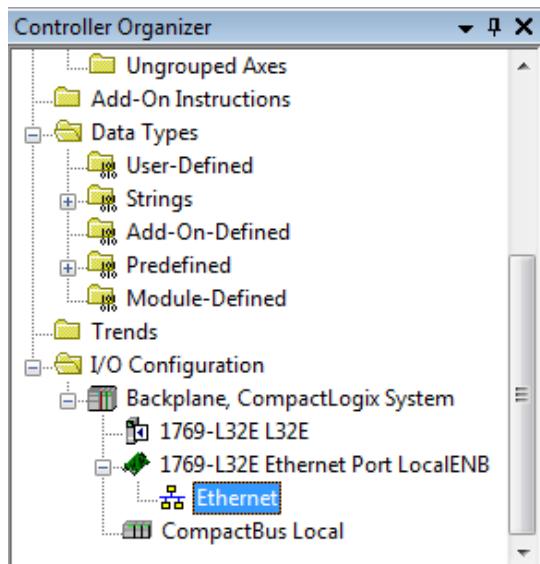
- Set up the Implicit assembly values. O to T stands for Originator to Target and T to O is for Target to Originator. O to T values are written by the PLC, where the T to O values are read by the PLC. Use the drop-down list in each column to narrow the selection to the desired tag. The maximum available tags are 124 O to T and 124 T to O.

NOTE: If you named any function blocks in the canvas, they will show up as the new name in the drop down selection.

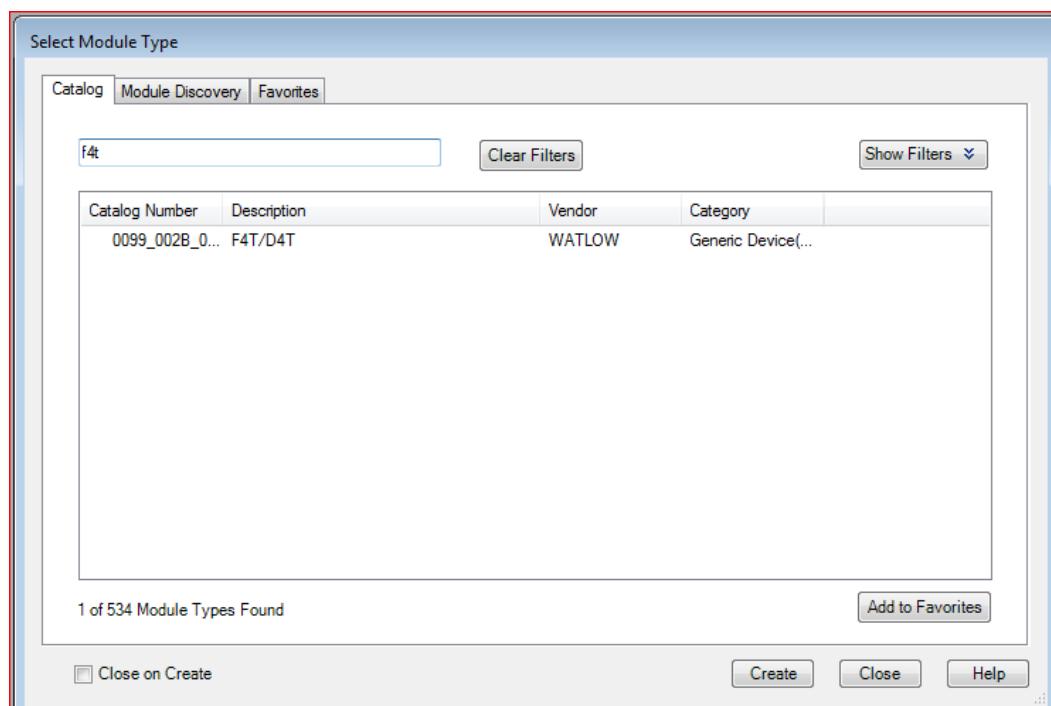
	Member	Type	Parameters
1		uint	Control Loop 1 Control Mode
2		Float	Control Loop 1 Set Point
3			None
4			None

Adding device to RSLogix 5000:

