Instruction Manual
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Instruction Manual

Foundation™ Fieldbus Communication Option for MLT 1, MLT 2 and CAT 200

3rd Edition 10/2003











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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

Cert. Reg. No. 254969 QM

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PREFACE

The purpose of this manual is to provide information concerning the technology, components and functions of FOUNDATION™ Fieldbus in combination with a MLT or CAT 200 analyzer.

Some sections may describe equipment not used in your configuration. The user should become thoroughly familiar with the operation of this module before operating it. Read this instruction manual completely.

Definitions

The following definitions apply to WARNINGS, CAUTIONS and NOTES found throughout this publication.

WARNING

Highlights an operation or maintenance procedure, practice, condition, statement, etc. If not strictly observed, could result in injury, death, or long-term health hazards of personnel.

CAUTION

Highlights an operation or maintenance procedure, practice, condition, statement, etc. If not strictly observed, could result in damage to or destruction of equipment, or loss of effectiveness.

NOTE



Highlights an essential operating procedure, condition or statement.

IMPORTANT

SAFETY INSTRUCTIONS

INTENDED USE STATEMENT

The equipment covered by or referred to within this manual is inteded for use as an industrial process measurement device only. It is not intended for use in medical, diagnostic, or life support applications, and no independent agency certifications or approvals are to be implied as covering such applications.

SAFETY SUMMARY

If this equipment is used in a manner not specified in the related instructions, protective systems may be impaired.

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To avoid loss of life, personal injury and damage to this equipment and on-site property, do not operate or service this instrument before reading and understanding all related instruction manuals and receiving appropriate training. Save these instructions.

WARNING

EXPLOSION HAZARD

In principle FOUNDATION™ Fieldbus signals as described in this manual are NOT INTRINSICALLY SAFE according to national and international standards for explosion protection for equipment to be used in hazardous areas, except stated on the equipment's nameplate label!

Do not connect NON INTRINSICALLY SAFE circuits to INTRINSICALLY SAFE ciruits!

Connecting NON INTRINSICALLY SAFE circuits to INTRINSICALLY SAFE ciruits voids the safety of the whole equipment and could result in injury, death, or long-term health hazards of personnel and/or damage to or destruction of equipment!

TABLE OF CONTENTS

PREFACE P-1
Definitions P-1
Safety Instructions P-2

SECTION 1
FOUNDATION™ Fieldbus Technology 1-1
1-1 Overview 1-1
1-2 Introduction 1-1
1-2-1 Function Blocks 1-2
1-2-2 Device Descriptions 1-3
1-3 Instrument Specific Function 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 1-8
1-4-5 Function Block Scheduling 1-9
1-5 References 1-10
1-5-1 Fieldbus Foundation 1-10
1-6 Implemented Function Blocks 1-11

SECTION 2
Transducer Block 2-1
2-1 List of Transducer Block Parameters 2-2
2-2 Transducer Block Parameter Descriptions 2-5
2-3 Transducer Block Parameter Attribute Definitions 2-7
2-4 Transducer Block Enumerations 2-9
2-4-1 Gas Control State 2-9
2-4-2 Calibration States 2-9
2-4-3 Calibration Step Control 2-10
2-4-4 Measurement Options 2-11
2-4-5 Calibration Options 2-11
2-4-6 Sensor Options 2-12
2-4-7 Analyzer Options 2-12
2-4-8 Access Mode Control 2-13

Table of Contents

2-4-9 Detailed Status 2-13
2-4-9-1 Detailed Maintenance 2-13
2-4-9-2 Detailed Failure 2-14
2-4-9-3 Detailed Status 2-15
2-4-10 Function Call Control 2-16
2-5 Transducer Block Channel Assignments 2-17
2-5-1 I/O Channel Assignments for AI-Blocks 2-17
2-5-2 I/O Channel Assignment for A0-Blocks 2-17
2-6 Simulation of TBlk States 2-18
2-7 Supported Transducer Block Errors 2-18
2-7-1 Out of Service 2-18
2-7-2 Block Configuration Error 2-18
2-7-3 Input Failure/ Process Variable has BAD Status 2-18
2-7-4 Device needs Maintenance Now 2-18
2-7-5 Simulate Active 2-18
2-7-6 Other Error 2-18

SECTION 3
Resource Block 3-1
3-1 Mapping of the PlantWeb Alerts 3-1
3-2 PWA_SIMULATE 3-3

SECTION 4
Analog Input (AI) Function Block 4-1
4-1 Simulation 4-3
4-2 Filtering 4-4
4-3 Signal Conversion 4-4
4-4 Block Errors 4-6
4-5 Modes 4-6
4-6 Alarm Detection 4-7
4-7 Status Handling 4-8
4-8 Advanced Features 4-8
4-9 Application Information 4-9
4-9-1 Application Example 1
Temperature Transmitter 4-9
4-9-2 Application Example 2
Pressure Transmitter used to Measure Level in Open Tank 4-10
4-9-3 Application Example 3
Differential Pressure Transmitter used to Measure Flow 4-11
4-10 Troubleshooting 4-12

Table of Contents

SECTION 5
Analog Output (AO) Function Block 5-1
5-1 Setting the Output 5-2
5-2 Setpoint Selection and Limiting 5-3
5-3 Conversion and Status Calculation 5-3
5-4 Simulation 5-4
5-5 Action on Fault Detection 5-4
5-6 Block Errors 5-5
5-7 Modes 5-5
5-8 Status Handling 5-5

SECTION 6
Input Selector (ISEL) Function Block 6-1
6-1 Block Errors 6-3
6-2 Modes 6-4
6-3 Alarm Detection 6-4
6-4 Block Execution 6-4
6-5 Status Handling 6-5
6-6 Application Information 6-5
6-7 Troubleshooting 6-7

SECTION 7
Arithmetic (ARTHM) Function Block 7-1
7-1 Block Errors 7-4
7-2 Modes 7-4
7-3 Alarm Detection 7-5
7-4 Block Execution 7-5
7-5 Status Handling 7-6
7-6 Application Information 7-6

SECTION 8
Proportional / Integral / Derivative (PID) Function Block 8-1
8-1 Setpoint Selection and Limiting 8-4
8-2 Filtering 8-5
8-3 Feedforward Calculation 8-5
8-4 Tracking 8-5
8-5 Output Selection and Limiting 8-6
8-6 Bumpless Transfer and Setpoint Tracking 8-6
8-7 PID Equation Structures 8-6
8-8 Reverse and Direct Action 8-7

Table of Contents

8-9 Reset Limiting 8-7
8-10 Block Errors 8-7
8-11 Modes 8-8
8-12 Alarm Detection 8-8
8-13 Status Handling 8-9
8-14 Closed Loop Control 8-9
8-15 Application Information 8-10
8-15-1 Application Example 1
Basic PID Block for Steam Heater Control 8-11
8-15-2 Application Example 2
Feedforward Control 8-12
8-15-3 Application Example 3
Cascade Control with Master and Slave Loops 8-13
8-15-4 Application Example 4
Cascade Control with Override 8-14
8-16 Troubleshooting 8-15

APPENDIX
Operation with EMERSON™ Process Management DeltaV™ A-1
A-1 About DeltaV Software with AMS inside A-1
A-2 Install the Analyzer onto DeltaVTM A-1

SECTION 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.

Emerson 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 sub-classing specified classes. This approach permits extending function block definitions as new requirements are discovered and as technology advances.

Fig. 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.

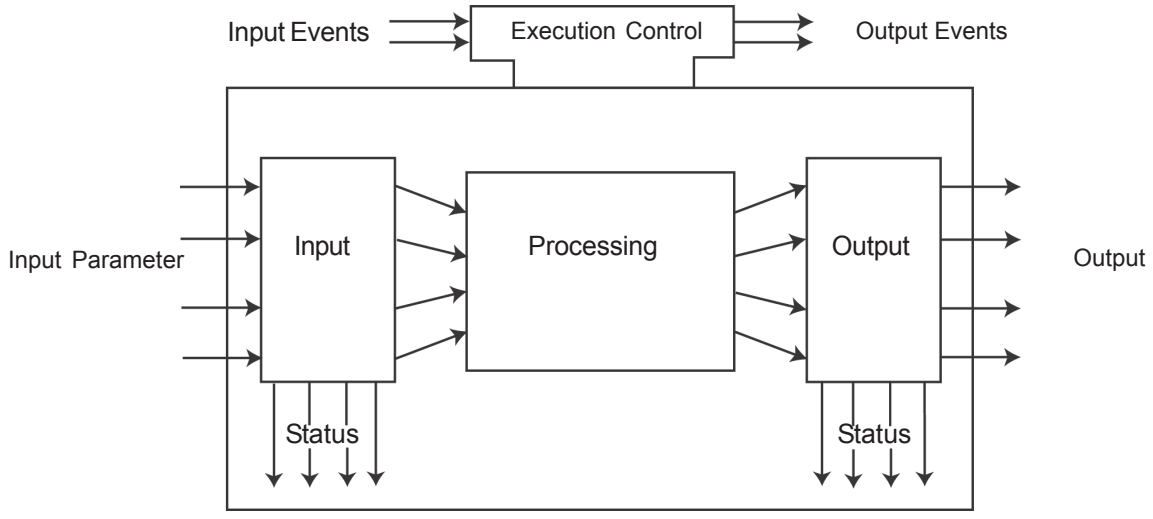


Fig. 1-1
Function Block Internal Structure

1-2-2 Device Descriptions

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 Function 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

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

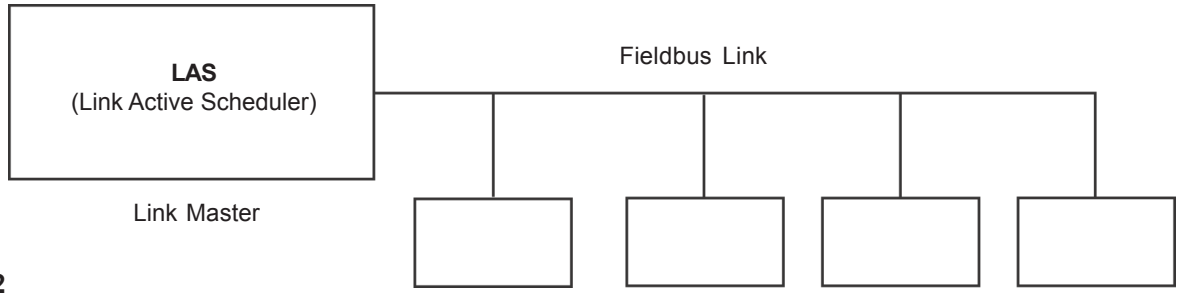


Fig. 1-2
Single Link Fieldbus Network

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 Emerson 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.

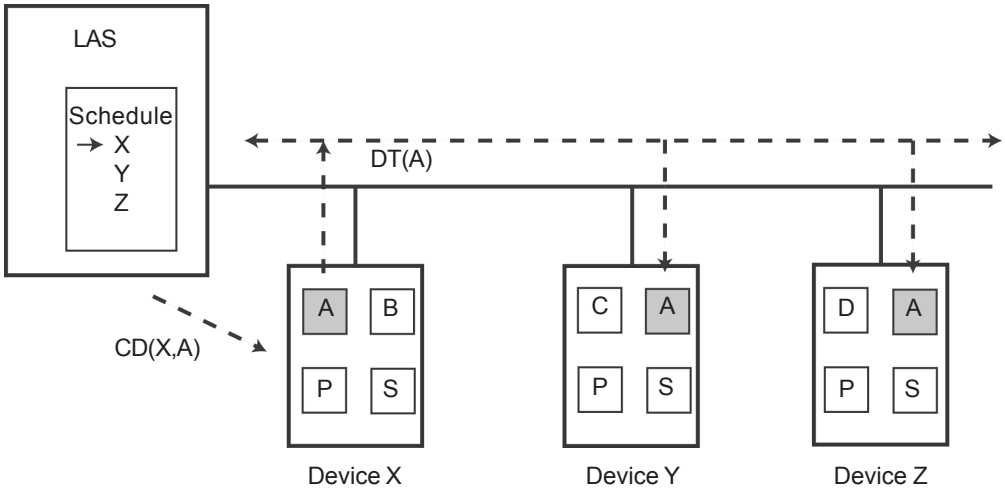
- **Publisher/Subscriber:** This type of reporting is used to transfer critical process loop data, such as the process variable. The data producers (publishers) post the data in a buffer that is transmitted to the subscriber (S), when the publisher receives the Compel data. The buffer contains only one 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.

1-4-3 Scheduled Transfers

Fig. 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.“

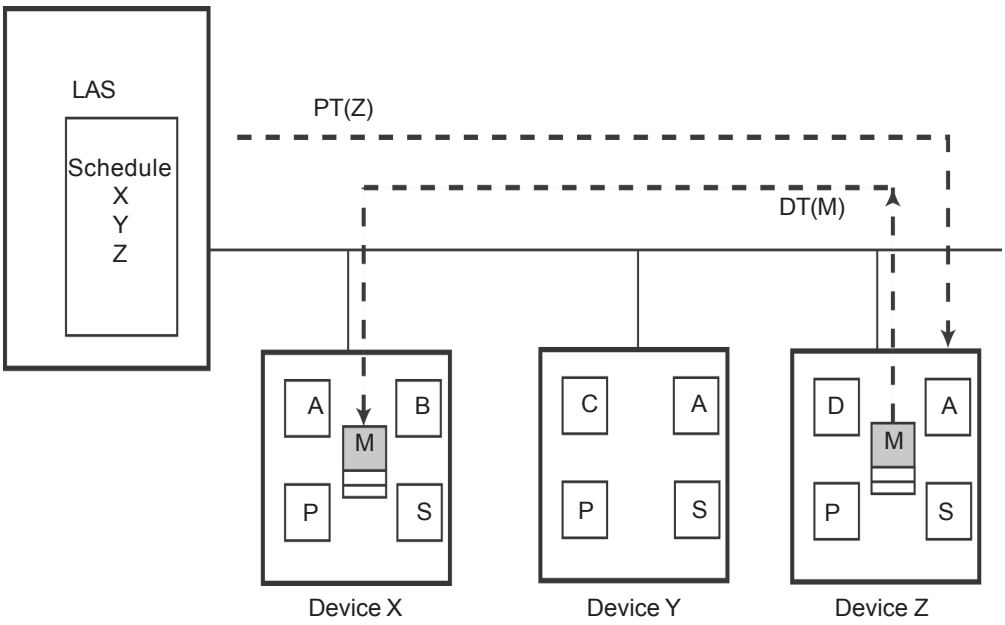


LAS = Link Active Scheduler
P = Publisher
S = Subscriber
CD = Compel Data
DT = Data Transfer Packet

Fig. 1-3
Scheduled Data Transfer

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.



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

Fig. 1-4
Unscheduled Data Transfer

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.

