

Instruction Manual

ETC00624

12/2001

Instruction Manual

Foundation™ Fieldbus

Communication Option for

BINOS 100 2M, BINOS 100 F & CAT 100

Software Revision 3

1st Edition 12/2001



ROSEMOUNT
Analytical

www.EmersonProcess.com


EMERSON
Process Management

ESSENTIAL INSTRUCTIONS

READ THIS PAGE BEFORE PROCEEDING!

Emerson Process Management (Rosemount Analytical) designs, manufactures and tests its products to meet many national and international standards. Because these instruments are sophisticated technical products, you **MUST properly install, use, and maintain them** to ensure they continue to operate within their normal specifications. The following instructions **MUST be adhered to** and integrated into your safety program when installing, using and maintaining Emerson Process Management (Rosemount Analytical) products. Failure to follow the proper instructions may cause any one of the following situations to occur: Loss of life; personal injury; property damage; damage to this instrument; and warranty invalidation.

- **Read all instructions** prior to installing, operating, and servicing the product.
- If you do not understand any of the instructions, **contact your Emerson Process Management (Rosemount Analytical) representative** for clarification.
- **Follow all warnings, cautions, and instructions** marked on and supplied with the product.
- **Inform and educate your personnel in the proper installation, operation, and maintenance of the product.**
- **Install your equipment as specified in the Installation Instructions of the appropriate Instruction Manual and per applicable local and national codes.** Connect all products to the proper electrical and pressure sources.
- To ensure proper performance, **use qualified personnel** to install, operate, update, program, and maintain the product.
- When replacement parts are required, ensure that qualified people use replacement parts specified by Emerson Process Management (Rosemount Analytical). Unauthorized parts and procedures can affect the product's performance, place the safe operation of your process at risk, **and VOID YOUR WARRANTY.** Look-alike substitutions may result in fire, electrical hazards, or improper operation.
- **Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified persons, to prevent electrical shock and personal injury.**

The information contained in this document is subject to change without notice. Misprints reserved.

1st Edition 12/2001

© 2001 by Emerson Process Management

Emerson Process Management
GmbH & Co. OHG
Industriestrasse 1
D-63594 Hasselroth
Germany
T +49 (0) 6055 884-0
F +49 (0) 6055 884-209
Internet: www.EmersonProcess.com



CONTENTS

Section 1	Foundation Fieldbus Technology	1-1
1.1	Overview	1-1
1.2	Introduction	1-2
1.2.1	Function Blocks	1-2
1.2.2	Device Descriptions.....	1-3
1.3	Instrument-Specific Functions Blocks.....	1-4
1.3.1	Resource Blocks	1-4
1.3.2	Transducer Blocks.....	1-4
1.3.3	Alerts	1-4
1.4	Network Communication	1-5
1.4.1	Link Active Scheduler (LAS).....	1-5
1.4.2	Device Addressing	1-6
1.4.3	Scheduled Transfers	1-6
1.4.4	Unscheduled Transfers	1-7
1.4.5	Function Block Scheduling	1-8
1.5	References.....	1-9
1.5.1	Fieldbus Foundation.....	1-9
Section 2	Transducer Block Specification	2-1
2.1	Parameter Descriptions.....	2-2
2.2	Parameter Attribute Definitions.....	2-6
2.3	Parameter Access Methods	2-9
2.4	Enumerations	2-11
2.4.1	Calibration Check Status.....	2-11
2.4.2	Calibration Check Step Control	2-11
2.4.3	Sensor Gas Type	2-12
2.4.4	Analyzer Options	2-12
2.4.5	Calibration Options.....	2-12
2.4.6	Calibration Valve Control.....	2-13

2.4.7	Detailed Status	2-13
2.4.8	Measurement Options	2-13
2.4.9	Pump Controller	2-14
2.4.10	Remote Exclusive Access	2-14
2.4.11	Channel Assignments	2-14
2.5	Supported Block Errors	2-14
2.5.1	Transducer Block	2-14
2.5.2	Resource Block	2-15

Section 3 Analog Input (AI) Function Block 3-1

3.1	Simulation.....	3-3
3.2	Filtering.....	3-4
3.3	Signal Conversion	3-4
3.4	Block Errors.....	3-5
3.5	Modes	3-6
3.6	Alarm Detection.....	3-6
3.7	Status Handling	3-7
3.8	Advanced Features	3-7
3.9	Application Information.....	3-8
3.9.1	Application Example 1	3-8
3.9.2	Application Example 2.....	3-9
3.9.3	Application Example 3.....	3-10
3.10	Troubleshooting.....	3-11

Section 4 Analog Output (AO) Function Block 4-1

4.1	Setting the Output	4-2
4.2	Setpoint Selection and Limiting	4-3
4.3	Conversion and Status Calculation	4-3
4.4	Simulation.....	4-4
4.5	Action on Fault Detection	4-4
4.6	Block Errors.....	4-4
4.7	Modes	4-5

4.8	Status Handling.....	4-5
Section 5 Input Selector (ISEL) Function Block		5-1
5.1	Block Errors.....	5-3
5.2	Modes	5-4
5.3	Alarm Detection.....	5-4
5.4	Block Execution.....	5-4
5.5	Status Handling.....	5-5
5.6	Application Information.....	5-5
5.7	Troubleshooting.....	5-7
Section 6 Proportional / Integral / Derivative (PID) Function Block		6-1
6.1	Setpoint Selection and Limiting	6-5
6.2	Filtering.....	6-6
6.3	Feedforward Calculation	6-6
6.4	Tracking	6-6
6.5	Output Selection and Limiting.....	6-6
6.6	Bumpless Transfer and Setpoint Tracking	6-7
6.7	PID Equation Structures.....	6-7
6.8	Reverse and Direct Action.....	6-7
6.9	Reset Limiting.....	6-8
6.10	Block Errors.....	6-8
6.11	Modes	6-8
6.12	Alarm Detection.....	6-9
6.13	Status Handling.....	6-10
6.14	Application Information.....	6-10
6.15	Closed Loop Control.....	6-10
6.15.1	Application Example 1	6-12
6.15.2	Application Example 2.....	6-13
6.15.3	Application Example 3.....	6-14

6.15.4 Application Example 4	6-15
6.16 Troubleshooting.....	6-16

FIGURES

Figure 1-1. Function Block Internal Structure	1-3
Figure 1-2. Single Link Fieldbus Network.....	1-5
Figure 1-3. Scheduled Data Transfer	1-7
Figure 1-4. Unscheduled Data Transfer	1-7
Figure 1-5. Example of Link Schedule.....	1-8
Figure 2-1. Parameter Access.....	2-10
Figure 2-2. Calibration Check State Diagram.....	2-11
Figure 3-1. Analog Input Function Block Schematic.....	3-3
Figure 3-2. Analog Input Function Block Timing Diagram	3-4
Figure 4-1. Analog Output Function Block Schematic.....	4-2
Figure 4-2. Analog Output Function Block Timing Diagram	4-3
Figure 5-1. Input Selector Function Block Schematic.....	5-3
Figure 6-1. PID Function Block Schematic.....	6-5
Figure 6-2. PID Function Block Setpoint Selection.....	6-6

TABLES

Table 2-1. Parameter Descriptions.....	2-2
Table 2-2. Parameter Attribute Definitions	2-6
Table 2-3. Calibration Check Status Enumerations.....	2-11
Table 2-4. Calibration Check Step Control Enumerations.....	2-11
Table 2-5. Sensor Gas Type	2-12
Table 2-6. Analyzer Options.....	2-12
Table 2-7. Calibration Options.....	2-12
Table 2-8. Calibration Valve Control	2-13
Table 2-9. Detailed Status.....	2-13
Table 2-10. Measurement Options	2-13
Table 2-11. Pump Controller	2-14
Table 2-12. Remote Exclusive Access.....	2-14
Table 2-13. I/O Channel Assignments (AI Blocks)	2-14
Table 2-14. I/O Channel Assignments (AO Blocks)	2-14

Table 3-1. Definitions of Analog Input Function Block System Parameters.....	3-1
Table 3-2. Block Error Conditions	3-5
Table 3-3. Alarm Priorities	3-7
Table 3-4. Troubleshooting AI Block	3-11
Table 4-1. Analog Output Function Block System Parameters.	4-1
Table 5-1. Input Selector Function Block System Parameters	5-1
Table 5-2. Block Error Conditions	5-3
Table 5-3. Alarm Priorities	5-4
Table 5-4. Troubleshooting ISEL Block.	5-7
Table 6-1. PID Function Block System Parameters	6-2
Table 6-2. Block Error Conditions	6-8
Table 6-3. Alarm Priorities	6-10
Table 6-4. Troubleshooting for PID	6-16

1 FOUNDATION FIELDBUS TECHNOLOGY

1.1 OVERVIEW

FOUNDATION Fieldbus is an all digital, serial, two-way communication system that interconnects field equipment such as sensors, actuators, and controllers. Fieldbus is a Local Area Network (LAN) for instruments used in both process and manufacturing automation with built-in capacity to distribute the control application across the network. It is the ability to distribute control among intelligent field devices on the plant floor and digitally communicate that information at high speed that makes FOUNDATION Fieldbus an enabling technology.

Fisher-Rosemount offers a full range of products from field devices to the DeltaV scalable control system to allow an easy transition to Fieldbus technology.

The Fieldbus retains the features of the 4-20 mA analog system, including standardized physical interface to the wire, bus powered devices on a single wire, and intrinsic safety options, and enables additional capabilities such as:

- ◆ Increased capabilities due to full digital communications.
- ◆ Reduced wiring and wire terminations due to multiple devices on one set of wires.
- ◆ Increased selection of suppliers due to interoperability.
- ◆ Reduced loading on control room equipment with the distribution of some control and input/output functions to field devices.
- ◆ Speed options for process control and manufacturing applications.

NOTE: The following descriptions and definitions are not intended as a training guide for Foundation Fieldbus technology but are presented as an overview for those not familiar with Fieldbus and to define device specific attributes for the Fieldbus system engineer. Anyone attempting to implement Fieldbus communications and control with this analyzer must be well versed in Fieldbus technology and protocol and must be competent in programming using available tools such as DeltaV. See “References” below for additional sources for Fieldbus technology and methodology.

1.2 INTRODUCTION

A Fieldbus system is a distributed system composed of field devices and control and monitoring equipment integrated into the physical environment of a plant or factory. Fieldbus devices work together to provide I/O and control for automated processes and operations. The Fieldbus Foundation provides a framework for describing these systems as a collection of physical devices interconnected by a Fieldbus network. One of the ways that the physical devices are used is to perform their portion of the total system operation by implementing one or more function blocks.

1.2.1 *Function Blocks*

Function blocks within the Fieldbus device perform the various functions required for process control. Because each system is different, the mix and configuration of functions are different. Therefore, the Fieldbus FOUNDATION has designed a range of function blocks, each addressing a different need.

Function blocks perform process control functions, such as analog input (AI) and analog output (AO) functions as well as proportional-integral-derivative (PID) functions. The standard function blocks provide a common structure for defining function block inputs, outputs, control parameters, events, alarms, and modes, and combining them into a process that can be implemented within a single device or over the Fieldbus network. This simplifies the identification of characteristics that are common to function blocks.

The Fieldbus FOUNDATION has established the function blocks by defining a small set of parameters used in all function blocks called universal parameters. The FOUNDATION has also defined a standard set of function block classes, such as input, output, control, and calculation blocks. Each of these classes also has a small set of parameters established for it. They have also published definitions for transducer blocks commonly used with standard function blocks. Examples include temperature, pressure, level, and flow transducer blocks.

The FOUNDATION specifications and definitions allow vendors to add their own parameters by importing and subclassing specified classes. This approach permits extending function block definitions as new requirements are discovered and as technology advances.

Figure 1-1 illustrates the internal structure of a function block. When execution begins, input parameter values from other blocks are snapped-in by the block. The input snap process ensures that these values do not change during the block execution. New values received for these parameters do not affect the snapped values and will not be used by the function block during the current execution.

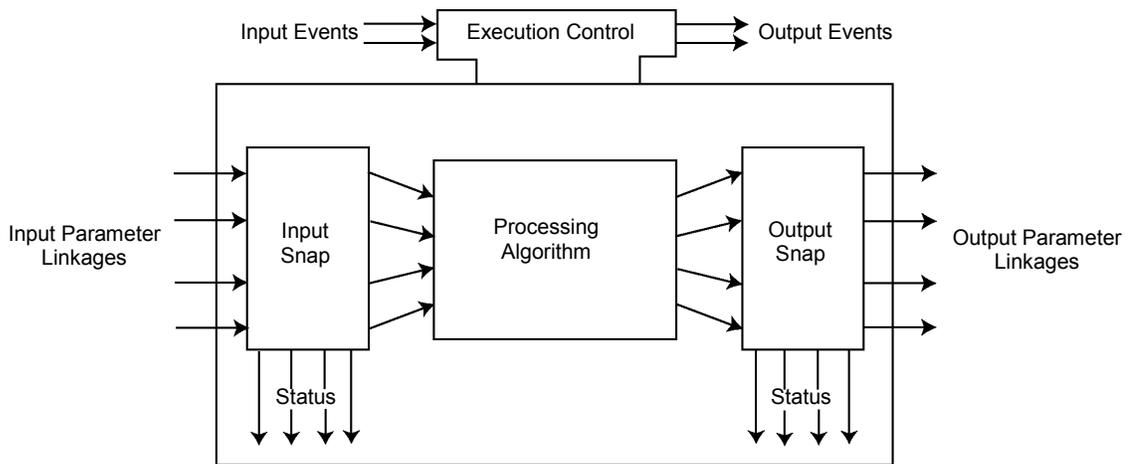


Figure 1-1. Function Block Internal Structure

Once the inputs are snapped, the algorithm operates on them, generating outputs as it progresses. Algorithm executions are controlled through the setting of contained parameters. Contained parameters are internal to function blocks and do not appear as normal input and output parameters. However, they may be accessed and modified remotely, as specified by the function block.

Input events may affect the operation of the algorithm. An execution control function regulates the receipt of input events and the generation of output events during execution of the algorithm. Upon completion of the algorithm, the data internal to the block is saved for use in the next execution, and the output data is snapped, releasing it for use by other function blocks.

A block is a tagged logical processing unit. The tag is the name of the block. System management services locate a block by its tag. Thus the service personnel need only know the tag of the block to access or change the appropriate block parameters.

Function blocks are also capable of performing short-term data collection and storage for reviewing their behavior.

1.2.2 Device Descriptions

Device Descriptions are specified tool definitions that are associated with the function blocks. Device descriptions provide for the definition and description of the function blocks and their parameters.

To promote consistency of definition and understanding, descriptive information, such as data type and length, is maintained in the device description. Device Descriptions are written using an open language called the Device Description Language (DDL). Parameter transfers between function blocks can be easily verified because all parameters are described using the same language. Once written, the device description can be stored on an external medium, such as a CD-ROM or diskette. Users can then read the device description from the external medium. The use of an open language in the device description permits interoperability of function blocks within devices from various vendors. Additionally, human interface devices, such as operator consoles and computers, do not have to be programmed specifically for each type of

device on the bus. Instead their displays and interactions with devices are driven from the device descriptions.

Device descriptions may also include a set of processing routines called methods. Methods provide a procedure for accessing and manipulating parameters within a device.

1.3 INSTRUMENT-SPECIFIC FUNCTIONS BLOCKS

In addition to function blocks, Fieldbus devices contain two other block types to support the function blocks. These are the resource block and the transducer block. The resource block contains the hardware specific characteristics associated with a device. Transducer blocks couple the function blocks to local input/output functions.

1.3.1 *Resource Blocks*

Resource blocks contain the hardware specific characteristics associated with a device; they have no input or output parameters. The algorithm within a resource block monitors and controls the general operation of the physical device hardware. The execution of this algorithm is dependent on the characteristics of the physical device, as defined by the manufacturer. As a result of this activity, the algorithm may cause the generation of events. There is only one resource block defined for a device. For example, when the mode of a resource block is “out of service,” it impacts all of the other blocks.

1.3.2 *Transducer Blocks*

Transducer blocks connect function blocks to local input/output functions. They read sensor hardware and write to effector (actuator) hardware. This permits the transducer block to execute as frequently as necessary to obtain good data from sensors and ensure proper writes to the actuator without burdening the function blocks that use the data. The transducer block also isolates the function block from the vendor specific characteristics of the physical I/O.

1.3.3 *Alerts*

When an alert occurs, execution control sends an event notification and waits a specified period of time for an acknowledgment to be received. This occurs even if the condition that caused the alert no longer exists. If the acknowledgment is not received within the pre-specified time-out period, the event notification is retransmitted. This assures that alert messages are not lost.

Two types of alerts are defined for the block, events and alarms. Events are used to report a status change when a block leaves a particular state, such as when a parameter crosses a threshold. Alarms not only report a status change when a block leaves a particular state, but also report when it returns back to that state.

1.4 NETWORK COMMUNICATION

Figure 1-2 illustrates a simple Fieldbus network consisting of a single segment (link).

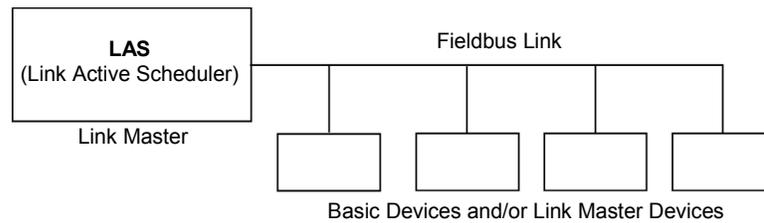


Figure 1-2. Single Link Fieldbus Network

1.4.1 Link Active Scheduler (LAS)

All links have one and only one Link Active Scheduler (LAS). The LAS operates as the bus arbiter for the link. The LAS does the following:

- ◆ recognizes and adds new devices to the link.
- ◆ removes non-responsive devices from the link.
- ◆ distributes Data Link (DL) and Link Scheduling (LS) time on the link. Data Link Time is a network-wide time periodically distributed by the LAS to synchronize all device clocks on the bus. Link Scheduling time is a link-specific time represented as an offset from Data Link Time. It is used to indicate when the LAS on each link begins and repeats its schedule. It is used by system management to synchronize function block execution with the data transfers scheduled by the LAS.
- ◆ polls devices for process loop data at scheduled transmission times.
- ◆ distributes a priority-driven token to devices between scheduled transmissions.

Any device on the link may become the LAS, as long as it is capable. The devices that are capable of becoming the LAS are called link master devices. All other devices are referred to as basic devices. When a segment first starts up, or upon failure of the existing LAS, the link master devices on the segment bid to become the LAS. The link master that wins the bid begins operating as the LAS immediately upon completion of the bidding process. Link masters that do not become the LAS act as basic devices. However, the link masters can act as LAS backups by monitoring the link for failure of the LAS and then bidding to become the LAS when a LAS failure is detected.

Only one device can communicate at a time. Permission to communicate on the bus is controlled by a centralized token passed between devices by the LAS. Only the device with the token can communicate. The LAS maintains a list of all devices that need access to the bus. This list is called the “Live List.”

Two types of tokens are used by the LAS. A time-critical token, compel data (CD), is sent by the LAS according to a schedule. A non-time critical token, pass token (PT), is sent by the LAS to each device in ascending numerical order according to address.

1.4.2 Device Addressing

Fieldbus uses addresses between 0 and 255. Addresses 0 through 15 are reserved for group addressing and for use by the data link layer. For all Fisher-Rosemount Fieldbus devices addresses 20 through 35 are available to the device. If there are two or more devices with the same address, the first device to start will use its programmed address. Each of the other devices will be given one of four temporary addresses between 248 and 251. If a temporary address is not available, the device will be unavailable until a temporary address becomes available.