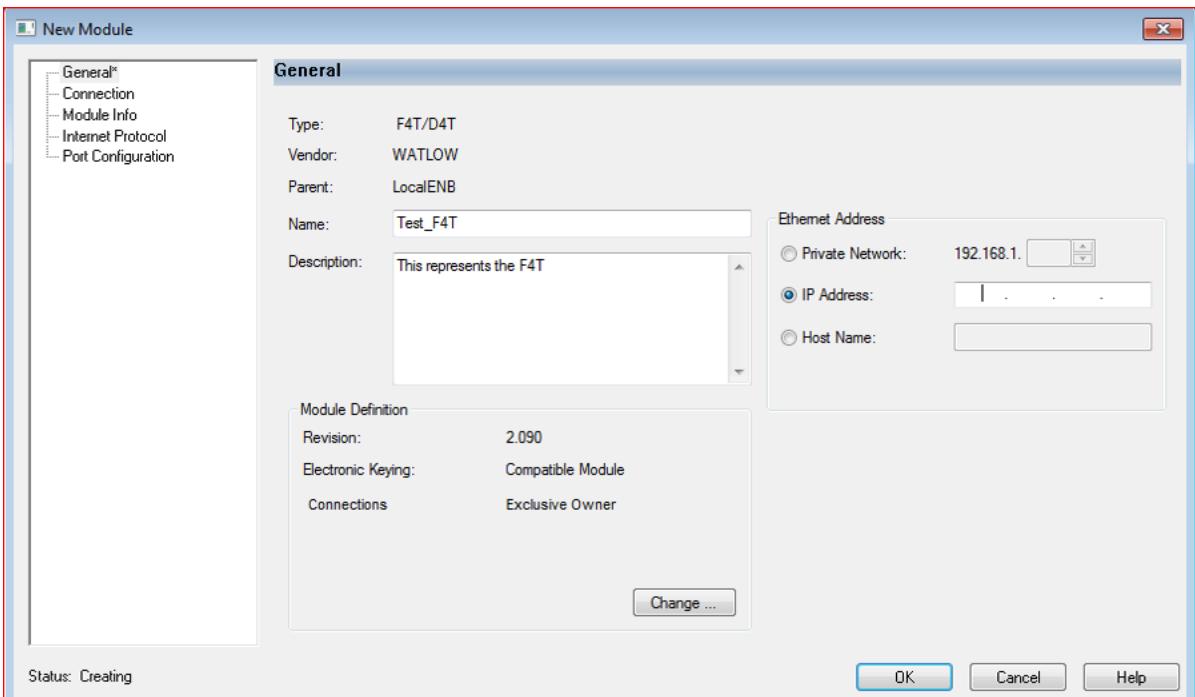
1. Install the F4T EDS file using the import tool. The EDS file, "F4T_D4T.eds", can be downloaded from the **F4T Register List**, see <https://www.watlow.com/f4t> > "Related Documentation" > "Software & Demos" > F4T D4T EDS (Electronic Data Sheet) file for EtherNet/IP. The actual file that is downloaded is the F4T_D4T.eds.
2. With an RSLogix 5000 project opened, find the Ethernet port of your PLC inside the Controller Organizer.



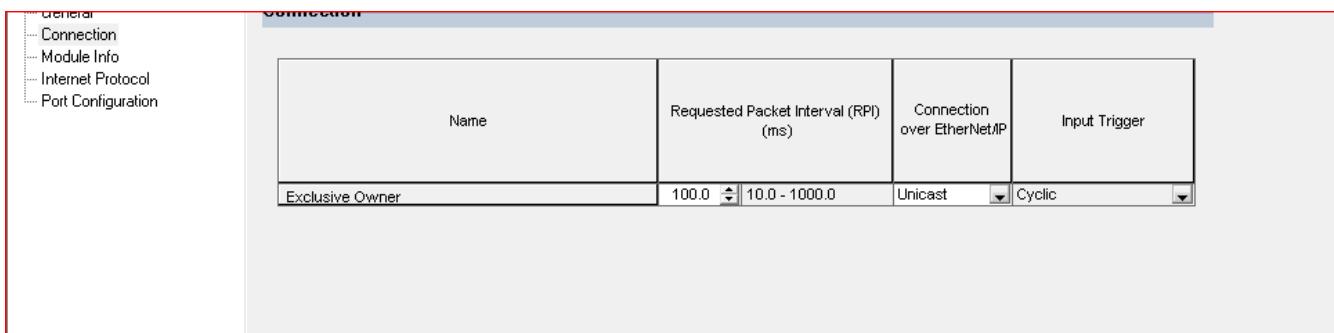
3. Right click and select New Module.
4. Search for F4T, and select the F4T module.



5. Enter a device name, description, and the IP address of the F4T.



For Connection info, the recommended Requested Packet Interval (RPI) is 100ms.



Select OK and download the configuration to the PLC.