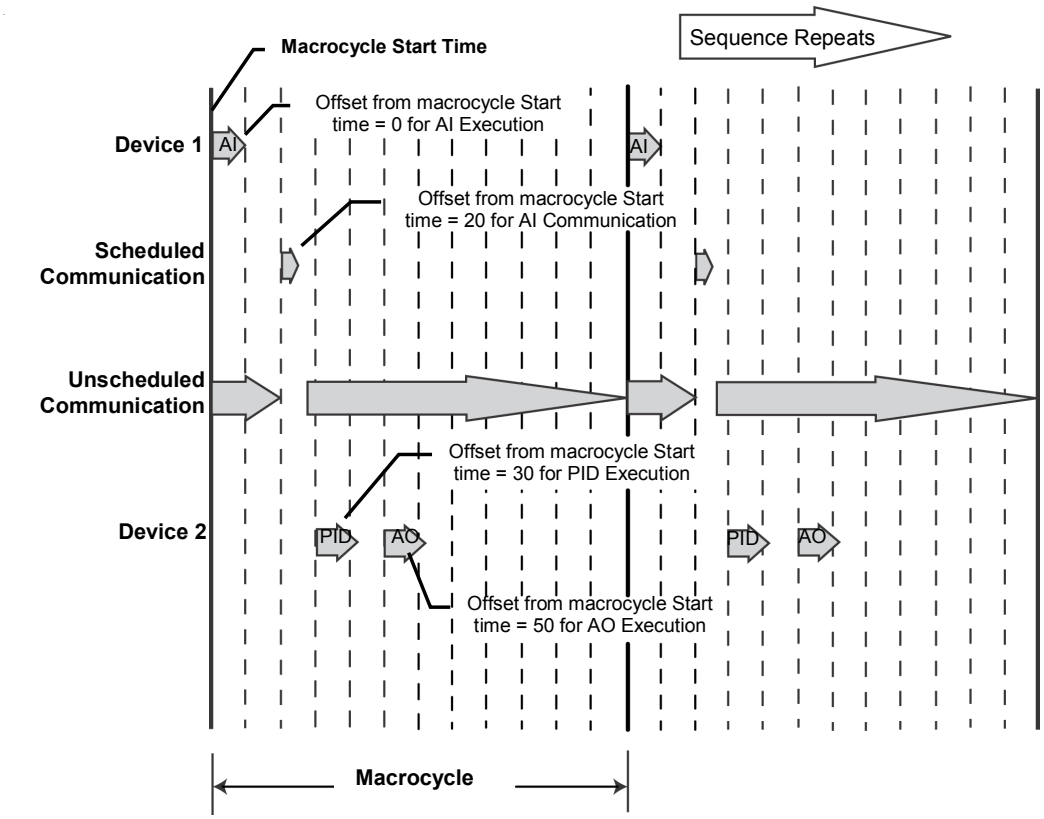


Fig. 1-5
Example of Link Schedule
(Showing scheduled and unscheduled communication)

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

Tab. 1-1
Fieldbus Foundation Documents

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 World_FIP 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 insomuch 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:

9005 Mountain Ridge Drive
Bowie Buldg - Suite 190
Austin, TX 78759-5316, USA

Tel: +1.512.794.8890
Fax: +1.512.794.8893
Email: info@fieldbus.org
Internet: www.fieldbus.org

1-6 Implemented Function Blocks

For the MLT we have implemented the following function blocks :

	Intended Use or Transducer Block Channel Assignments
Resource Block (RB)	
TransducerBlock (TB)	
Analog-Input Block 1 (AI1)	PRIMARY_VARIABLE_1 (see Table 7? 1)
Analog-Input Block 2 (AI2)	PRIMARY_VARIABLE_2 (see Table 7? 1)
Analog-Input Block 3 (AI3)	SENSOR_FLOW_1 (see Table 7? 1)
Analog-Input Block 4 (AI4)	SENSOR_FLOW_2 (see Table 7? 1)
Analog-Input Block 5 (AI5)	SENSOR_PRESSURE_1(read) (see Table 7? 1)
Analog-Output Block1 (AO1)	SENSOR_PRESSURE_1(write) (seeTable 7? 2)
Analog-Output Block2 (AO2)	SENSOR_PRESSURE_2(write) (seeTable 7? 2)
Arithmetic Block (ARTHM)	4th order polynomial for any AI-block
PID Block (PID)	proportional/integral/derivative control of any AI-block
Input Selector Block (ISEL)	selector of any AI-block

Tab. 1-2
Implemented Function Blocks

SECTION 2
Transducer Block

The **Transducer Block part** was designed to provide the information necessary to interface the MLT to the Fieldbus. The data structures should be used for transferring Fieldbus information between the MLT's Object Dictionary and other hosts and devices on Fieldbus.

Three tables are used to describe the MLT parameters. The List of Parameters table defines the relative index value used to reference the parameter in the MLT Transducer Block Object Dictionary and the mnemonic used to reference the parameter, as well as the View(s)in which the parameter is contained. The Parameter Descriptions table 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 of the document. The I/O channel assignments and their status values are shown in the Channel Assignments section.

Finally the default values for parameters are defined. These are the parameters which will be loaded into the Fieldbus Interface Board's database before any communication to the transducer itself is performed.

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.

2-1 List of Transducer Block Parameters

This section defines parameter access for a basic sensor. Parameter access is described in FF-890.

Relative Index	Parameter Mnemonic	VIEW_1	VIEW_2	VIEW_3 1st	VIEW_3 2nd	VIEW_4 1st	VIEW_4 2nd	VIEW_4 3rd	VIEW_4 4th
1	ST_REV	2	2	2	2	2			
2	TAG_DESC								
3	STRATEGY					2			
4	ALERT_KEY					1			
5	MODE_BLK	4		4					
6	BLOCK_ERR	2		2					
7	UPDATE_EVT								
8	BLOCK_ALM								
9	TRANSDUCER_DIRECTORY								
10	TRANSDUCER_TYPE	2	2	2		2			
11	XD_ERROR	1		1					
12	COLLECTION_DIRECTORY								
13	PRIMARY_VALUE_TYPE_1		2						
14	PRIMARY_VALUE_1	5		5					
15	PRIMARY_VALUE_RANGE_1							11	
16	CAL_POINT_HI_1		4						
17	CAL_POINT_LO_1		4						
18	CAL_MIN_SPAN_1							4	
19	CAL_UNIT_1							2	
20	CAL_GAS_TIME_1							2	
21	CAL_ZERO_TOLERANCE_1							4	
22	CAL_SPAN_TOLERANCE_1							4	
23	CAL_SLOPE_1				4				
24	CAL_CONSTANT_1				4				
25	CAL_ZERO_INTERVAL_1							2	
26	CAL_ZERO_DATE_1				7				
27	CAL_SPAN_INTERVAL_1							2	
28	CAL_SPAN_DATE_1				7				
29	CAL_ ZERO_SPAN_INTERVAL_1							2	
30	CAL_ ZERO_SPAN_DATE_1				7				
31	SPAN_CAL_DATE_1							7	
32	ZERO_CAL_DATE_1							7	
33	SENSOR_TYPE_1							2	
34	SENSOR_RANGE_1							11	
35	SENSOR_ID_1					30			
36	SENSOR_FILTER_VALUE_1							4	
37	SENSOR_RAW_CONCENTRATION_1				4				
38	SENSOR_AVG_CYCLES_1							2	
39	SENSOR_AVG_METHOD_1							1	
40	SENSOR_NOISE_REFVAL_1							4	

Tab. 2-1
Transducer Block Parameters

2-1 List of Transducer Block Parameters

Relative Index	Parameter Mnemonic	VIEW_1	VIEW_2	VIEW_3 1st	VIEW_3 2nd	VIEW_4 1st	VIEW_4 2nd	VIEW_4 3rd	VIEW_4 4th
41	SENSOR_NOISE_LEVEL_1							4	
42	SENSOR_NOISE_TUNE_1							4	
43	SENSOR_ZTEMPERATURE_1				4				
44	SENSOR_STEMPERATURE_1				4				
45	SENSOR_TEMP_OFFSET_1				4				
46	SENSOR_CROSS_INTF_OFFSET_1				4				
47	SENSOR_TEMP_FACTOR_1				4				
48	SENSOR_PRESSURE_1	5		5					
49	SENSOR_PRESSURE_FACTOR_1				4				
50	SENSOR_FLOW_1	5		5					
51	SENSOR_OPTS_1							4	
52	PRIMARY_VALUE_TYPE_2		2						
53	PRIMARY_VALUE_2	5		5					
54	PRIMARY_VALUE_RANGE_2								11
55	CAL_POINT_HI_2		4						
56	CAL_POINT_LO_2		4						
57	CAL_MIN_SPAN_2								4
58	CAL_UNIT_2								2
59	CAL_GAS_TIME_2								2
60	CAL_ZERO_TOLERANCE_2								4
61	CAL_SPAN_TOLERANCE_2								4
62	CAL_SLOPE_2				4				
63	CAL_CONSTANT_2				4				
64	CAL_ZERO_INTERVAL_2								2
65	CAL_ZERO_DATE_2				7				
66	CAL_SPAN_INTERVAL_2								2
67	CAL_SPAN_DATE_2				7				
68	CAL_ ZERO_SPAN_INTERVAL_2								2
69	CAL_ ZERO_SPAN_DATE_2				7				
70	SPAN_CAL_DATE_2								7
71	ZERO_CAL_DATE_2								7
72	SENSOR_TYPE_2								2
73	SENSOR_RANGE_2								11
74	SENSOR_ID_2					30			
75	SENSOR_FILTER_VALUE_2								4
76	SENSOR_RAW_CONCENTRATION_2				4				
77	SENSOR_AVG_CYCLES_2								2
78	SENSOR_AVG_METHOD_2								1
79	SENSOR_NOISE_REFVAL_2								4
80	SENSOR_NOISE_LEVEL_2								4

Tab. 2-1 (cont'd)
Transducer Block Parameters

2-1 List of Transducer Block Parameters

Relative Index	Parameter Mnemonic	VIEW_1	VIEW_2	VIEW_3 1st	VIEW_3 2nd	VIEW_4 1st	VIEW_4 2nd	VIEW_4 3rd	VIEW_4 4th
81	SENSOR_NOISE_TUNE_2								4
82	SENSOR_ZTEMPERATURE_2				4				
83	SENSOR_STEMPERATURE_2				4				
84	SENSOR_TEMP_OFFSET_2				4				
85	SENSOR_CROSS_INTF_OFFSET_2				4				
86	SENSOR_TEMP_FACTOR_2				4				
87	SENSOR_PRESSURE_2	5		5					
88	SENSOR_PRESSURE_FACTOR_2				4				
89	SENSOR_FLOW_2	5		5					
90	SENSOR_OPTS_2								4
91	ANALYZER_OPTS					1			
92	MEASUREMENT_OPTS					2			
93	GAS_CTRL_STATE	2		2					
94	CAL_STATE	2		2					
95	CAL_STEP			1					
96	CAL_OPTS					1			
97	FUNCTION_CALL			1					
98	DETAILED_FAILURE			4					
99	DETAILED_MAINTENANCE			4					
100	DETAILED_STATUS			4					
101	SIM_DETAILED_FAILURE			4					
102	SIM_DETAILED_MAINTENANCE			4					
103	SIM_DETAILED_STATUS			4					
104	DEVICE_TIME			7					
105	MODULE_SN						20		
106	MANUFACTURING_DATE						30		
107	ANALYZER_HW_VERSION						30		
108	ANALYZER_SW_VERSION						30		
109	ACCESS_MODE					1			
110	STATS_ATTEMPTS			4					
111	STATS_TIMEOUTS			4					
	Totals	***45***	***24***	***86***	***116***	***72***	***110***	***83***	***83***

Tab. 2-1 (cont'd)
Transducer Block Parameters

2-2 Transducer Block Parameter Descriptions

This table gives a description of all parameters in the above table, or gives the location in the Fieldbus specifications that the description can be found.

Parameter Mnemonic	Description
ACCESS_MODE	This parameter controls access to the transducer block parameters. See Table 6-8.
ALERT_KEY	See FF-891 section 5.3.
ANALYZER_HW_VERSION	The type of the analyzer hardware including boot image version string
ANALYZER_OPTS	The installed analyzer options
ANALYZER_SW_VERSION	The version number of the analyzer software
BLOCK_ALM	See FF-891 section 5.3.
BLOCK_ERR	See FF-891 section 5.3.
CAL_CONSTANT_n	The zero correction offset (calculated by zero calibration).
CAL_GAS_TIME	Purge delay time (in secs) for calibration gas supply
CAL_MIN_SPAN_n	See FF-903 section 3.3.
CAL_OPTS	The calibration options. See Table 6-5.
CAL_POINT_HI_n	See FF-903 section 3.3
CAL_POINT_LO_n	See FF-903 section 3.3
CAL_SLOPE_n	This parameter represents the span correction factor (calculated by span calibration).
CAL_SPAN_DATE_n	The date/time the next automatic span calibration will be started.
CAL_SPAN_INTERVAL_n	The time interval (in hours) for automatic span calibrations (0 = OFF).
CAL_SPAN_TOLERANCE_n	The allowed deviation tolerance (% of CAL_POINT_HI_n) for a span calibration.
CAL_STATE	This parameter represents the present state a calibration cycle is in.
CAL_STEP	This parameter is used to control zero and/or span calibrations. See Table 6-3 for the definition of states.
CAL_UNIT_n	See FF-903 section 3.3.
CAL_ZERO_DATE_n	The date/time the next automatic zero calibration will be started.
CAL_ZERO_INTERVAL_n	The time interval (in hours) for automatic zero calibrations (0 = OFF).
CAL_ZERO_SPAN_DATE_n	The date/time the next automatic zero & span calibrations will be started.
CAL_ZERO_SPAN_INTERVAL_n	The time interval (in hours) for automatic zero & span calibrations (0 = OFF).
CAL_ZERO_TOLERANCE_n	The allowed deviation tolerance (% of CAL_POINT_HI_n) for a zero calibration.
COLLECTION_DIRECTORY	See FF-891 section 5.3.
DETAILED_FAILURE	This is a bit-enumerated value used to communicate the failures of the device. SeeTable 6-9.
DETAILED_MAINTENANCE	This is a bit-enumerated value used to communicate the maintenance requests of the device. SeeTable 6-10.
DETAILED_STATUS	This is a bit-enumerated value used to communicate the status of the device. See Table 6-11 - Detailed
DEVICE_TIME	This is the analyzer's internal real time clock. It is used to automatically start time/date controlled procedures. To synchronize it with the FF-central date/time we should write to in certain time intervals.
FUNCTION_CALL	This parameter is used to call certain device procedures. SeeTable 6-12 for the definition of the states.
GAS_CTRL_STATE	The state of controlling the gas valves as well as gas pumps.
MANUFACTURING_DATE	The analyzer's manufacturing date string
MEASUREMENT_OPTS	The different kind of options for the measurement.
MODE_BLK	See FF-891 section 5.3.
MODULE_SN	The analyzer's serial number
PRIMARY_VALUE_n	See FF-903 section 3.3.
PRIMARY_VALUE_RANGE_n	See FF-903 section 3.3.
PRIMARY_VALUE_TYPE_n	See FF-903 section 3.3 and 4.1.
SENSOR_AVG_CYCLES_n	The number of preaveraging cycles for digital signal filtering.
SENSOR_AVG_METHOD_n	The preaveraging method for digital signal filtering (arithmetic or sliding).
SENSOR_CROSS_INTF_OFFSET_n	The zero correction of cross interference compensation.
SENSOR_FILTER_VALUE_n	The t90 response time (in secs) for gas change.