1.4.3 Scheduled Transfers

Information is transferred between devices over the Fieldbus using three different types of reporting.

- **Publisher/Subscriber:** This type of reporting is used to transfer critical process loop data, such as the process variable. The data producers (publishers) post the data in a buffer that is transmitted to the subscriber (S), when the publisher receives the Compel data. The buffer contains only one copy of the data. New data completely overwrites previous data. Updates to published data are transferred simultaneously to all subscribers in a single broadcast. Transfers of this type can be scheduled on a precisely periodic basis.
- **Report Distribution:** This type of reporting is used to broadcast and multicast event and trend reports. The destination address may be predefined so that all reports are sent to the same address, or it may be provided separately with each report. Transfers of this type are queued. They are delivered to the receivers in the order transmitted, although there may be gaps due to corrupted transfers. These transfers are unscheduled and occur in between scheduled transfers at a given priority.
- **Client/Server:** This type of reporting is used for request/response exchanges between pairs of devices. Like Report Distribution reporting, the transfers are queued, unscheduled, and prioritized. Queued means the messages are sent and received in the order submitted for transmission, according to their priority, without overwriting previous messages. However, unlike Report Distribution, these transfers are flow controlled and employ a retransmission procedure to recover from corrupted transfers.

Figure 1-3 diagrams the method of scheduled data transfer. Scheduled data transfers are typically used for the regular cyclic transfer of process loop data between devices on the Fieldbus. Scheduled transfers use publisher/subscriber type of reporting for data transfer. The Link Active Scheduler maintains a list of transmit times for all publishers in all devices that need to be cyclically transmitted. When it is time for a device to publish data, the LAS issues a Compel Data (CD) message to the device. Upon receipt of the CD, the device broadcasts or “publishes” the data to all devices on the Fieldbus. Any device that is configured to receive the data is called a “subscriber.”

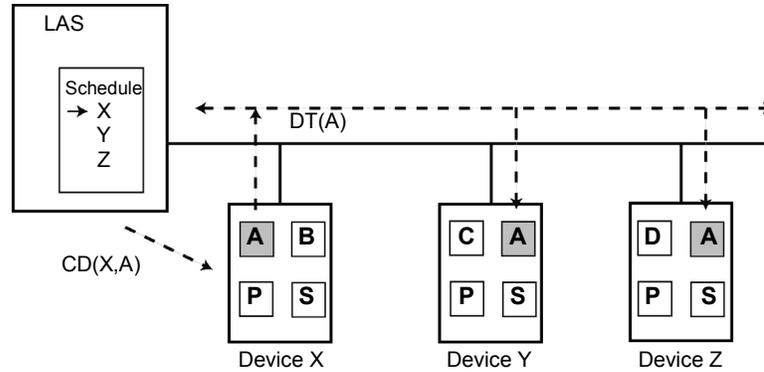


Figure 1-3. Scheduled Data Transfer

LAS = Link Active Scheduler
 P = Publisher
 S = Subscriber
 CD = Compel Data
 DT = Data Transfer Packet

1.4.4 Unscheduled Transfers

Figure 1-4 diagrams an unscheduled transfer. Unscheduled transfers are used for things like user-initiated changes, including set point changes, mode changes, tuning changes, and upload/download. Unscheduled transfers use either report distribution or client/server type of reporting for transferring data.

All of the devices on the Fieldbus are given a chance to send unscheduled messages between transmissions of scheduled data. The LAS grants permission to a device to use the Fieldbus by issuing a pass token (PT) message to the device. When the device receives the PT, it is allowed to send messages until it has finished or until the “maximum token hold time” has expired, whichever is the shorter time. The message may be sent to a single destination or to multiple destinations.

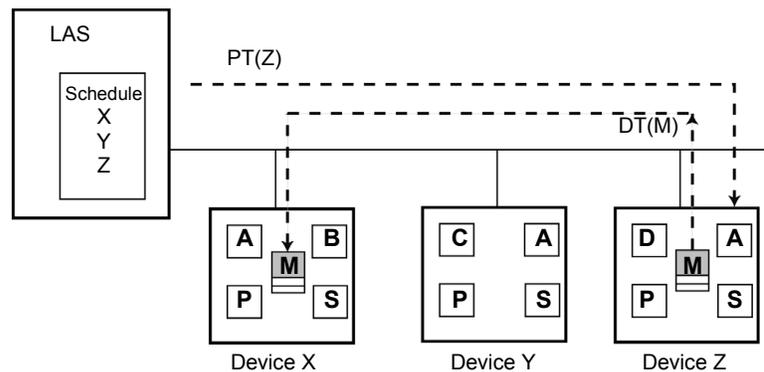


Figure 1-4. Unscheduled Data Transfer

LAS = Link Active Scheduler
 P = Publisher
 S = Subscriber
 P = Pass Token
 M = Message

1.4.5 Function Block Scheduling

Figure 1-5 shows an example of a link schedule. A single iteration of the link-wide schedule is called the macrocycle. When the system is configured and the function blocks are linked, a master link-wide schedule is created for the LAS. Each device maintains its portion of the link-wide schedule, known as the Function Block Schedule. The Function Block Schedule indicates when the function blocks for the device are to be executed. The scheduled execution time for each function block is represented as an offset from the beginning of the macrocycle start time.

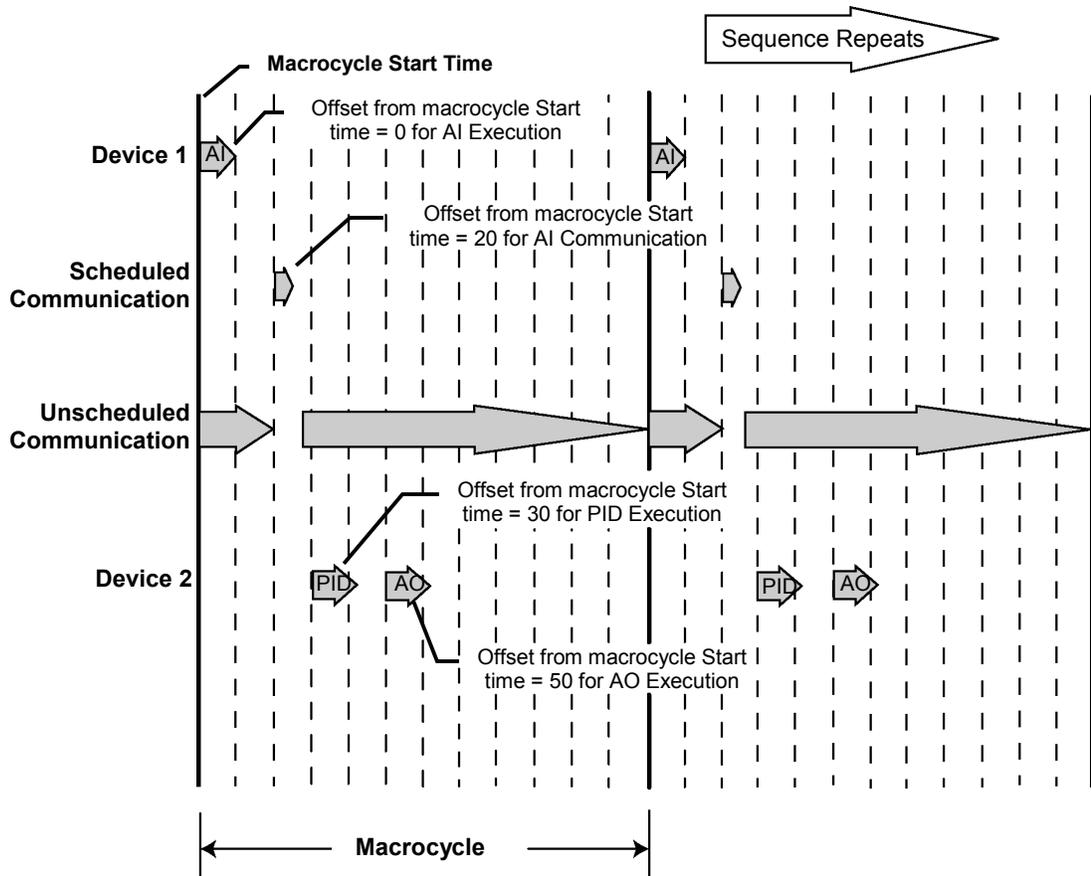


Figure 1-5. Example of Link Schedule
(Showing scheduled and unscheduled communication)

To support synchronization of schedules, periodically Link Scheduling (LS) time is distributed. The beginning of the macrocycle represents a common starting time for all Function Block schedules on a link and for the LAS link-wide schedule. This permits function block executions and their corresponding data transfers to be synchronized in time.

1.5 REFERENCES

The following *Fieldbus FOUNDATION* documents should be used to gain an understanding of Fieldbus, and are referenced wherever appropriate in the document:

Document Number	Document Title
FF-890	Fieldbus Foundation™ Fieldbus Specification — Function Block Application Process – Part 1
FF-891	Fieldbus Foundation™ Fieldbus Specification — Function Block Application Process – Part 2
FF-902	Fieldbus Foundation™ Fieldbus Specification — Transducer Block Application Process – Part 1
FF-903	Fieldbus Foundation™ Fieldbus Specification — Transducer Block Application Process – Part 2
RMD-D9800039	Rosemount Common Practice Resource Block Specification

1.5.1 *Fieldbus Foundation*

The Fieldbus Foundation is the leading organization dedicated to a single international, interoperable Fieldbus standard. Established in September 1994 by a merger of WorldFIP North America and the Interoperable Systems Project (ISP), the foundation is a not-for-profit corporation that consists of nearly 120 of the world's leading suppliers and end users of process control and manufacturing automation products. Working together, these companies have provided unparalleled support for a worldwide Fieldbus protocol, and have made major contributions to the IEC/ISA Fieldbus standards development.



Important differences exist between the Fieldbus Foundation and other Fieldbus initiatives. The foundation's technology - FOUNDATION Fieldbus - is unique inasmuch as it is designed to support mission-critical applications where the proper transfer and handling of data is essential. Unlike proprietary network protocols, FOUNDATION Fieldbus is neither owned by any individual company, or controlled by a single nation or regulatory body. Rather, it is an "open," interoperable Fieldbus that is based on the International Standards Organization's Open System Interconnect (OSI/ISO) seven-layer communications model. The FOUNDATION specification is compatible with the officially sanctioned SP50 standards project of The International Society for Measurement and Control (ISA) and the International Electrotechnical Committee (IEC).

Contact information:

9390 Research Blvd., Suite II-250 • Austin, Texas 78759-9780 USA

Tel: +1.512.794.8890 • Fax: +1.512.794.8893

Email: info@fieldbus.org

Internet: www.fieldbus.org

2 TRANSDUCER BLOCK SPECIFICATION

The Transducer Block Specification provides the information necessary to interface the CAT100 or the BINOS 100 2M to the Fieldbus. The data structures should be used for transferring Fieldbus information between the analyzer's Object Dictionary and other hosts and devices on Fieldbus.

Two tables are used to describe the analyzer parameters. The Parameter Descriptions table defines the relative index value used to reference the parameter in the analyzer Transducer Block Object Dictionary and the mnemonic used to reference the parameter, as well as the View(s) in which they are contained. This table also gives a brief description of the behavior of each of the parameters. The Parameter Attributes table describes the key attributes of each of the parameters.

The transmitter specific detailed status and its relationship to standard Fieldbus block alarms and errors are shown in a table in the Detailed Status section. The I/O channel assignments and their status values are shown in the Channel Assignments section.

Finally the default values for parameters are defined. Static parameters will be set to the default value when a restart with defaults is invoked in the Resource block. Dynamic parameter default values are specified to aid in configuring static simulations of the transducer block. For example, when creating a placeholder for this device in a host application's database.

Transducer Block

2.1 PARAMETER DESCRIPTIONS

This table gives a description of all the parameters or gives the location in the Fieldbus specifications where the description can be found. Parameter access is described in FF-890.

Table 2-1. Parameter Descriptions

Relative Index	Parameter Mnemonic	Description	View 1	View 2	View 3	View 4-1	View 4-2	View 4-3
63	AIR_PRESSURE	The current air pressure (in hPa): if pressure sensor is installed this is a dynamic variable; if no pressure sensor is installed we have to input the current value. If we use remote pressure we have to input via AO block. There we have to select appropriate CHANNEL assignment.	5		5			
4	ALERT_KEY	See FF-891 section 5.3.				1		
64	ANALYZER_OPTS	The installed analyzer options					2	
66	ANALYZER_SERIAL_NUMBER	The analyzer serial number					10	
67	ANALYZER_SW_VERSION	The version number of the analyzer software					32	
8	BLOCK_ALM	See FF-891 section 5.3.						
6	BLOCK_ERR	See FF-891 section 5.3.	2		2			
21	CAL_CONSTANT_1	The zero correction offset (calculated by zero calibration).				4		
42	CAL_CONSTANT_2	The zero correction offset (calculated by zero calibration).				4		
59	CAL_GAS_TIME	Purge delay time (in secs) for calibration gas supply					2	
18	CAL_MINIMUM_SPAN_1	See FF-903 section 3.3. In the BINOS, a calibration is used for checking the analyzer only. The calculation of the Primary Value is not effected.				4		
39	CAL_MINIMUM_SPAN_2	See FF-903 section 3.3. In the BINOS, a calibration is used for checking the analyzer only. The calculation of the Primary Value is not effected.				4		
58	CAL_OPTS	The calibration options.					1	
16	CAL_POINT_HI_1	See FF-903 section 3.3		4				
37	CAL_POINT_HI_2	See FF-903 section 3.3		4				
17	CAL_POINT_LO_1	See FF-903 section 3.3		4				

Transducer Block

Relative Index	Parameter Mnemonic	Description	View 1	View 2	View 3	View 4-1	View 4-2	View 4-3
38	CAL_POINT_LO_2	See FF-903 section 3.3		4				
22	CAL_PRESSURE_FACTOR_1	The factor of pressure influence onto concentration measurement. Relates pressure to pressure factor.			4			
43	CAL_PRESSURE_FACTOR_2	The factor of pressure influence onto concentration measurement. Relates pressure to pressure factor.			4			
20	CAL_SLOPE_1	This parameter represents the span correction factor (calculated by span calibration).				4		
41	CAL_SLOPE_2	This parameter represents the span correction factor (calculated by span calibration).				4		
56	CAL_STATE	This parameter represents the present state the calibration check cycle is in. Refer to table 1 for the definition of states.	1		1			
57	CAL_STEP	This parameter is used to initiate a zero or span calibration. See table 2 for the definition of states.			1			
19	CAL_UNIT_1	See FF-903 section 3.3.				2		
40	CAL_UNIT_2	See FF-903 section 3.3.				2		
65	CAL_VALVE_STATE	The state of the calibration gas valves.					1	
60	CAL_ZERO_INTERVAL	The time interval (in hours) for automatic zero calibrations of both channels.					2	
61	CAL_ZERO_SPAN_INTERVAL	The time interval (in hours) for automatic zero & span calibrations of both channels.					2	
12	COLLECTION_DIRECTORY	See FF-891 section 5.3.						
62	DETAILED_STATUS	This is a bit-enumerated value used to communicate the status of the BINOS (This is similar in nature to the command 48 status bits in HART). See Table 2-9.			4			
70	MEASUREMENT_OPTS	The different kind of options for the measurement.					1	
5	MODE_BLK	See FF-891 section 5.3.	4		4			
14	PRIMARY_VALUE_1	See FF-903 section 3.3.	5		5			
35	PRIMARY_VALUE_2	See FF-903 section 3.3.	5		5			
15	PRIMARY_VALUE_RANGE_1	See FF-903 section 3.3.				11		
36	PRIMARY_VALUE_RANGE_2	See FF-903 section 3.3.				11		

Transducer Block

Relative Index	Parameter Mnemonic	Description	View	View	View	View	View	View
			1	2	3	4-1	4-2	4-3
13	PRIMARY_VALUE_TYPE_1	See FF-903 section 3.3 and 4.1.		2				
34	PRIMARY_VALUE_TYPE_2	See FF-903 section 3.3 and 4.1.		2				
71	PUMP_CTRL	The instance of the device which controls the optional internal pump.					1	
69	REMOTE_EXCLUSIVE	This parameter disallows to switch into the local operator interface mode (switching in local operator interface mode would disable to change a parameter via FFBUS). After a timeout period without writing to parameters the exclusive mode will be disabled again.					1	
68	REMOTE_SECURITY	This parameter controls access to the special service transducer block parameters. A special access code must be entered to enable changes to this static service parameters. After a timeout period, the parameter will be reset to 0 and access will be restricted. While service parameter access is enabled, parameters may not be changed via the local operator interface on the field device.					2	
74	SENSOR_CAL_DATE	See FF-903 section 3.3.						7
73	SENSOR_CAL_LOC	See FF-903 section 3.3.						32
72	SENSOR_CAL_METHOD	See FF-903 sections 3.3 and 4.5.						1
75	SENSOR_CAL_WHO	See FF-903 section 3.3.						32
29	SENSOR_CROSS_INTF_OFFSET_1	The zero correction of cross interference compensation.				4		
50	SENSOR_CROSS_INTF_OFFSET_2	The zero correction of cross interference compensation.					4	
55	SENSOR_DETECTOR_SEL	This parameter assigns compensation defaults for installed detector type.					1	
25	SENSOR_FILTER_VALUE_1	The t90 response time (in secs) for gas change.				4		
46	SENSOR_FILTER_VALUE_2	The t90 response time (in secs) for gas change.				4	4	
33	SENSOR_GAS_TYPE_1	The measurement type and assigns compensation defaults for gas type.				1		
54	SENSOR_GAS_TYPE_2	The measurement type and assigns compensation defaults for gas type.					1	
24	SENSOR_ID_1	The id description of the channel sensor.				20		
45	SENSOR_ID_2	The id description of the channel sensor.				20	20	
32	SENSOR_NOISE_REDUCTION_1	This parameter represents the value for dynamic noise reduction.				4		
53	SENSOR_NOISE_REDUCTION_2	This parameter represents the value for dynamic noise reduction.					4	

Transducer Block

Relative Index	Parameter Mnemonic	Description	View	View	View	View	View	View
			1	2	3	4-1	4-2	4-3
31	SENSOR_PRESSURE_FACTOR_1	This parameter represents the span correction of pressure compensation.				4		
52	SENSOR_PRESSURE_FACTOR_2	This parameter represents the span correction of pressure compensation.					4	
26	SENSOR_RAW_CONCENTRATION_1	This parameter represents the raw value of A/D-Conversion of measurement channel.			4			
47	SENSOR_RAW_CONCENTRATION_2	This parameter represents the raw value of A/D-Conversion of measurement channel.			4			
27	SENSOR_RAW_TEMPERATURE_1	This parameter represents the raw value of A/D-Conversion of temperature measurement.			4			
48	SENSOR_RAW_TEMPERATURE_2	This parameter represents the raw value of A/D-Conversion of temperature measurement.			4			
30	SENSOR_TEMP_FACTOR_1	This parameter represents the span correction of temperature compensation.				4		
51	SENSOR_TEMP_FACTOR_2	This parameter represents the span correction of temperature compensation.					4	
28	SENSOR_TEMP_OFFSET_1	This parameter represents the zero correction of temperature compensation.			4			
49	SENSOR_TEMP_OFFSET_2	This parameter represents the zero correction of temperature compensation.			4			
23	SENSOR_TYPE_1	See FF-903 section 3.3 and 4.3.				2		
44	SENSOR_TYPE_2	See FF-903 section 3.3 and 4.3.				2	2	
1	ST_REV	See FF-891 section 5.3.	2	2	2	2	2	2
76	STATS_ATTEMPTS	Total number of messages sent to the transducer a/d board.			4			
77	STATS_FAILURES	Total number of failed a/d board message attempts.			4			
78	STATS_TIMEOUTS	Total number of timed out a/d board message attempts.			4			
3	STRATEGY	See FF-891 section 5.3.				2		
2	TAG_DESC	See FF-891 section 5.3.						
9	TRANSDUCER_DIRECTORY	See FF-903 section 3.3.						
10	TRANSDUCER_TYPE	See FF-903 sections 3.3.	2	2	2	2		
7	UPDATE_EVT	See FF-891 section 5.3.						
11	XD_ERROR	See Table 2-9 and FF-903 section 3.3.	1		1			

Transducer Block

2.2 PARAMETER ATTRIBUTE DEFINITIONS

The parameters not described in FF-891 or FF-903 are described in the following table. This table also includes some parameters defined in FF-891 or FF-903, but are redefined for this application. This table has the same definitions as the one in FF-891, except that the columns for Use/Model and Direction have been omitted because all parameters are contained. Refer to FF-891, section 5 (Block Parameters), for a further explanation of this table.