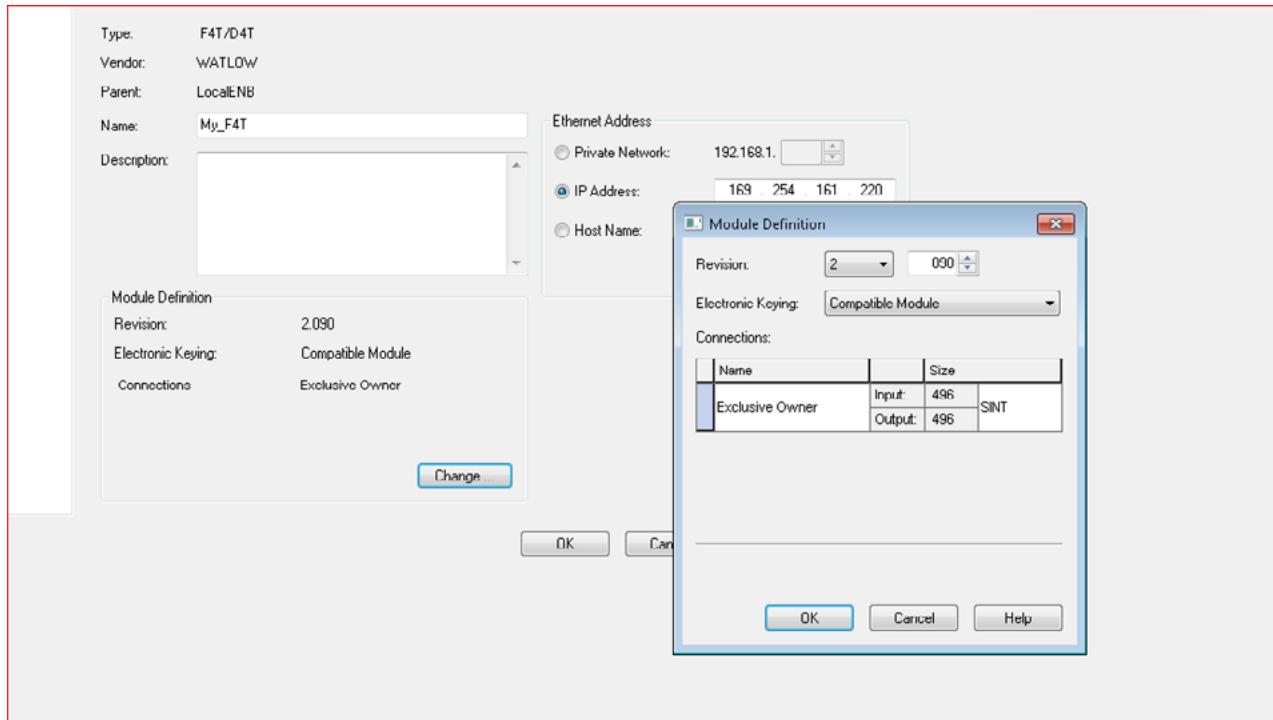
The data received in the PLC will be an array of 496 1-byte entries. Each tag consumes 4 bytes. ($496 / 4 = 124$ tags).

Name	Value	Force Mask	Style	Data Type	Description	Constant
- F4T_Module:0	{...}	{...}		_0099:002B_046...		<input checked="" type="checkbox"/>
+ F4T_Module:0.Data	{...}	{...}	Decimal	SINT[496]		<input checked="" type="checkbox"/>
- F4T_Module:1	{...}	{...}		_0099:002B_046...		<input checked="" type="checkbox"/>
+ F4T_Module:1.ConnectionFaulted	0		Decimal	BOOL		<input checked="" type="checkbox"/>
+ F4T_Module:1.Data	{...}	{...}	Decimal	SINT[496]		<input checked="" type="checkbox"/>

Interpreting the data:

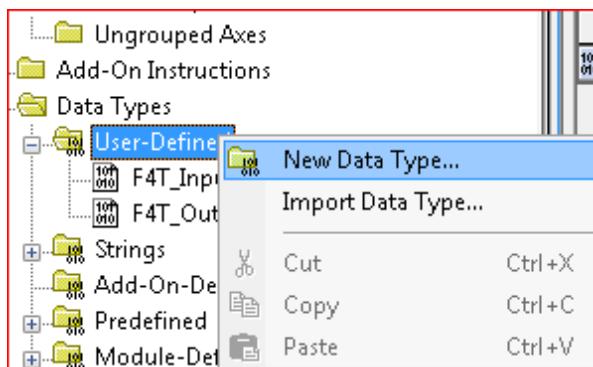
Data will be returned as an array of one data type. Therefore, a user defined data type can be utilized to give the data meaning. If all the data is the same, the module data can set the array type as desired.

For example, if all the expected read and write data are floats, go into the module info and select the REAL data type. This will interpret every single value as a float.



If the data is different, follow these steps to interpret the data.

1. Create a new User-Defined Data Type.



2. This will be the table where each value for either the O to T or T to O values are defined.

Refer to COMPOSER to see each data type. Name the Data Type desired.

The screenshot shows two windows side-by-side. The top window is titled 'Network: F4T (169.254.161.220)' and displays a table of implicit assemblies. The bottom window is a configuration dialog for a new input, with a red border around it.