Tab. 2-2
Transducer Block Parameter Descriptions

2-1 List of Transducer Block Parameters

Parameter Mnemonic	Description
SENSOR_FLOW_n	The current gas flow (in l/min) of a measurement sensor. If the optional flow sensor is installed this is a dynamic variable. If the sensor is not installed we do not use for further evaluations.
SENSOR_ID_n	String which contents the measurement sensor's identifier as well as the measured gas type.
SENSOR_NOISE_LEVEL_n	This is the percentage level of the reference value the dynamic noise filtering becomes active.
SENSOR_NOISE_REFVAL_n	This parameter is a reference value (in ppm) for the dynamic noise filter.
SENSOR_NOISE_TUNE_n	Tuning factor how extremely the dynamic noise filter reduces dynamic noises.
SENSOR_OPTS_n	The installed sensor specific options.
SENSOR_PRESSURE_n	The current pressure (in hPa) of a measurement sensor:
	If internal pressure sensor is installed this is a readonly dynamic variable.
	If no pressure sensor is installed we can input the current pressure value.
	If we use remote pressure we have to input via AO block. There we have to select appropriate assignment by the CHANNEL-parameter.
SENSOR_PRESSURE_FACTOR_n	This parameter represents the span correction of pressure compensation.
SENSOR_RANGE_n	See FF-903 section 3.3.
SENSOR_RAW_CONCENTRATION_n	This parameter represents the raw value of A/D-Conversion of measurement channel.
SENSOR_STEMPERATURE_n	This parameter is the temperature (in °C) used for compensation of span corrections.
SENSOR_TEMP_FACTOR_n	This parameter represents the span correction of temperature compensation
SENSOR_TEMP_OFFSET_n	This parameter represents the zero correction of temperature compensation.
SENSOR_TYPE_n	See FF-903 section 3.3 and 4.3.
SENSOR_ZTEMPERATURE_n	This parameter is the temperature (in °C) used for compensation of zero corrections.
SIM_DETAILED_FAILURE	This is a bit-enumerated value used to simulate the failures of the device. SeeTable 6-9.
SIM_DETAILED_MAINTENANCE	This is a bit-enumerated value used to simulate the maintenance requests of the device. SeeTable 6-10.
SIM_DETAILED_STATUS	This is a bit-enumerated value used to simulate the stati of the device. SeeTable 6-11.
SPAN_CAL_DATE_n	The date the last span calibration was performed.
ST_REV	See FF-891 section 5.3.
STATS_ATTEMPTS	Total number of messages sent to the transducer a/d board.
STATS_FAILURES	Total number of failed a/d board message attempts.
STATS_TIMEOUTS	Total number of timed out a/d board message attempts.
STRATEGY	See FF-891 section 5.3.
TAG_DESC	See FF-891 section 5.3.
TRANSDUCER_DIRECTORY	See FF-903 section 3.3.
TRANSDUCER_TYPE	See FF-903 sections 3.3.
UPDATE_EVT	See FF-891 section 5.3.
XD_ERROR	SeeTable 6-9, Table 6-10, Table 6-11and FF-903 section 3.3.
ZERO_CAL_DATE_n	The date the last zero calibration was performed.

Tab. 2-2 (cont'd)
Transducer Block Parameter Descriptions

2-3 Transducer Block 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 an explanation of this table.

Parameter Mnemonic	Obj Type	Data Type / Structure	Store	Size	Valid Range	Initial Value	Units	Mode	Other	Range Check
ACCESS_MODE	S	Unsigned8	S	1	See Table 6-8	0	Enumerated			Yes
ANALYZER_HW_VERSION	S	Octet String	S	30			none		Read Only	
ANALYZER_OPTS	S	Unsigned8	S	1	See Table 6-7		Bit String		Read Only	
ANALYZER_SW_VERSION	S	Octet String	S	30			none		Read Only	
CAL_CONSTANT_n	S	Floating Point	D	4			none		Read Only	
CAL_GAS_TIME	S	Unsigned16	S	2	2 - 1000	2	Sec	O/S	Note 5-2	Yes
CAL_OPTS	S	Unsigned8	S	1	See Table 6-5	0	Bit String	O/S	Note 5-2	Yes
CAL_POINT_HI_n	S	Floating Point	S	4		100	CAL_UNIT	O/S	Note 5-2	
CAL_POINT_LO_n	S	Floating Point	S	4		0	CAL_UNIT	O/S	Note 5-2	
CAL_SLOPE_n	S	Floating Point	D	4		0			Read Only	
CAL_SPAN_DATE_n	S	Date-(11)	D	7		0		O/S	Note 5-4	Yes
CAL_SPAN_INTERVAL_n	S	Unsigned16	S	2	0-999	0	Hours	O/S	Note 5-4	Yes
CAL_SPAN_TOLERANCE_n	S	Floating Point	S	4	0 - 100	10	%	O/S	Note 5-2	Yes
CAL_STATE	S	Unsigned16	D	2	See Table 6-2	0	Bit String		Read Only	
CAL_STEP	S	Unsigned8	D	1	See Table 6-3	0	Enumerated		Note 5-2	Yes
CAL_UNIT_n	S	Unsigned16	S	2	ppm, % (see FF-903 sect. 4.10 Units Codes)	%	Enumerated	O/S	Note 5-2	
CAL_ZERO_DATE_n	S	Date-(11)	D	7		0		O/S	Note 5-4	Yes
CAL_ZERO_INTERVAL_n	S	Unsigned16	S	2	0-999	0	Hours	O/S	Note 5-4	Yes
CAL_ZERO_SPAN_DATE_n	S	Date-(11)	D	7		0		O/S	Note 5-4	Yes
CAL_ZERO_SPAN_INTERVAL_n	S	Unsigned16	S	2	0-999	0	Hours	O/S	Note 5-4	Yes
CAL_ZERO_TOLERANCE_n	S	Floating Point	S	4	0 - 100	10	%	O/S	Note 5-2	Yes
COLLECTION_DIRECTORY	A	Array of Unsigned32	N	Var	FF-903 section 3.3		None		Read Only	
DETAILED_FAILURE	S	Unsigned32	D	4	See Table 6-9	0	Bit String		Read Only	
DETAILED_MAINTENANCE	S	Unsigned32	D	4	See Table 6-10	0	Bit String		Read Only	
DETAILED_STATUS	S	Unsigned32	D	4	See Table 6-11	0	Bit String		Read Only	
DEVICE_TIME	S	Date-(11)	D	7		0				Yes
FUNCTION_CALL	S	Unsigned8	D	1	See Table 6-12	0	Enumerated	O/S	Note 5-2	Yes
GAS_CTRL_STATE	S	Unsigned16	D	2	See Table 6-1	0	Bit String		Note 5-2	Yes
MANUFACTURING_DATE	S	Octet String	S	30		0	none		Read Only	
MEASUREMENT_OPTS	S	Unsigned16	S	2	See Table 6-4	0	Bit String	O/S	Note 5-2	Yes
MODULE_SN	S	Octet String	S	20		0	none		Read Only	
PRIMARY_VALUE_n	R	DS-65	D	5		0	PVR		Read Only	

Tab. 2-3
Transducer Block Parameter Attribute Definitions

2-3 Transducer Block Parameter Attribute Definitions

Parameter Mnemonic	Obj Type	Data Type / Structure	Store	Size	Valid Range	Initial Value	Units	Mode	Other	Range Check
PRIMARY_VALUE_RANGE_n	R	DS-68	S	11	0-100%		PVR	O/S	Note 5-2	
PRIMARY_VALUE_TYPE_n	S	Unsigned16	S	2	See section 4.1 in FF-903	65535 (other)	Enumerated		Read Only	
SENSOR_AVG_CYCLES_n	S	Unsigned16	S	2		1	none		Read Only	
SENSOR_AVG_METHOD_n	S	Unsigned8	S	1	0: arithmetic 1: sliding	0	Enumerated		Read Only	
SENSOR_CROSS_INTF_OFFSET_n	S	Floating Point	D	4			none		Read Only	
SENSOR_FILTER_VALUE_n	S	Floating Point	S	4	0.01-1000	2	Sec	O/S	Note 5-2	Yes
SENSOR_FLOW_n	S	DS-65	D	5		0	l/min		Read Only	
SENSOR_ID_n	S	Octet String	S	30		NULL	none		Read Only	
SENSOR_NOISE_LEVEL_n	S	Floating Point	S	4	0 – 100	0	%		Read Only	
SENSOR_NOISE_REFVAL_n	S	Floating Point	S	4	0 – 1000000	0	ppm		Read Only	
SENSOR_NOISE_TUNE_n	S	Floating Point	S	4	1 – 1000	0	none		Read Only	
SENSOR_OPTS_n	S	Unsigned32	S	4	See Table 6-6	0	Bit String		Read Only	
SENSOR_PRESSURE_n	R	DS-65	D	5	0.0-2000.0	1013	hPa		Note 5-1	Note 5-3
SENSOR_PRESSURE_FACTOR_n	S	Floating Point	D	4		1	none		Read Only	
SENSOR_RANGE_n	R	DS-68	S	11	0-100 %		PVR		Read Only	
SENSOR_RAW_CONCENTRATION_n	S	Floating Point	D	4		0	ADC Counts		Read Only	
SENSOR_STEMPERATURE_n	S	Floating Point	D	4		0	° C		Read Only	
SENSOR_TEMP_FACTOR_n	S	Floating Point	D	4		1	none		Read Only	
SENSOR_TEMP_OFFSET_n	S	Floating Point	D	4		0	none		Read Only	
SENSOR_TYPE_n	S	Unsigned16	S	2	See FF-903 sect. 4.3 Sensor Types	65535 (Non-Std)	Enumerated		Read Only	
SENSOR_ZTEMPERATURE_n	S	Floating Point	D	4		0	° C		Read Only	
SIM_DETAILED_FAILURE	S	Unsigned32	D	4	See Table 6-9	0	Bit String	O/S	Note 5-5	
SIM_DETAILED_MAINTENANCE	A	Array of Unsigned8	D	4	See Table 6-10	0	Bit String	O/S	Note 5-5	
SIM_DETAILED_STATUS	S	Unsigned32	D	4	See Table 6-11	0	Bit String	O/S	Note 5-5	
SPAN_CAL_DATE_n	S	Date-(11)	S	7		0	none		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	
ZERO_CAL_DATE_n	S	Date-(11)	S	7		0	none		Read Only	

Tab. 2-3
Transducer Block Parameter Attribute Definitions

Note 5-1: Writable only if PRES_REMOTE bit of SENSOR_OPTS_n is set, otherwise is only Readable.
Note 5-2: This parameter is Read Only if the “local parameter access active ” bit or the "parameter access via serial service interface active" bit is on in the DETAILED_STATUS word.
Note 5-3: Range check is only done if in SENSOR_OPTS_n the bit PRES_CORR is set.
Note 5-4: This parameter is similar to Note 5-2 and additionally Read Only if VALVES_INST of SENSOR_OPTS_n is cleared.
Note 5-5: Writable only if Simulation-bit of DETAILED_STATUS is set otherwise Read Only.

2-4 Transducer Block Enumerations

2-4-1 Gas Control State

Bit Number	FFValue of GAS_CTRL_	Description
15	0x8000	Sample Gas Valve for Snsr1 opened
14	0x4000	Zero Gas Valve for Snsr1 opened
13	0x2000	Span Gas Valve for Snsr1 opened
12	0x0100	Sample Gas pump for Snsr1 running
11	0x0800	Sample Gas Valve for Snsr2 opened
10	0x0400	Zero Gas Valve for Snsr2 opened
9	0x0200	Span Gas Valve for Snsr2 opened
8	0x0100	Sample Gas pump for Snsr2 running

Tab. 2-4
Gas Control State

During a running calibration procedure of a sensor (see Table 2-5) the gas control states are controlled by this procedure.

So it is refused to change this states by operator during this running procedures.

2-4-2 Calibration States

Bit Number	FF-Value of CAL_STATE	Description
15	0x8000	running zero calibration on Snsr1
14	0x4000	running span calibration on Snsr1
13	0x2000	purging changed gas on Snsr1
12	0x1000	running cross interference calibration of Snsr2 onto Snsr1
11	0x0800	running zero calibration on Snsr2
10	0x0400	running span calibration on Snsr2
9	0x0200	purging changed gas on Snsr2
8	0x0100	running cross interference calibration of Snsr1 onto Snsr2

Tab. 2-5
Calibration States

2-4-3 Calibration Step Control

Value	CAL_STEP – Description
0	No Action
1	Zero Calibration Snsr1
2	Zero Calibration Snsr2
3	Zero Calibration Snsr1+2
4	Span Calibration Snsr1
5	Span Calibration Snsr2
6	Span Calibration Snsr1+2
7	Zero & Span Calibration Snsr1
8	Zero & Span Calibration Snsr2
9	Zero & Span Calibration Snsr1+2
10	Cross Interference Calibration of Snsr2 onto Snsr1
11	Cross Interference Calibration of Snsr1 onto Snsr2
12	Cancel running Calibration of Snsr1
13	Cancel running Calibration of Snsr2
14	Cancel running Calibration of Snsr1+2
15	Load factory Calibration of Snsr1
16	Load factory Calibration of Snsr2
17	Load factory Calibration of Snsr1+2

Tab. 2-6
Calibration Control Enumerations

To start a calibration procedure of a sensor is only allowed if there is no procedure already running on the same sensor (seeTable 2-5).

If we do not want to wait for finishing the already running procedure we have first to cancel it before starting the new procedure.

