



Actuator controls

AC(V) 01.2/AC(V)ExC 01.2

Foundation Fieldbus



Read operation instructions first.

- Observe safety instructions.

Purpose of the document:

This document contains information for the commissioning staff of the distributed control system and DCS software engineers. This document is intended to support the actuator integration into the DCS via fieldbus interface.

Reference documents:

- Operation instructions (Assembly and commissioning) for the actuator
- Manual (Operation and setting) AC 01.2 actuator controls Foundation Fieldbus

Reference documents can be downloaded from the Internet (www.auma.com) or ordered directly from AUMA (refer to <Addresses>).

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1. Safety instructions

1.1. Prerequisites for the safe handling of the product

Standards/directives The end user or the contractor must ensure that all legal requirements, directives, guidelines, national regulations and recommendations with respect to assembly, electrical connection, commissioning and operation are met at the place of installation.

They include among others:

- Standards and directives such as IEC 60079 "Explosive atmospheres":
 - Part 14: Electrical installations design, selection and erection.
 - Part 17: Electrical installations inspection and maintenance.
- Applicable configuration guidelines for fieldbus applications.

Safety instructions/warnings All personnel working with this device must be familiar with the safety and warning instructions in this manual and observe the instructions given. Safety instructions and warning signs on the device must be observed to avoid personal injury or property damage.

Qualification of staff Assembly, electrical connection, commissioning, operation, and maintenance must be carried out by suitably qualified personnel authorised by the end user or contractor of the plant only.

Prior to working on this product, the staff must have thoroughly read and understood these instructions and, furthermore, know and observe officially recognised rules regarding occupational health and safety.

Work performed in potentially explosive atmospheres is subject to special regulations which have to be observed. The end user or contractor of the plant is responsible for respect and control of these regulations, standards, and laws.

Electrostatic charging Highly efficient charge generating processes (processes more efficient than manual friction) on the device surface must be excluded at any time, since they will lead to propagating brush discharges and therefore to ignition of a potentially explosive atmosphere.

This also applies to fireproof coatings or covers available as an option.

Ignition dangers Gearboxes were subjected to an ignition hazard assessment in compliance with the currently applicable standard according to ISO 80079-36/ -37. Hot surfaces, mechanically generated sparks as well as static electricity and stray electric currents were identified and assessed as major potential ignition sources. Protective measures to prevent the likelihood that ignition sources arise were applied to the gearboxes. This includes in particular lubrication of the gearbox, the IP protection codes and the warnings and notes contained in these operation instructions.

Commissioning Prior to commissioning, imperatively check that all settings meet the requirements of the application. Incorrect settings might present a danger to the application, e.g. cause damage to the valve or the installation. The manufacturer will not be held liable for any consequential damage. Such risk lies entirely with the user.

Operation Prerequisites for safe and smooth operation:

- Correct transport, proper storage, mounting and installation, as well as careful commissioning.
- Only operate the device if it is in perfect condition while observing these instructions.
- Immediately report any faults and damage and allow for corrective measures.
- Observe recognised rules for occupational health and safety.
- Observe national regulations.
- During operation, the housing warms up and surface temperatures > 60 °C may occur. To prevent possible burns, we recommend checking the surface temperature prior to working on the device using an appropriate thermometer and wearing protective gloves.

Protective measures	The end user or the contractor are responsible for implementing required protective measures on site, such as enclosures, barriers, or personal protective equipment for the staff.
Maintenance	To ensure safe device operation, the maintenance instructions included in this manual must be observed. Any device modification requires prior written consent of the manufacturer.

1.2. Range of application

AUMA actuator controls are exclusively designed for the operation of AUMA actuators. Other applications require explicit (written) confirmation by the manufacturer. The following applications are not permitted, e.g.:

- motor control
- pump control

No liability can be assumed for inappropriate or unintended use.

Observance of these operation instructions is considered as part of the device's designated use.

1.3. Warnings and notes

The following warnings draw special attention to safety-relevant procedures in these operation instructions, each marked by the appropriate signal word (DANGER, WARNING, CAUTION, NOTICE).



Indicates an imminently hazardous situation with a high level of risk. Failure to observe this warning results in death or serious injury.



Indicates a potentially hazardous situation with a medium level of risk. Failure to observe this warning could result in death or serious injury.



Indicates a potentially hazardous situation with a low level of risk. Failure to observe this warning could result in minor or moderate injury. May also be used with property damage.



Potentially hazardous situation. Failure to observe this warning could result in property damage. Is not used for personal injury.

Safety alert symbol  warns of a potential personal injury hazard.

The signal word (here: DANGER) indicates the level of hazard.

1.4. References and symbols

The following references and symbols are used in these instructions:

Information The term **Information** preceding the text indicates important notes and information.

 Symbol for CLOSED (valve closed)

 Symbol for OPEN (valve open)

M ▶ **Via the menu to parameter**

Describes the menu path to the parameter. When using the push buttons of local controls, the required parameter can be quickly found on the display. Display texts are shaded in grey: **Display**.

➡ Result of a process step

Describes the result of a preceding process step.

Warning signs at the device

The following warning signs can be attached to the device.

**General warning sign**

General warning of a danger zone.

**Hot surface**

Warning of hot surfaces, e.g. possibly caused by high ambient temperatures or strong direct sunlight.

**Electrical voltage**

Hazardous voltage! Warning of electric shock. At some devices, the warning sign additionally includes a time interval, e.g. 30 s. Once power supply is switched off, you will have to wait for the indicated period. Only then may the device be opened.