Table 2-2. Parameter Attribute Definitions

Parameter Mnemonic	Obj Type	Data Type/Structure	Store	Size	Valid Range	Initial Value	Units	Mode	Other	Range Check
AIR_PRESSURE	S	DS-65	D/S	45	800.0-1300.0	1013	hPa		Note 1	Note 5
ANALYZER_OPTS	S	Unsigned16	S	2			Bit String	O/S	Note 2	
ANALYZER_SERIAL_NUMBER	S	Octet String	S	10			N/A	O/S	Note 2	
ANALYZER_SW_VERSION	S	Octet String	N	32			N/A		Read Only	
CAL_CONSTANT_n	S	Floating Point	D	4					Read Only	
CAL_GAS_TIME	S	Unsigned16	S	2			Sec		Note 3	Yes
CAL_OPTS	S	Unsigned8	S	1			Bit String		Note 3	Yes
CAL_POINT_HI_n	S	Floating Point	S	4					Note 3	Yes
CAL_POINT_LO_n	S	Floating Point	S	4					Note 3	Yes
CAL_PRESSURE_FACTOR_n	S	Floating Point	D	4					Read Only	
CAL_SLOPE_n	S	Floating Point	D	4					Read Only	
CAL_STATE	S	Unsigned8	D	1	See Table 2-3	0	Enumerated		Read Only	
CAL_STEP	S	Unsigned8	D/S	1		0	Enumerated		Note 3	Yes
CAL_UNIT_n	S	Unsigned16	S	2	See FF-903 section 4.10 Units Codes		Enumerated	O/S	Note 2	
CAL_VALVE_STATE	S	Unsigned8	D/S	1			Bit String		Note 3	Yes
CAL_ZERO_INTERVAL	S	Unsigned16	S	2	0-399		Hours		Note 3	Yes
CAL_ZERO_SPAN_INTERVAL	S	Unsigned16	S	2	0-399		Hours		Note 3	Yes

Transducer Block

Parameter Mnemonic	Obj Type	Data Type/Structure	Store	Size	Valid Range	Initial Value	Units	Mode	Other	Range Check
DETAILED_STATUS	S	Unsigned32	D	4	See Table 2-9		Bit String		Read Only	
MEASUREMENT_OPTS	S	Unsigned8	S	1	See Table 2-10		Bit String	O/S	Note 3	
PRIMARY_VALUE_RANGE_n	R	DS-68	S	11	0-100%		PRV	O/S	Note 2	
PRIMARY_VALUE_TYPE_n	S	Unsigned16	N	2	See section 4.1 in FF-903	65535 (other)	Enumerated		Read Only	
PUMP_CTRL	S	Unsigned8	S	1	See Table 2-8		Enumerated	O/S	Note 3	Yes
REMOTE_EXCLUSIVE	S	Unsigned8	S	1	0-1	0	Bit String		Note 4	Yes
REMOTE_SECURITY	S	Unsigned16	S	2	0-9999	0			Note 4	Yes
SENSOR_CROSS_INTF_OFFSET_n	S	Floating Point	D	4					Read Only	Yes
SENSOR_DETECTOR_SEL	S	Unsigned16	S	2				O/S	Note 2	
SENSOR_FILTER_VALUE	S	Unsigned16	S	2	2-60		Sec		Note 3	Yes
SENSOR_GAS_TYPE	S	Unsigned8	S	1			Enumerated	O/S	Note 2	
SENSOR_ID_n	S	Octet String	S	20				O/S	Note 2	
SENSOR_NOISE_REDUCTION_n	S	Unsigned16	S	2				O/S	Note 2	
SENSOR_PRESSURE_FACTOR_n	S	Floating Point	D	4					Read Only	
SENSOR_RAW_CONCENTRATION_n	S	Floating Point	D	4			ADC Counts		Read Only	
SENSOR_RAW_TEMPERATURE_n	S	Floating Point	D	4			ADC Counts		Read Only	
SENSOR_TEMP_FACTOR_n	S	Floating Point	D	4					Read Only	
SENSOR_TEMP_OFFSET_n	S	Floating Point	D	4					Read Only	
SENSOR_TYPE_n	S	Unsigned16	N	2	See FF-903 section 4.2 Transducer Types	65535 (ZrO2)	Enumerated		Read Only	
STATS_ATTEMPTS	S	Unsigned32	D	4	0-16777215	0			Read Only	
STATS_FAILURES	S	Unsigned32	D	4	0-16777215	0			Read Only	
STATS_TIMEOUTS	S	Unsigned32	D	4	0-16777215	0			Read Only	

Note 1: Read only if “Pressure sensor installed” bit ANALYZER_OPTS is set or “LOCAL_MODE” bit in DETAILED_STATUS is set, otherwise is Writable in OOS.

Transducer Block

Note 2: This parameter is Read Only unless the SERVICE_MODE bit is on in the DETAILED_STATUS word when it is Writable in OOS only.

Note 3: This parameter is Read Only if the "LOCAL_MODE" bit is on in the DETAILED_STATUS word.

Note 4: When writing to this parameter, also cause the host application to re-read REMOTE_SECURITY and REMOTE_EXCLUSIVE.

Note 5: Range check is only done if bits "Pressure sensor installed" and "External pressure measurement enabled" of ANALYZER_OPTS are cleared.

2.3 PARAMETER ACCESS METHODS

In the CAT 100 or BINOS100 it is possible to access parameters by the Local Operator Interface (LOI) (which is the front panel using the keys) and/or by the Foundation Fieldbus option (remote).

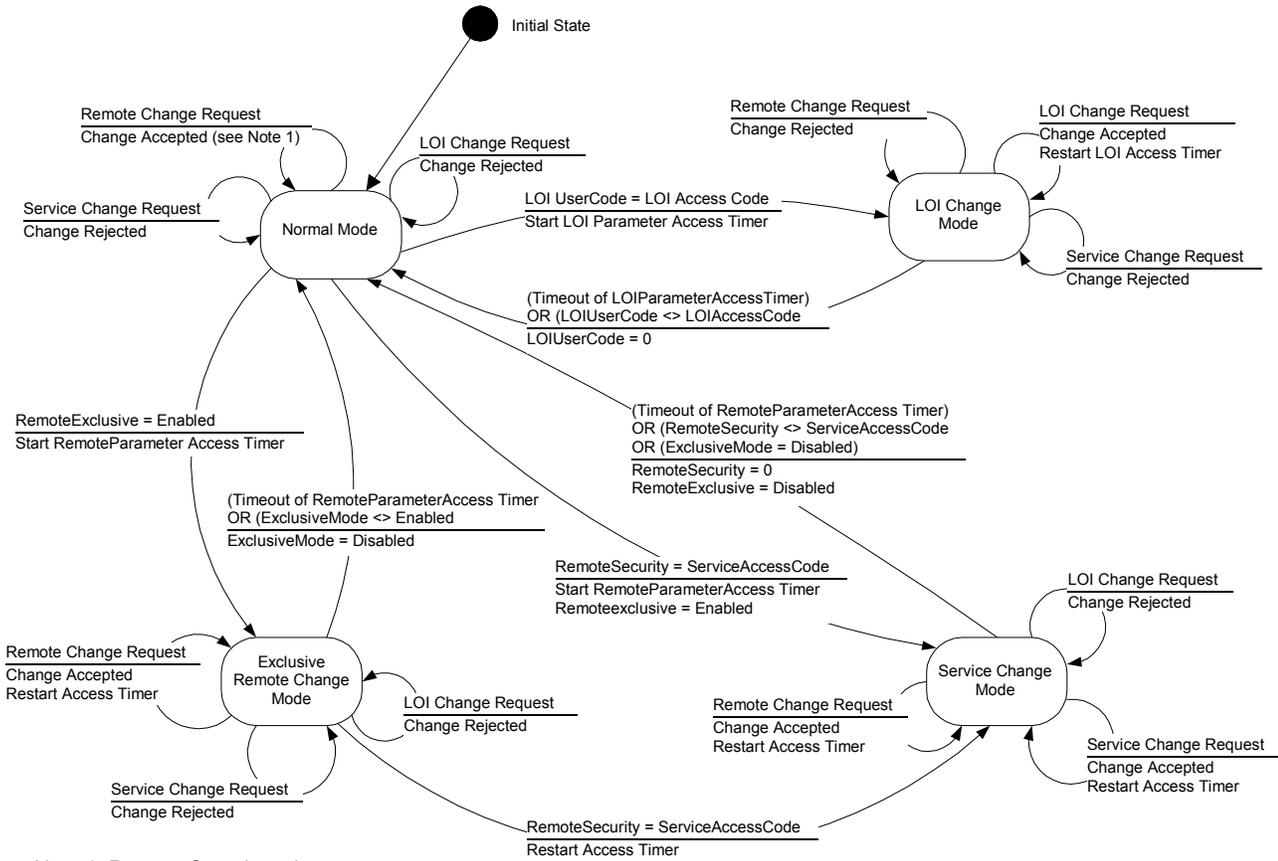
Also there is a distinction between normal "user parameters" and "service parameters." With *user* parameters the user is able for example to configure different measurement modes such as start, calibration procedures, etc. The *service* parameters are ones which are used by Rosemount service people. They use these parameters to install different options, configure measurement ranges or do some optimizations for the instrument.

There are four different access modes, **Normal**, **LOI Change Mode**, **Exclusive Remote Change Mode** and **Service Change Mode**. In all four modes the Foundation Fieldbus option is allowed to read *user* as well as *service* parameters. But to write parameters depends on the current mode.

- Normal:** In this mode "user parameters" can be written remotely by the FF option. *Service* parameters cannot be changed remotely nor can any parameter be changed by the LOI. This mode is also the only mode with access to all the other modes.
- LOI Change Mode:** This is the only mode allowing read/write access to *user* parameters by the local operator interface (LOI). This mode can be accessed from the "Normal" mode by entering the correct LOIUserCode on the front panel.
Going into this mode also starts a timer (LOI Parameter Access Timer). Changing any parameter restarts this timer. If a timeout of this timer occurs (no access of a parameter for a certain time) the mode automatically switches back to "Normal" mode.
- Exclusive Remote Change Mode:** For remote parameter access this mode is similar to the "Normal" mode, the difference being that it is not possible to go into the "LOI Change Mode."
This mode may be accessed by setting the "RemoteExclusive" parameter to "Enabled." Going into this mode also starts a timer (RemoteParameterAccessTimer) which will cause an automatic transition to Normal mode if no parameter is accessed for a certain time.
- Service Change Mode:** The "Service Change" mode is the only mode which allows full remote access to all parameters (*user* and *service* parameters). This mode may be accessed by setting the "RemoteSecurity" parameter to the correct ServiceAccessCode which is known only by Rosemount service staff.
Going into this mode also starts a timer (RemoteParameterAccessTimer) which will cause an automatic transition into Normal mode if no parameter is accessed for a certain time.

The block diagram in Figure 2-1 below shows the relationships and entry between the four access modes.

Transducer Block



Note 1: Remote Security value always reads 0 no matter what value it has been changed to.

Figure 2-1. Parameter Access

2.4 ENUMERATIONS

2.4.1 Calibration Check Status

Value	CAL_STATE - Description
0	Normal
1	Zeroing Sensor 1
2	Zeroing Sensor 2
3	Zeroing 1&2
4	Spanning Sensor 1
5	Spanning Sensor 2
6	Purging Process Sample Gas

Table 2-3. Calibration Check Status Enumerations (CAL_STATE)

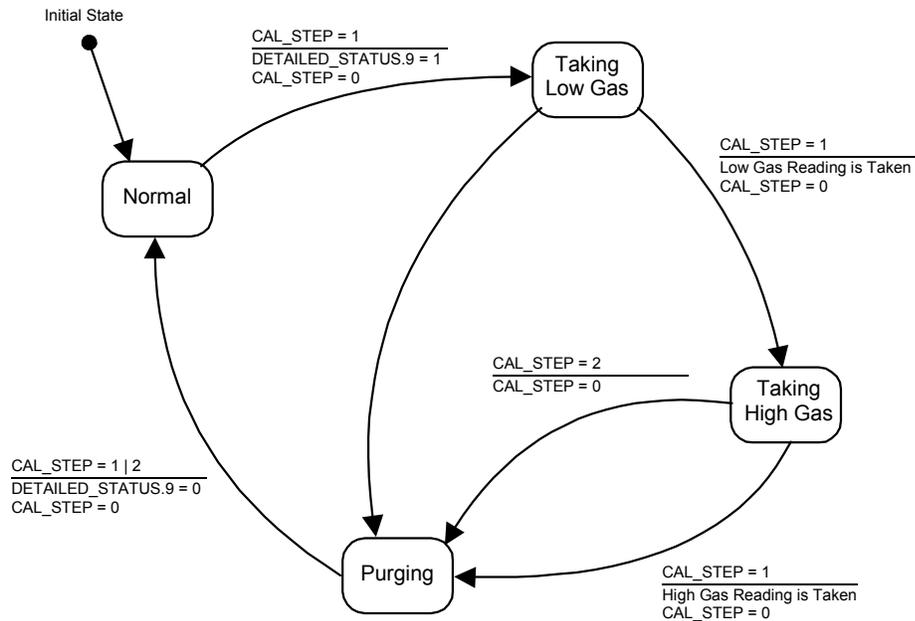


Figure 2-2. Calibration Check State Diagram

2.4.2 Calibration Check Step Control

Value	CAL_STATE - Description
0	No Action
1	Zero Sensor 1
2	Zero Sensor 2
3	Zero Sensor 1&2
4	Span Sensor 1
5	Span Sensor 2
6	Complete Calibration Sensor 1&2
7	Span Sensor 1&2

Table 2-4. Calibration Check Step Control Enumerations (CAL_STEP)

2.4.3 Sensor Gas Type

Value	SENSOR_GAS_TYPE - Description
0	Inactive
1	Default Setting Type 1
2	Default Setting Type 2
3	Default Setting Type 3
4	Default Setting Type 4
5	Default Setting Type 5
6	Analog Flow Sensor
7	Analog Pressure Sensor

**Table 2-5. Sensor Gas Type
(SENSOR_GAS_TYPE)**

2.4.4 Analyzer Options

Bit Number	Value Of ANALYZER_OPTS	Pneumonic	Description
0	0x0001		Linearization compensation enabled for sensor 1
1	0x0002		Linearization compensation enabled for sensor 2
2	0x0004		Temperature zero compensation enabled for sensor 1
3	0x0008		Temperature zero compensation enabled for sensor 2
4	0x0010		Temperature span compensation enabled for sensor 1
5	0x0020		Temperature span compensation enabled for sensor 2
6	0x0040		Analog preamp gain high for sensor 1
7	0x0080		Analog preamp gain high for sensor 2
8	0x0100		Differential measurement mode used for sensor 1
9	0x0200		Differential measurement mode used for sensor 2
10	0x0400	INTRL_PUMP	Internal pump installed
11	0x0800	INTRL_VALVES	Internal valve unit installed
12	0x1000	PRES_SENSOR	Pressure sensor installed
13	0x2000	DIG_INPUTS	Digital inputs installed
14	0x4000	PUMP_KEY	Front Panel with Pump-Key installed
15	0x8000	PRES_EXTRL	External pressure measurement enabled.

Notes: It is not possible to set PRES_SENSOR and PRES_EXTRL in parallel. If this were to happen, PRES_SENSOR bit would be set and PRES_EXTRL bit would be cleared.

Also, it is not possible to set PUMP_KEY without setting INTRL_PUMP. If this were to happen, both PUMP_KEY and INTRL_PUMP bits would be cleared.

Table 2-6. Analyzer Options

2.4.5 Calibration Options

Bit Number	Value Of CAL_OPTS	Description
0	0x0001	Cross-Compensation Calibration Enabled
1	0x0002	Automatic Calibration Enabled
2	0x0004	Calibration Tolerance Check Enabled
3	0x0008	Clear Tolerance Failures after some minutes

Note: It is not possible to set bit 3 without setting bit 2. If this were to happen, both bits 2 and 3 would be cleared.

Table 2-7. Calibration Options

2.4.6 Calibration Valve Control

Bit Number	Value Of CAL_VALVE_STATE	Description
0	0x0001	Sample Gas Valve for Sensor 1
1	0x0002	Sample Gas Valve for Sensor 2
2	0x0004	Zero Gas Valve for Sensor 1
3	0x0008	Zero Gas Valve for Sensor 2
4	0x0010	Span Gas Valve for Sensor 1
5	0x0020	Span Gas Valve for Sensor 2
6	0x0040	Internal Pump Running

Table 2-8. Calibration Valve Control

2.4.7 Detailed Status

Alarm Number	Value Of DETAILED_STATUS	Description	Value of XD_ERROR (see FF-903)
0	0	No Alarm Active	NONE
1	0x00000001	Factory configuration is loaded	CONFIGURATION_ERROR
2	0x00000002	Concentration measurement for sensor 1 is not running.	IO_FAILURE
3	0x00000004	Concentration measurement for sensor 2 is not running.	IO_FAILURE
4	0x00000008	Temperature measurement is not running	IO_FAILURE
5	0x00000010	Zero calibration tolerance check failure for sensor 1	CALIBRATION_FAILURE
6	0x00000020	Zero calibration tolerance check failure for sensor 2	CALIBRATION_FAILURE
7	0x00000040	Span calibration tolerance check failure for sensor 1	CALIBRATION_FAILURE
8	0x00000080	Span calibration tolerance check failure for sensor 2	CALIBRATION_FAILURE
9	0x00000100	Measurement range overflow – sensor 1	ALGORITHM_ERROR
10	0x00000200	Measurement range overflow – sensor 2	ALGORITHM_ERROR
11	0x00000400	Span gas does not match measurement range for sensor 1	CONFIGURATION_ERROR
12	0x00000800	Span gas does not match measurement range for sensor 2	CONFIGURATION_ERROR
13	0x00001000	installed air pressure sensor delivers erroneous measurement	IO_FAILURE
14	0x00002000	checksum of EPROM is erroneous	ELECTRICAL_FAILURE
15	0x00004000	erroneous RAM-test	DATA_INTEGRITY_ERROR
16	0x00008000	EXCLUSIVE_MODE parameter access enabled	NONE
17	0x00010000	LOCAL_MODE parameter access enabled	NONE
18	0x00020000	SERVICE_MODE access enabled	NONE
19	0x00040000	No valid sample gas measurement running	NONE
20	0x00080000	Installed pump is not running	NONE

Table 2-9. Detailed Status

2.4.8 Measurement Options

Bit Number	Value Of MEASUREMENT_OPTS	Description
0	0x0001	Cross-Compensation Enabled

Table 2-10. Measurement Options

Transducer Block

2.4.9 Pump Controller

Value	PUMP_CTRL – Description	Qualifying ANALYZER_OPT Bits		
		INTRL_PUMP	DIG_INPUTS	PUMP_KEY
0	Front Panel Key			X
1	System Parameter 'PUMP'	X		
2	Digital Input		X	

Table 2-11. Pump Controller

2.4.10 Remote Exclusive Access

Bit Number	Value Of REMOTE_EXCLUSIVE	Description
0	0x0001	REMOTE_EXCLUSIVE mode enabled

Table 2-12. Remote Exclusive Access

2.4.11 Channel Assignments

Transducer Block Channel Value	Process Variable	XD_SCALE UNITS
1	Sensor 1 PV	%, ppm
2	Sensor 2 PV	%, ppm
4	Air Pressure (read)	hPa

Table 2-13. I/O Channel Assignments (AI Blocks)

Transducer Block Channel Value	Process Variable	XD_SCALE UNITS
3	Air Pressure (write)	hPa

Table 2-14. I/O Channel Assignments (AO Blocks)

The assignment of air pressure is only possible if the device has enabled the external pressure measurement (see Analyzer Options).