2-4 Transducer Block Enumerations

2-4-4 Measurement Options

Bit Number	Value of MEASUREMENT_OPTS	Pneumonic	Description
15	0x8000	XCMP_1	Cross-Compensation Enabled for Snsr1
14	0x4000	SPLINE_1	Multiple Splines Linearization Enabled for Snsr1
13	0x2000	POLYNOM_1	4th Order Polynomial Linearization Enabled for Snsr1
12	0x1000		reserved
11	0x0800		reserved
10	0x0400		reserved
9	0x0200		reserved
8	0x0100		reserved
7	0x0080	XCMP_2	Cross-Compensation Enabled for Snsr2
6	0x0040	SPLINE_2	Multiple Splines Linearization Enabled for Snsr2
5	0x0020	POLYNOM_2	4th Order Polynomial Linearization Enabled for Snsr2

Tab. 2-7
Measurement Options

2-4-5 Calibration Options

Bit Number	Value of CAL_OPTS	Description
15	0x8000	Calibration Deviation Tolerance Check Enabled for Snsr1
14	0x4000	reserved
13	0x2000	reserved
12	0x1000	reserved
11	0x0800	Calibration Deviation Tolerance Check Enabled for Snsr2

Tab. 2-8
Calibration Options

2-4-6 Sensor Options

Bit Number	Value of SENSOR_OPTS_n	Pneumonic	Description
31	0x80000000		not usable
30	0x40000000	MUX1_ZTEMP	Multiplexer1 input is used for temperature zero correction
29	0x20000000	MUX2_ZTEMP	Multiplexer2 input is used for temperature zero correction
28	0x10000000	OTHER_ZTEMP	other sensor is used for temperature zero correction
27	0x08000000		reserved
26	0x04000000	MUX1_STEMP	Multiplexer1 input is used for temperature span correction
25	0x02000000	MUX2_STEMP	Multiplexer2 input is used for temperature span correction
24	0x01000000	OTHER_STEMP	other sensor is used for temperature span correction of sensor
23	0x00800000	PRES_SENSOR	pressure sensor installed
22	0x00400000	PRES_MANMEAS	manual pressure input is used for pressure measurement
21	0x00200000	PRES_SNSMEAS	built-in pressure sensor is used for pressure measurement
20	0x00100000	PRES_CORR	pressure measurement is used for span correction
19	0x00080000	PRES_REMOTE	remote pressure measurement is used for pressure measurement
18	0x00040000		reserved
17	0x00020000		reserved
16	0x00010000		reserved
15	0x00008000	FLOW_SENSOR	flow sensor installed
14	0x00004000	PUMP_INST	pump installed
13	0x00002000	VALVES_INST	valves installed
12	0x00001000	HEATER_INST	heater installed

Tab. 2-9
Sensor Options

2-4-7 Analyzer Options

Bit Number	Value of ANALYZER_OPTS	Description
7	0x80	Serial Gas Flow through Analyzer Cells (otherwise parallel)
6	0x40	Sensor2 not built-in
5	0x20	FF host is master of date/time

Tab. 2-10
Analyzer Options

2-4-8 Access Mode Control

Value	ACCESS_MODE – Description
0	Normal
1	Fieldbus access only

Tab. 2-11
Parameter Access Mode Enumerations (ACCESS_MODE)

2-4-9 Detailed Status

2-4-9-1 Detailed Maintenance

Bit Number	Value of DETAILED_MAINTENANCE	Description	Value of XD_ERROR (see FF-903)
31	0x80000000	not usable	
30	0x40000000	Deviation too high for zero calibration of Snsr1	CALIBRATION_FAILURE
29	0x20000000	Deviation too high for span calibration of Snsr1	CALIBRATION_FAILURE
28	0x10000000	Measurement too noisy during zero calibration of Snsr1	CALIBRATION_FAILURE
27	0x08000000	Measurement too noisy during span calibration of Snsr1	CALIBRATION_FAILURE
26	0x04000000	digital input notifies maintenance request for Snsr1	IO_FAILURE
25	0x02000000	reserved	NONE
24	0x01000000	reserved	NONE
23	0x00800000	reserved	NONE
22	0x00400000	Deviation too high for zero calibration of Snsr2	CALIBRATION_FAILURE
21	0x00200000	Deviation too high for span calibration of Snsr2	CALIBRATION_FAILURE
20	0x00100000	Measurement too noisy during zero calibration of Snsr2	CALIBRATION_FAILURE
19	0x00080000	Measurement too noisy during span calibration of Snsr2	CALIBRATION_FAILURE
18	0x00040000	digital input notifies maintenance request for Snsr2	IO_FAILURE
17	0x00020000	reserved	NONE
16	0x00010000	reserved	NONE
15	0x00008000	Maintenance interval for the device expired	GENERAL_FAILURE
14	0x00004000	factory configuration loaded	DATA_INTEGRITY_FAILURE
13	0x00002000	measurement sensors running in w rong mode and	IO_FAILURE
12	0x00001000	reserved	NONE
11	0x00000800	reserved	NONE
10	0x00000400	reserved	NONE
9	0x00000200	reserved	NONE
8	0x00000100	reserved	NONE

Tab. 2-12
Detailed Maintenance

2-4-9-2 Detailed Failure

Bit Number	Value of DETAILED_FAILURE	Description	Value of XD_ERROR (see FF-903)
31	0x80000000	not usable	
30	0x40000000	Chopper motor turning fails for Snsr1	ELECTRICAL_FAILURE
29	0x20000000	A/D converter out of range for Snsr1	ALGORITHM_ERROR
28	0x10000000	Source light failed for Snsr1	ELECTRICAL_FAILURE
27	0x08000000	Detector component failed for Snsr1	ELECTRICAL_FAILURE
26	0x04000000	Heater control failed for Snsr1	ELECTRICAL_FAILURE
25	0x02000000	Sensor of temperature correction failed for Snsr1	IO_FAILURE
24	0x01000000	Pressure measurement for pressure correction failed for Snsr1	IO_FAILURE
23	0x00800000	digital input notifies failure for Snsr1	IO_FAILURE
22	0x00400000	interfering measurement onto Snsr1 failed	IO_FAILURE
21	0x00200000	over temperature shut down for Snsr1	GENERAL_FAILURE
20	0x00100000	reserved	NONE
19	0x00080000	reserved	NONE
18	0x00040000	reserved	NONE
17	0x00020000	reserved	NONE
16	0x00010000	reserved	NONE
15	0x00008000	reserved	NONE
14	0x00004000	Chopper motor turning fails for Snsr2	ELECTRICAL_FAILURE
13	0x00002000	A/D converter out of range for Snsr2	ALGORITHM_ERROR
12	0x00001000	Source light failed for Snsr2	ELECTRICAL_FAILURE
11	0x00000800	Detector component failed for Snsr2	ELECTRICAL_FAILURE
10	0x00000400	Heater control failed for Snsr2	ELECTRICAL_FAILURE
9	0x00000200	Sensor of temperature correction failed for Snsr2	IO_FAILURE
8	0x00000100	Pressure measurement for pressure correction failed for Snsr2	IO_FAILURE
7	0x00000080	digital input notifies failure for Snsr2	IO_FAILURE
6	0x00000040	interfering measurement onto Snsr2 failed	IO_FAILURE
5	0x00000020	over temperature shut down for Snsr2	GENERAL_FAILURE
4	0x00000010	reserved	NONE
3	0x00000008	Communication to sensor electronics failed.	ELECTRICAL_FAILURE
2	0x00000004	No communication to transducer device	ELECTRICAL_FAILURE

Tab. 2-13
Detailed Failure

2-4-9-3 Detailed Status

Bit Number	FF-Value of DETAILED_STATUS	Description	Value of XD_ERROR (see FF-903)
31	0x80000000	not usable	
30	0x40000000	Raw signal for Snsr1 is a simulated one	CONFIGURATION_ERROR
29	0x20000000	No valid sample gas measurement running for Snsr1	NONE
28	0x10000000	Any calibration in progress for Snsr1	NONE
27	0x08000000	Snsr1 is still in warming up phase	NONE
26	0x04000000	Snsr1 is in a defined state of measurement interruption	NONE
25	0x02000000	Snsr1 is in standby-mode	NONE
24	0x01000000	Any of secondary measurements for Snsr1 in simulation mode	CONFIGURATION_ERROR
23	0x00800000	digital input notifies an 'out of service' mode for Snsr1	NONE
22	0x00400000	linearization procedure of Snsr1 produces an underflow	ALGORITHM_ERROR
21	0x00200000	linearization procedure of Snsr1 produces an overflow	ALGORITHM_ERROR
20	0x00100000	installed sample gas pump of Snsr1 not running	NONE
19	0x00080000	reserved	NONE
18	0x00040000	reserved	NONE
17	0x00020000	reserved	NONE
16	0x00010000	reserved	NONE
15	0x00008000	Snsr2 not built in	NONE
14	0x00004000	Raw signal for Snsr2 is a simulated one	CONFIGURATION_ERROR
13	0x00002000	No valid sample gas measurement running for Snsr2	NONE
12	0x00001000	Any calibration in progress for Snsr2	NONE
11	0x00000800	Snsr2 is still in warming up phase	NONE
10	0x00000400	Snsr2 is in a defined state of measurement interruption	NONE
9	0x00000200	Snsr2 is in standby-mode	NONE
8	0x00000100	Any of secondary measurements for Snsr2 in simulation mode	CONFIGURATION_ERROR
7	0x00000080	digital input notifies an 'out of service' mode for Snsr2	NONE
6	0x00000040	linearization procedure of Snsr2 produces an underflow	ALGORITHM_ERROR
5	0x00000020	linearization procedure of Snsr2 produces an overflow	ALGORITHM_ERROR
4	0x00000010	installed sample gas pump of Snsr2 not running	NONE
3	0x00000008	local parameter access active	NONE
2	0x00000004	parameter access via local serial service interface active	NONE
1	0x00000002	Status simulation active	NONE

Tab. 2-14
DetailedStatus

2-4-10 Function Call Control

Value	FUNCTION_CALL – Description
0	No Action
1	Acknowledge and clear Failures Snsr1
2	Acknowledge and clear Maintenance Requests Snsr1
3	Acknowledge and clear Function Controls Snsr1
4	Acknowledge and clear Failures Snsr2
5	Acknowledge and clear Maintenance Requests Snsr2
6	Acknowledge and clear Function Controls Snsr2
7	Set FF Host as master of date/time
8	Set sensor device's clock as master of date/time
9	Load transducer's factory configuration

Tab. 2-15
Function Call Enumerations (FUNCTION_CALL)

2-5 Transducer Block Channel Assignments

2-5-1 I/O Channel Assignments for AI-Blocks

Transducer Block Channel Value	Process Variable	XD_SCALE UNITS
1	PRIMARY_VALUE_1	%, ppm
2	PRIMARY_VALUE_2	%, ppm
3	SENSOR_FLOW_1	l/min
4	SENSOR_FLOW_2	l/min
5	SENSOR_PRESSURE_1(read)	hPa
6	SENSOR_PRESSURE_2(read)	hPa

Tab. 2-16
I/O Channel Assignments for AI-Blocks

2-5-2 I/O Channel Assignment for A0-Blocks

Transducer Block Channel Value	Process Variable	XD_SCALE UNITS
7	SENSOR_PRESSURE_1(write)	hPa
8	SENSOR_PRESSURE_2(write)	hPa

Tab. 2-17
I/O Channel Assignments for AI-Blocks

The assignment of SENSOR_PRESSURE_n is only possible if the device has not enabled the PRES_SNSMEAS-bit of SENSOR_OPTS_n (seeTable 2-9)

2-6 Simulation of TBlk States

The TBlk parameters which are evaluated for the PWAs (=PlantWeb Alerts) (DETAILED_FAILURE, DETAILED_STATUS and DETAILED_MAINTENANCE) can be simulated.
For the simulation use the parameters SIM_DETAILED_FAILURE, SIM_DETAILED_MAINTENANCE and SIM_DETAILED_STATUS.
For activating the simulation mode of these use the bit „Status simulation active“ in SIM_DETAILED_STATUS .

Having this bit activated the values of DETAILED_FAILURE, DETAILED_MAINTENANCE, DETAILED_STATUS equal the values of SIM_DETAILED_FAILURE, SIM_DETAILED_MAINTENANCE and SIM_DETAILED_STATUS.
That means the user has the opportunity to simulate the TBlk-states by writing to the SIM_DETAILED_XXXX-parameter bits. By this means he has the opportunity to check the correct mapping onto the PWA's XXXX_ACTIVE-parameters of the RBlk.

2-7 Supported Transducer Block Errors

2-7-1 Out of Service

Set whenever the transducer block actual mode is OOS

2-7-2 Block Configuration Error

Set whenever there is a communication error between the round board and the a/d board.

2-7-3 Input Failure/ Process Variable has BAD Status

Set whenever PRIMARY_VARIABLE_1 or PRIMARY_VARIABLE_2 has BAD status.

2-7-4 Device needs Maintenance Now

Set whenever DETAILED_FAILURE is unequal ‘0’.

2-7-5 Simulate Active

Set whenever „Status simulation active“-bit of DETAILED_STATUS is set.

2-7-6 Other Error

Set whenever XD_ERROR is non-zero.

SECTION 3
Resource Block

3-1 Mapping of the PlantWeb Alerts

Advisory Alert	What this Alert is Detecting?	What is the effect on the instrument?	R block	Tblock	Relevant Parameters	Health	Bit
PlantWeb Alerts Simulate Active	The alerts are simulated and might not come from live detection		RB.BLOCK_ERR 3 Simulate Active PWA_SIMULATE	DETAILED_STATUS 30 Status simulation active	RB.SIMULATE_STATE	90	2
Inactive Measurement Mode	Local operator or technician switched device into inactive state.	The affected PV quality status will go to BAD		DETAILED_STATUS 5 Sensor 1 is in a defined state of measurement pause 21 Sensor 2 is in a defined state of measurement pause 6 Sensor 1 is in standby-mode 22 Sensor 2 is in standby-mode	DETAILED_STATUS 2 No valid sample gas measurement..Snsr1 18 No valid sample gas measurement..Snsr2	90	3
Inactive Gas Pump	There is installed a sample gas pump but it is not switched on.	The affected PV quality status will go to BAD		DETAILED_STATUS 11 Installed sample gas pump of sensor 1 not running 27 Installed sample gas pump of sensor 2 not running	SENSOR_OPTS_1:PUMP_INST SENSOR_OPTS_1:FLOW_SENSOR SENSOR_FLOW_1:value SENSOR_FLOW_1:status SENSOR_OPTS_2:PUMP_INST SENSOR_OPTS_2:FLOW_SENSOR SENSOR_FLOW_2:value SENSOR_FLOW_2:status	90	4
Maintenance Interval Expired	Maintenance period defined by user is due	No impact		DETAILED_MAINTENANCE 16 maintenance interval expired		90	5
Diagnostic Condition Active	Local operator or technician switched device into simulation/diagnostic state.	No impact		DETAILED_STATUS 1 raw signal simulated for sens1 7 2nd measurement simulated for sens1 17 raw signal simulated for sens2 23 2nd measurement simulated for sens2 8 digital input notifies 'out of service' mode for sensor 1 24 digital input notifies 'out of service' mode for sensor 2		90	8

Tab. 3-1
MLT PWA Mapping - Advice

Maintenance Alert	What this Alert is Detecting?	What is the effect on the instrument?	Rblock	Tblock	Relevant Parameters	Health	Bit
Calibration Error	During the calibration, the deviation or noise exceeded acceptable ranges.	Analyzer continues to operate, but affected PV quality status will go to UNCERTAIN.	RB.BLOCK_ERR 0 Other	DETAILED_MAINTENANCE 1 deviation of zero cal Sens1 2 deviation of span cal Sens1 3 noise during zero cal Sens1 4 noise during span cal Sens1 9 deviation of zero cal Sens2 10 deviation of span cal Sens2 11 noise during zero cal Sens2 12 noise during span cal Sens2	CAL_OPTS:0 CAL_OPTS:4	70	1
External Maintenance Request	A digital input signals a maintenance request from an external facility.	Analyzer continues to operate, but affected PV quality status will go to UNCERTAIN.		DETAILED_MAINTENANCE 5 digital input notify for Snsr1 13 digital input notify for Snsr2		70	2
Configuration Error	Analyzer configuration does not match definition or configuration has been lost	Analyzer continues to operate, but affected PV quality status will go to UNCERTAIN.		DETAILED_MAINTENANCE 17 failed battery caused factory config 18 wrong mode of sensors		70	4
Linearizer out of range	The raw signal readings are out of linearizer's defined range.	Analyzer continues to operate, but affected PV quality status will go to UNCERTAIN.		DETAILED_STATUS 9 linearization proc. of sensor 1 produces an underflow 10 linearization proc. of sensor 1 produces an overflow 25 linearization proc. of sensor 2 produces an underflow 26 linearization proc. of sensor 2 produces an overflow	PRIMARY_VALUE_1: value SENSOR_RAW_CONCENTRATION_1 PRIMARY_VALUE_2: value SENSOR_RAW_CONCENTRATION_2	40	16