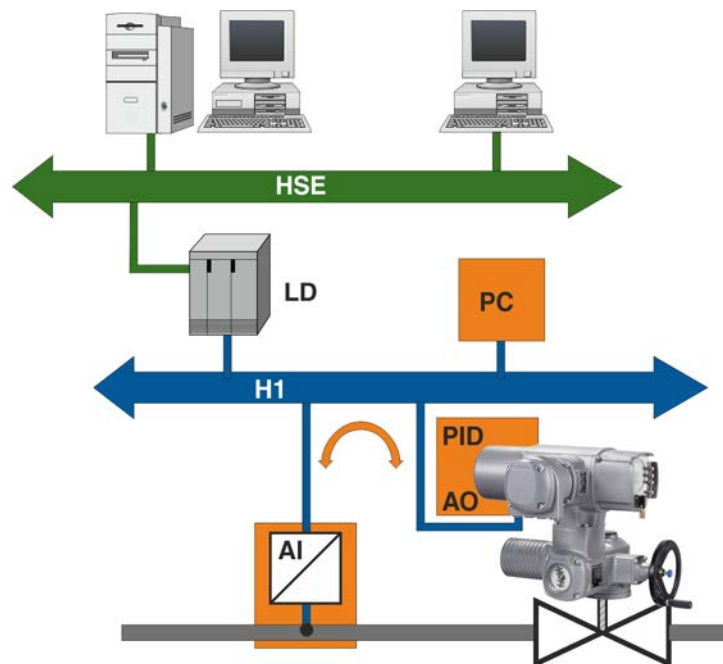
2. General information regarding Foundation Fieldbus

	For the exchange of information among automation systems and between automation systems and the connected distributed field devices, the use of serial fieldbus systems as communication system is state-of-the-art. Thousands of applications have proved impressively that, in comparison with conventional technology, cost savings of up to 40 % in wiring, commissioning, and maintenance are achieved by using fieldbus technology. While in the past the fieldbus systems used were often manufacturer specific and incompatible with other bus systems, the systems employed today are almost exclusively open and standardized. This means that the user does not depend on individual suppliers and can choose within a large product range the best product at the most competitive price.
Historical development	In 1992, an international group, the ISP (Interoperable Systems Project) was founded with the intention to create an internationally uniform fieldbus standard for use in hazardous environments. At the same time, the manufacturers and users of the French FIP (Flux Information Process; previously: Factory Instrumentation Protocol) established the international user organisation WorldFIP. Together with the FIP North America, they were a strong counterweight to the ISP consortium. In 1994, for technical, economic, and political reasons, the ISP and the WorldFIP merged to form the Fieldbus Foundation. The aim of the Fieldbus Foundation was and is to create a single, international fieldbus standard for hazardous environments which will find widespread use as IEC standardised fieldbus.
User organisation	The Fieldbus Foundation is an independent non-profit organisation. The mission is to develop and support a global, uniform fieldbus infrastructure for automation tasks – the Foundation Fieldbus. Members include users and manufacturers of field devices and automation systems. The Fieldbus Foundation contains various workshops which are responsible, among others, for technical support, marketing, and support of the members. Website of the Fieldbus Foundation: www.fieldbus.org.
Certification of the devices	This fieldbus is an open fieldbus standard which enables devices of different manufacturers to be integrated in one system and, if required, ensures their interchangeability (interoperability). This is only feasible when all devices exactly meet the specification. If the devices are approved by Fieldbus Foundation, this implies a guarantee for the user and manufacturer that those devices comply with the specification.

2.1. Performance features

	The Foundation Fieldbus provides a broad spectrum of services and functions compared to other fieldbus systems: • Bus-powered field devices • Line or tree topology • Deterministic (predictable) dynamic behaviour • Distributed data transfer (DDT) • Standardised block model for uniform device interfaces (interoperability, interchangeability) • Trend functions and alarm treatment • Flexible extension options based on device descriptions • Intrinsic safety for use in hazardous areas (option)
Decentralised process data processing	The distributed data transmission within the Foundation Fieldbus network enables individual field devices to independently perform automation tasks via standardised function blocks. If a field device contains e.g. the PID function block, it is able to independently control a process variable. This automation decentralisation from the automation to the field level relieves the central process control.

Figure 1: Typical Foundation Fieldbus structure



HSE FF bus based on high speed Ethernet

H1 FF bus based on H1

LD Linking device

PC Power Conditioner (FF H1 power supply)

Actuator controls with function blocks:

PID Process controller

AO Analogue output (valve setpoint)

AI Analog Input (e.g. flow rate measured by sensor)

2.2. Layered communications model

The structure of Foundation Fieldbus is based on the ISO/OSI reference model (International Standards Organisation - Open Systems Interconnection). This model consists of 7 layers. Foundation Fieldbus just uses three layers:

- Layer 1: Physical layer
- Layer 2: Data link layer
- Layer 7: Application layer

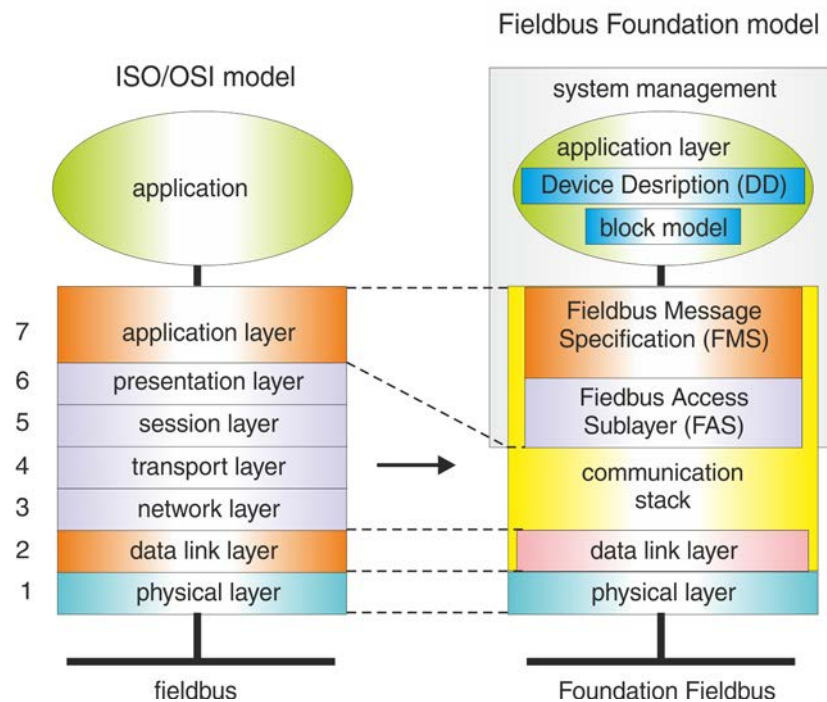
As is the case for many other bus systems, layers three to six are not used. Layer 7 is subdivided into a Fieldbus Access Sublayer (FAS) and a Fieldbus Message Specification (FMS). The Communication Stack covers the tasks of layers 2 and 7.