2.5 SUPPORTED BLOCK ERRORS

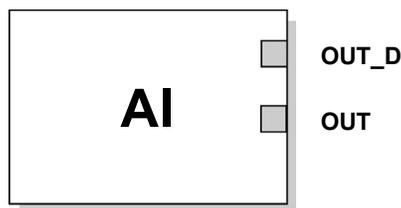
2.5.1 Transducer Block

- ◆ Out of Service
Set whenever the transducer block actual mode is “oos.”
- ◆ Block Configuration Error
Set whenever there is a communication error between the round board and the a/d board.
- ◆ Other Error
Set whenever XD_ERROR is non-zero.

2.5.2 *Resource Block*

- ◆ Out of Service
Set whenever the resource block actual mode is “oos.”
- ◆ Power Up
- ◆ Block Configuration Error
Configuration error is used to indicate that the user selected an item in FEATURES_SEL or CYCLE_SEL that was not set in FEATURES or CYCLE_TYPE respectively.
- ◆ Simulate Active
Set whenever the simulate enable switch is set on the Fieldbus Interface card.

3 ANALOG INPUT (AI) FUNCTION BLOCK



OUT = The block output value and status
OUT_D = Discrete output that signals a selected alarm condition

The Analog Input (AI) function block processes field device measurements and makes them available to other function blocks. The output value from the AI block is in engineering units and contains a status indicating the quality of the measurement. The measuring device may have several measurements or derived values available in different channels. Use the channel number to define the variable that the AI block processes.

The AI block supports alarming, signal scaling, signal filtering, signal status calculation, mode control, and simulation. In Automatic mode, the block's output parameter (OUT) reflects the process variable (PV) value and status. In Manual mode, OUT may be set manually. The Manual mode is reflected on the output status. A discrete output (OUT_D) is provided to indicate whether a selected alarm condition is active. Alarm detection is based on the OUT value and user specified alarm limits. Figure 3-1 on page 3–3 illustrates the internal components of the AI function block, and Table 3-1 lists the AI block parameters and their units of measure, descriptions, and index numbers.

Table 3-1. Definitions of Analog Input Function Block System Parameters.

Parameter	Index Number	Units	Description
ACK_OPTION	23	None	Used to set auto acknowledgment of alarms.
ALARM_HYS	24	Percent	The amount the alarm value must return within the alarm limit before the associated active alarm condition clears.
ALARM_SEL	38	None	Used to select the process alarm conditions that will cause the OUT_D parameter to be set.
ALARM_SUM	22	None	The summary alarm is used for all process alarms in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status parameter. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.
ALERT_KEY	04	None	The identification number of the plant unit. This information may be used in the host for sorting alarms, etc.
BLOCK_ALM	21	None	The block alarm is used for all configuration, hardware, connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status parameter. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.

Analog Input Function Block

Parameter	Index Number	Units	Description
BLOCK_ERR	06	None	This parameter reflects the error status associated with the hardware or software components associated with a block. It is a bit string, so that multiple errors may be shown.
CHANNEL	15	None	The CHANNEL value is used to select the measurement value. Refer to the appropriate device manual for information about the specific channels available in each device. The CHANNEL parameter must be configured before configuring the XD_SCALE parameter.
FIELD_VAL	19	Percent	The value and status from the transducer block or from the simulated input when simulation is enabled.
GRANT_DENY	12	None	Options for controlling access of host computers and local control panels to operating, tuning, and alarm parameters of the block. Not used by device.
HI_ALM	34	None	The HI alarm data, which includes a value of the alarm, a timestamp of occurrence and the state of the alarm.
HI_HI_ALM	33	None	The HI HI alarm data, which includes a value of the alarm, a timestamp of occurrence and the state of the alarm.
HI_HI_LIM	26	EU of PV_SCALE	The setting for the alarm limit used to detect the HI HI alarm condition.
HI_HI_PRI	25	None	The priority of the HI HI alarm.
HI_LIM	28	EU of PV_SCALE	The setting for the alarm limit used to detect the HI alarm condition.
HI_PRI	27	None	The priority of the HI alarm.
IO_OPTS	13	None	Allows the selection of input/output options used to alter the PV. Low cutoff enabled is the only selectable option.
L_TYPE	16	None	Linearization type. Determines whether the field value is used directly (Direct), is converted linearly (Indirect), or is converted with the square root (Indirect Square Root).
LO_ALM	35	None	The LO alarm data, which includes a value of the alarm, a timestamp of occurrence and the state of the alarm.
LO_LIM	30	EU of PV_SCALE	The setting for the alarm limit used to detect the LO alarm condition.
LO_LO_ALM	36	None	The LO LO alarm data, which includes a value of the alarm, a timestamp of occurrence and the state of the alarm.
LO_LO_LIM	32	EU of PV_SCALE	The setting for the alarm limit used to detect the LO LO alarm condition.
LO_LO_PRI	31	None	The priority of the LO LO alarm.
LO_PRI	29	None	The priority of the LO alarm.
LOW_CUT	17	%	If percentage value of transducer input fails below this, PV = 0.
MODE_BLK	05	None	The actual, target, permitted, and normal modes of the block. Target: The mode to "go to" Actual: The mode the "block is currently in" Permitted: Allowed modes that target may take on Normal: Most common mode for target
OUT	08	EU of OUT_SCALE	The block output value and status.
OUT_D	37	None	Discrete output to indicate a selected alarm condition.
OUT_SCALE	11	None	The high and low scale values, engineering units code, and number of digits to the right of the decimal point associated with OUT.
PV	07	EU of XD_SCALE	The process variable used in block execution.
PV_FTIME	18	Seconds	The time constant of the first-order PV filter. It is the time required for a 63% change in the IN value.
SIMULATE	09	None	A group of data that contains the current transducer value and status, the simulated transducer value and status, and the enable/disable bit.
STRATEGY	03	None	The strategy field can be used to identify grouping of blocks. This data is not checked or processed by the block.
ST_REV	01	None	The revision level of the static data associated with the function block. The revision value will be incremented each time a static parameter value in the block is changed.

Analog Input Function Block

Parameter	Index Number	Units	Description
TAG_DESC	02	None	The user description of the intended application of the block.
UPDATE_EVT	20	None	This alert is generated by any change to the static data.
VAR_INDEX	39	% of OUT Range	The average absolute error between the PV and its previous mean value over that evaluation time defined by VAR_SCAN.
VAR_SCAN	40	Seconds	The time over which the VAR_INDEX is evaluated.
XD_SCALE	10	None	The high and low scale values, engineering units code, and number of digits to the right of the decimal point associated with the channel input value. The XD_SCALE units code must match the units code of the measurement channel in the transducer block. If the units do not match, the block will not transition to MAN or AUTO.

3.1 SIMULATION

To support testing, either change the mode of the block to manual and adjust the output value, or enable simulation through the configuration tool and manually enter a value for the measurement value and its status. In both cases, the ENABLE jumper on the field device must first be set.

NOTE:

All Fieldbus instruments have a simulation jumper. As a safety measure, the jumper has to be reset every time there is a power interruption. This measure is to prevent devices that went through simulation in the staging process from being installed with simulation enabled.

With simulation enabled, the actual measurement value has no impact on the OUT value or the status.

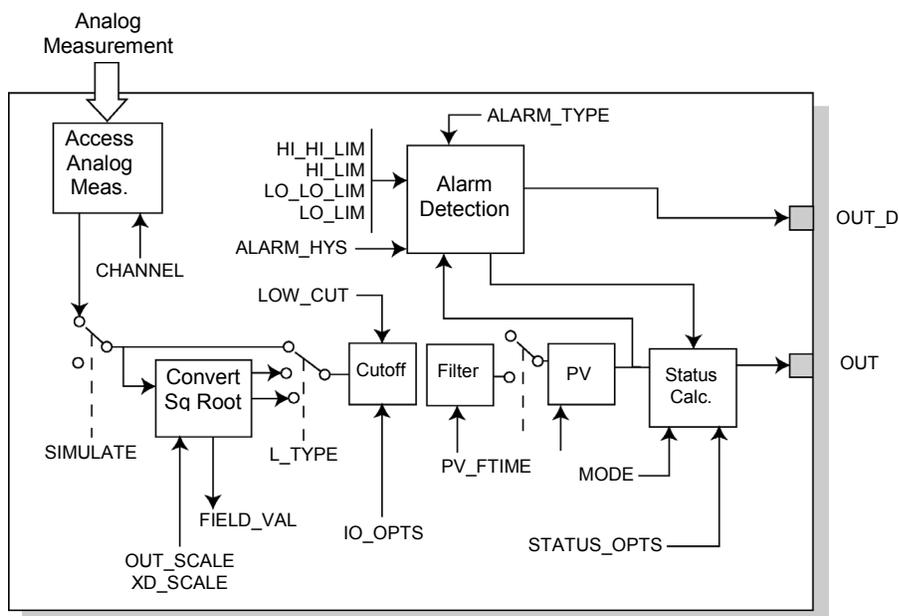


Figure 3-1. Analog Input Function Block Schematic

OUT = The block output value and status
OUT_D = Discrete output that signals a selected alarm condition

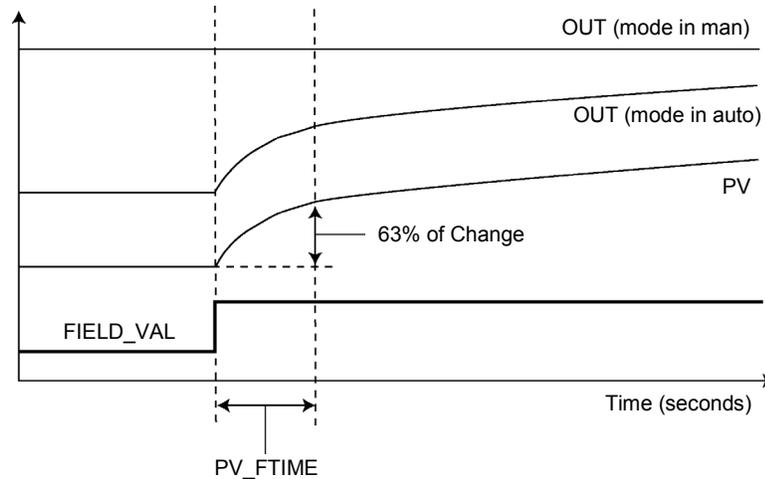


Figure 3-2. Analog Input Function Block Timing Diagram

3.2 FILTERING

The filtering feature changes the response time of the device to smooth variations in output readings caused by rapid changes in input. The filter time constant (in seconds) can be adjusted using the PV_FTIME parameter. Set the filter time constant to zero to disable the filter feature.

3.3 SIGNAL CONVERSION

Set the signal conversion type with the Linearization Type (L_TYPE) parameter. View the converted signal (in percent of XD_SCALE) through the FIELD_VAL parameter.

$$\text{FIELD_VAL} = \frac{100 \times (\text{Channel Value} - \text{EU} * @0\%)}{(\text{EU} * @100\% - \text{EU} * @0\%)}$$

*XD_SCALE values

Choose from direct, indirect, or indirect square root signal conversion with the L_TYPE parameter.

Direct

Direct signal conversion allows the signal to pass through the accessed channel input value (or the simulated value when simulation is enabled).

$$\text{PV} = \text{Channel Value}$$

Indirect

Indirect signal conversion converts the signal linearly to the accessed channel input value (or the simulated value when simulation is enabled) from its specified range (XD_SCALE) to the range and units of the PV and OUT parameters (OUT_SCALE).

$$PV = \left(\frac{\text{FIELD_VAL}}{100} \right) \times (\text{EU}^{**} @ 100\% - \text{EU}^{**} @ 0\%) + \text{EI}^{**} @ 0\%$$

*OUT_SCALE values

Indirect Square Root

Indirect Square Root signal conversion takes the square root of the value computed with the indirect signal conversion and scales it to the range and units of the PV and OUT parameters.

$$PV = \sqrt{\left(\frac{\text{FIELD_VAL}}{100} \right) \times (\text{EU}^{**} @ 100\% - \text{EU}^{**} @ 0\%) + \text{eu}^{**} @ 0\%}$$

*OUT_SCALE values

When the converted input value is below the limit specified by the LOW_CUT parameter, and the Low Cutoff I/O option (IO_OPTS) is enabled (True), a value of zero is used for the converted value (PV). This option is useful to eliminate false readings when the differential pressure measurement is close to zero, and it may also be useful with zero-based measurement devices such as flow meters.

NOTE: Low Cutoff is the only I/O option supported by the AI block. It is possible to set the I/O option in Manual or Out of Service mode only.

3.4 BLOCK ERRORS

Table 3-2 lists conditions reported in the BLOCK_ERR parameter. Conditions in *italics* are inactive for the AI block and are given here only for reference.

Table 3-2. Block Error Conditions

Condition Number	Condition Name and Description
0	<i>Other</i>
1	Block Configuration Error: the selected channel carries a measurement that is incompatible with the engineering units selected in XD_SCALE, the L_TYPE parameter is not configured, or CHANNEL = zero.
2	<i>Link Configuration Error</i>
3	Simulate Active: Simulation is enabled and the block is using a simulated value in its execution.
4	<i>Local Override</i>
5	<i>Device Fault State Set</i>
6	<i>Device Needs Maintenance Soon</i>
7	Input Failure/Process Variable has Bad Status: The hardware is bad, or a bad status is being simulated.
8	Output Failure: The output is bad based primarily upon a bad input.
9	<i>Memory Failure</i>
10	<i>Lost Static Data</i>
11	<i>Lost NV Data</i>
12	<i>Readback Check Failed</i>
13	<i>Device Needs Maintenance Now</i>
14	<i>Power Up</i>
15	Out of Service: The actual mode is out of service.

3.5 MODES

The AI Function Block supports three modes of operation as defined by the MODE_BLK parameter:

- ◆ **Manual (Man)** The block output (OUT) may be set manually
- ◆ **Automatic (Auto)** OUT reflects the analog input measurement or the simulated value when simulation is enabled.
- ◆ **Out of Service (O/S)** The block is not processed. FIELD_VAL and PV are not updated and the OUT status is set to Bad: Out of Service. The BLOCK_ERR parameter shows Out of Service. In this mode, changes can be made to all configurable parameters. The target mode of a block may be restricted to one or more of the supported modes.

3.6 ALARM DETECTION

A block alarm will be generated whenever the BLOCK_ERR has an error bit set. The types of block error for the AI block are defined above.

Process Alarm detection is based on the OUT value. The alarm limits of the following standard alarms can be configured:

- High (HI_LIM)
- High high (HI_HI_LIM)
- Low (LO_LIM)
- Low low (LO_LO_LIM)

In order to avoid alarm chattering when the variable is oscillating around the alarm limit, an alarm hysteresis in percent of the PV span can be set using the ALARM_HYS parameter. The priority of each alarm is set in the following parameters:

- HI_PRI
- HI_HI_PRI
- LO_PRI
- LO_LO_PRI

Alarms are grouped into five levels of priority:

Table 3-3. Alarm Priorities

Priority	Priority Description Number
0	The priority of an alarm condition changes to 0 after the condition that caused the alarm is corrected.
1	An alarm condition with a priority of 1 is recognized by the system, but is not reported to the operator.
2	An alarm condition with a priority of 2 is reported to the operator, but does not require operator attention (such as diagnostics and system alerts).
3-7	Alarm conditions of priority 3 to 7 are advisory alarms of increasing priority.
8-15	Alarm conditions of priority 8 to 15 are critical alarms of increasing priority.

3.7 STATUS HANDLING

Normally, the status of the PV reflects the status of the measurement value, the operating condition of the I/O card, and any active alarm condition. In Auto mode, OUT reflects the value and status quality of the PV. In Man mode, the OUT status constant limit is set to indicate that the value is a constant and the OUT status is *Good*.

The **Uncertain** - EU range violation status is always set, and the PV status is set high- or low-limited if the sensor limits for conversion are exceeded.

In the STATUS_OPTS parameter, select from the following options to control the status handling:

BAD if Limited – sets the OUT status quality to *Bad* when the value is higher or lower than the sensor limits.

Uncertain if Limited – sets the OUT status quality to *Uncertain* when the value is higher or lower than the sensor limits.

Uncertain if in Manual mode – The status of the Output is set to *Uncertain* when the mode is set to Manual.

NOTES:

- The instrument must be in Manual or Out of Service mode to set the status option.
- The AI block only supports the BAD if Limited option. Unsupported options are not grayed out; they appear on the screen in the same manner as supported options.

3.8 ADVANCED FEATURES

The AI function block provided with Fisher-Rosemount Fieldbus devices provides added capability through the addition of the following parameters:

ALARM_TYPE – Allows one or more of the process alarm conditions detected by the AI function block to be used in setting its OUT_D parameter.

OUT_D – Discrete output of the AI function block based on the detection of process alarm condition(s). This parameter may be linked to other function blocks that require a discrete input based on the detected alarm condition.

VAR_SCAN – Time period in seconds over which the variability index (VAR_INDEX) is computed.

VAR_INDEX – Process variability index measured as the integral of average absolute error between PV and its mean value over the previous evaluation period. This index is calculated as a percent of OUT span and is updated at the end of the time period defined by VAR_SCAN.

3.9 APPLICATION INFORMATION

The configuration of the AI function block and its associated output channels depends on the specific application. A typical configuration for the AI block involves the following parameters:

- CHANNEL** If the device supports more than one measurement, verify that the selected channel contains the appropriate measurement or derived value.
- L_TYPE** Select **Direct** when the measurement is already in the engineering units that are desired for the block output.

Select **Indirect** when it is desired to convert the measured variable into another, for example, pressure into level or flow into energy.

Select **Indirect Square Root** when the block I/O parameter value represents a flow measurement made using differential pressure, and when square root extraction is not performed by the transducer.
- SCALING** **XD_SCALE** provides the range and units of the measurement and **OUT_SCALE** provides the range and engineering units of the output.