Tab. 3-2
MLT PWA Mapping - Maintenance

3-1 Mapping of the PlantWeb Alerts

Failure Alert	What this Alert is Detecting?	What is the effect on the instrument?	Rblock	Tblock	Relevant Parameters	Health	Bit
External Failure Signal	A digital input signals a failure from an external facility.	The affected PV quality status will go to BAD		DETAILED_FAILURE 9 digital input notifies failure for Snsr1 25 digital input notifies failure for Snsr2		10	9
Temperature Sensor Malfunction	This detects an out of range temperature sensor.	The affected PV quality status will go to BAD		DETAILED_FAILURE 6 Sensor of temp. corr. failed for sensor 1 22 Sensor of temp. corr. failed for sensor 2	SENSOR_ZTEMPERATURE_1 SENSOR_STEMPERATURE_1 SENSOR_ZTEMPERATURE_2 SENSOR_STEMPERATURE_2	10	11
Pressure Compensation Malfunction	The sensor which is used for pressure compensation calculations is out of order.	The affected PV quality status will go to BAD		DETAILED_FAILURE 7 Pressure measurement for pressure correction failed for Snsr1 23 Pressure measurement for pressure correction failed for Snsr2	SENSOR_PRESSURE_1:value SENSOR_PRESSURE_1:status SENSOR_PRESSURE_2:value SENSOR_PRESSURE_2:status SENSOR_OPTS_1: PRES_REMOTE SENSOR_OPTS_2: PRES_REMOTE	10	12
Interfering Gas Compensation Failure	It notifies a failure in interfering gas measurements.	The affected PV quality status will go to BAD		DETAILED_FAILURE 8 interfering meas. onto Snsr1 failed 24 interfering meas. onto Snsr2 failed	PRIMARY_VALUE_2:value PRIMARY_VALUE_2:status PRIMARY_VALUE_1:value PRIMARY_VALUE_1:status	10	13
Temperature out of Range	This detects an out of range temperature inside the device.	The affected PV quality status will go to BAD		DETAILED_FAILURE 5 Heater control failed for Snsr1 21 Heater control failed for Snsr2 10 over temperature shut down for Snsr1 26 over temperature shut down for Snsr2	SENSOR_ZTEMPERATURE_1 SENSOR_STEMPERATURE_1 SENSOR_ZTEMPERATURE_2 SENSOR_STEMPERATURE_2 SENSOR_OPTS_1: HEATER_INST SENSOR_OPTS_2: HEATER_INST	10	14
Sensor Engine Hardware Failure	Various faults will cause the analysis to be bad includig failure in chopper motor, light source or the detector component	output will not be valid or analyzer will not operate		DETAILED_FAILURE 1 Chopper motor failure Snsr1 17 Chopper motor failure Snsr2 2 A/D converter out of range for Snsr1 18 A/D converter out of range for Snsr2 3 Source light failed for Snsr1 19 Source light failed for Snsr2 4 Detector component failed for Snsr1 20 Detector component failed for Snsr2 28 Sensor Communication failed		10	16
Output Board NV Memory Failure	The non-volatile parameter storage on the CPU board has become unreliable		RB.BLOCK_ERR 0 Other 11 Lost NV Data RB.DETAILED_STATUS 4 NV Integrity error			10	22
Sensor Board Electronics Failure	This occurs when the electronics of the sensor can not reliably send data to the Fieldbus Output Electronics Board.	Data will be unusable, bad quality alarm will be sent to the operator and the analyzer will be taken out of service.	RB.BLOCK_ERR 0 Other 13 Device Needs Maintenance Now 15 Out of service RB.DETAILED_STATUS 1 Sensor transducer error	DETAILED_FAILURE 29 No communication to transducer device		10	23
Output Board Electronics Failure	This occurs when the electronics can not reliably collect data from the sensors	Data will be unusable, a bad quality alarm will be sent to the operator and the analyzer will be taken out of service.	RB.BLOCK_ERR 0 Other 9 Memory Failure 13 Device Needs Maintenance Now 15 Out of service RB.DETAILED_STATUS 2 Manufacturing block integrity error 5 Register test failure 6 ROM integrity error			10	24

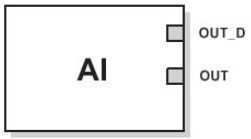
Tab. 3-3
MLT PWA Mapping - Failed

3-2 PWA_SIMULATE

Having PWA_SIMULATE == ON allows simulating the RBlk-parameters FAILED_ACTIVE, MAINT_ACTIVE and ADVISE_ACTIVE.
„Allow simulating“ means that these parameters get write permission and the host's written value is the only one which is used for parameter's read back value. The data which come via 1451-protocol from the MLT itself is not used in this case (also no wired-OR).

There are some bits of DETAILED_STATUS of the RBlk (not TBlk!) which are mapped to FAILED_ACTIVE („Electronics Failure“ and „NV memory failure“).
We also allow simulating them in this state. Hereby is used a wired-OR logic of these DETAILED_STATUS bits and of the appropriate FAILED_ACTIVE bits.

SECTION 4
Analog Input (AI) Function Block



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

Fig. 4-1
Analog input function block

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 3-2 on page 3–3 illustrates the internal components of the AI function block while table 3-1 lists the AI block parameters and their units of measure, descriptions and index numbers.

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	4	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.

Tab. 4-1
Definitions of Analog Input Function Block System Parameters

4 Analog Input (AI) Function Block

Parameter	Index Number	Units	Description
BLOCK_ERR	6	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	5	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	8	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	7	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	9	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	3	None	The strategy field can be used to identify grouping of blocks. This data is not checked or processed by the block.
ST_REV	1	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.

Tab. 4-1 (cont’d)
Definitions of Analog Input Function Block System Parameters

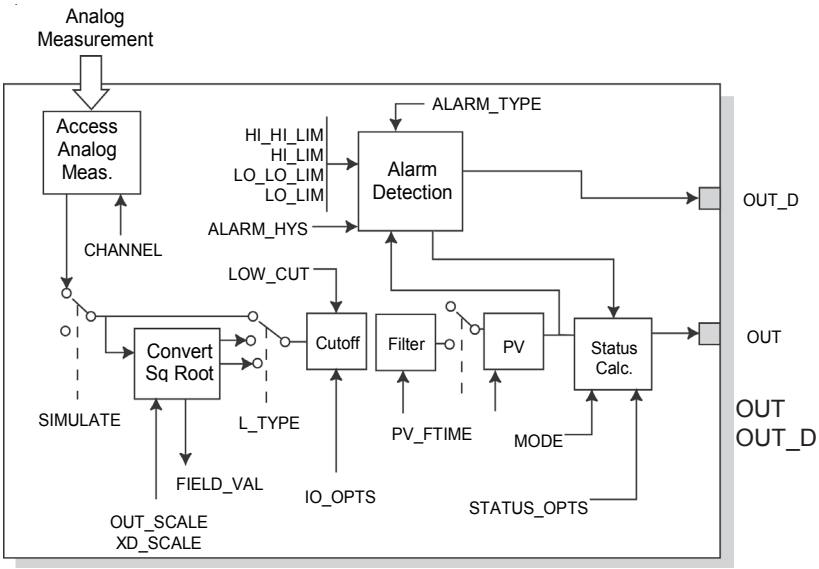
Parameter	Index Number	Units	Description
TAG_DESC	2	None	The user description of the intended application of the block.
UPDATE_EVT	20	None	This alert is generated by any change to the static data.
VAR_INDEX	39	% of OUT Range	The average absolute error between the PV and its previous mean value over that 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.

Tab. 4-1 (cont'd)
Definitions of Analog Input Function Block System Parameters

4-1 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.
With simulation enabled, the actual measurement value has no impact on the OUT value or the status.

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.



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

Fig. 4-2
Analog Input Function Block Schematic

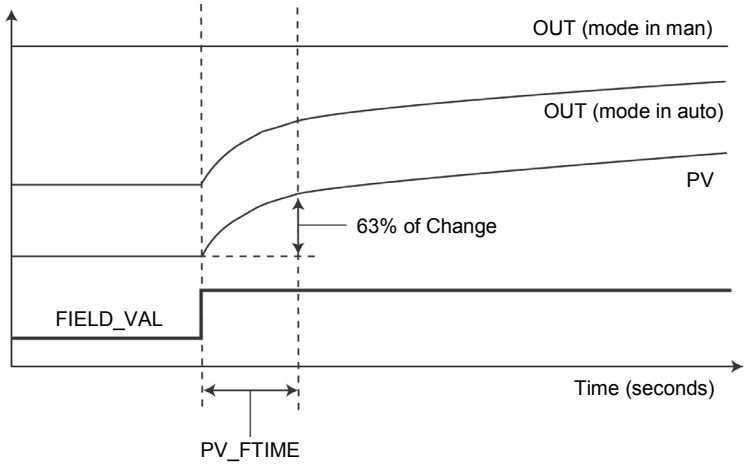


Fig. 4-3
Analog Input Function Block Timing Diagram

4-2 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.

4-3 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.

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

*XD_SCALE values

4-3 Signal Conversion

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).
  PV = 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).

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

*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.

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

*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.



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.

4-4 Block Errors

Table 32 lists conditions reported in the BLOCK_ERR parameter. Conditions in *italics* are inactive for the AI block and are here listed for reference only.

Condition Number	Condition Name and Description
0	*Other*
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	*Link Configuration Error*
3	**Simulate Active:** Simulation is enabled and the block is using a simulated value in its execution.
4	*Local Override*
5	*Device Fault State Set*
6	*Device Needs Maintenance Soon*
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	*Memory Failure*
10	*Lost Static Data*
11	*Lost NV Data*
12	*Readback Check Failed*
13	*Device Needs Maintenance Now*
14	*Power Up*
15	**Out of Service:** The actual mode is out of service.

Tab. 4-2
Block Error Conditions

4-5 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.

4-6 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:

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).
03. Jul	Alarm conditions of priority 3 to 7 are advisory alarms of increasing priority.
Aug 15	Alarm conditions of priority 8 to 15 are critical alarms of increasing priority.

Tab. 4-3
Alarm Priorities

4-7 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 *Goo*d.

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.



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.

4-8 Advanced Features

The AI function block provided with Emerson 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.

4-9 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:

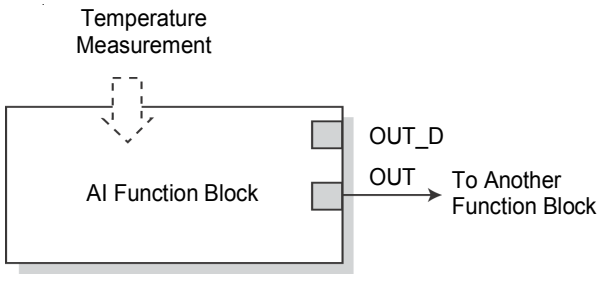
- **CHANNEL** If the device supports more than one measurement, verify that the selected channel contains the appropriate measurement or derived value.
- **L_TYPE**
  Select **Direct** when the measurement is already in the engineering units that are desired for the block output. Select **Indirect**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

4-9-1 Application Example 1 Temperature Transmitter

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

Parameter	Configured Values
L_TYPE	Direct
XD_SCALE	Not Used
OUT_SCALE	Not Used

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



4-9-2 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).

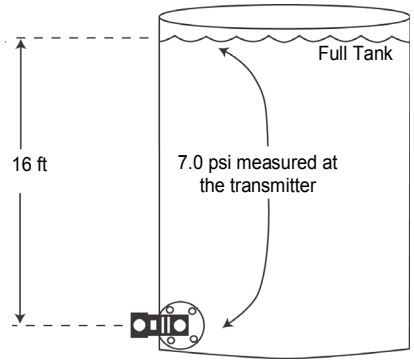


Fig. 4-5
Situation #1 Diagram

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

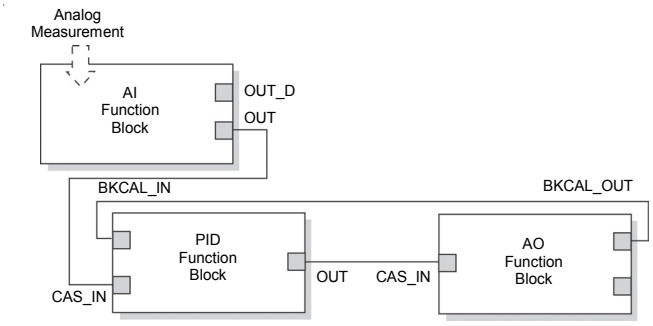


Fig. 4-6
Function Block Diagram for a Pressure Transmitter used in Level Measurement

Situation #2

The transmitter in situation #2 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

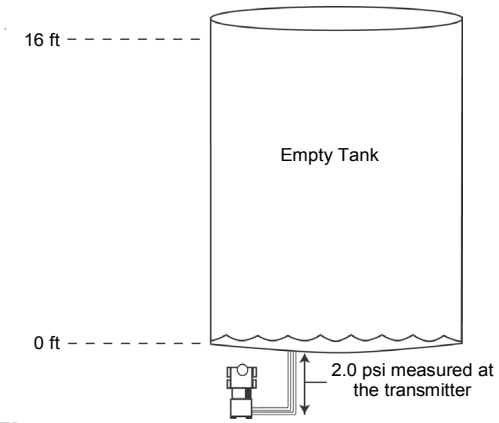


Fig. 4-7
Stuation #2 Diagram

4-9-3 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 H2 0 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

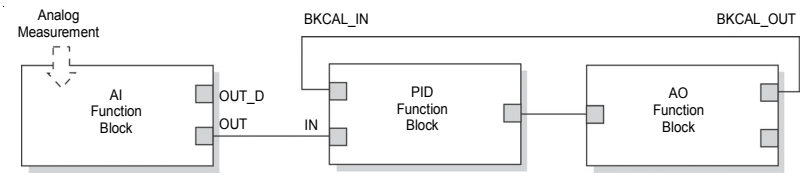


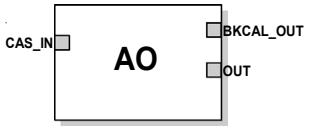
Fig. 4-8
Function Block Diagram for Differential Pressure Transmitter in Flow Measurement

4-10 Troubleshooting

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: 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	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	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: 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.

Tab. 4-4
Troubleshooting AI Block

SECTION 5
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.

Fig. 5-1
Analog output function block

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 5-2 illustrates the internal components of the AO function block, and Table 5-1 lists the definitions of the 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 w indup and to provide bumpless transfer to closed loop control.
BLOCK_ERR	None	The summary of active error conditions associated w ith 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	Allow s 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 w ith the OUT value.
SIMULATE	EU of XD_SCALE	Enables simulation and allow s 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 allow ed.
SP_LO_LIM	EU of PV_SCALE	The low est setpoint value allow ed.
SP_RATE_DN	EU of PV_SCALE per second	Ramp rate for dow nw ard 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 upw ard setpoint changes. When the ramp rate is set to zero, the setpoint is used immediately.
SP_WRK	EU of PV_SCALE	The w orking 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.