The special feature of Foundation Fieldbus is the device-dependent application layer, placed above the 7th layer. Whereas the actual application process is not determined for the ISO/OSI model, the Fieldbus Foundation defines a special application layer. This layer contains a block model with function block and a device description (DD). Depending on which blocks are implemented in the block model of a device, users can access a variety of services.

Thus, the Foundation Fieldbus specification consists of 3 main function elements:

- Physical layer
- Communication stack
- Application layer

Figure 2:



2.3. Physical layer

The lowest bus level, the physical layer, is based on IEC standard 61158-2. This layer defines how the physical connection to the fieldbus network as well as the data transmission are to be performed.

Foundation Fieldbus uses two systems for the communication. The low H1 version for communication and direct connection of the field devices, the fast HSE version based on Industrial Ethernet within the DCS and for connecting Remote Operations Management (ROM) systems.

2.3.1. H1 bus

The following summary gives a brief overview of the features and functions of the H1 bus. For detailed information, refer to the various Application Guides of the Fieldbus Foundation (e.g. AG-140, AG-163, AG-181, FD-043).

- Data transfer: Manchester coding
- Data transfer rate 31.25 kbit/s (default setting, cannot be modified).
- Requirements for perfect communication: Sufficient power supply for the field devices, i.e. minimum 9 volts for each device. Software tools are available for network planning, calculating the resulting currents and terminal voltages on the basis of network topology, the cable resistance, and the supply voltage. E.g. DesignMATE™, available via www.fieldbus.org.
- Field device connection via H1 version. The Foundation Fieldbus Power Conditioner is connected to the bus line in the same way (parallel) as a field device. Field devices supplied by additional supply sources have to be connected to these sources as well.
- The maximum power consumption of current consuming devices within H1 networks must be lower than the electric power supplied by the Foundation Fieldbus Power Conditioner.
- Network topologies: Line topology; when using junction boxes or segment barriers, also star, tree or a combination of these topologies.
- Device connections: Typically via short spurs to enable connection/disconnection of the devices without impairing communication to other users.
- Maximum length of a spur: 120 m, depending on the number of spurs used as well as the number of devices per spur.

- Maximum cable length of an H1 segment without repeater: 1,900 m.
- Maximum cable length of an H1 segment using maximum 4 repeaters: $5 \times 1,900 \text{ m} = 9.5 \text{ km}$.
All spurs from the field devices to the junction boxes have to be included in the total length calculation.
- Number of field devices per segment: In non-intrinsically safe areas: Max. 32, in explosion-hazardous areas, this number is reduced to significantly fewer devices (due to power supply limitations). Based on the available H1 bandwidth, the typical number of devices per segment is, however, max. 10 – 14 devices per segment.
- Fieldbus cable: Type A (recommended), only this type is specified for the maximum segment length of 1,900 m.
- Termination: Two terminators per bus segment, typically one at each end of the longest fieldbus cable.
- Bus cable shielding: If shielded cables are used (recommended), the shield is typically only earthed at one single point within the segment (typically near the Foundation Fieldbus power supply). Apart from this, other earthing philosophies are available (refer to AG-181).

2.3.2. High Speed Ethernet (HSE)

HSE is based on standard Ethernet technology. The required components are widely used and are available at comparatively low costs. The HSE data transfer speed runs at 100 Mbit/s and can be equipped with both copper cables and optical fibre cables. The Ethernet operates by using random (not deterministic) CSMA bus access.

This method cannot be applied to all automation applications, as for some parts, real-time requirements have to be met. The extremely high transmission rate enables the HSE to respond sufficiently fast when the bus load is low and only few devices are connected. With respect to process automation demands, real-time requirements are nevertheless met in any case.

If the bus load must be reduced due to the multitude of connected devices, or if several HSE sub networks are to be combined to create a larger network, Ethernet switches must be used. A switch reads the target address of the data packets that must be forwarded and then passes the packets on to the associated sub network. This way, the bus load and the resulting bus access time can be controlled to best adapt it to the respective requirements.

2.3.3. Connection between H1 and HSE

To connect the comparatively slow H1 segments to the HSE network, linking devices (connecting devices) are required (refer to figure "Typical Foundation Fieldbus structure" in chapter "Performance features").

The linking device adapts the data transfer rates and the data telegrams of both networks while considering the direction of transmission. This way, powerful and widely branched networks can be installed in larger plants.

2.3.4. Data transmission and power supply

Within the Foundation Fieldbus network, a device transmitting data typically varies the power consumption by $\pm 10 \text{ mA}$ at 31.25 kbit/s to generate a typical $\pm 0.5 \text{ V}$ voltage change for power supply with a 50 Ohm impedance. This voltage variation is modulated onto the 9 – 32 V DC H1 power supply.

2.4. Communication stack

The field devices used with Foundation Fieldbus are capable of independently assuming automation tasks, i.e.:

- Each field device can directly exchange data with other devices (e.g. reading measuring values, forwarding control values).
- All field devices send and receive data at pre-defined points in time.
- Specific mechanism ensure that never two or more devices simultaneously access the bus.