3.9.1 Application Example 1 *Temperature Transmitter*

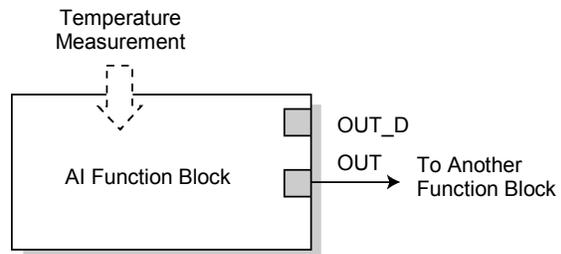
Situation

A temperature transmitter with a range of –200 to 450 °C.

Solution

The table below lists the appropriate configuration settings, and the figure illustrates the correct function block configuration.

Parameter	Configured Values
L_TYPE	Direct
XD_SCALE	Not Used
OUT_SCALE	Not Used

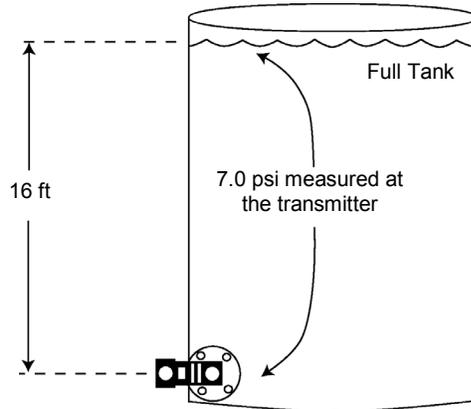


3.9.2 Application Example 2

Pressure Transmitter used to Measure Level in Open Tank

Situation #1

The level of an open tank is to be measured using a pressure tap at the bottom of the tank. The level measurement will be used to control the level of liquid in the tank. The maximum level at the tank is 16 ft. The liquid in the tank has a density that makes the level correspond to a pressure of 7.0 psi at the pressure tap (see diagram below).

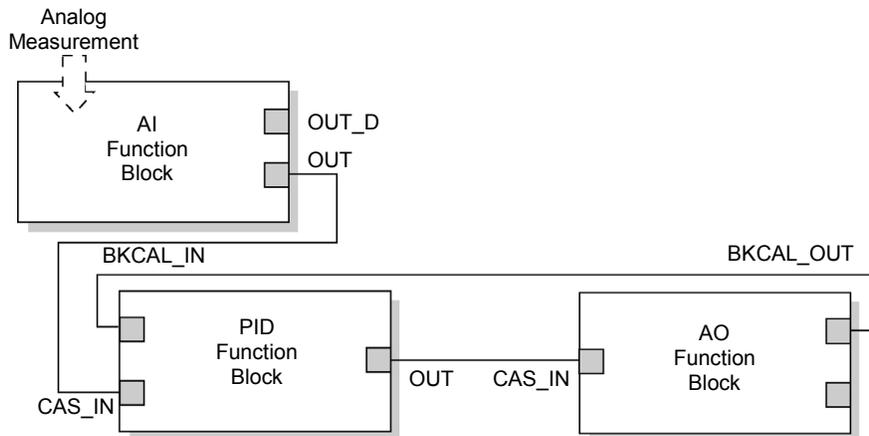


Situation #1 Diagram

Solution to Situation #1

The table below lists the appropriate configuration settings, and the figure illustrates the correct function block configuration.

Parameter	Configured Values
L_TYPE	Indirect
XD_SCALE	0 to 7 psi
OUT_SCALE	0 to 16 ft

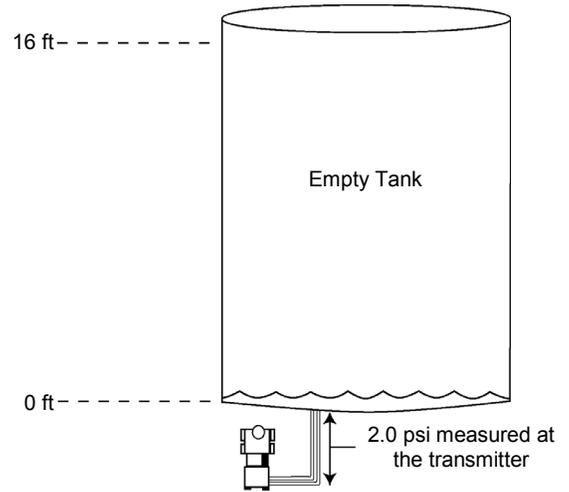


Function Block Diagram for a Pressure Transmitter used in Level Measurement

Situation #2

The transmitter in situation #1 is installed below the tank in a position where the liquid column is in the impulse line, when the tank is empty, is equivalent to 2.0 psi.

Parameter	Configured Values
L_TYPE	Indirect
XD_SCALE	2 to 9 psi
OUT_SCALE	0 to 16 ft



Situation #2 Diagram

3.9.3 Application Example 3

Differential Pressure Transmitter used to Measure Flow

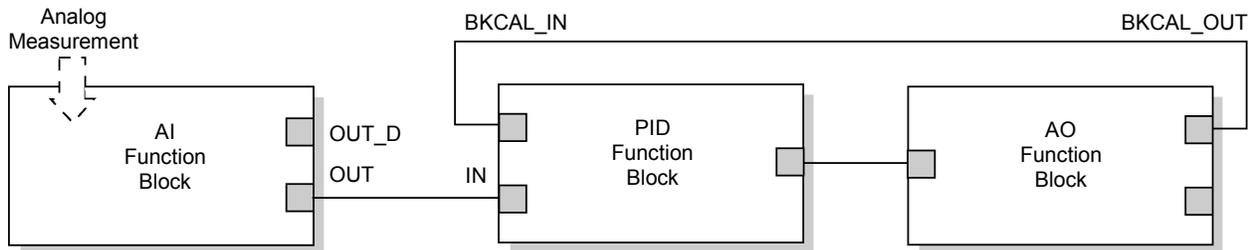
Situation

The liquid flow in a line is to be measured using the differential pressure across an orifice plate in the line, and the flow measurement will be used in a flow control loop. Based on the orifice specification sheet, the differential pressure transmitter was calibrated for 0 to 20 in H₂O for a flow of 0 to 800 gal/min, and the transducer was not configured to take the square root of the differential pressure.

Solution

The table below lists the appropriate configuration settings, and the figure illustrates the correct function block configuration.

Parameter	Configured Values
L_TYPE	Indirect Square Root
XD_SCALE	0 to 20 in
OUT_SCALE	0 to 800 gal/min



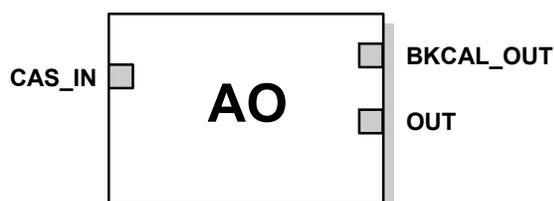
Function Block Diagram for Differential Pressure Transmitter in Flow Measurement

3.10 TROUBLESHOOTING

Table 3-4. Troubleshooting AI Block

Symptom	Possible Causes	Corrective Action
Mode will not leave OOS	1. Target mode not set.	1. Set target mode to something other than OOS.
	2. Configuration error	2. BLOCK_ERR will show the configuration error bit set. The following are parameters that must be set before the block is allowed out of OOS: <ul style="list-style-type: none"> a. CHANNEL must be set to a valid value and cannot be left at initial value of 0. b. XD_SCALE.UNITS_INDX must match the units in the transducer block channel value. c. L_TYPE must be set to Direct, Indirect, or Indirect Square Root and cannot be left at initial value of 0.
	3. Resource block	3. The actual mode of the Resource block is OOS. See Resource Block Diagnostics for corrective action.
	4. Schedule	4. Block is not scheduled and therefore cannot execute to go to Target Mode. Schedule the block to execute.
Process and/or block alarms will not work.	1. Features	1. FEATURES_SEL does not have Alerts enabled. Enable the Alerts bit.
	2. Notification	2. LIM_NOTIFY is not high enough. Set equal to MAX_NOTIFY.
	3. Status Options	3. STATUS_OPTS has Propagate Fault Forward bit set. This should be cleared to cause an alarm to occur.
Value of output does not make sense	1. Linearization Type	1. L_TYPE must be set to Direct, Indirect, or Indirect Square Root and cannot be left at initial value of 0.
	2. Scaling	2. Scaling parameters are set incorrectly: <ul style="list-style-type: none"> a. XD_SCALE.EU0 and EU100 should match that of the transducer block channel value. b. OUT_SCALE.EU0 and EU100 are not set properly.
Cannot set HI_LIMIT, HI_HI_LIMIT, LO_LIMIT, or .LO_LO_LIMIT Values	1. Scaling	1. Limit values are outside the OUT_SCALE.EU0 and OUT_SCALE.EU100 values. Change OUT_SCALE or set values within range.

4 ANALOG OUTPUT (AO) FUNCTION BLOCK



- CAS_IN** = The remote point value from another function block.
- BKCAL_OUT** = The value and status required by the BKCAL_IN input of another block to prevent reset windup and to provide bumpless transfer to closed loop control.
- OUT** = The block output and status.

The Analog Output (AO) function block assigns an output value to a field device through a specified I/O channel. The block supports mode control, signal status calculation, and simulation. Figure 3-1 illustrates the internal components of the AO function block, and Table 3-1 lists the definitions of the system parameters.

Table 4-1. Analog Output Function Block System Parameters.

Parameters	Units	Description
BKCAL_OUT	EU of PV_SCALE	The value and status required by the BKCAL_IN input of another block to prevent reset windup and to provide bumpless transfer to closed loop control.
BLOCK_ERR	None	The summary of active error conditions associated with the block. The block errors for the Analog Output block are Simulate Active , Input Failure/Process Variable has Bad Status , Output Failure , Read back Failed , and Out of Service .
CAS_IN	EU of PV_SCALE	The remote setpoint value from another function block.
IO_OPTS	None	Allows you to select how the I/O signals are processed. The supported I/O options for the AO function block are SP_PV Track in Man , Increase to Close , and Use PV for BKCAL_OUT .
CHANNEL	None	Defines the output that drives the field device.
MODE	None	Enumerated attribute used to request and show the source of the setpoint and/or output used by the block.
OUT	EU of XD_SCALE	The primary value and status calculated by the block in Auto mode. OUT may be set manually in Man mode.
PV	EU of PV_SCALE	The process variable used in block execution. This value is converted from READBACK to show the actuator position in the same units as the setpoint value.
PV_SCALE	None	The high and low scale values, the engineering units code, and the number of digits to the right of the decimal point associated with the PV.
READBACK	EU of XD_SCALE	The measured or implied actuator position associated with the OUT value.
SIMULATE	EU of XD_SCALE	Enables simulation and allows you to enter an input value and status.
SP	EU of PV_SCALE	The target block output value (setpoint).
SP_HI_LIM	EU of PV_SCALE	The highest setpoint value allowed.
SP_LO_LIM	EU of PV_SCALE	The lowest setpoint value allowed.
SP_RATE_DN	EU of PV_SCALE per second	Ramp rate for downward setpoint changes. When the ramp rate is set to zero, the setpoint is used immediately.
SP_RATE_UP	EU of PV_SCALE per second	Ramp rate for upward setpoint changes. When the ramp rate is set to zero, the setpoint is used immediately.
SP_WRK	EU of PV_SCALE	The working setpoint of the block. It is the result of setpoint rate-of-change limiting. The value is converted to percent to obtain the block's OUT value.

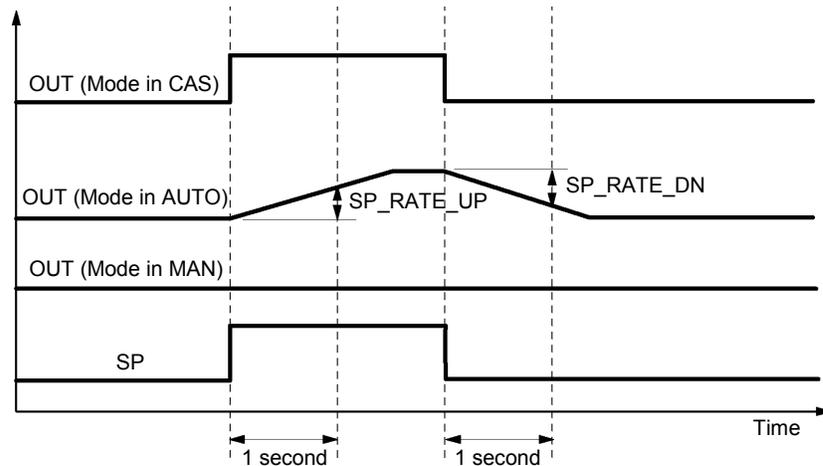


Figure 4-2. Analog Output Function Block Timing Diagram

4.2 SETPOINT SELECTION AND LIMITING

To select the source of the SP value use the **MODE** attribute. In Automatic (Auto) mode, the local, manually-entered SP is used. In Cascade (Cas) mode, the SP comes from another block through the CAS_IN input connector. In RemoteCascade (RCas) mode, the SP comes from a host computer that writes to RCAS_IN. The range and units of the SP are defined by the **PV_SCALE** attribute.

In Manual (Man) mode the SP automatically tracks the PV value when you select the **SP-PV Track in Man** I/O option. The SP value is set equal to the PV value when the block is in manual mode, and is enabled (True) as a default. You can disable this option in Man or O/S mode only.

The SP value is limited to the range defined by the setpoint high limit attribute (SP_HI_LIM) and the setpoint low limit attribute (SP_LO_LIM).

In Auto mode, the rate at which a change in the SP is passed to **OUT** is limited by the values of the setpoint upward rate limit attribute (SP_RATE_UP) and the setpoint downward rate limit attribute (SP_RATE_DN). A limit of zero prevents rate limiting, even in Auto mode.

4.3 CONVERSION AND STATUS CALCULATION

The working setpoint (SP_WRK) is the setpoint value after limiting. You can choose to reverse the conversion range, which will reverse the range of **PV_SCALE** to calculate the **OUT** attribute, by selecting the **Increase to Close** I/O option. This will invert the **OUT** value with respect to the setpoint based on the **PV_SCALE** and **XD_SCALE**.

In Auto mode, the converted SP value is stored in the **OUT** attribute. In Man mode, the **OUT** attribute is set manually, and is used to set the analog output defined by the **CHANNEL** parameter.

You can access the actuator position associated with the output channel through the **READBACK** parameter (in **OUT** units) and in the PV attribute (in engineering units). If the actuator does not support position feedback, the PV and **READBACK** values are based on the **OUT** attribute.

The working setpoint (SP_WRK) is the value normally used for the **BKCAL_OUT** attribute. However, for those cases where the **READBACK** signal directly (linearly) reflects the **OUT** channel, you can choose to allow the PV to be used for **BKCAL_OUT** by selecting the **Use PV for BKCAL_OUT** I/O option.

NOTE: **SP_PV Track in Man, Increase to Close, and Use PV for BKCAL_OUT** are the only I/O options that the AO block supports. You can set I/O options in **Manual** or **Out of Service** mode only.

4.4 SIMULATION

When simulation is enabled, the last value of **OUT** is maintained and reflected in the field value of the **SIMULATE** attribute. In this case, the **PV** and **READBACK** values and statuses are based on the **SIMULATE** value and the status that you enter.

4.5 ACTION ON FAULT DETECTION

To define the state to which you wish the valve to enter when the CAS_IN input detects a bad status and the block is in CAS mode, configure the following parameters:

FSTATE_TIME: The length of time that the AO block will wait to position the **OUT** value to the **FSTATE_VAL** value upon the detection of a fault condition. When the block has a target mode of CAS, a fault condition will be detected if the **CAS_IN** has a **BAD** status or an **Initiate Fault State** substatus is received from the upstream block.

FSTATE_VAL: The value to which the OUT value transitions after **FSTATE_TIME** elapses and the fault condition has not cleared. You can configure the channel to hold the value at the start of the failure action condition or to go to the failure action value (**FAIL_ACTION_VAL**).

4.6 BLOCK ERRORS

The following conditions are reported in the **BLOCK_ERR** attribute:

Input failure/process variable has *Bad* status – The hardware is bad, the Device Signal Tag (DST) does not exist, or a **BAD** status is being simulated.

Out of service – The block is in Out of Service (O/S) mode.

Output failure – The output hardware is bad.

Readback failed – The readback failed.

Simulate active – Simulation is enabled and the block is using a simulated value in its execution.

4.7 MODES

The Analog Output function block supports the following modes:

Manual (Man) – You can manually set the output to the I/O channel through the **OUT** attribute. This mode is used primarily for maintenance and troubleshooting.

Automatic (Auto) – The block output (OUT) reflects the target operating point specified by the setpoint (SP) attribute.

Cascade (Cas) – The SP attribute is set by another function block through a connection to CAS_IN. The SP value is used to set the **OUT** attribute automatically.

RemoteCascade (RCas) – The SP is set by a host computer by writing to the RCAS_IN parameter. The SP value is used to set the **OUT** attribute automatically.

Out of Service (O/S) – The block is not processed. The output channel is maintained at the last value and the status of OUT is set to *Bad: Out of Service*. The **BLOCK_ERR** attribute shows *Out of Service*.

Initialization Manual (Iman) – The path to the output hardware is broken and the output will remain at the last position.

Local Override (LO) – The output of the block is not responding to **OUT** because the resource block has been placed into LO mode or fault state action is active.

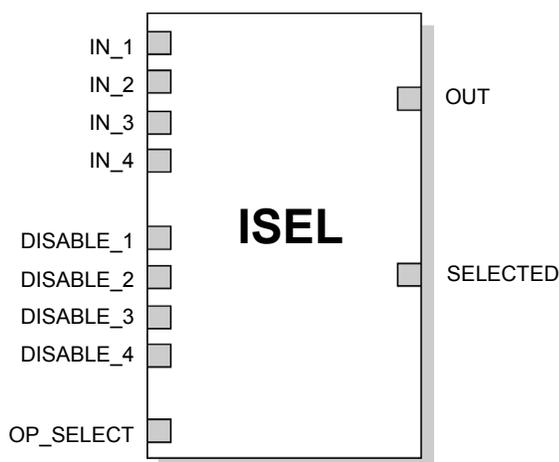
The target mode of the block may be restricted to one or more of the following modes: Man, Auto, Cas, RCas, or O/S.

4.8 STATUS HANDLING

Output or readback fault detection are reflected in the status of PV, OUT, and BKCAL_OUT. A limited SP condition is reflected in the BKCAL_OUT status. When simulation is enabled through the SIMULATE attribute, you can set the value and status for PV and READBACK.

When the block is in Cas mode and the CAS_IN input goes bad, the block sheds mode to the next permitted mode.

5 INPUT SELECTOR (ISEL) FUNCTION BLOCK



- IN (1-4)** = Input used in the selection algorithm.
- DISABLE (1-4)** = Discrete input used to enable or disable the associated input channel.
- OP_SELECT** = Input used to override algorithm.
- TRK_VAL** = The value after scaling applied to OUT in Local Override mode.
- SELECTED** = The selected channel number.
- OUT** = The block output and status.

The Input Selector (ISEL) function block can be used to select the first good, Hot Backup, maximum, minimum, or average of as many as four input values and place it at the output. The block supports signal status propagation. There is no process alarm detection in the Input Selector function block. Figure 5-1 illustrates the internal components of the ISEL function block. Table 5-1 lists the ISEL block parameters and their descriptions, units of measure, and index numbers.

Table 5-1. Input Selector Function Block System Parameters

Parameter	Index Number	Units	Description
ALERT_KEY	04	None	The identification number of the plant unit. This information may be used in the host for sorting alarms, etc.
BLOCK_ALM	24	None	The block alarm is used for all configuration, hardware, connection failure, or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status parameter. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.
BLOCK_ERR	06	None	This parameter reflects the error status associated with the hardware or software components associated with a block. It is a bit string, so that multiple errors may be shown.
DISABLE_1	15	None	A Connection from another block that disables the associated input from the selection.
DISABLE_2	16	None	A Connection from another block that disables the associated input from the selection.