Implicit Assembly (O to T) Table:

Member	Type	Parameters
1	Float	Control Loop
2	Float	Control Loop 2 Set Point
3	Float	Power Control Heat Proportional Band 1
4	Float	Alarm 1 High Set Point
5	None	
6	None	

New Input Configuration Dialog:

Name:	F4T_Inputs
Description:	(empty text area)
Members:	Data Type Size: 16 byte(s)
<input type="button"/> Name Data Type Style Description External Access	

3. Fill the table with the appropriate data types. When complete, select ok and repeat the process for the outputs.

The screenshot shows a configuration dialog with a red border. A smaller 'Select Data Type' dialog is overlaid on the main window. The main window contains a table of members and a description text area.

Select Data Type Dialog:

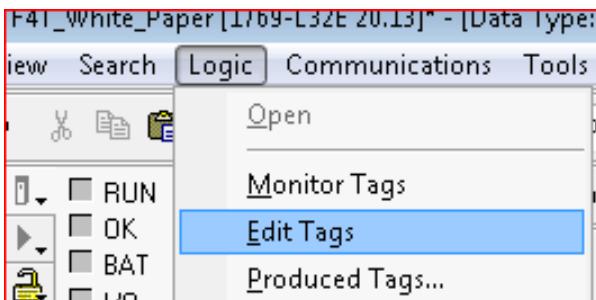
Data Types:

- REAL
- MID_ENHANCED
- PIDE_AUTOTUNE
- POSITION_PROP
- PROP_INT
- PULSE_MULTIPLIER
- RAMP_SOAK
- RATE_LIMITER
- REdundant Input

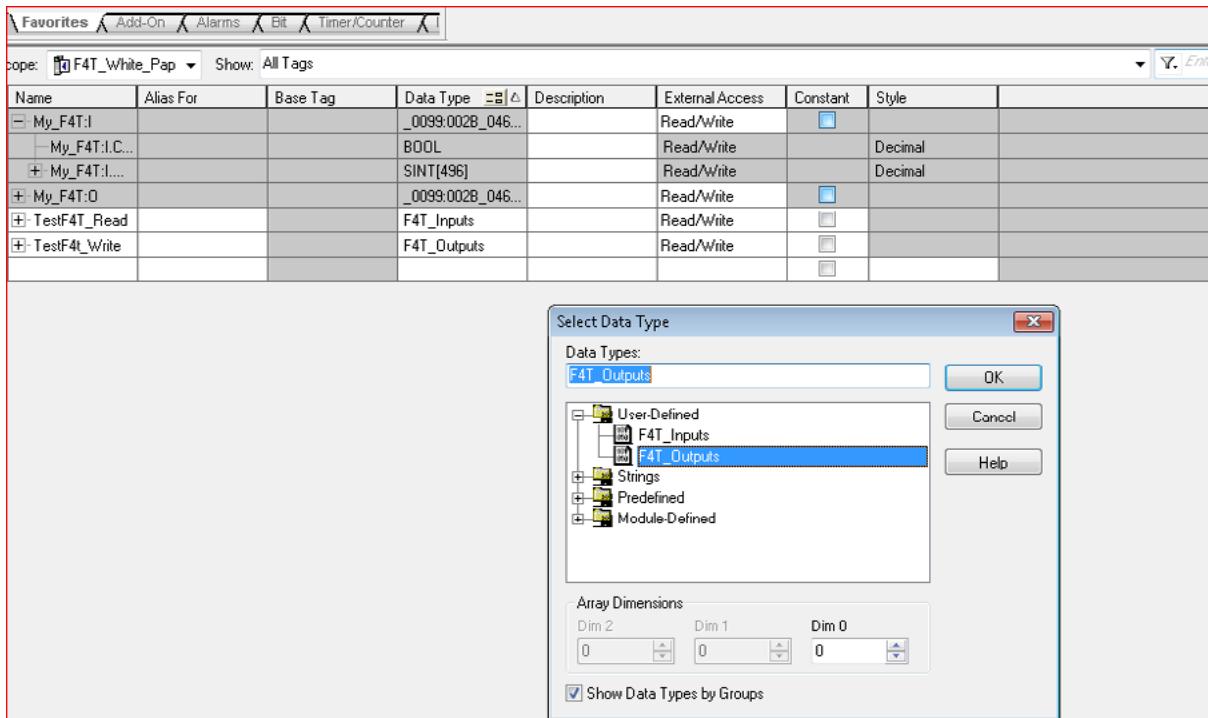
Table Members:

Name	Data Type	Style	Description
CL1_Set	REAL	Float	
FI_2_Set	RFAI	Float	
CL1_Prop	REAL	Float	
ALM1_Hi_Set	REAL	Float	