To meet these requirements, the Foundation Fieldbus needs a central communication control system (Link Active Scheduler = LAS).

2.4.1. Link Active Scheduler - LAS

A field device performing the Link Active Scheduler (LAS) function controls and schedules the bus communication. It controls all bus activities by means of specific data telegrams that it sends to the available devices. Since the LAS also continuously polls unassigned device addresses, it is possible to connect devices during operation and to integrate them in the bus communication.

Devices which can be used as LAS are called Link Master Devices (LM). Basic devices (BD) do not have LAS capacity.

In a redundant system containing several link master devices, only one link master takes over the LAS task. If the active LAS device fails, another link master device will take over (fail-operational design).

The LAS ensures both updating and continuous transmission of the Live List to all other Link Master Devices. If a device is removed from or added to the list, the LAS transmits this change to all link master devices (broadcast message). This way, all link masters have access to the current live list so that they can become the LAS without any loss of information, if required.

2.4.2. Communication control

The communication services of the FF specification define both scheduled and unscheduled data transmission. Time-critical tasks, such as the control of process variables, are exclusively performed by scheduled services, whereas programming and diagnostic functions are carried out using unscheduled communication services.

Scheduled data transmission

To solve communication tasks in time and without access conflicts, all time-critical tasks are based on a defined transmission schedule. The pertaining definitions are created by the Foundation Fieldbus system operator during the configuration of the FF system.

The LAS periodically broadcasts a time synchronisation signal (TD: Time Distribution) on the fieldbus so that all devices have exactly the same data link time. In scheduled transmission, the point in time and the sequence of data telegrams are defined in detail.

For this reason, the FF H1 system is also called deterministic fieldbus system.

For each action to be performed (e.g. execution of a function block or transmission of a process value), a defined period is added to the schedule. Based on this schedule, a transmission list is generated which defines when a specific field device is prompted to send its data. Upon receipt of a special trigger telegram (CD: Compel Data), the respective device (publisher) broadcasts the data in the reception buffer of all devices which are configured to receive this data (subscriber).

This type of transmission is therefore called the "publisher-subscriber" method.

Unscheduled data transmission

Device parameters and diagnostic data are typically only transmitted when needed, i.e. on request. The transmission of this data is not time-critical. For such communication tasks, the Foundation Fieldbus offers unscheduled data transmission.

Permission for a certain device to use the fieldbus for unscheduled communication tasks is granted by the LAS device, provided that no scheduled data transmission is active.

Every device may use the bus as long as required until it either returns the bus access right (token), or until the maximum granted time to use the token has elapsed.

Unscheduled transmission offers two data transmission methods: "Client Server" to adapt device settings, configuration upload/download of diagnostic data as well as "Report Distribution" to send alarms.

2.4.3. Services

The Fieldbus Access Sublayer (FAS) and the Fieldbus Message Specification (FMS) layer form the interface between the data link layer and the user application (refer to figure 2). The services provided by both FAS and FMS are invisible for the user.

However, performance and functionality of the communication system considerably depend on these services.

Fieldbus Access Sublayer (FAS)

The FAS services create Virtual Communication Relationships (VCR) which are used by the higher-level FMS layer to execute its tasks. VCRs describe different types of communication processes and enable faster processing of the associated activities. Foundation Fieldbus communication uses the three different VCR types as follows (refer to table).

Client/server	Report Distribution	Publisher/Subscriber
User communication	Events, alarms, trends	Process data transmission
Setpoint changes, operating data and device data changes, upload/download, alarm value adaptation, remote diagnostics.	Send process alarms to user consoles, transmitting trend data for long term data logging	Transfer process values of sensors and other devices
Unscheduled	Unscheduled	Scheduled

The Publisher/Subscriber VCR type is used to transmit the input and output data of function blocks. As described above, scheduled data transmission is based on this type of VCR.

The Client/Server VCR type is the basis for operator initiated requests, such as setpoint changes, adaptations and change of control parameters, diagnostics, device upload, and download, etc.

Report Distribution is used to send alarms or event notifications to the user console or similar devices. Client/Server and Report Distribution data transmission is unscheduled, due to the fact that the time of transmission cannot be foreseen and therefore not be scheduled.

Fieldbus Message Specification (FMS)

The FMS provides the services for standardised communication. Data types that are communicated via the fieldbus are assigned to certain communication services. For uniform and clear assignment, object descriptions are used. Object descriptions contain definitions of all standard transmission message formats as well as application-specific data. Special, predefined communication services are available for each object type.

Object descriptions are collected together in a structure called an object dictionary.

2.5. Application layer

An important criterion for a fieldbus system to be accepted by the market is the interoperability of the devices. Interoperability characterises the capability of devices of different manufacturers to communicate with each other. In addition, it must be ensured that a device from one manufacturer can be substituted with that of another.

This requires an open protocol specification which defines uniform device functions and application interfaces. Other network users and application programs can use these interfaces to access the functions and parameters of the field devices. The Foundation Fieldbus meets these requirements by means of standardised function blocks and device descriptions.

2.5.1. Block model

Foundation Fieldbus assigns all functions and device data to three different types of blocks:

- Resource block
- One or several function blocks
- Several transducer blocks

Resource block

The resource block describes characteristics of a fieldbus device, e.g. device name, manufacturer, serial number, hardware and firmware version, etc.

Function blocks

Function blocks describe the device functions and define how these can be accessed. The charts of scheduled data transmission are based on these function blocks. Each

block (including the pertaining inputs and outputs) has a definite task. Each FF device is equipped with at least one function block.

The FF specification provides defined function blocks which can be used to describe the typical functions. They are listed below:

AI	Analog Input
AO	Analog Output
DI	Discrete Input
DO	Discrete Output
PID	Proportional/integral/derivative
SC	Signal Characteriser
IS	Input Selector

Transducer blocks

Transducer blocks enhance the application options of a device. Their data enables the input and/or output parameters of a function block to be influenced. Measuring and positioning data can be calibrated and reset, characteristics can be linearised or physical units can be reset using additional process data.