Tab. 5-1
Analog Output Function Block System Parameters

5-1 Setting the Output

To set the output for the AO block, you must first set the mode to define the manner in which the block determines its setpoint. In Manual mode the value of the output attribute (OUT) must be set manually by the user, and is independent of the setpoint. In Automatic mode, OUT is set automatically based on the value specified by the setpoint (SP) in engineering units and the I/O options attribute (IO_OPTS). In addition, you can limit the SP value and the rate at which a change in the SP is passed to OUT.

In Cascade mode, the cascade input connection (CAS_IN) is used to update the SP. The back calculation output (BKCAL_OUT) is wired to the back calculation input (BKCAL_IN) of the upstream block that provides CAS_IN. This provides bumpless transfer on mode changes and windup protection in the upstream block. The OUT attribute or an analog readback value, such as valve position, is shown by the process value (PV) attribute in engineering units.

To support testing, you can enable simulation, which allows you to manually set the channel feedback. There is no alarm detection in the AO function block.

To select the manner of processing the SP and the channel output value configure the setpoint limiting options, the tracking options, and the conversion and status calculations.

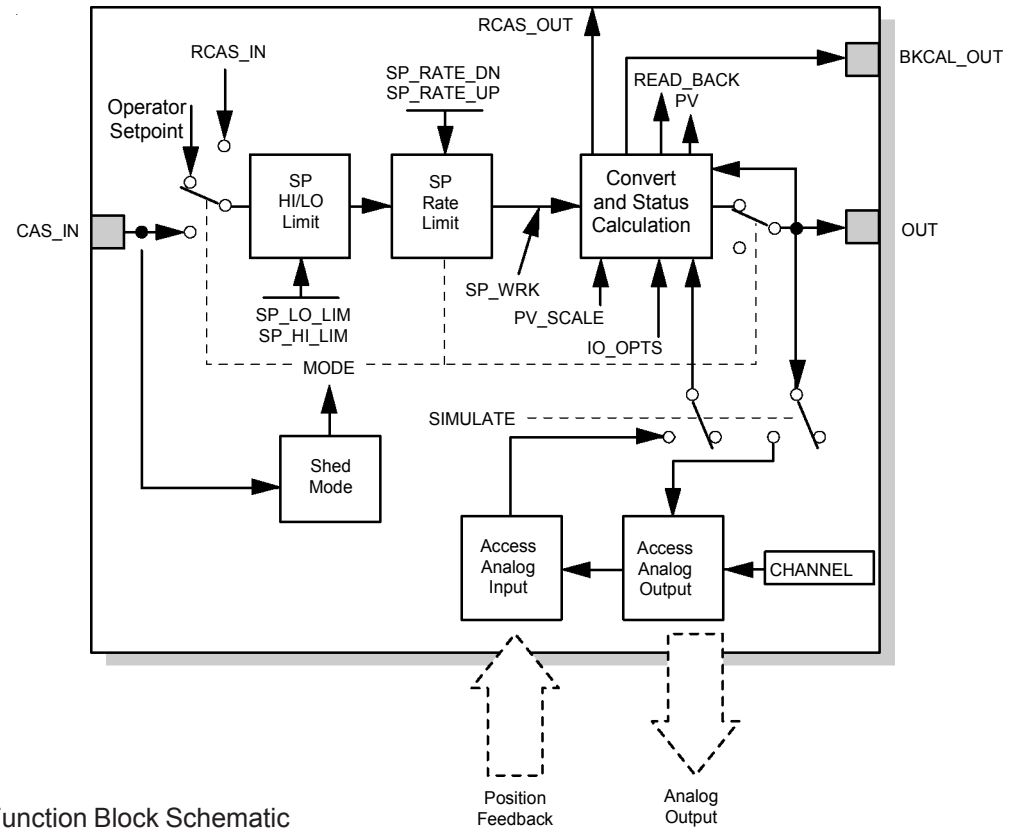


Fig. 5-2
Analog Output Function Block Schematic

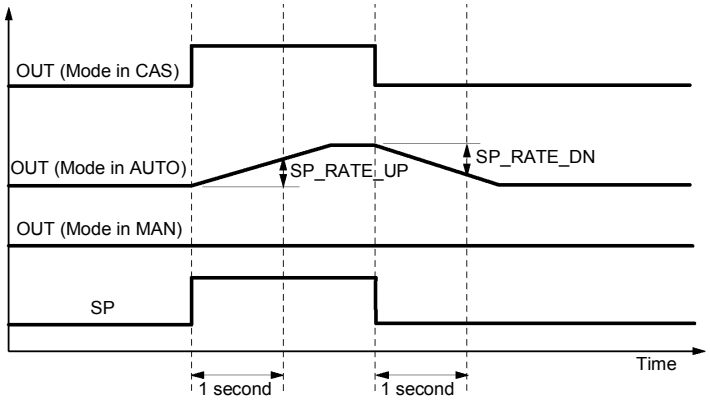


Fig. 5-3
Analog Output Function Block Timing Diagram

5-2 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.

5-3 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.

5-4 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.

5-5 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).

5-6 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.

5-7 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 Servic*e. The **BLOCK_ERR** attribute shows *Out of Servic*e.
- **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.

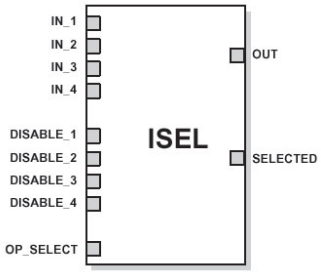
The target mode of the block may be restricted to one or more of the following modes: Man, Auto, Cas, RCas, or O/S.

5-8 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.

SECTION 6
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.

Fig. 6-1
Input Selector (ISEL) Function Block

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 5-2 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.

Parameter	Index Number	Units	Description
ALERT_KEY	4	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	6	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.

Tab. 6-1
Input Selector Function Block System Parameters

6 Input Selector (ISEL) 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	9	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	5	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	7	EU of IN	The block output value and status.
OUT_UNITS	8	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	3	None	The strategy field can be used to identify grouping of blocks. This data is not checked or processed by the block.
ST_REV	1	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	2	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.

Tab. 6-1 (cont’d)
Input Selector Function Block System Parameters

6 Input Selector (ISEL) Function Block

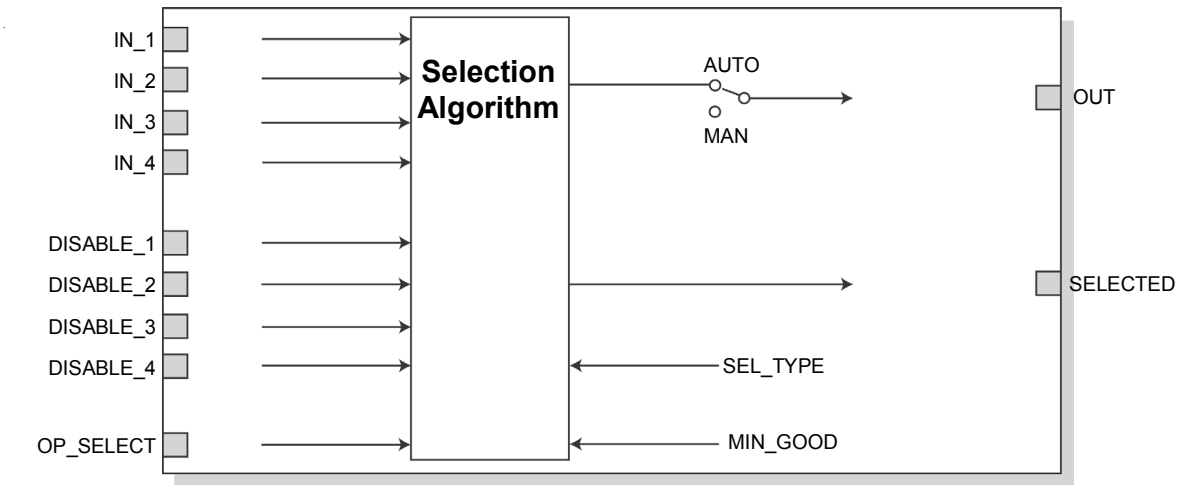


Fig. 6-2
Input Selector Function Block Schematic

6-1 Block Errors

Table 5-2 lists conditions reported in the BLOCK_ERR parameter.

Conditions in *italics* are inactive for the ISEL block and are listed for reference only.

Condition Number	Condition Name and Description
0	**Other:** The output has a quality of uncertain.
1	*Block Configuration Error*
2	*Link Configuration Error*
3	*Simulate Active*
4	**Local Override**: The actual mode is LO.
5	*Device Fault State Set*
6	*Device Needs Maintenance Soon*
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	*Lost Static Data*
11	*Lost NV Data*
12	*Readback Check Failed*
13	*Device Needs Maintenance Now*
14	**Power Up:** The device was just powered-up.
15	**Out of Service:** The actual mode is out of service.

Tab. 6-2
Block Error Conditions

6-2 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 caNn be made to all configurable parameters. The target mode of a block may be restricted to one or more of the supported modes.

6-3 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:

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).
03. Jul	Alarm conditions of priority 3 to 7 are advisory alarms of increasing priority.
Aug 15	Alarm conditions of priority 8 to 15 are critical alarms of increasing priority.

Tab. 5-3
Alarm Priorities

6-4 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 DISABLE_N is active, the associated input is not used in the selection algorithm.
If 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.

6-5 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.

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

6-6 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 fig. 5-3) or it can use the block to calculate the average temperature of the four inputs (see fig. 5-4).

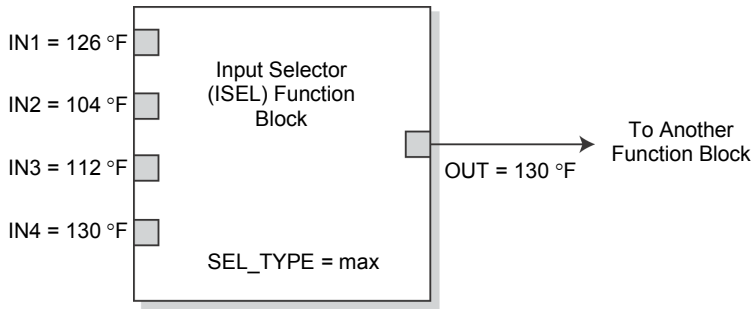


Fig. 6-3
Input Selector Function Block Application Example (SEL_TYPE = max).

6-6 Application Information

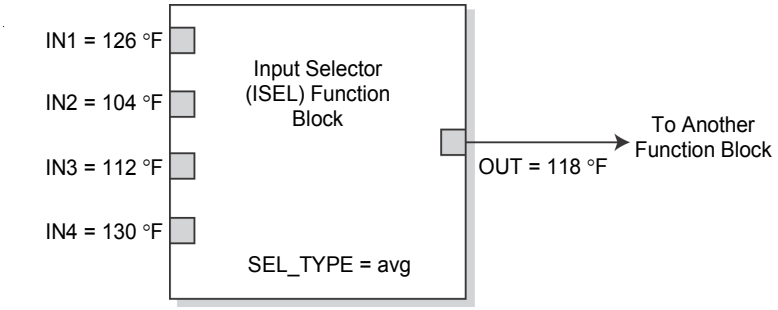


Fig. 6-4
Input Selector Function Block Application Example (SEL_TYPE = avg.).

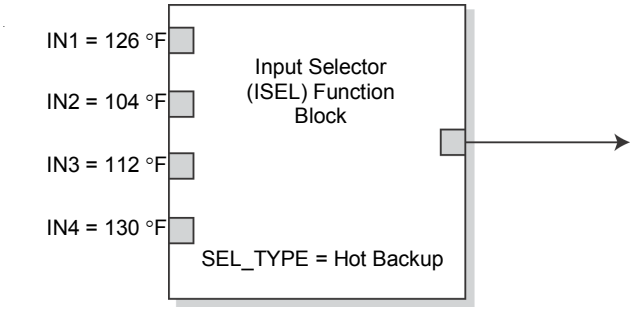


Fig. 6-5
Input Selector Function Block Application Example (SEL_TYPE = Hot Back-up).

	IN1		IN2		Out		Selected	
Time	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

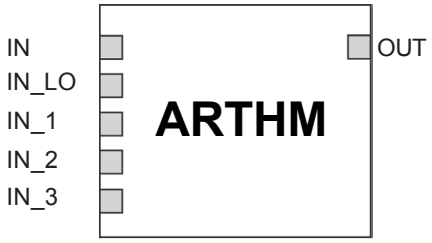
Tab. 6-4
Input Selector Function Blocks

6-7 Troubleshooting

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.

Tab. 6-5
Troubleshooting ISEL Block

SECTION 7
Arithmetic (ARTHM) Function Block



The Arithmetic function block provides the ability to configure a range extension function for a primary input and applies the nine (9) different arithmetic types as compensation to or augmentation of the range extended input. All operations are selected by parameter and input connection.

The nine (9) arithmetic functions are Flow Compensation Linear, Flow Compensation Square Root, Flow Compensation Approximate, BTU Flow, Traditional Multiply and Divide, Average, Summer, Fourth Order Polynomial, and Simple HTG Compensate Level.

This Arithmetic function block supports mode control (Auto, Manual, Out of Service). There is no standard alarm detection in this block.

7 Arithmetic (ARTHM) Function Block

Index Number	Parameter	Units	Description
4	ALERT_KEY	None	The identification number of the plant unit. This information may be used in the host fro sorting alarms, etc.
29	ARITH_TYPE	None	The set of 9 arithmetic functions applied as compensation to or augmentation of the range extended input.
30	BAL_TIME	Seconds	Specifies the time for a block value to match an input, output, or calculated value or the time for dissipation of the internal balancing bias.
31	BIAS	None	The bias value
21	BIAS_IN_1	None	The bias value for IN_1.
23	BIAS_IN_2	None	The bias value for IN_2.
25	BIAS_IN_3	None	The bias value for IN_3.
36	BLOCK_ALM	None	This 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.
6	BLOCK_ERR	None	The summary of active error conditions associated with the block. The possible block errors are Block configuration error, Simulate active, Local override, Input failure/process variable has Bad status, Output failure, Readback failed, Out of service, and Other. Each function block reports none or a subset of these error conditions.
27	COMP_HI_LIM	EU of PV	Determines the high limit of the compensation input.
28	COMP_LO_LIM	EU of PV	Determines the low limit of the compensation input.
32	GAIN	None	The proportional gain (multiplier) value.
22	GAIN_IN_1	None	The proportional gain (multiplier) value for IN_1
24	GAIN_IN_2	None	The proportional gain (multiplier) value for IN_2
26	GAIN_IN_3	None	The proportional gain (multiplier) value for IN_3
12	GRANT_DENY	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.
14	IN	Determined by source or EU of PV_SCALE	The analog input value and status. The number of inputs is an extensible parameter in some function blocks.
16	IN_1	Determined by supplying block or source.	The first analog input value and status.
17	IN_2	Determined by supplying block or source.	The second analog input value and status.
18	IN_3	Determined by supplying block or source.	The third analog input value and status.
15	IN_LO	None	The value used for the input whenever IN is below range.
13	INPUT_OPTS	None	Sets the options for using IN, IN_LO, IN_1, IN_2 and IN_3 when any are either Bad or Uncertain.
5	MODE_BLK	None	The mode record of the block. MODE contains the actual, target, permitted, and normal modes. In some function blocks, this parameter is used to request and show the source of the setpoint, the source of the output, and/or the block operating state.
8	OUT	EU of OUT_SCALE or Percent or EU of IN	The analog output value and status. The number of outputs is an extensible parameter in some blocks.
33	OUT_HI_LIM	EU of OUT_SCALE or Supplied by IN	The maximum output value allowed.