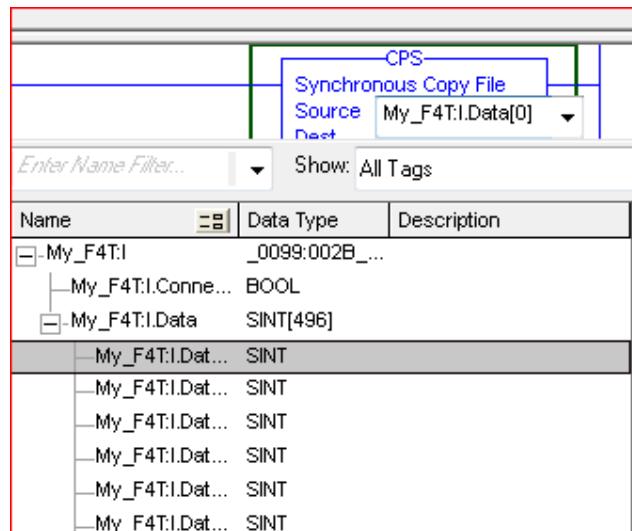
4. Navigate to Edit Tags.



5. Create 2 new tags. Link the read values to the input user defined type and the write values to the output.



6. Navigate to the main routine and add 2 new CPS instructions to the PLC logic. For the source of the readable data, put the first element of the array, then put the read tag that was created for the destination.



7. For the write data, put the write tag that was created as the source and put the first element of the input data as the destination.



8. The program is now complete and when running the data will be of the desired type.

				F4T_Inputs		
	(...)	(...)				
TestF4T_Read	55.0		Float	REAL		
TestF4T_Read	0.0		Float	REAL		
TestF4T_Read	24.0		Float	REAL		
TestF4T_Read	0.0		Float	REAL		
	(...)	(...)		F4T_Outputs		
TestF4t_Write	55.0		Float	REAL		
TestF4t_Write	0.0		Float	REAL		

Explicit Communications (exception based messaging)

Explicit messaging is executed on demand and can vary in size. Every message must be individually configured to execute a specific Message Type, e.g., CIP Generic and a specific Service Type, e.g., Get Attribute Single or Set Attribute Single. Each device will interpret the message, act upon the task and then generate a response. This message type encapsulates information about the protocol itself as well as the instructions that need to be carried out in a TCP/IP packet. When a message is sent using TCP/IP it requires a response from the device. As stated above, this type of message is reserved for diagnostics, configuration or non-time sensitive data. Instructing a control loop to initiate an Autotune is rarely done and therefore should be done explicitly. Some tags may need to be modified by a keypad in addition to the PLC access. The parameters are read/written on an exception based concept; in other words, read/write only when needed.

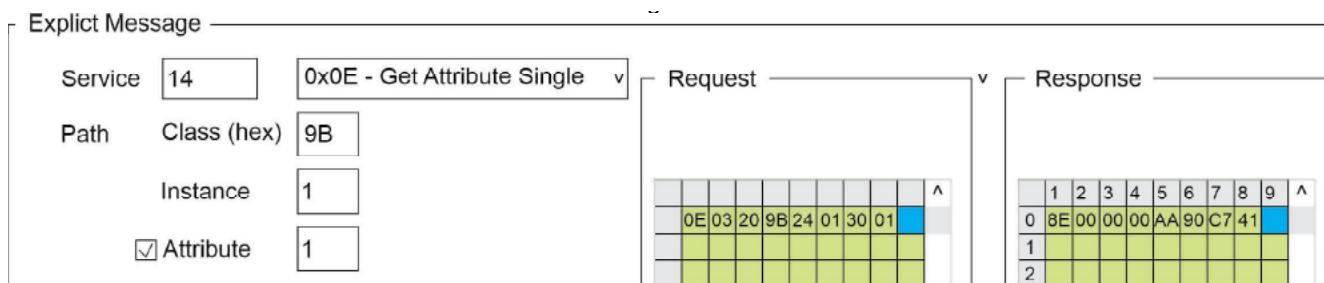
Only Get Attribute Single and Set Attribute Single are supported in the F4T®.

An explicit message contains numbers in following order:

- 1) Service Code, (0x0E for Get Attribute Single or 0x10 for Set Attribute Single).
- 2) Quantity of bytes specified 0x03
- 3) Segment 0x20 for 8-bit class. See EPATH in ODVA Specification documentation.
- 4) Class in byte format (0x01 to 0xFF)
- 5) Segment 0x24 for 8-bit Instance. See EPATH in ODVA Specification documentation.
- 6) Instance in byte format (0x01 to 0xFF)
- 7) Segment 0x30 for 8-bit attribute. See EPATH in ODVA Specification documentation.
- 8) Attribute in byte format (0x01 to 0xFF)

The controller response is contained in the last four bytes in Little Endian format.