Further objects

Besides the three block types, the following additional objects are defined within the block model:

Link objects define the connections between different function blocks, both internal to the field device as well as across the fieldbus network.

Alert objects allow reporting alarms and events on the fieldbus.

Trend objects allow trending function block data for access and analysis from higher-level systems.

View objects are predefined groupings of data and block parameter sets that can be used to group and display the parameters according to their tasks: Process control, configuration, maintenance and additional information.

2.5.2. Device descriptions

During start-up and maintenance as well as when performing diagnostic functions, an open communication system must ensure that higher-level control computers or control systems can access all field devices and that respective controls are available.

The device descriptions (DDs) contain the necessary information to fulfill these requirements. They provide all information needed to understand the meaning of the device data and display them correctly on the operator console.

2.5.3. System management

The system management of each device has the following tasks:

- Synchronisation of device activities in compliance with the predefined transmission schedule
- Cyclical processing of transmission list (LAS only) within the predefined schedule.

Further tasks performed by the system management:

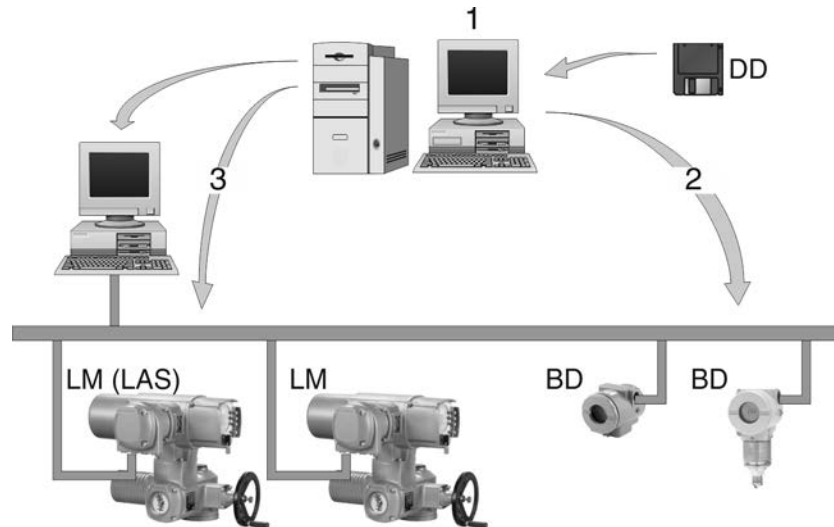
- Automatic assignment of LAS function to another Link Master if the active LAS fails.
- Synchronisation of clock information
- Automatic address assignment for new devices within the communication network

The automatic assignment of a provisional device address allows the assignment of a clear and unambiguous device address at the commissioning during active communication. For this address assignment procedure, special default addresses are reserved allowing to access the new devices which are not yet configured. A new device is integrated in the communication network after assigning a device tag as well as a new, clear, unambiguous node address. The default address used is then available again for the assignment of further devices, still due to be configured.

2.5.4. System configuration

Scheduled communication as well as all fieldbus devices must be configured before their first start-up (refer to figure below). This requires a configuration tool, e.g. the NI-FBUS Configurator by National Instruments.

Figure 3:



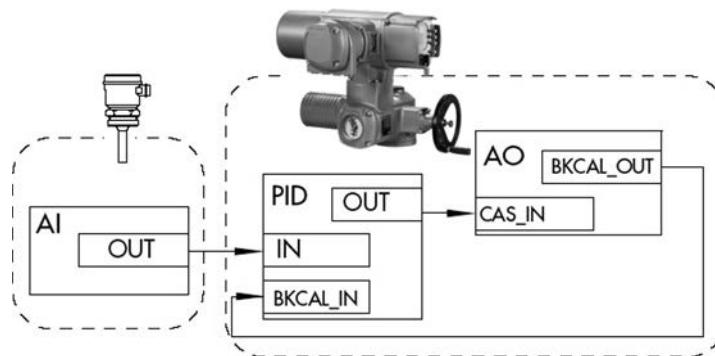
- 1 Configuration device
- 2 Configuring basic devices
- 3 Configuring LAS and link master

Prior to the actual commissioning, the Device Descriptions (DD) for all devices to be configured must be entered using configuration tools. The configuration software must either be able to access the device descriptions in the available libraries, or the device descriptions must be loaded via external data storage devices.

The configuration software helps to determine how and with which devices the measurement and control tasks of a plant are processed by connecting the function blocks of the field devices. This task can be performed using a graphical user interface. For this, just connect inputs and outputs of the corresponding block symbols and define the block behaviour.

The figure below shows an example of a filling level control. The sensor output value is connected to a PID function block. This block can be provided e.g. by actuator controls. The subsequent analogue output acts on the actuator positioner for filling level control by means of the valve.

Figure 4:



2.6. Topology

Several structures are available for Foundation Fieldbus:

Point-to-point topology, whereby only one device is connected to each line.