Tab. 7-1
Arithmetic Block Parameters

7 Arithmetic (ARTHM) Function Block

Index Number	Parameter	Units	Description
34	OUT_LO_LIM	EU of OUT_RANGE or	The minimum output value allowed.
		Supplied by IN	
11	OUT_RANGE	None	Range of the output
9	PRE_OUT	EU of OUT	The pre-trip limit from SP or zero.
7	PV	EU of OUT or EU of	The process variable used in block execution and alarm limit detection.
		PV_SCALE	
10	PV_SCALE	None	The high and low scale values, engineering units code, and number of digits to
			the right of the decimal point associated with OUT.
19	RANGE_HI	None	The high limit for IN.
20	RANGE_LO	None	The low limit for IN. If IN is less than RANGE_LO, then IN_LO is used.
3	STRATEGY	None	The strategy field can be used to identify grouping of blocks. This data is not
			checked or processed by the block.
1	ST_REV	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.
2	TAG_DESC	None	The user description of the intended application of the block.
35	UPDATE_EVT	None	This alert is generated by any changes to the static data.

Tab. 7-1 (cont'd)
Arithmetic Block Parameters

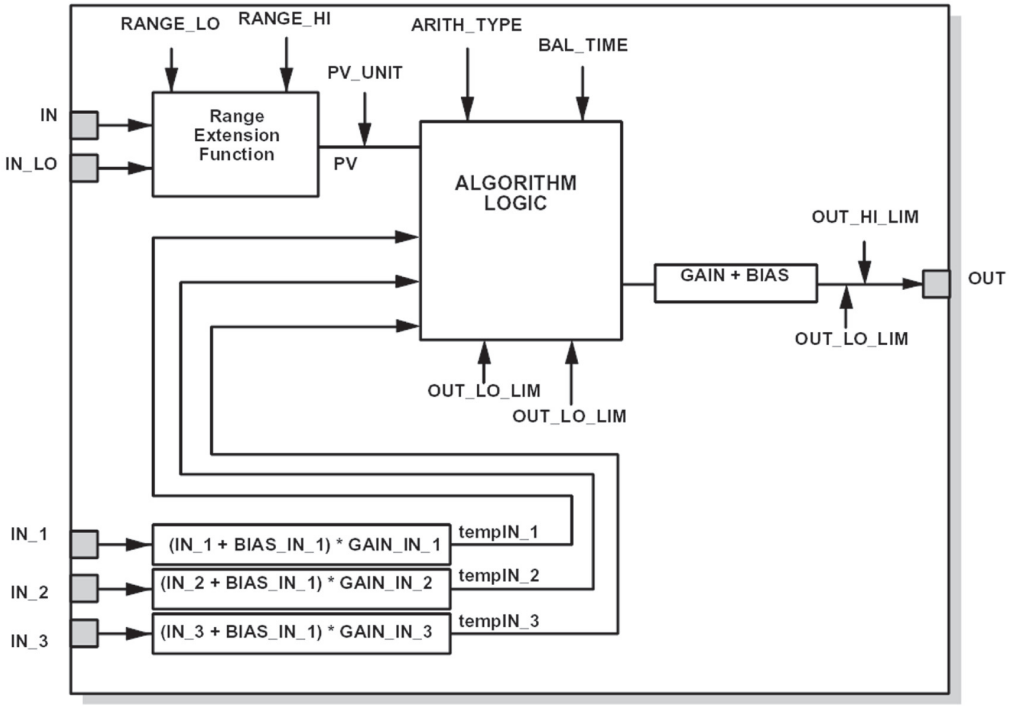


Fig. 7-2
Arithmetic Function Block Schematic

7-1 Block Errors

Table 6-2 lists conditions reported in the BLOCK_ERR parameter.
Conditions in *italics* are inactive for the ARTHM block and are listed here only for your reference.

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

Tab. 7-2
BLOCK_ERR parameters

7-2 Modes

The ARTHM block supports the following modes:

- **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, you can make changes to all configurable parameters.

The target mode of a block bay be restricted to one or more of the supported modes.

7-3 Alarm Detection

A block alarm will be generated whenever the BLOCK_ERR has anerror bit set. The types of block error for the ARTHM block aredefined above.
Alarms are grouped into five levels of priority:

Priority Number	Priority Description
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.

Tab. 7-3
Alarm Level Priorities

7-4 Block Execution

The Arithmetic function block provides range extension and compensation through nine (9) arithmetic types.
There are two inputs (IN and IN_LO) used in calculating PV. PV is then combined with up to three inputs (IN_1, IN_2, and IN_3) through the user selected compensation function (ARITH_TYPE) to calculate the value of func. A gain is applied to func and then a bias is added to get the value PRE_OUT. In AUTO, PRE_OUT is used for OUT.

Range Extension and Calculation of PV
When both IN and IN_LO are usable, the following formula is applied to calculate range extension for PV:

$$PV = G * IN + (1 - G) * IN_LO$$

(G has a range from 0 to 1, for IN from RANGE_LO to RANGE_HI.)

Compensation Input Calculations
For each of the inputs IN_1, IN_3, IN_4 there is a gain and bias. The compensation terms (t) are calculated as follows:

- When IN_(k) is usable:
  $t(k) = GAIN_IN(k) * (BIAS_IN(k) + IN_(k))$
- When IN_(k) is not usable, then t(k) gets the value of the last t(k) computed with a usable input.

7-5 Status Handling

IN_x Use Bad
IN_x Use Uncertain
IN_LO Use Uncertain
IN Use Uncertain

For complete descriptions of supported input options, refer to the Option Bitstring Parameters topic.

7-6 Application Information

The Arithmetic function block can be used to calculate tank level changes based on greatly changing temperature conditions in devices that depend on the physical properties of the fluid.

For example, a differential pressure cell's analog input can be scaled initially to provide a 4-20 mA signal for 0-100% of level indication. As the temperature of the system rises, the density of the fluid decreases. For a system that requires accurate level indication at widely ranging temperature, changing density proves inconvenient.

The Arithmetic function block allows for the automatic compensation of this change by incorporating gain and bias adjustments to the temperature signal. It then applies both the compensated temperature signal and the level signal to a characteristic system equation. The result is a level that is a true indication of fluid in the vessel.

Different fluids over the same temperature range have different effects on level due to their thermal expansion coefficients. Vessel geometry also plays a major role. As the height of the vessel increases, the effect of thermal expansion becomes more apparent. The following figure shows the relative temperature effects on a level signal.

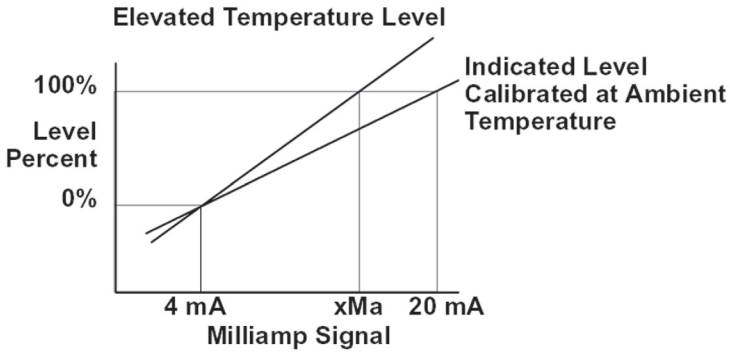


Fig. 7-3
Relative Temperature Effects on Level

7-6 Application Information

The calculation is done by applying the level signal to the IN connector, the liquid temperature to the IN_1 connector, and the ambient air temperature to the IN_2 connector. Select the Arithmetic type (ARITH_TYPE) of Flow Compensation - Linear.

This allows a ratio to be set up that increases the level indication at block output for an increase in the tank temperature relative to ambient temperature.

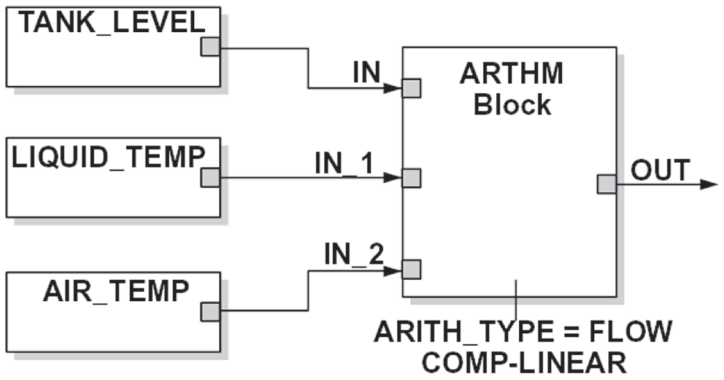


Fig. 7-4
Arithmetic Function Block Diagram Example

This application can be applied to very large storage tanks whose contents are subject to thermal expansion and contraction during seasonal changes in temperature.

7-7 Advanced Topics

Arithmetic Types

The parameter ARITH_TYPE determines how PV and the compensation terms (t) are combined. User may select from nine (9) commonly used math functions, depicted below. COMP_HI and COMP_LO are compensation limits.

Flow Compensation Linear	Flow Compensation Square Root
$func = PV \bullet f$ COMP_HI $f = \frac{t(1)}{t(2)}$ COMP_LO	$func = PV \bullet f$ COMP_HI $f = \sqrt{\frac{t(1) \bullet t(3)}{t(2)}}$ COMP_LO

If there is a divide by zero and the numerator is positive, f is set to COMP_HI; if the numerator is negative, then f is set to COMP_LO.

The square root of a negative value will equal the negative of the square root of the absolute value. Imaginary roots are not supported.

Flow Compensation Approximate	BTU Flow	Traditional Multiply and Divide
$func = PV \bullet f$ COMP_HI $f = t(1) \bullet t(2) \bullet t(3)^2$ COMP_LO	$f = PV \bullet f$ COMP_HI $f = t(1) - t(2)$ COMP_LO	$f = PV \bullet f$ COMP_HI $f = \frac{t(1)}{t(2)} + t(3)$ COMP_LO

If there is a divide by zero and numerator is positive, f will be limited to COMP_HI; if the numerator is negative, f will be limited to COMP_LO. Compensation inputs which are not usable are not included in the calculation. PV is always included.

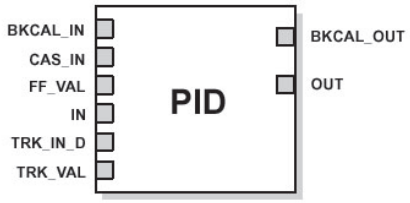
7-8 TROUBLESHOOTING

Refer to Table 6-4 to troubleshoot any problems that you encounter.

Symptom	Possible Causes	Corrective Action
Model will not leave OOS	Target model not set	Set target mode to something other than OOS
	Configuration error	BLOCK_ERR will show the configuration error set. ARITH_TYPE must be set to a valid value and cannot be left at 0.
	Resource Block	The actual mode of the Resource block is OOS. See Resource block diagnostics for corrective action.
	Schedule	Block is not scheduled and therefore cannot execute to go to the target mode. Typically, BLOCK_ERR will show “Power-Up” for all blocks that are not scheduled. Schedule the block to execute.
Status of outputs is BAD	Inputs	Input has BAD status.
Block alarms will not work	Features	FEATURES_SEL does not have Alerts enabled. Enable the Alert bit.
	Notification	LIM_NOTIFY is not high enough. Set equal to MAX_NOTIFY.
	Status Options	STATUS_OPTS has the Propagate Fault Forward bit set. This must be cleared to cause the alarm to occur.

Tab. 7-4
Troubleshooting

SECTION 8
Proportional / Integral / Derivative (PID) Function Block



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

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

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

Where
GAIN: Proportional gain value.
t_r: Integral action time constant (RESET parameter) in seconds.
s: Laplace operator
t_d: Derivative action time constant (RATE parameter).
a: 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.

8 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 8-1 lists the PID block parameters and their descriptions, units of measure, and index numbers, and fig. 8-1 illustrates the internal components of the PID function block.

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	4	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	6	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.
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.

Tab. 8-1
PID Function Block System Parameters

8 PID Function Block

Parameter	Index Number	Units	Description
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	5	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	9	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	7	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.
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	8	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	3	None	The strategy field can be used to identify grouping of blocks. This data is not checked or processed by the block.
ST_REV	1	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	2	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.

Tab. 8-1 (cont'd)
PID Function Block System Parameters

8-1 Setpoint Selection And Limiting

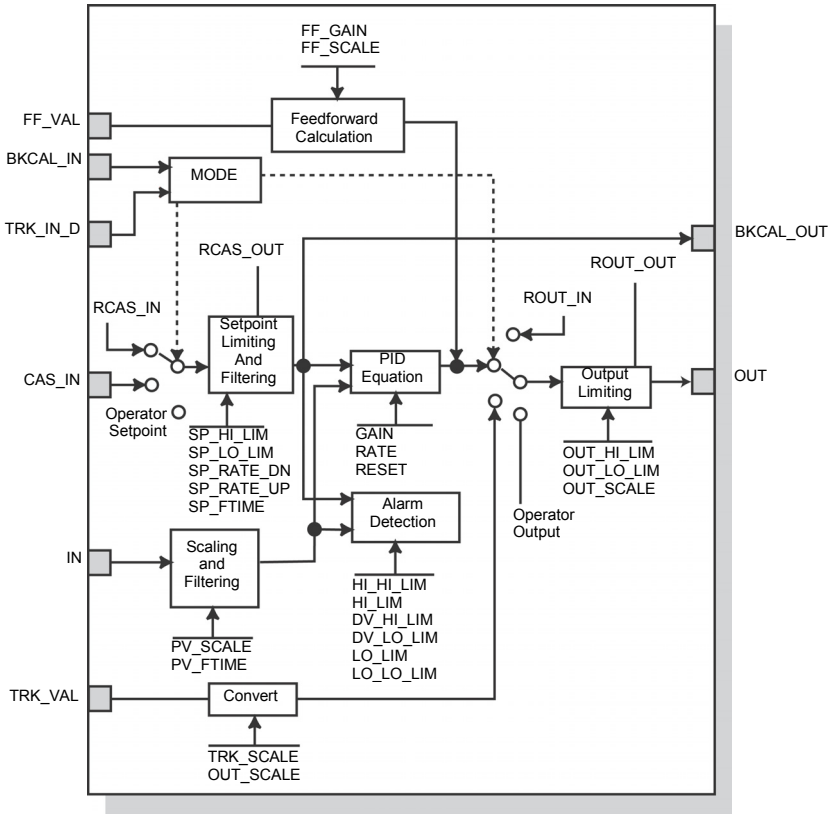


Fig. 8-1
PID Function Block Schematic

8-1 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 8-2 illustrates the method for setpoint selection.