Input Selector Function Block

Parameter	Index Number	Units	Description
DISABLE_3	17	None	A Connection from another block that disables the associated input from the selection.
DISABLE_4	18	None	A Connection from another block that disables the associated input from the selection.
GRANT_DENY	09	None	Options for controlling access of host computers and local control panels to operating, tuning, and alarm parameters of the block. Not used by device.
IN_1	11	Determined by source	The connection input from another block. One of the inputs to be selected from.
IN_2	12	Determined by source	The connection input from another block. One of the inputs to be selected from.
IN_3	13	Determined by source	The connection input from another block. One of the inputs to be selected from.
IN_4	14	Determined by source	The connection input from another block. One of the inputs to be selected from.
MIN_GOOD	20	None	The minimum number of good inputs
MODE_BLK	05	None	The actual, target, permitted, and normal modes of the block. Target: The mode to "go to" Actual: The mode the "block is currently in" Permitted: Allowed modes that target may take on Normal: Most common mode for target
OP_SELECT	22	None	Overrides the algorithm to select 1 of the 4 inputs regardless of the selection type.
OUT	07	EU of IN	The block output value and status.
OUT_UNITS	08	None	The engineering units of the output. Typically, all inputs have the same units and the value is also the same.
SELECTED	21	None	The selected input number (1–4).
SELECT_TYPE	19	None	Specifies selection method (see Block Execution)
STATUS_OPTS	10	None	Allows selection of options for status handling and processing. The supported status option for the PID block is Target to Manual if Bad IN.
STRATEGY	03	None	The strategy field can be used to identify grouping of blocks. This data is not checked or processed by the block.
ST_REV	01	None	The revision level of the static data associated with the function block. The revision value will be incremented each time a static parameter value in the block is changed.
TAG_DESC	02	None	The user description of the intended application of the block.
UPDATE_EVT	23	None	This alert is generated by any change to the static data.

Input Selector Function Block

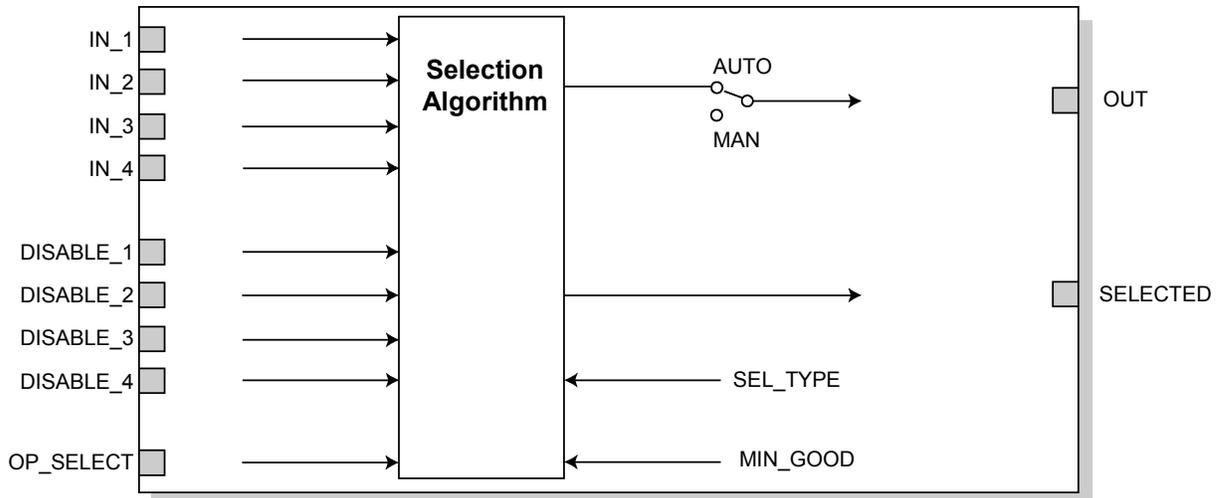


Figure 5-1. Input Selector Function Block Schematic

5.1 BLOCK ERRORS

Table C-2 lists conditions reported in the BLOCK_ERR parameter. Conditions in *italics* are inactive for the ISEL block and are given here only for reference.

Table 5-2. Block Error Conditions

Condition Number	Condition Name and Description
0	Other: The output has a quality of uncertain.
1	<i>Block Configuration Error</i>
2	<i>Link Configuration Error</i>
3	<i>Simulate Active</i>
4	Local Override: The actual mode is LO.
5	<i>Device Fault State Set</i>
6	<i>Device Needs Maintenance Soon</i>
7	Input Failure/Process Variable has Bad Status: One of the inputs is Bad or not connected.
8	Output Failure: The output has the quality of Bad.
9	Memory Failure: A memory failure has occurred in FLASH, RAM, or EEROM memory.
10	<i>Lost Static Data</i>
11	<i>Lost NV Data</i>
12	<i>Readback Check Failed</i>
13	<i>Device Needs Maintenance Now</i>
14	Power Up: The device was just powered-up.
15	Out of Service: The actual mode is out of service.

5.2 MODES

The ISEL function block supports three modes of operation as defined by the MODE_BLK parameter:

- **Manual (Man)** The block output (OUT) may be set manually.
- **Automatic (Auto)** OUT reflects the selected value.
- **Out of Service (O/S)** The block is not processed. The BLOCK_ERR parameter shows Out of Service. In this mode, changes can be made to all configurable parameters. The target mode of a block may be restricted to one or more of the supported modes.

5.3 ALARM DETECTION

A block alarm will be generated whenever the BLOCK_ERR has an error bit set. The types of block error for the ISEL block are defined above.

Alarms are grouped into five levels of priority:

Table 5-3. Alarm Priorities

Priority	Priority Description Number
0	The priority of an alarm condition changes to 0 after the condition that caused the alarm is corrected.
1	An alarm condition with a priority of 1 is recognized by the system, but is not reported to the operator.
2	An alarm condition with a priority of 2 is reported to the operator, but does not require operator attention (such as diagnostics and system alerts).
3-7	Alarm conditions of priority 3 to 7 are advisory alarms of increasing priority.
8-15	Alarm conditions of priority 8 to 15 are critical alarms of increasing priority.

5.4 BLOCK EXECUTION

The ISEL function block reads the values and statuses of as many as four inputs. To specify which of the six available methods (algorithms) is used to select the output, configure the selector type parameter (SEL_TYPE) as follows:

- **max** selects the maximum value of the inputs.
- **min** selects the minimum value of the inputs.
- **avg** calculates the average value of the inputs.
- **mid** calculates the middle of three inputs or the average of the middle two inputs if four inputs are defined.
- **1st Good** selects the first available good input.
- **Hot Backup** latches on the selected input and continues to use it until it is bad.

If the DISABLE_N is active, the associated input is not used in the selection algorithm.

Input Selector Function Block

If the OP_SELECT is set to a value between 1 and 4, the selection type logic is overridden and the output value and status is set to the value and status of the input selected by OP_SELECT.

SELECTED will have the number of the selected input unless the SEL_TYPE is average, in which case it will have the number of inputs used to calculate its value.

5.5 STATUS HANDLING

In Auto mode, OUT reflects the value and status quality of the selected input. If the number of inputs with Good status is less than MIN_GOOD, the output status will be Bad.

In Man mode, the OUT status high and low limits are set to indicate that the value is a constant and the OUT status is always Good.

In the STATUS_OPTS parameter, the following options can be selected from to control the status handling:

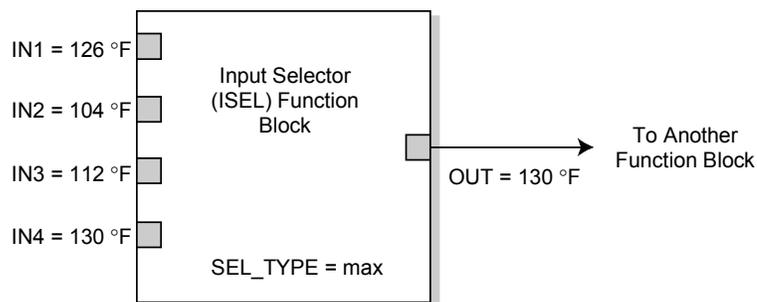
- **Use Uncertain as Good:** sets the OUT status quality to Good when the selected input status is Uncertain.
- **Uncertain if in Manual mode:** The status of the Output is set to Uncertain when the mode is set to manual.

NOTE:

The instrument must be in Manual or Out of Service mode to set the status option.

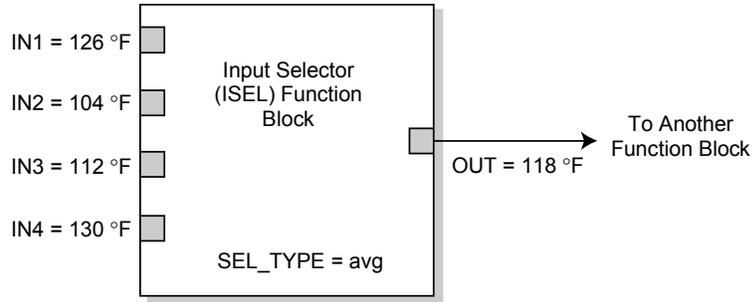
5.6 APPLICATION INFORMATION

The ISEL function block can be used to select the maximum temperature input from four inputs and send it to a PID function block to control a process water chiller (see first diagram below) or it can use the block to calculate the average temperature of the four inputs (see second diagram below).

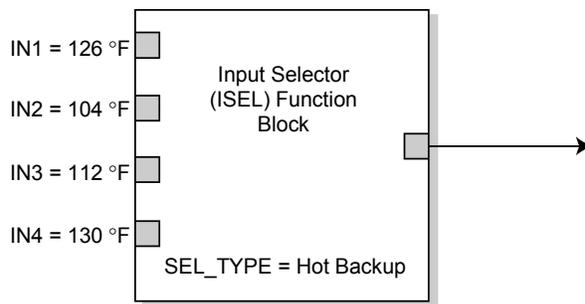


Input Selector Function Block Application Example (SEL_TYPE = max).

Input Selector Function Block



Input Selector Function Block Application Example (SEL_TYPE = avg).



Input Selector Function Block Application Example (SEL_TYPE = Hot Backup).

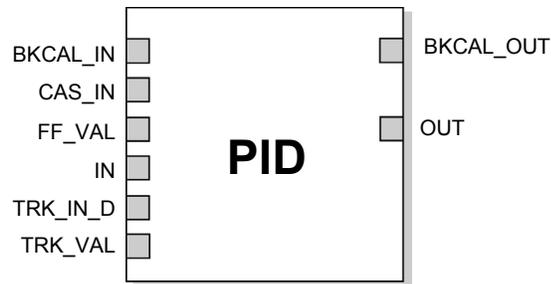
Time	IN1		IN2		Out		Selected	
	Value	Status	Value	Status	Value	Status	Value	Status
T ₀	Good	20	Good	21	Good	20	Good	1
T ₁	Bad	20	Good	21	Good	21	Good	2
T ₂	Good	20	Good	21	Good	21	Good	2

5.7 TROUBLESHOOTING

Table 5-4. Troubleshooting ISEL Block.

Symptom	Possible Causes	Corrective Action
Mode will not leave OOS	1. Target mode not set.	1. Set target mode to something other than OOS.
	2. Configuration error	2. BLOCK_ERR will show the configuration error bit set. SELECT_TYPE must be set to a valid value and cannot be left at 0.
	3. Resource block	3. The actual mode of the Resource block is OOS. See Resource Block Diagnostics for corrective action.
	4. Schedule	4. Block is not scheduled and therefore cannot execute to go to Target Mode. Schedule the block to execute.
Status of output is bad.	1. Inputs	1. All inputs have Bad status.
	2. OP selected	2. OP_SELECT is not set to 0 (or it is linked to an input that is not 0), and it points to an input that is Bad.
	3. Min good	3. The number of Good inputs is less than MIN_GOOD.
Block alarms will not work	1. Features	1. FEATURES_SEL does not have Alerts enabled. Enable Alerts bit..
	2. Notification	2. LIM_NOTIFY is not high enough. Set equal to MAX_NOTIFY.
	1. Status Options	1. STATUS_OPTS has Propagate Fault Forward bit set. This should be cleared to cause an alarm to occur.

6 PROPORTIONAL / INTEGRAL / DERIVATIVE (PID) FUNCTION BLOCK



BKCAL_IN	= The analog input value and status from another block's BKCAL_OUT output that is used for backward output tracking for bumpless transfer and to pass limit status.	TRK_IN_D	= Initiates the external tracking function.
CAS_IN	= The remote setpoint value from another function block.	TRK_VAL	= The value after scaling applied to OUT in Local Override mode.
FF_VAL	= The feedforward control input value and status.	BKCAL_OUT	= The value and status required by the BKCAL_IN input of another function block to prevent reset windup and to provide bumpless transfer to closed loop control.
IN	= The connection for the process variable from another function block.	OUT	= The block output and status.

The PID function block combines all of the necessary logic to perform proportional / integral / derivative (PID) control. The block supports mode control, signal scaling and limiting, feedforward control, override tracking, alarm limit detection, and signal status propagation.

The block supports two forms of the PID equation: Standard and Series. Choose the appropriate equation using the FORM parameter. The Standard ISA PID equation is the default selection.

$$\text{StandardOut} = \text{GAIN} \times e^x \left(1 + \frac{1}{\tau_r s + 1} + \frac{\tau_d s}{\alpha \times \tau_d s + 1} \right) + F$$

$$\text{SeriesOut} = \text{GAIN} \times e^x \left[\left(1 + \frac{1}{\tau_r s} \right) + \left(\frac{\tau_d s + 1}{\alpha \times \tau_d s + 1} \right) \right] + F$$

Where

- GAIN: Proportional gain value.
- τ_r : Integral action time constant (RESET parameter) in seconds.
- s: Laplace operator
- τ_d : Derivative action time constant (RATE parameter).
- α : Fixed smoothing factor of 0.1 applied to RATE.
- F: Feedforward control contribution from the feedforward input (FF_VAL parameter).
- e: Error between setpoint and process variable.

PID Function Block

To further customize the block for use in an application, it is possible to configure filtering, feedforward inputs, tracking inputs, setpoint and output limiting, PID equation structures, and block output action. Table 6-1 lists the PID block parameters and their descriptions, units of measure, and index numbers, and Figure 6-1 illustrates the internal components of the PID function block.

Table 6-1. PID Function Block System Parameters

Parameter	Index Number	Units	Description
ACK_OPTION	46	None	Used to set auto acknowledgment of alarms.
ALARM_HYS	47	Percent	The amount the alarm value must return to within the alarm limit before the associated active alarm condition clears.
ALARM_SUM	45	None	The summary alarm is used for all process alarms in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status parameter. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.
ALERT_KEY	04	None	The identification number of the plant unit. This information may be used in the host for sorting alarms, etc.
ALG_TYPE	74	None	Selects filtering algorithm as Backward or Bilinear.
BAL_TIME	25	Seconds	The specified time for the internal working value of bias to return to the operator set bias. Also used to specify the time constant at which the integral term will move to obtain balance when the output is limited and the mode is AUTO, CAS, or RCAS.
BIAS	66	EU of OUT_SCALE	The bias value used to calculate output for a PD type controller.
BKCAL_HYS	30	Percent	The amount the output value must change away from the its output limit before limit status is turned off.
BKCAL_IN	27	EU of OUT_SCALE	The analog input value and status from another block's BKCAL_OUT output that is used for backward output tracking for bumpless transfer and to pass limit status.
BKCAL_OUT	31	EU of PV_SCALE	The value and status required by the BKCAL_IN input of another block to prevent reset windup and to provide bumpless transfer of closed loop control.
BLOCK_ALM	44	None	The block alarm is used for all configuration, hardware, connection failure, or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the active status in the status parameter. As soon as the Unreported status is cleared by the alert reporting task, and other block alert may be reported without clearing the Active status, if the subcode has changed.
BLOCK_ERR	06	None	This parameter reflects the error status associated with the hardware or software components associated with a block. It is a bit string so that multiple errors may be shown.
BYPASS	17	None	Used to override the calculation of the block. When enabled, the SP is sent directly to the output.
CAS_IN	18	EU of PV_SCALE	The remote setpoint value from another block.
CONTROL_OPTS	13	None	Allows definition of control strategy options. The supported control options for the PID block are Track enable, Track in Manual, SP-PV Track in Man, SP-PV Track in LO or IMAN, Use PV for BKCAL OUT, and Direct Acting
DV_HI_ALM	64	None	The DV HI alarm data, which includes a value of the alarm, a timestamp of occurrence, and the state of the alarm.
DV_HI_LIM	57	EU of PV_SCALE	The setting for the alarm limit used to detect the deviation high alarm condition.
DV_HI_PRI	56	None	The priority of the deviation high alarm.
DV_LO_ALM	65	None	The DV LO alarm data, which includes a value of the alarm, a timestamp of occurrence, and the state of the alarm.
DV_LO_LIM	59	EU of PV_SCALE	The setting for the alarm limit use to detect the deviation low alarm condition.
DV_LO_PRI	58	None	The priority of the deviation low alarm.

PID Function Block

Parameter	Index Number	Units	Description
ERROR	67	EU of PV_SCALE	The error (SP-PV) used to determine the control action.
FF_ENABLE	70	None	Enables the use of feedforward calculations
FF_GAIN	42	None	The feedforward gain value. FF_VAL is multiplied by FF_GAIN before it is added to the calculated control output.
FF_SCALE	41	None	The high and low scale values, engineering units code, and number of digits to the right of the decimal point associated with the feedforward value (FF_VAL).
FF_VAL	40	EU of FF_SCALE	The feedforward control input value and status.
GAIN	23	None	The proportional gain value. This value cannot = 0.
GRANT_DENY	12	None	Options for controlling access of host computers and local control panels to operating, tuning, and alarm parameters of the block. Not used by the device.
HI_ALM	61	None	The HI alarm data, which includes a value of the alarm, a timestamp of occurrence, and the state of the alarm.
HI_HI_ALM	60	None	The HI HI alarm data, which includes a value of the alarm, a timestamp of occurrence, and the state of the alarm.
HI_HI-LIM	49	EU of PV_SCALE	The setting for the alarm limit used to detect the HI HI alarm condition.
HI_HI_PRI	48	None	The priority of the HI HI Alarm.
HI_LIM	51	EU of PV_SCALE	The setting for the alarm limit used to detect the HI alarm condition.
HI_PRI	50	None	The priority of the HI alarm.
IN	15	EU of PV_SCALE	The connection for the PV input from another block.
LO_ALM	62	None	The LO alarm data, which includes a value of the alarm, a timestamp of occurrence, and the state of the alarm.
LO_LIM	53	EU of PV_SCALE	The setting for the alarm limit used to detect the LO alarm condition.
LO_LO_ALM	63	None	The LO LO alarm data, which includes a value of the alarm, a timestamp of occurrence, and the state of the alarm.
LO_LO_LIM	55	EU of PV_SCALE	The setting for the alarm limit used to detect the LO LO alarm condition.
LO_LO_PRI	54	None	The priority of the LO LO alarm.
LO_PRI	52	None	The priority of the LO alarm.
MATH_FORM	73	None	Selects equation form (series or standard).
MODE_BLK	05	None	The actual, target, permitted, and normal modes of the block. Target: The mode to "go to" Actual: The mode the "block is currently in" Permitted: Allowed modes that target may take on Normal: Most common mode for target.
OUT	09	EU of OUT_SCALE	The block input value and status.
OUT_HI_LIM	28	EU of OUT_SCALE	The maximum output value allowed.
OUT-LO_LIM	29	EU of OUT_SCALE	The minimum output value allowed
OUT_SCALE	11	None	The high and low scale values, engineering units code, and number of digits to the right of the decimal point associated with OUT.
PV	07	EU of PV_SCALE	The process variable used in block execution.
PV_FTIME	16	Seconds	The time constant of the first-order PV filter. It is the time required for a 63 percent change in the IN value.
PV_SCALE	10	None	The high and low scale values, engineering units code, and number of digits to the right of the decimal point associated with PV.
RATE	26	Seconds	The derivative action time constant.
RCAS_IN	32	EU of PV_SCALE	Target setpoint and status that is provided by a supervisory host. Used when mode is RCAS.
RCAS_OUT	35	EU of PV_SCALE	Block setpoint and status after ramping, filtering, and limiting that is provided to a supervisory host for back calculation to allow action to be taken under limiting conditions or mode change. Used when mode is RCAS.
RESET	24	Seconds per repeat	The integral action time constant.