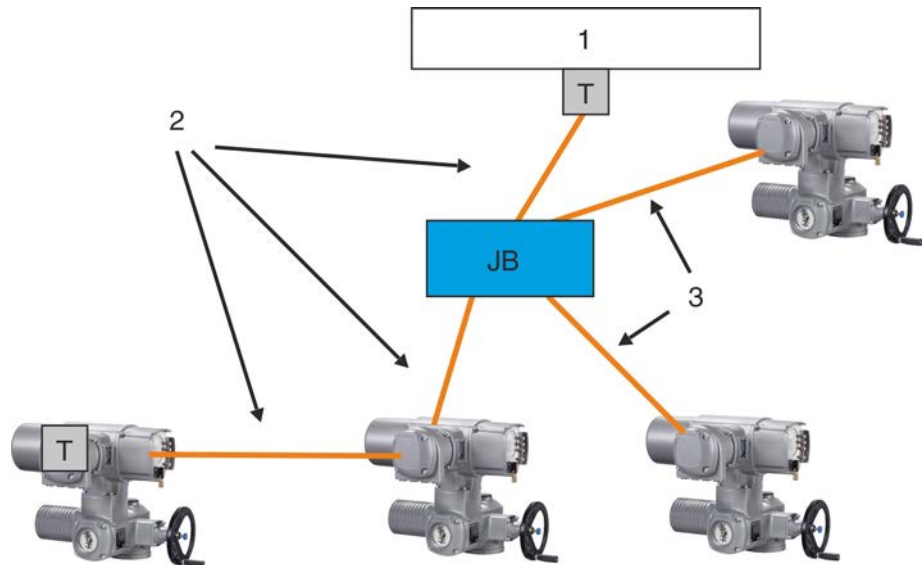
Bus with **spurs**; for this structure, the fieldbus devices are connected to the bus segment via spurs.

Line topology; for this structure, the fieldbus cable of a segment is led from device to device and connected to the terminals of each fieldbus user. Due to the AUMA plug/socket connector, installations with AUMA actuators implementing this topology can easily and individually be disconnected from the network without impairing the availability of the remaining segment.

Tree topology; for this structure, the devices of one fieldbus segment are connected to a common junction box via separate fieldbus cables. The maximum spur length must be observed when implementing this topology. It is furthermore possible to combine the topology options mentioned.

Die genannten Topologieoptionen können auch kombiniert werden.

Figure 5:



- 1 DCS
- 2 Trunk
- 3 Spurs
- JB Junction Box

Spurs or tee connectors are possible for Foundation Fieldbus. The possible fieldbus line length is determined by the type of cable, the cross section, and the type of the bus supply.

Cable length = trunk length + total spur length

Maximum length = 1,900 metres with cable type A

By using up to four repeaters, a maximum of $5 \times 1,900 \text{ m} = 9,500 \text{ m}$ can be achieved.

A terminator is to be installed at both ends of the main trunk.

Number of devices	Permissible spur length
The number of devices possible on a fieldbus depends on the power consumption of devices, the type of cable used, the use of repeaters, etc. For details please refer to Physical Layer Standard.	Permissible spur length for one device per spur - any further device reduces the permissible spur length by 30 metres
25 – 32	1 m
19 – 24	30 m
15 – 18	60 m
13 – 14	90 m
1 – 12	120 m

For details regarding the different topology options, please refer to the Application Guides published by Fieldbus Foundation:

AG-140 31.25 kbit/s Wiring and Installation

AG-163 31.25 kbit/s Intrinsically Safe Systems

AG-170 Function Block Capabilities in Hybrid/Batch Applications

AG-181 System Engineering Guidelines

Bus cables Various types of fieldbus cables can be applied for Foundation Fieldbus. The following table lists the cable types specified by the IEC/ISA 61158-2 Physical Layer Standard.

Type A is the preferred fieldbus cable. This cable should be used in new installations. However, other cable types may be used for the fieldbus wiring (e.g type B, C, and D). Their disadvantage is the reduced cable length; therefore, their use is not recommended.

Table 1: Bus cables

	Type A (Reference)	Type B	Type C	Type D
Cable design	Twisted conduct- or pair	One or multiple twisted conduct- or pairs, overall shield	Multiple twisted pairs, not shield- ed	Multiple twisted pairs, not shield- ed
Cross section (nominal)	0.8 mm ² (AWG 18)	0.32 mm ² (AWG 22)	0.13 mm ² (AWG 26)	1.25 mm ² (AWG 16)
Loop resistance (DC current)	44 Ω/km	112 Ω/km	264 Ω/km	40 Ω/km
Impedance at 31.25 kHz	100 Ω ±20 %	100 Ω ±30 %	Not specified	Not specified
Wave attenuation at 39 kHz	3 dB/km	5 dB/km	8 dB/km	8 dB/km
Capacitive asymmetry	2 nF/km	2 nF/km	Not specified	Not specified
Group delay distortion (7.9 – 39 kHz)	1.7 µs/km	Not specified	Not specified	Not specified
Degree of shield coverage	90 %	Not specified	Not specified	Not specified
Recommended network expan- sion (incl. spur lines)	1,900 m.	1,200 m	400 m	200 m

3. Commissioning

3.1. Introduction

AUMATIC controls with Foundation Fieldbus are commissioned via the fieldbus network. This includes both PD tag and device address setting as well as configuration of the function block application.

3.2. Network configuration

This section contains information on how to adapt AUMATIC actuator controls to fieldbus network requirements.

3.2.1. Tag and device address

Before connecting devices with Foundation Fieldbus, PD Tag (Physical Device Tag) and device addresses must be assigned.

The PD Tag is an identifier used for the device. Up to 32 alpha-numerical characters can be used for data entry.

Address ranges

The device address is used to identify devices during communication. The valid address range is between 16 and 247 (0x10_{hex} and 0xF7_{hex}). Link master devices are assigned lower addresses, basic devices higher addresses. An appropriate address range is available for each of these device types.

The AUMATIC can be placed within both ranges: within the basic device range or within the link master device range. The factory setting for the AUMATIC is to start with address 247 (0xF7_{hex}) and as basic device. If the AUMATIC is to be operated as link master device, the MIB parameter BOOT_OPERAT_FUNCTIONAL_CLASS has to be changed from 0x01 (BASIC) to 0x02 (LM). After this, the AUMATIC has to be rebooted.