Class 0x9B, Instance 0x01, Attribute 1 was requested to be read which is analog input 1 of card in slot 1 of an F4T. The result returned 0x41C790AA = 24.94564 °C using Little Endian format.



EtherNet/IP Summary

By using both forms of communication, EtherNet/IP can prioritize time-critical I/O communications (implicit) over non-critical messages (explicit) while allowing for both to occur simultaneously. Watlow EtherNet/IP equipped devices supports both Implicit and Explicit communications. Users should determine the tags that will be transferred and segregate the tags between implicit and explicit requirements.

Tags that are explicit may be changed from two locations depending on logic. If the same tag were part of the implicit assembly, the value changed via keypad would be over written every several hundred milliseconds by the PLC. Some users are surprised that a value keeps resetting after changing from the keypad yet no longer exhibits that action when the Ethernet cable is disconnected.

Implicit Data table only contains data and no identifiers of the data. It is imperative that the quantity of inputs/outputs expected to be sent/received be of the correct size and known during the setup process. Failure to match both originator and target results in connection error messages on PLC or incorrect data being identified. This is the number one mistake new users make on commissioning Watlow products with PLCs.

Use message type CIP Generic Get Attribute Single to read tags and Set Attribute Single to write tags.

Troubleshooting

1. Unable to connect from PLC to F4T®.
 - a. Check if link LED is illuminated to check for cable integrity (green LED near RJ45).
 - b. Check if IP address and subnet mask are on same logical network.
 - i. When using recommended Fixed IP addressing mode, cycle power to F4T® for new IP address to be in effect.
 - ii. Check if F4T® may be pinged from PC/PLC if possible.
 - c. Check if EtherNet/IP protocol is enabled in F4T®.
 - d. Check CIP Implicit Assembly Input and Output Member Quantity values in F4T® to match Output and Input Members of PLC.
2. Intermittent loss of Ethernet connection.
 - a. Check for managed switch having IGMP snooping capability.
 - b. Check for duplicate IP address.
 - c. Check for intermittent Ethernet cable.
 - d. Check for power supply disruptions to F4T or Ethernet switch.
3. Wrong tag values being displayed in PLC.
 - a. Check for correct tag definition on PLC and in F4T.
 - b. Check display units correctly selected for communications. The setting is independent from F4T screen display units.
 - c. For sensor readings, ensure valid sensors are connected. Check sensor status to determine valid values.
4. Unable to change a value on F4T while Ethernet cable is connected.
 - a. Check if parameter being changed is tag in implicit assembly. The PLC constantly writes to the F4T input tags.
 - b. Check that security is not enabled in F4T for access. Passwords might be active preventing change.

7

Chapter 7: Appendix

F4T® Base Specifications

Line Voltage/Power

- High voltage option: 100 to 240V~ (ac) 50/60Hz ±5%
- Low voltage option: 24 to 28V (~ ac) (dc) +10/-15%, 50/60Hz ±5%
- Power consumption: 23 W, 54VA

Environment

- NEMA 4X/IP65 - front panel mount configuration only
- 0 to 122°F (-18 to 50°C) operating temperature
- -40 to 185°F (-40 to 85°C) storage temperature
- 0 to 90% RH, non-condensing

Agency Approvals

- UL®/EN 61010 Listed, File E185611 QUYX
- UL® 508 Reviewed
- CSA CC.C#14, File 158031
- FM Class 3545 (configurations with limit modules)
- AMS 2750 E compliant: Analog input process values. Tip: Maximize field calibration accuracy and uniformity by using advanced F4T® features such as Calibration Offset and Linearization Function Blocks. Refer to user manual for details.
- RoHS by design, China RoHS Level 2, W.E.E.E.
- CE
- Windows® Hardware Certification

User Interface

- 4.3 inch TFT PCAP color graphic touch screen
- LED backlife >50K hours
- 4 keys: Home, Main Menu, Back, Help
- The following languages are available in the F4T® by selecting Main_Menu/Settings/ Global/Language: English, German, French, Italian, Spanish, Japanese, Korean and Chinese

Control Loops

- 1 to 4 PID or ON-OFF control loops
- 0 to 6 Limit loops
- User-selectable action: heat, cool or heat/cool
- Auto-tune with TRU-TUNE+ adaptive control

Control Loops and Over-Temperature Limits

- Input sampling: 10Hz
- Output update: 10Hz

Communications

- EtherNet/IP
-

Profile Ramp and Soak Option

- Profile engine affects 1 to 4 loops in sync
 - 40 profiles with 50 steps per profile
-