PID Function Block

Parameter	Index Number	Units	Description
ROUT_IN	33	EU of OUT_SCALE	Target output and status that is provided by a supervisory host. Used when mode is ROUT.
ROUT_OUT	36	EU of OUT_SCALE	Block output that is provided to a supervisory host for a back calculation to allow action to be taken under limiting conditions or mode change. Used when mode is RCAS.
SHED_OPT	34	None	Defines action to be taken on remote control device timeout.
SP	08	EU of PV_SCALE	The target block setpoint value. It is the result of setpoint limiting and setpoint rate of change limiting.
SP_FTIME	69	Seconds	The time constant of the first-order SP filter. It is the time required for a 63 percent change in the IN value.
SP_HI_LIM	21	EU of PV_SCALE	The highest SP value allowed.
SP_LO_LIM	22	EU of PV_SCALE	The lowest SP value allowed.
SP_RATE_DN	19	EU of PV_SCALE per second	Ramp rate for downward SP changes. When the ramp rate is set to zero, the SP is used immediately.
SP-RATE_UP	20	EU of PV_SCALE per second	Ramp rate for upward SP changes. When the ramp rate is set to zero, the SP is used immediately.
SP_WORK	68	EU of PV_SCALE	The working setpoint of the block after limiting and filtering is applied.
STATUS_OPTS	14	None	Allows selection of options for status handling and processing. The supported status option for the PID block is Target to Manual if Bad IN.
STRATEGY	03	None	The strategy field can be used to identify grouping of blocks. This data is not checked or processed by the block.
ST_REV	01	None	The revision level of the static data associated with the function block. The revision value will be incremented each time a static parameter value in the block is changed.
STRUCTURE.CONFIG	75	None	Defines PID equation structure to apply controller action.
TAG_DESC	02	None	The user description of the intended application of the block.
TRK_IN_D	38	None	Discrete input that initiates external tracking.
TRK_SCALE	37	None	The high and low scale values, engineering units code, and number of digits to the right of the decimal point associated with the external tracking value (TRK_VAL).
TRK_VAL	39	EU of TRK SCALE	The value (after scaling from TRK_SCALE to OUT_SCALE) applied to OUT in LO mode.
UBETA	72	Percent	Used to set disturbance rejection vs. tracking response action for a 2.0 degree of freedom PID.
UGAMMA	71	Percent	Used to set disturbance rejection vs. tracking response action for a 2.0 degree of freedom PID.
UPDATE_EVT	43	None	This alert is generated by any changes to the static data.

PID Function Block

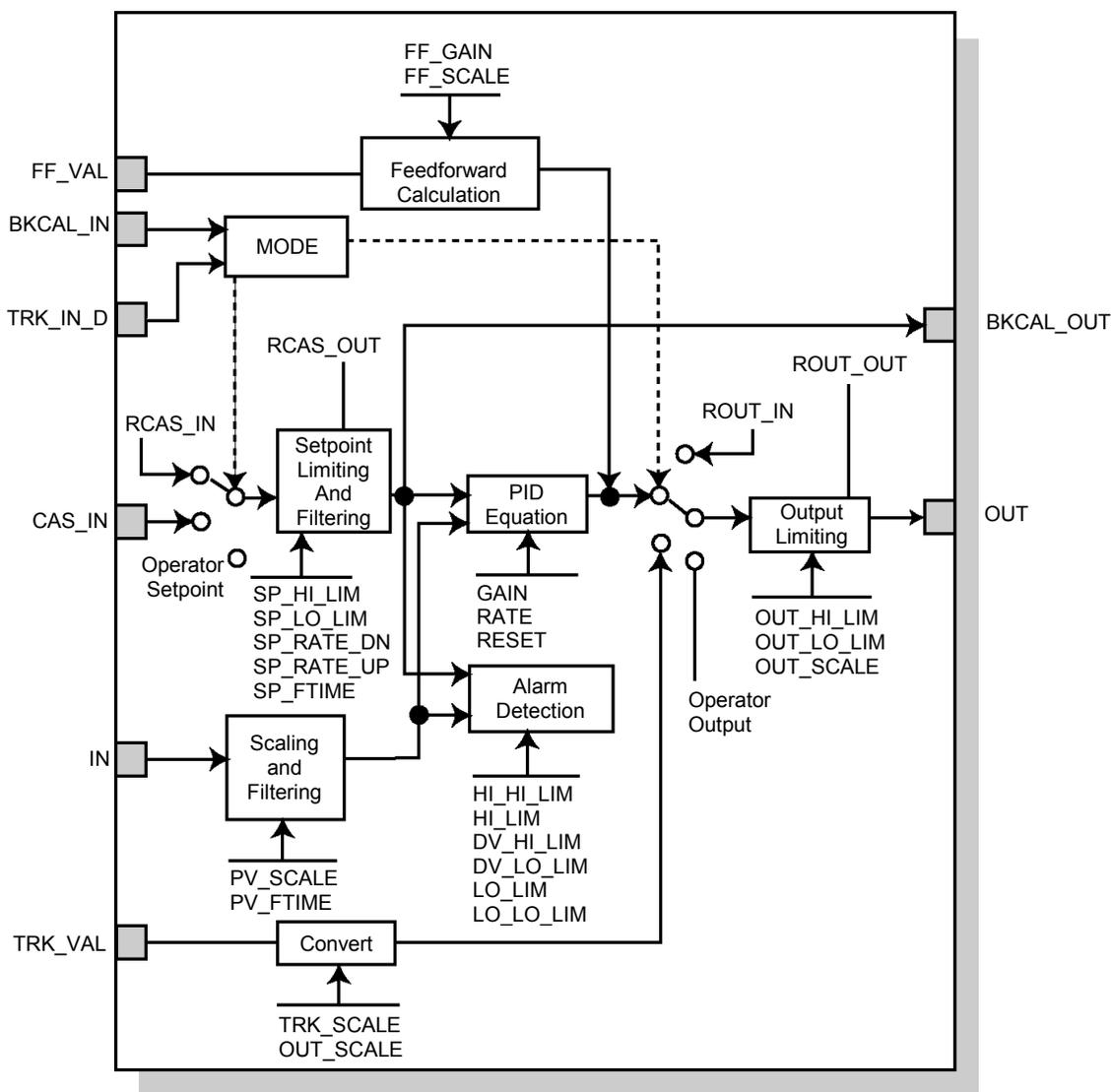


Figure 6-1. PID Function Block Schematic

6.1 SETPOINT SELECTION AND LIMITING

The setpoint of the PID block is determined by the mode. The SP_HI_LIM and SP_LO_LIM parameters can be configured to limit the setpoint. In **Cascade** or **RemoteCascade** mode, the setpoint is adjusted by another function block or by a host computer, and the output is computed based on the setpoint.

In **Automatic** mode, the setpoint is entered manually by the operator, and the output is computed based on the setpoint. In Auto mode, it is also possible adjust the setpoint limit and the setpoint rate of change using the SP_RATE_UP and SP_RATE_DN parameters.

In **Manual** mode the output is entered manually by the operator, and is independent of the setpoint. In **RemoteOutput** mode, the output is entered by a host computer, and is independent of the setpoint.

Figure 6-2 illustrates the method for setpoint selection.

PID Function Block

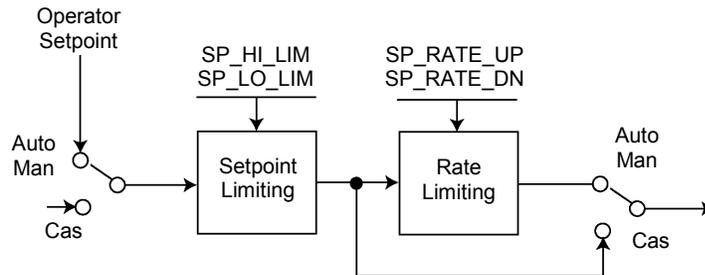


Figure 6-2. PID Function Block Setpoint Selection

6.2 FILTERING

The filtering feature changes the response time of the device to smooth variations in output readings caused by rapid changes in input. The filtering feature can be configured with the `FILTER_TYPE` parameter, and the filter time constant (in seconds) can be adjusted using the `PV_FTIME` or `SP_FTIME` parameters. Set the filter time constant to zero to disable the filter feature.

6.3 FEEDFORWARD CALCULATION

The feedforward value (`FF_VAL`) is scaled (`FF_SCALE`) to a common range for compatibility with the output scale (`OUT_SCALE`). A gain value (`FF_GAIN`) is applied to achieve the total feedforward contribution.

6.4 TRACKING

Output tracking is enabled through the control options. Control options can be set in Manual or Out of Service mode only.

The **Track Enable** control option must be set to *True* for the track function to operate. When the Track in Manual control option is set to *True*, tracking can be activated and maintained only when the block is in **Manual** mode. When **Track in Manual** is *False*, the operator can override the tracking function when the block is in **Manual** mode. Activating the track function causes the block's actual mode to revert to **Local Override**.

The `TRK_VAL` parameter specifies the value to be converted and tracked into the output when the track function is operating. The `TRK_SCALE` parameter specifies the range of `TRK_VAL`.

When the `TRK_IN_D` parameter is *True* and the **Track Enable** control option is *True*, the `TRK_VAL` input is converted to the appropriate value and output in units of `OUT_SCALE`.

6.5 OUTPUT SELECTION AND LIMITING

Output selection is determined by the mode and the setpoint. In **Automatic**, **Cascade**, or **RemoteCascade** mode, the output is computed by the PID control equation. In **Manual** and **RemoteOutput** mode, the output may be entered manually (see also **Setpoint Selection and Limiting**). The output can be limited by configuring the `OUT_HI_LIM` and `OUT_LO_LIM` parameters.

6.6 BUMPLESS TRANSFER AND SETPOINT TRACKING

The method for can be configured tracking the setpoint by configuring the following control options (CONTROL_OPTS):

SP-PV Track in Man — Permits the SP to track the PV when the target mode of the block is Man.

SP-PV Track in LO or IMan — Permits the SP to track the PV when the actual mode of the block is Local Override (LO) or Initialization Manual (IMan).

When one of these options is set, the SP value is set to the PV value while in the specified mode.

The value that a master controller uses can be selected for tracking by configuring the **Use PV for BKCAL_OUT** control option. The BKCAL_OUT value tracks the PV value. BKCAL_IN on a master controller connected to BKCAL_OUT on the PID block in an open cascade strategy forces its OUT to match BKCAL_IN, thus tracking the PV from the slave PID block into its cascade input connection (CAS_IN). If the **Use PV for BKCAL_OUT** option is not selected, the working setpoint (SP_WRK) is used for BKCAL_OUT.

Control options can be set in **Manual** or **Out of Service** mode only. When the mode is set to **Auto**, the SP will remain at the last value (it will no longer follow the PV).

6.7 PID EQUATION STRUCTURES

Configure the STRUCTURE parameter to select the PID equation structure. Select one of the following choices:

- PI Action on Error, D Action on PV
- PID Action on Error
- I Action on Error, PD Action on PV

Set RESET to zero to configure the PID block to perform integral only control regardless of the STRUCTURE parameter selection. When RESET equals zero, the equation reduces to an integrator equation with a gain value applied to the error:

$$\frac{\text{GAIN} \times e(s)}{s}$$

Where

- GAIN: Proportional gain value.
- e: Error.
- s: Laplace operator.

6.8 REVERSE AND DIRECT ACTION

To configure the block output action, enable the **Direct Acting** control option. This option defines the relationship between a change in PV and the corresponding change in output. With **Direct Acting** enabled (True), an increase in PV results in an increase in the output.

Control options can be set in **Manual** or **Out of Service** mode only.

NOTE:

Track Enable, Track in Manual, SP-PV Track in Man, SP-PV Track in LO or IMan, Use PV for BKCAL_OUT, and Direct Acting are the only control options supported by the PID function block. Unsupported options are not grayed out; they appear on the screen in the same manner as supported options.

6.9 RESET LIMITING

The PID function block provides a modified version of feedback reset limiting that prevents windup when output or input limits are encountered, and provides the proper behavior in selector applications.

6.10 BLOCK ERRORS

Table D-2 lists conditions reported in the BLOCK_ERR parameter. Conditions in *italics* are inactive for the PID block and are given here only for your reference.

Table 6-2. Block Error Conditions

Condition Number	Condition Name and Description
0	<i>Other:</i>
1	Block Configuration Error: The BY_PASS parameter is not configured and is set to 0, the SP_HI_LIM is less than the SP_LO_LIM, or the OUT_HI_LIM is less than the OUT_LO_LIM.
2	<i>Link Configuration Error</i>
3	<i>Simulate Active</i>
4	Local Override: The actual mode is LO.
5	<i>Device Fault State Set</i>
6	<i>Device Needs Maintenance Soon</i>
7	Input Failure/Process Variable has Bad Status: The parameter linked to IN is indicating a Bad status.
8	<i>Output Failure</i>
9	<i>Memory Failure</i>
10	<i>Lost Static Data</i>
11	<i>Lost NV Data</i>
12	<i>Readback Check Failed</i>
13	<i>Device Needs Maintenance Now</i>
14	<i>Power Up</i>
15	Out of Service: The actual mode is out of service.

6.11 MODES

The PID function block supports the following modes:

Manual (Man)—The block output (OUT) may be set manually.

Automatic (Auto)—The SP may be set manually and the block algorithm calculates OUT.

Cascade (Cas)—The SP is calculated in another block and is provided to the PID block through the CAS_IN connection.

RemoteCascade (RCas)—The SP is provided by a host computer that writes to the RCAS_IN parameter.

RemoteOutput (Rout)—The OUT is provided by a host computer that writes to the ROUT_IN parameter

Local Override (LO)—The track function is active. OUT is set by TRK_VAL. The BLOCK_ERR parameter shows Local override.

Initialization Manual (IMan)—The output path is not complete (for example, the cascade-to-slave path might not be open). In IMan mode, OUT tracks BKCAL_IN.

Out of Service (O/S)—The block is not processed. The OUT status is set to *Bad: Out of Service*. The BLOCK_ERR parameter shows Out of service.

The Man, Auto, Cas, and O/S modes can be configured as permitted modes for operator entry.

6.12 ALARM DETECTION

A block alarm will be generated whenever the BLOCK_ERR has an error bit set. The types of block error for the AI block are defined above.

Process alarm detection is based on the PV value. The alarm limits of the following standard alarms can be configured:

- High (HI_LIM)
- High high (HI_HI_LIM)
- Low (LO_LIM)
- Low low (LO_LO_LIM)

Additional process alarm detection is based on the difference between SP and PV values and can be configured via the following parameters:

- Deviation high (DV_HI_LIM)
- Deviation low (DV_LO_LIM)

In order to avoid alarm chattering when the variable is oscillating around the alarm limit, an alarm hysteresis in percent of the PV span can be set using the ALARM_HYS parameter. The priority of each alarm is set in the following parameters:

- HI_PRI
- HI_HI_PRI
- LO_PRI
- LO_LO_PRI
- DV_HI_PRI
- DV_LO_PRI

Alarms are grouped into five levels of priority:

Table 6-3. Alarm Priorities

Priority	Priority Description Number
0	The priority of an alarm condition changes to 0 after the condition that caused the alarm is corrected.
1	An alarm condition with a priority of 1 is recognized by the system, but is not reported to the operator.
2	An alarm condition with a priority of 2 is reported to the operator, but does not require operator attention (such as diagnostics and system alerts).
3-7	Alarm conditions of priority 3 to 7 are advisory alarms of increasing priority.
8-15	Alarm conditions of priority 8 to 15 are critical alarms of increasing priority.

6.13 STATUS HANDLING

If the input status on the PID block is *Bad*, the mode of the block reverts to **Manual**. In addition, the **Target to Manual if Bad IN** status option can be selected to direct the target mode to revert to manual. The status option can be set in **Manual** or **Out of Service** mode only.

NOTE:

Target to Manual if Bad IN is the only status option supported by the PID function block. Unsupported options are not grayed out; they appear on the screen in the same manner as supported options.

6.14 APPLICATION INFORMATION

The PID function block is a powerful, flexible control algorithm that is designed to work in a variety of control strategies. The PID block is configured differently for different applications. The following examples describe the use of the PID block for closed-loop control (basic PID loop), feedforward control, cascade control with master and slave, and complex cascade control with override.

6.15 CLOSED LOOP CONTROL

To implement basic closed loop control, compute the error difference between the process variable (PV) and setpoint (SP) values and calculate a control output signal using a PID (Proportional Integral Derivative) function block.

The proportional control function responds immediately and directly to a change in the PV or SP. The proportional term **GAIN** applies a change in the loop output based on the current magnitude of the error multiplied by a gain value.

The integral control function reduces the process error by moving the output in the appropriate direction. The integral term **RESET** applies a correction based on the magnitude and duration of the error. Set the RESET parameter to zero for integral-only control. To reduce reset action, configure the RESET parameter to be a large value.

The derivative term **RATE** applies a correction based on the anticipated change in error. Derivative control is typically used in temperature control where large measurement lags exist.

The MODE parameter is a switch that indicates the target and actual mode of operation. Mode selection has a large impact on the operation of the PID block:

- **Manual** mode allows the operator to set the value of the loop output signal directly.
- **Automatic** mode allows the operator to select a setpoint for automatic correction of error using the **GAIN**, **RESET**, and **RATE** tuning values.
- **Cascade** and **Remote Cascade** modes use a setpoint from another block in a cascaded configuration.
- **Remote Out** mode is similar to **Manual** mode except that the block output is supplied by an external program rather than by the operator.
- **Initialization Manual** is a non-target mode used with cascade configurations while transitioning from manual operation to automatic operation.
- **Local Override** is a non-target mode that instructs the block to revert to Local Override when the tracking or fail-safe control options are activated.
- **Out of Service** mode disables the block for maintenance.

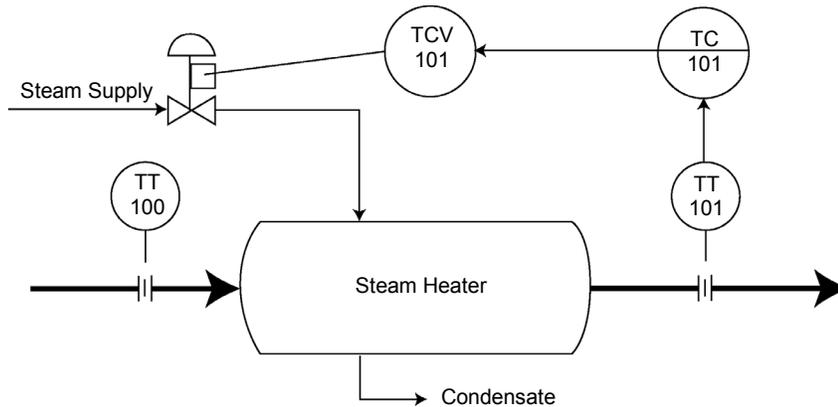
Abrupt changes in the quality of the input signal can result in unexpected loop behavior. To prevent the output from changing abruptly and upsetting the process, select the **SP-PV Track in Man I/O** option. This option automatically sets the loop to **Manual** if a *Bad* input status is detected. While in manual mode, the operator can manage control manually until a *Good* input status is reestablished.