Information

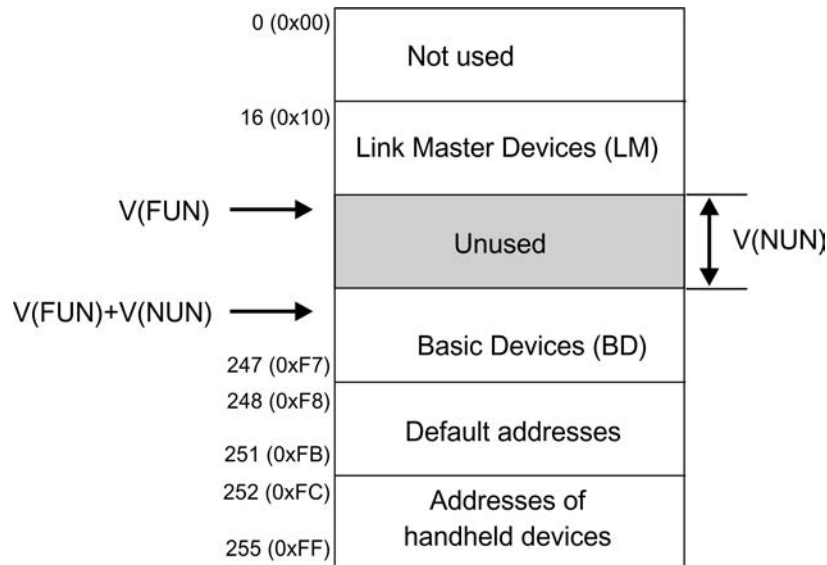
The device with the lowest address within the link master devices range adopts the LAS function.

The following parameters for address range setting should be adapted:

Parameters	Description
V(FUN)	First unpolled node; the highest address which can be assigned to a link master device is V(FUN) – 1.
V(NUN)	Number of unpolled nodes; here, the gap of unused consecutive addresses is defined. The first address which can be assigned to basic devices is V(VUN) + V(NUN).

Devices within the 'Unused' address range are excluded from communicating via Foundation Fieldbus, because the LAS does not periodically check this range for new devices. V(FUN) and V(NUN) parameters have to be adapted according to the addresses assigned within the Foundation Fieldbus network, the "unused" range should be selected in a way to ensure that the LAS does not unnecessarily poll the addresses of devices, not being connected.

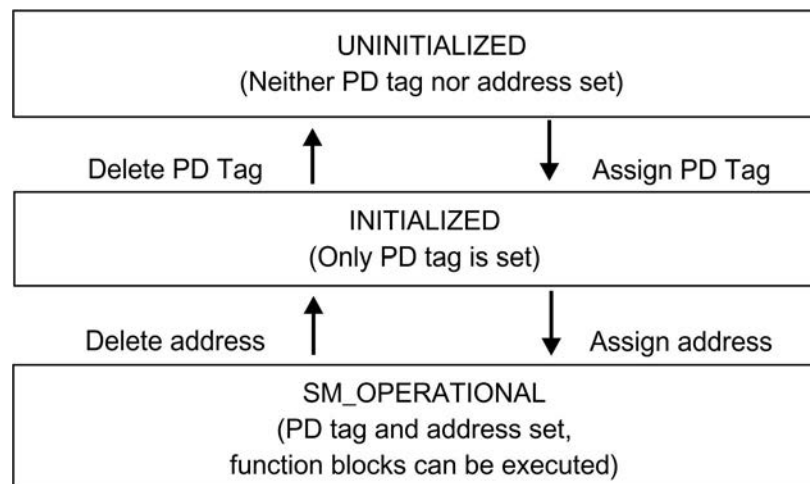
Figure 6:



Tag and device address setting

A Foundation Fieldbus Device can take on three states. If the state does not correspond to the SM_OPERATIONAL state, no function block will be executed

Figure 7:



AUMATIC default setting:

PD tag: AUMA AC 01.2

Address: 247 (0xF7_{hex}).

If two AUMATIC actuator controls are connected to the same address within the same Foundation Fieldbus network, one of the controls keeps the address assigned, whereas the other device uses a default address (from 248 [or 0xF8_{hex}] to 251 [or 0xFB_{hex}]).

Change the device address:

1. Delete the address (CLEAR_ADDRESS).
2. Assign new, unused address (SET_ADDRESS).

Change the PD tag:

1. Delete address and PD tag.
2. Then, assign again PD tag and address.

Devices for which the address has been deleted will wait within the default address range for a new setting (randomly chosen from a range of 248 (or 0xF8_{hex}) to 251 (or 0xFB_{hex}). At the same time, the device ID must be known to clearly identify the device. The worldwide unique device ID for the AUMATIC is 0A01FF0001WorksNoxSerialNo.

3.2.2. Link master parameter setting

To ensure stable communication, different parameters must be observed and adapted to the connected link master devices. When setting the parameters in compliance with table 16, the largest value of all devices connected to the same Foundation Fieldbus network must be used.

Link master parameters of the AUMATIC:

Symbol	Parameters	Description
V(ST)	Slot Time	Time necessary for an immediate device response (unit: 1/256 μ s). For the AUMATIC, set value ≥ 8 .
V(MID)	Minimum Inter PDU Delay	Minimum time between two data telegrams (unit: 1/256 μ s). For the AUMATIC, set value ≥ 6 .
V(MRD)	Maximum Re-sponse Delay	Maximum time permissible for a response (unit: slot time (V(ST))); For the AUMATIC, set value ≥ 5 .

3.2.3. Scheduling parameter setting

The process application is assembled using and combining function blocks. The scheduling of the connected function blocks is precisely defined during configuration of the function block application.

The combined blocks have to be executed simultaneously with other blocks within the communication schedule. Communication synchronisation is performed via the LAS.

The MACROCYCLE_DURATION parameter is used to define the cycle time of the devices connected to the network.

MACROCYCLE_DURATION specifies the macrocycle duration. The unit of this parameter is 1/32 ms and the default value for the AUMATIC is 32000 (0x7D00_{hex} = 1 s). This value can be optimised, if required.

3.3. Function blocks

Input and output parameters of function blocks can be connected via Foundation Fieldbus to perform the automation task.