Data Logging

- User selectable parameters: Up to a maximum of 128 active parameters depending on configuration
 - Logging interval: Programmable increments between 0.1 seconds and 60 minutes if logging to internal memory. Logging directly to USB; 1.0 seconds to 60 minutes
 - File types: .CSV for standard data logging or proprietary format for encrypted data log option
 - Storage: 80MB internal memory or to USB memory stick
 - File transfer: Internal memory to USB host port or to Ethernet Modbus® TCP
 - Transfer options: On demand by user or user programmable based on when a new data log file record is available. Utilizes TFTP and Samba protocols
 - Record: Date and time stamped
-

Batch Processing

- Compatible with many bar code types including Code 128, Code 39, Extended Code 39, Data Matrix, Interleaved 2 of 5, ISSN, SISAC, LOGMARS, QR, UCC/EAN-128 (GS1-128, UPC-A & E)
 - Compatible with most USB scanner types such as Zebra DS4308, DS2208, LI2208 and LS2208
 - USB port provides 500mA max. power supply for bar code scanner/base charging
 - Display can show bar code fields up to a maximum length of 48 characters. Characters might wrap to 2 rows after 24 characters
 - Part-Profile list entries – approximately 1,000 typical length part numbers of 15 characters each can be stored. Can easily import different part files via USB thumb drive connection to cover a higher quantity range of part lists
 - Program the bar code scanner to add an enter key (carriage return feed) at the end of each bar code data field sent to F4T/D4T. Refer to USB scanner user manual.
-

Trending

- 4 user programmable charts
- 6 pens available per chart
- View analog sensors, process values, set points and power

Number of Function Blocks by Ordering Option

Function Block	Basic	Set 1	Set 2
Alarm	6	8	14
Compare	None	4	16
Counter	None	4	16
Linearization	4	4	8
Logic	None	12	24
Math	None	12	24
Process Value	4	4	8
Special Output Function (including compressor)	None	2	4
Timer	None	6	16
Variable	4	12	24

Real Time Clock with Battery Backup

- Accuracy (typical): +/-3ppm over -15 to 50°C
- Typical battery life: 10 years at 77°F (25°C)
- Field replaceable lithium battery

Compare

- Greater than, less than, equal, not equal, greater than or equal, less than or equal

Counters

- Counts up or down, loads predetermined value on load signal

Linearization

- Interpolated or stepped

Logic

- And, nand, or, nor, equal, not equal, latch, flip-flop

Math

- Average, process scale, switch over, deviation scale, differential (subtract), ratio (divide), add, multiply, absolute difference, minimum, maximum, square root, sample and hold, pressure-to-altitude and dew point

Process Value

- Sensor backup, average, crossover, wet bulb-dry bulb, switch over, differential (subtract), ratio (divide), add, multiply, absolute difference, minimum, maximum, square root, altitude, Vaisala® relative humidity and pressure-to-altitude

Special Output Function

- Compressor control (cool and/or dehumidify with single compressor), motorized valve, sequencer

Timers

- On pulse, delay, one shot or retentive

Variable

- User value for digital or analog variable



Declaration of Conformity

Series (D or F)4T

WATLOW Electric Manufacturing Company

1241 Bundy Blvd.

Winona, MN 55987 USA



Declares that the following products:

Designation:	Series (D or F)4T 1/4 DIN Control
Model Numbers:	F4T X X (1 to 8) – X A(A,3) XX X – XXX D4T X X (1 to 8) – X A(A,3) XX 5 – XXX X = any number or letter.
Classification:	F4T = Process Controller Base D4T = Data logger Both Models rated – Installation Category II, IP65 or IP40 if flush mount option is used.
Rated Voltage and Frequency:	High Voltage 100 – 240 V~ (ac) 50/60 Hz, (D or F)4TXX(1, 2, 3, 4) Low Voltage 24 – 28 V~ (ac/dc) 50/60 Hz, (D or F)4TXX(5, 6, 7, 8)
Rated Power Consumption:	Up to 23 Watts with six modules loaded.

Only the front display is considered part of the ultimate enclosure, the unit is considered an open type process control, it requires an ultimate enclosure and at least one **Watlow EZ-ZONE® FM “Flex Module”** to have a useful function. All Flex Modules were tested as part of F4T system for compliance with the following directives.

2014/30/EU Electromagnetic Compatibility Directive

EN 61326-1:2013	Electrical equipment for measurement, control and laboratory use – EMC requirements (Industrial Immunity, Group 1 Class A¹ Emissions).
EN 55011:2016	Electrostatic discharge immunity
IEC 61000-4-2:2008	Radiated, radio-frequency electromagnetic field immunity, 10 V/m 80 MHz to 1 GHz, 3 V/m 1.4 GHz to 2.7 GHz
IEC 61000-4-3:2007 + A1/2008, A2/2010	Electrical fast-transient / burst immunity
IEC 61000-4-4:2012	Surge immunity
IEC 61000-4-5:2014 + A1/2017	Immunity to conducted disturbances induced by radio-frequency fields
IEC 61000-4-6:2013 + Corrigendum 2015	Voltage dips, short interruptions and voltage variations immunity
IEC 61000-4-11:2020	Limits for harmonic current emissions for equipment ≤ 16 Amps per phase
EN 61000-3-2:2014	Voltage fluctuations and flicker for equipment ≤ 16 Amps per phase
EN 61000-3-3 ² :2013	Specification for semiconductor sag immunity Figure R1-1
SEMI F47-0812	¹ NOTE: Caution: This equipment is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.