6.15.1 Application Example 1

Basic PID Block for Steam Heater Control

Situation

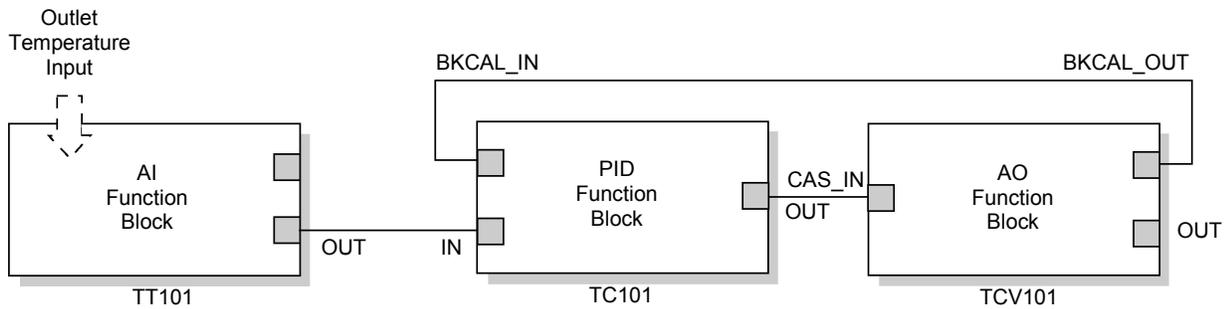
A PID block is used with an AI block and an AO block to control the flow steam used to heat a process fluid in a heat exchanger. The diagram below illustrates the process instrumentation.



PID Function Block Steam Heater Control Example

Solution

The PID loop uses TT101 as an input and provides a signal to the analog output TCV101. The BKCAL_OUT of the AO block and the BKCAL_IN of the PID block communicate the status and quality of information being passed between the blocks. The status indication shows that communications is functioning and the I/O is working properly. The diagram below illustrates the correct function block configuration.



PID Function Block Diagram for Steam Heater Control Example

6.15.2 Application Example 2

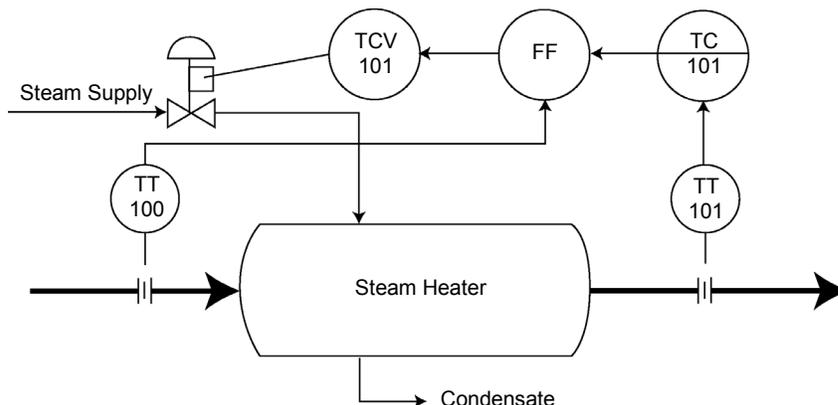
Feedforward Control

Situation

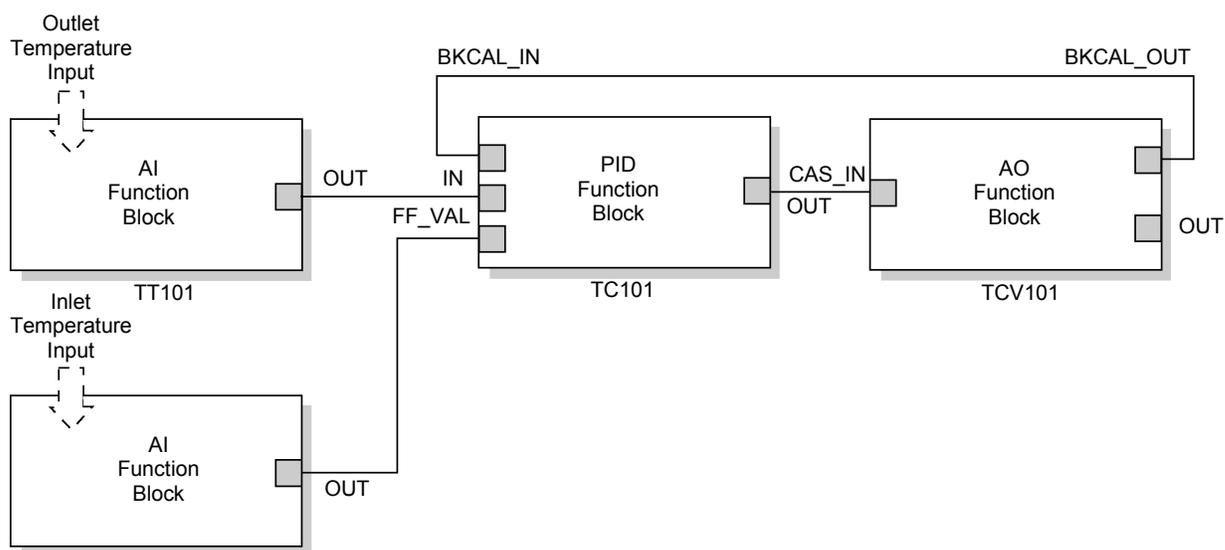
In the previous example, control problems can arise because of a time delay caused by thermal inertia between the two flow streams (TT100 and TT101). Variations in the inlet temperature (TT100) take an excessive amount of time to be sensed in the outlet (TT101). This delay causes the product to be out of the desired temperature range.

Solution

Feedforward control is added to improve the response time of the basic PID control. The temperature of the inlet process fluid (TT100) is input to an AI function block and is connected to the FF_VAL connector on the PID block. Feedforward control is then enabled (FF_ENABLE), the feedforward value is scaled (FF_SCALE), and a gain (FF_GAIN) is determined. The diagrams below illustrate the process instrumentation, and the correct function block configuration.



PID Function Block Feedforward Control Example



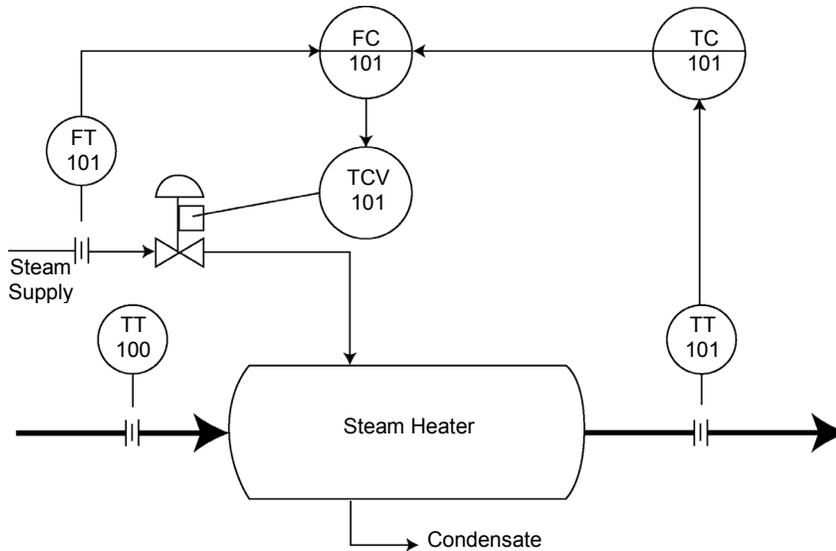
PID Function Block Diagram for Feedforward Control Example

6.15.3 Application Example 3

Cascade Control with Master and Slave Loops

Situation

A slave loop is added to a basic PID control configuration to measure and control steam flow to the steam heater. Variations in the steam pressure cause the temperature in the heat exchanger to change. The temperature variation will later be sensed by TT101. The temperature controller will modify the valve position to compensate for the steam pressure change. The process is slow and causes variations in the product temperature. The diagram below illustrates the process instrumentation.

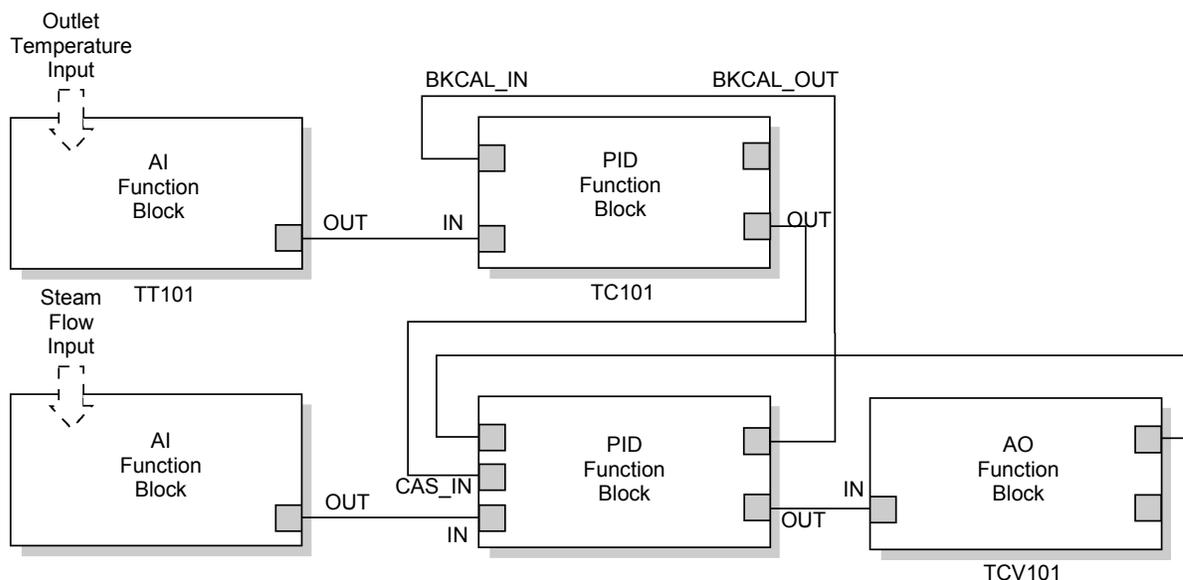


PID Function Block Cascade Control Example

Solution

If the flow is controlled, steam pressure variations will be compensated before they significantly affect the heat exchanger temperature. The output from the master temperature loop is used as the setpoint for the slave steam flow loop. The BKCAL_IN and BKCAL_OUT connections on the PID blocks are used to prevent controller windup on the master loop when the slave loop is in Manual or Automatic mode, or it has reached an output constraint. The diagram below illustrates the correct function block configuration.

PID Function Block



PID Function Block Diagram for Cascade Control Example

6.15.4 Application Example 4

Cascade Control with Override

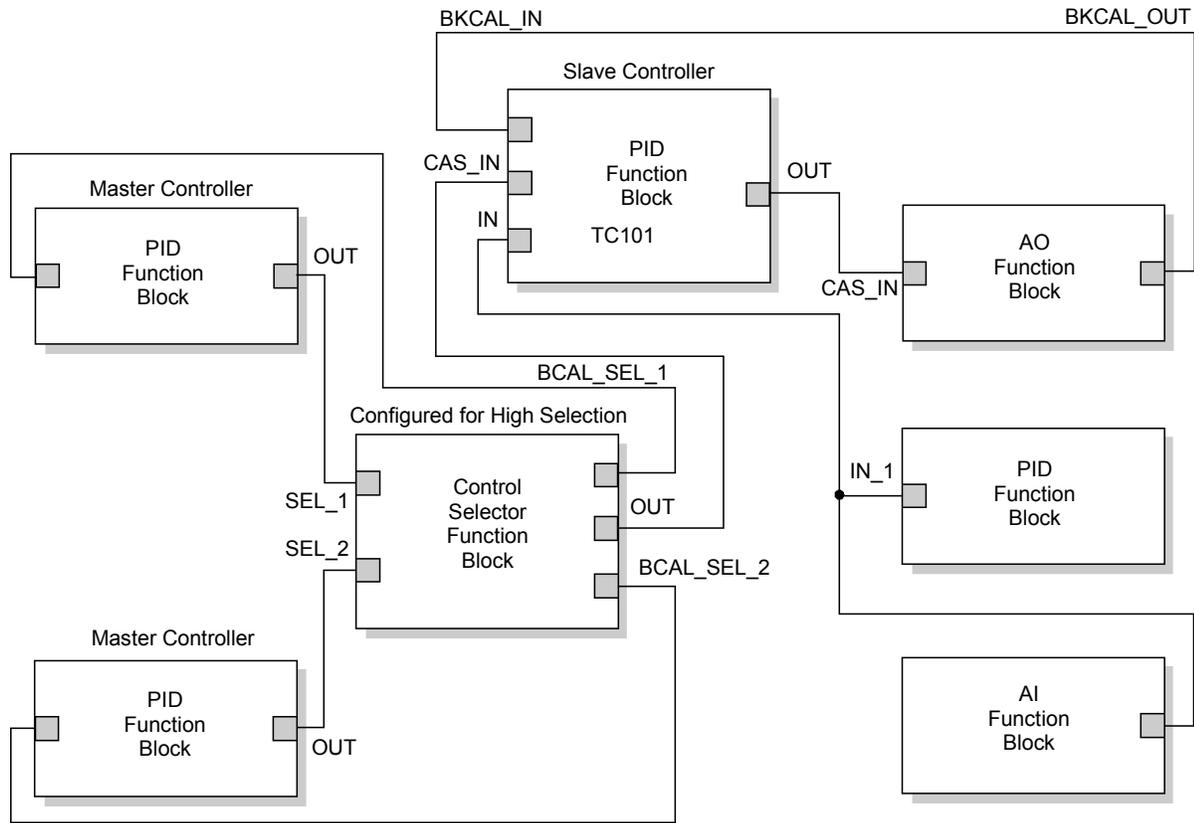
The PID function block can be used with other function blocks for complex control strategies. The diagram below illustrates the function block diagram for cascade control with override.

When configured for cascade control with override, if one of the PID function blocks connected to the selector inputs is deselected, that PID block filters the integral value to the selected value (the value at its BKCAL_IN). The selected PID block behaves normally and the deselected controller never winds up. At steady state, the deselected PID block offsets its OUT value from the selected value by the proportional term. When the selected block becomes output-limited, it prevents the integral term from winding further into the limited region.

When the cascade between the slave PID block and the Control Selector block is open, the open cascade status is passed to the Control Selector block and through to the PID blocks supplying input to it. The Control Selector block and the upstream (master) PID blocks have an actual mode of **IMan**.

If the instrument connected to the AI block fails, the AI block can be placed in **Manual** mode and set the output to some nominal value for use in the Integrator function block. In this case, IN at the slave PID block is constant and prevents the integral term from increasing or decreasing.

PID Function Block



PID Function Block Diagram for Cascade Control with Override

6.16 TROUBLESHOOTING

Table 6-4. Troubleshooting for PID

Symptom	Possible Causes	Corrective Action
Mode will not leave OOS	1. Target mode not set.	1. Set target mode to something other than OOS.
	2. Configuration error	2. BLOCK_ERR will show the configuration error bit set. The following are parameters that must be set before the block is allowed out of OOS: <ul style="list-style-type: none"> a. BYPASS must be off or on and cannot be left at initial value of 0. b. OUT_HI_LIM must be less than or equal to OUT_LO_LIM. c. SP_HI_LIM must be less than or equal to SP_LO_LIM.
	3. Resource block	3. The actual mode of the Resource block is OOS. See Resource Block Diagnostics for corrective action.
	4. Schedule	4. Block is not scheduled and therefore cannot execute to go to Target Mode. Schedule the block to execute.
Mode will not leave IMAN	1. Back Calculation	1. BKCAL_IN <ul style="list-style-type: none"> a. The link is not configured (the status would show "Not Connected"). Configure the BKCAL_IN link to the downstream block. b. The downstream block is sending back a Quality of "Bad" or a Status of "Not Invited". See the appropriate downstream block diagnostics for corrective action.

PID Function Block

Symptom	Possible Causes	Corrective Action
Mode will not change to AUTO	1. Target mode not set.	1. Set target mode to something other than OOS.
	2. Input	2. IN a. The link is not configured (the status would show "Not Connected"). Configure the IN link to the block. b. The upstream block is sending back a Quality of "Bad" or a Status of "Not Invited". See the appropriate upstream block diagnostics for corrective action.
Mode will not change to CAS	1. Target mode not set.	1. Set target mode to something other than OOS.
	2. Cascade input	2. CAS_IN a. The link is not configured (the status would show "Not Connected"). Configure the CAS_IN link to the block. b. The upstream block is sending back a Quality of "Bad" or a Status of "Not Invited". See the appropriate up stream block diagnostics for corrective action.
Mode sheds from RCAS to AUTO	1. Remote Cascade Value	1. Host system is not writing RCAS_IN with a quality and status of "good cascade" within shed time (see 2 below).
	2. Shed Timer	2. The mode shed timer, SHED_RCAS in the resource block is set too low. Increase the value.
Mode sheds from ROUT to MAN	1. Remote output value	1. Host system is not writing ROUT_IN with a quality and status of "good cascade" within shed time (see 2 below).
	2. Shed timer	2. The mode shed timer, SHED_RCAS, in the resource block is set too low. Increase the value.
Process and/or block alarms will not work.	1. Features	1. FEATURES_SEL does not have Alerts enabled. Enable the Alerts bit.
	2. Notification	2. LIM_NOTIFY is not high enough. Set equal to MAX_NOTIFY.
	3. Status Options	3. STATUS_OPTS has Propagate Fault Forward bit set. This should be cleared to cause an alarm to occur.

Foundation™ Fieldbus 100 Series

Instruction Manual

ETC 00624

12/2001

WORLD HEADQUARTERS

ROSEMOUNT ANALYTICAL EUROPE

Emerson Process Management

GmbH & Co. OHG

Industriestrasse 1

63594 Hasselroth

Germany

T 49 6055 884 0

F 49 6055 884209

Emerson Process Management

Rosemount Analytical Inc.

6565 P Davis Industrial Parkway

Solon, OH 44139 USA

T 440.914.1261

Toll Free in US and Canada 800.433.6076

F 440.914.1271

e-mail: gas.csc@EmersonProcess.com

www.raihome.com

GAS CHROMATOGRAPHY CENTER AND LATIN AMERICA

Emerson Process Management

Rosemount Analytical Inc.

11100 Brittmoore Park Drive

Houston, TX 77041

T 713 467 6000

F 713 827 3329

EUROPE, MIDDLE EAST AND AFRICA

Emerson Process Management

Shared Services Limited

Heath Place

Bognor Regis

West Sussex PO22 9SH

England

T 44 1243 863121

F 44 1243 845354

ASIA-PACIFIC

Emerson Process Management

Asia Pacific Private Limited

1 Pandan Crescent

Singapore 128461

Republic of Singapore

T 65 6 777 8211

F 65 6 777 0947

e-mail: analytical@ap.emersonprocess.com