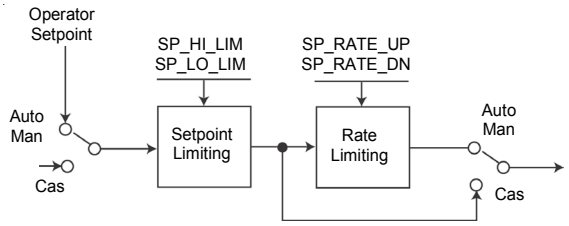


Fig. 8-2
PID Function Block Setpoint Selection

8-2 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.

8-3 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.

8-4 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.

8-5 Output Selection and Limiting

Output selection is determined by the mode and the setpoint. In **Automati**c, **Cascad**e, 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.

8-6 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 **Aut**o, the SP will remain at the last value (it will no longer follow the PV.

8-7 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
- 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:

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

Where

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

8-8 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.



***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.**

8-9 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.

8-10 Block Errors

Table 8-2 lists conditions reported in the BLOCK_ERR parameter. Conditions in *italics* are inactive for the PID block and are given here for reference only.

Condition Number	Condition Name and Description
0	*Other*:
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	*Link Configuration Error*
3	*Simulate Active*
4	**Local Override**: The actual mode is LO.
5	*Device Fault State Set*
6	*Device Needs Maintenance Soon*
7	**Input Failure/Process Variable has Bad Status:** The parameter linked to IN is indicating a Bad status.
8	*Output Failure*
9	*Memory Failure*
10	*Lost Static Data*
11	*Lost NV Data*
12	*Readback Check Failed*
13	*Device Needs Maintenance Now*
14	*Power Up*
15	**Out of Service:** The actual mode is out of service.

Tab. 8-2
Block Error Conditions

8-11 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 Servic*e. 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.

8-12 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

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.

Tab. 8-3
Alarm Priorities

8-13 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.



***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.**

8-14 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 **GAI**N, **RESE**T, 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.

8-15 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.

8-15 Application Information

8-15-1 Application Example 1
Basic PID Block for Steam Heater Control

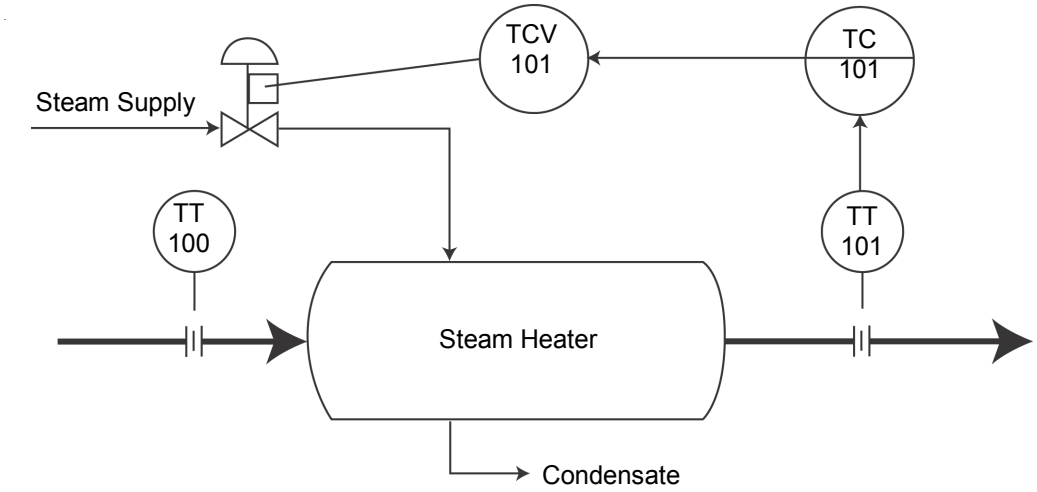


Fig. 8-2
PID Function Block Steam Heater Control Example

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.

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.

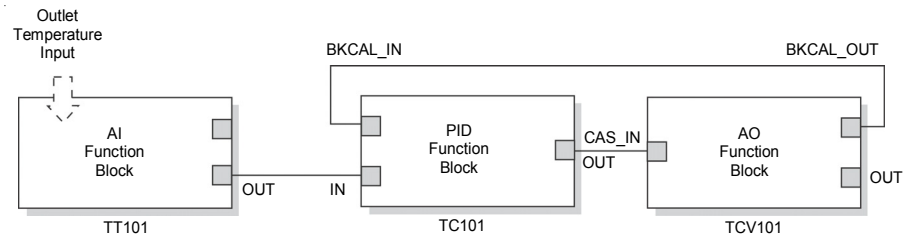


Fig. 8-3
PID Function Block Diagram for Steam Heater Control Example

8-15-2 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.

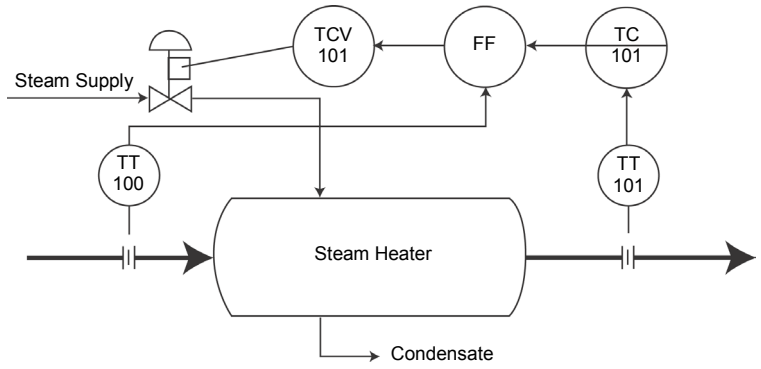


Fig. 8-4
PID Function Block Feedforward Control Example

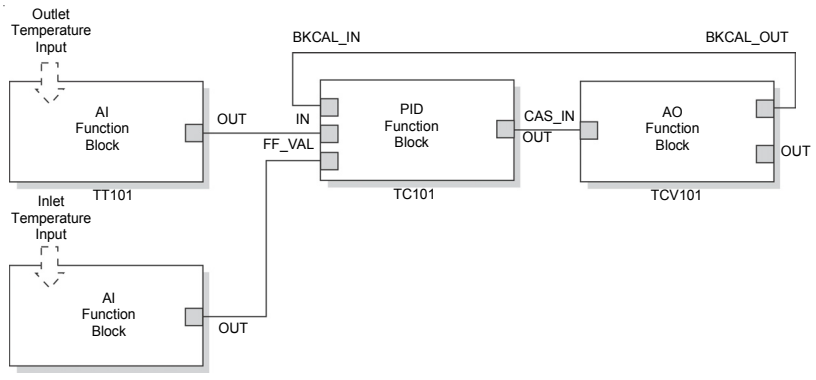


Fig. 8-5
PID Function Block Diagram for Feedforward Control Example

8-15-3 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

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.

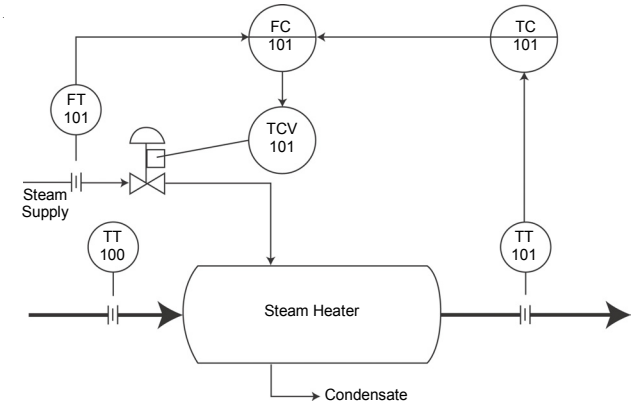


Fig. 8-6
PID Function Block Cascade Control Example

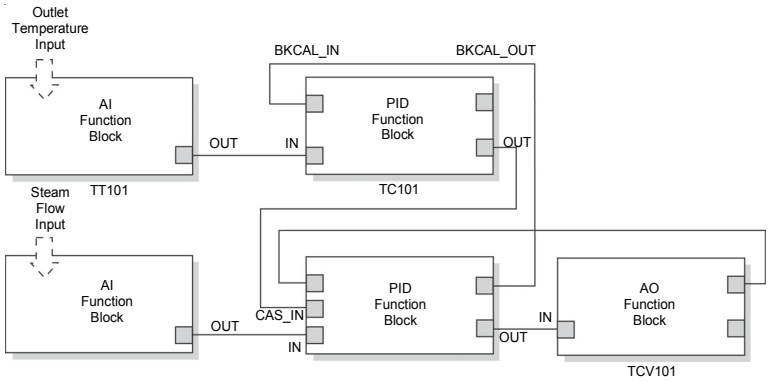


Fig. 8-7
PID Function Block Diagram for Cascade Control Example

8-15-4 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 **IMa**n.
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.

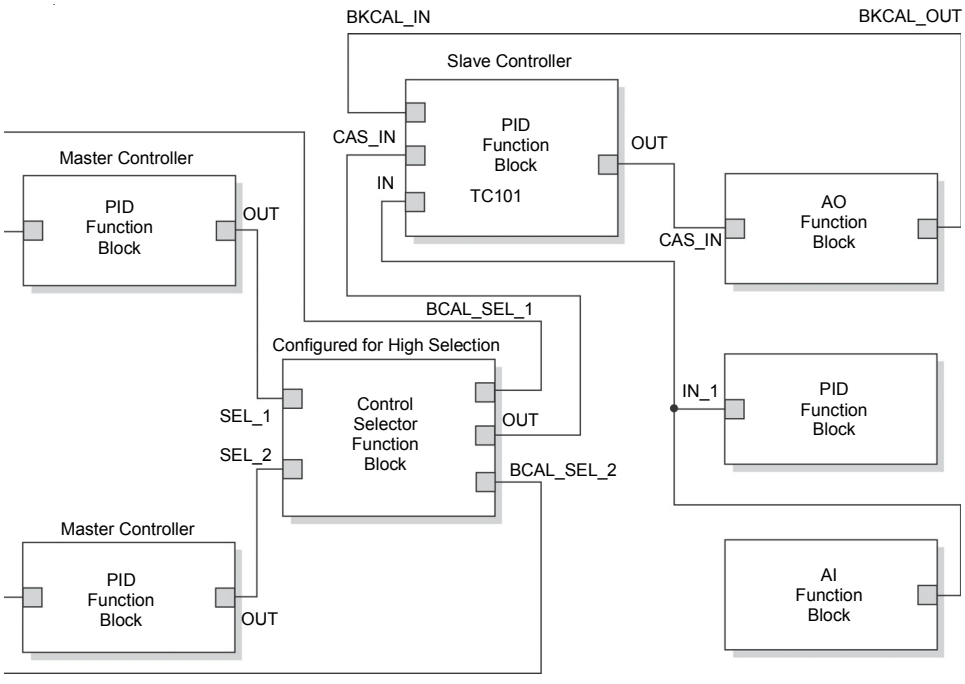


Fig. 8-8
PID Function Block Diagram for Cascade Control with Override

8-16 Troubleshooting

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: 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 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.
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.

Tab. 8-4
Troubleshooting for PID

APPENDIX
Operation with EMERSON™ Process Management DeltaV™

A-1 About DeltaV Software with AMS inside

AMS*inside* DeltaV software allows users to manage their instrumentation, and to perform on-line configurations of their instruments.
The ability to communicate with instruments and configure instruments on-line facilitates instrument commissioning and loop validation.

With AMS*inside*, users can also access status and diagnostic data from smart devices and monitor their performance.
AMS leverages the I/O capabilities of the control system to gather asset management data without interfering with the control system's operations.

A-2 Install the Analyzer onto DeltaV™



The following procedures assume that the DeltaV and the analyzer are installed and powered.

The following steps have to be performed to install a new device onto a DeltaV™ system:

- From the start menu select DeltaV > Engineering > DeltaV Explorer
- Select/Expand „Library" (right below DeltaV_System)
- Select „Fieldbus Devices", using right mouse button. Click on „Fieldbus Devices". This will bring up a list of options
- From the list, select „Add Device Definition..." This should give you a „Browse for folder" selection box.
  Browse to the directory that contains the 7 files needed to „register" a new device with DeltaV. These file will consist of 3 *.dll files, *.sym, *.ffo, *.fhx and *.reg file.
  The files probably will be on a floppy disk or a CD-ROM that accompanies your device. On CD-ROMs delivered together with Emerson Process Management analyzers the files are located in the directory \Fieldbus. Dependent on the existent system use the files of the appropriate subdirectory.
- After answering „yes" to the first prompt, DeltaV will start the installation.

Fig. A-1 shows the „Exploring DeltaV" screen for reference.

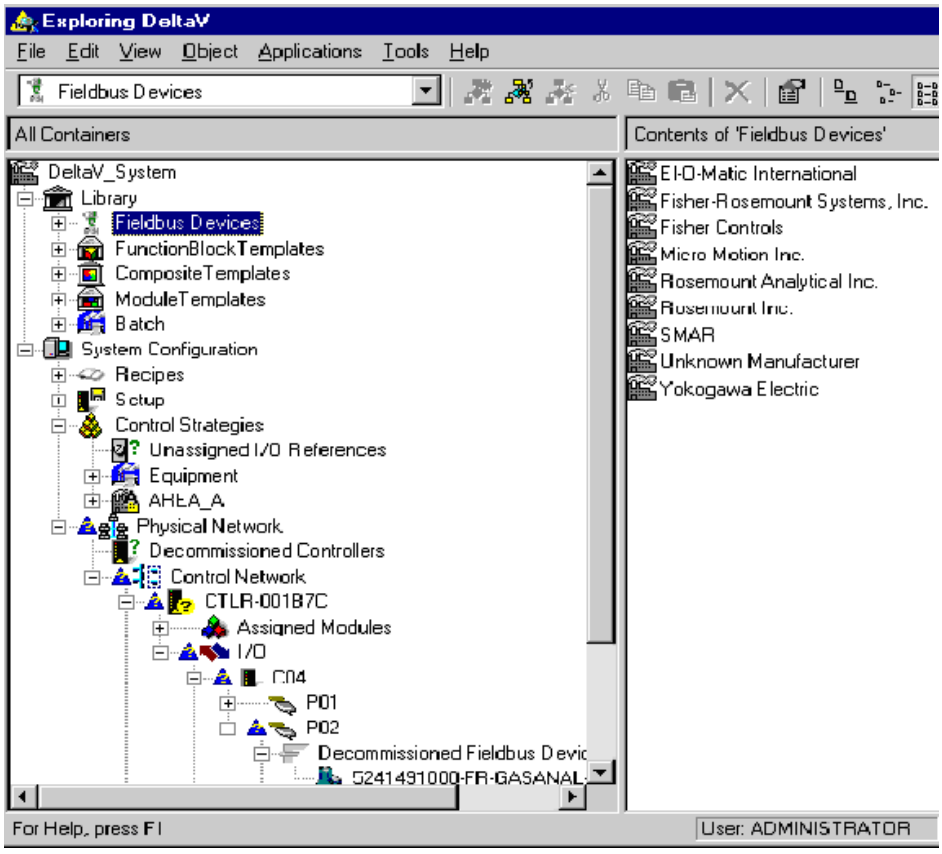


Fig. A-1
DeltaV Explorer

Instruction Manual
ETC01184
10/2003

Foundation™ Fieldbus MLT 1-2 & CAT 200

Foundation™ Fieldbus MLT 1-2 & CAT 200

Instruction Manual
ETC01184
10/2003

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

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