²NOTE: To comply with flicker requirements cycle time may need to be up to 160 seconds if load current is at 15A, or the maximum source impedance needs to be < 0.13Ω. Unit power of F4T model complies with 61000-3-3 requirements.

2014/35/EU Low-Voltage Directive

EN 61010-1:2010, A1:2019	Safety Requirements of electrical equipment for measurement, control and laboratory use. Part 1: General requirements
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Compliant with 2011/65/EU RoHS2 Directive



Please Recycle Properly.

Models contain a type BR2032 coin cell battery which shall be recycled at end of life per 2006/66/EC Battery Directive as amended by 2013/56/EU Directive.

Doug Kuchta

Name of Authorized Representative

Signature of Authorized Representative

Winona, Minnesota, USA

Place of Issue



Declaration of Conformity

Series EZ-ZONE® Flex Modules



WATLOW Electric Manufacturing Company
1241 Bundy Blvd.
Winona, MN 55987 USA

Declares that the following products:

Designation:	Series EZ-ZONE® Flex Modules
Model Numbers:	FMLA-(LAJ, LCJ, LEJ, MAJ, MCJ, MEJ, YEB ¹)A ¹ -A ¹ (A ¹ ,F ¹ ,B ¹ ,G ¹) X¹X¹ FMMA- X¹ (A ¹ ,C ¹ ,E,F ¹ ,K)(A ¹ ,C ¹ ,H,J,K)A ¹ -A ¹ (A ¹ ,F ¹ ,B ¹ ,G ¹) X¹X¹ FMHA-(R ¹ ,P ¹ ,C ¹ ,F ¹ ,B ¹ ,J,K,L ¹)A ¹ A ¹ -A ¹ (A ¹ ,F ¹ ,B ¹ ,G ¹) X¹X¹ ¹ FMCA- X AAA-A(A,F,B,G) XX ; Note: X ¹ = Any letter or number
Classification:	FMLA, FMMA and FMHA are Process Control modules, FMCA are Communication modules; Modules are Integrated Controls in either EZ-ZONE® CC, F4T or D4T Bases; Modules are IP10 when properly installed.
Rated Voltage and Frequency:	Relay, SSR or No-Arc Control outputs 24 to 240 V~ (ac) 50/60 Hz, Switched DC, Process and communications; low voltage SELV
Rated Power Consumption:	See manual for de-rating at increased temperatures. No-arc relays 15A 1.C, Dual SSR module 1.C 10A each output, Mechanical relay 5A 125 VA, 25 VA at 24 V~ (ac) 1.B, Discreet SSR 1/2A 1.C 20VA, Quad SSR 1.C 1.5A 50 VA, Hex I/O ELV 1.5A, all others SELV limited energy.

Flex Modules are considered components and have no function in and of themselves, it is only when installed in a **Watlow Series F4T or Series D4T** Base enclosure that they have useful function. Modules were tested as parts of these systems for compliance with the following directives.

2014/30/EU Electromagnetic Compatibility Directive

EN 61326-1:2013 Electrical equipment for measurement, control and laboratory use – EMC requirements (Industrial Immunity, Class B Emissions).

2014/35/EU Low-Voltage Directive

EN 61010-1:2010, Safety Requirements of electrical equipment for measurement, control and A1:2019 All options laboratory use. Part 1: General requirements compliant

EN 60730-1:2011 Automatic electrical controls for household and similar use – Particular EN 60730-2-9:2010 requirements for temperature sensing controls.

¹Food Service Compliant options. Only certain output options comply with 60730 spacing and dielectric requirements, see order information for compatible models.

Compliant with 2011/65/EU RoHS2 Directive

Per 2012/19/EU W.E.E Directive  Please Recycle Properly.

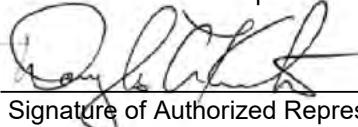
See the Declarations of Conformity for **Watlow Series F4T and Series D4T** models for further details on standards used for compliance.

Doug Kuchta

Name of Authorized Representative

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Title of Authorized Representative


Signature of Authorized Representative

Winona, Minnesota, USA

Place of Issue

January 2021

Date of Issue

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