Actuator controls comprise the following function blocks:

Units	Code	Description
1	RB2	Resource Block
4	AI	Analog Input function block
10	DI	Discrete Input function block
2	AO	Analog Output function block
8	DO	Discrete Output function block
1	PID	Process Controller function block
1	SC	Signal Characteriser function block
1	IS	Input Selector function block
1	AITB	Analog Input transducer block
1	DITB	Discrete Input transducer block
1	DOTB	Discrete Output transducer block
1	AOTB	Analog Output transducer block
1	PTB	Positioner Transducer Block (transducer block for controlling the actuator)
1	AUMACTB	AUMA Commissioning Transducer Block (transducer block for commissioning and parameter setting)
1	AUMADTB	AUMA Diagnosis Transducer Block (Transducer Block for diagnostics)

Each Discrete Input function block is connected to a common Discrete Input Transducer Block.

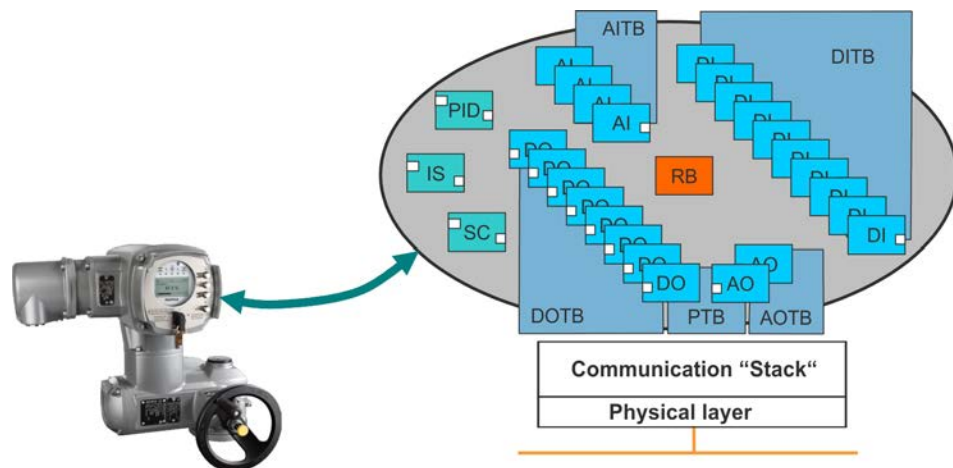
Each Analog Input function block is connected to a common Analog Input Transducer Block.

Depending on the channel configuration, the Discrete Output function block and the Analog Output function block are either connected to the Positioner Transducer Block, the Analog Output Transducer Block or the Discrete Output Transducer Block. For the PID function block, the IS function block, the SC function block and the RB2 function block, no transducer blocks are required.

Multiport valve:

For multiport valve product variant, the Discrete Output function block is connected to the Positioner Transducer Block. Multiport valve positions: Parameter CHANNEL "Ch PTB operation commands [8 bit]" value 8 (MPV position 1) through 15 (MPV position 8). For this, refer to table "CHANNEL parameter setting for Discrete Output function block (DO)". Ch PTB operation commands [8 bit]

Figure 8: Function blocks



3.3.1. Operation commands

Operation of AUMA actuators with actuator controls via Foundation Fieldbus can be performed via the Analog Output function block (AO) for setpoint operation commands or, alternatively, via the Discrete Output function block (DO) for OPEN - STOP - CLOSE commands.

Typically, actuators are either exclusively operated via an analogue setpoint operation command of the Analog Output function block (AO) or, as an alternative, via binary OPEN - CLOSE operation commands of the Discrete Output function blocks (DO).

Depending on the selected channel of the function block (CHANNEL parameter), received operation commands will either be processed by the Positioner Transducer Block (PTB), the Discrete Output Transducer Block (DOTB) or the Analog Output Transducer Block (AOTB), allowing for further settings such as dynamic change-over between an analogue setpoint command and binary OPEN - CLOSE operation commands.

Information

As the actuator may be controlled via different channels (CHANNEL parameter), certain restrictions apply for CHANNEL parameter setting irrespective of the function block used. They will be described in detail for commissioning of the respective function blocks.

Operation commands via Analog Output function block

The AO function block accepts setpoints between 0 and 100 %.

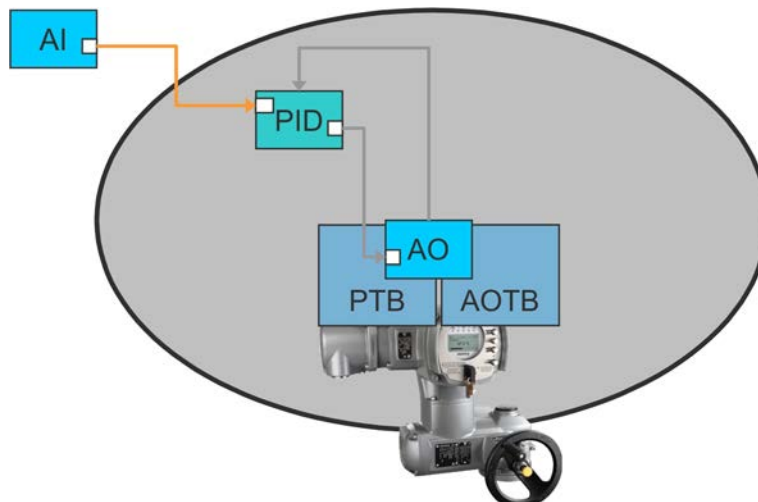
A setpoint of 0 % signifies that the actuator fully closes, a setpoint of 100 % signifies, that the actuator fully opens.

The integral PID function block can be used as controller function block to reduce the number of required external VCRs. This is not imperative. The PID function block can be integrated within another external device, e.g. the DCS; however, an additional VCR is then required for feedback from the AO to the PID.

For setpoint control via an Analog Output function block (AO), the setpoint signal is typically forwarded to the Positioner Transducer Block. In this case, the AO can

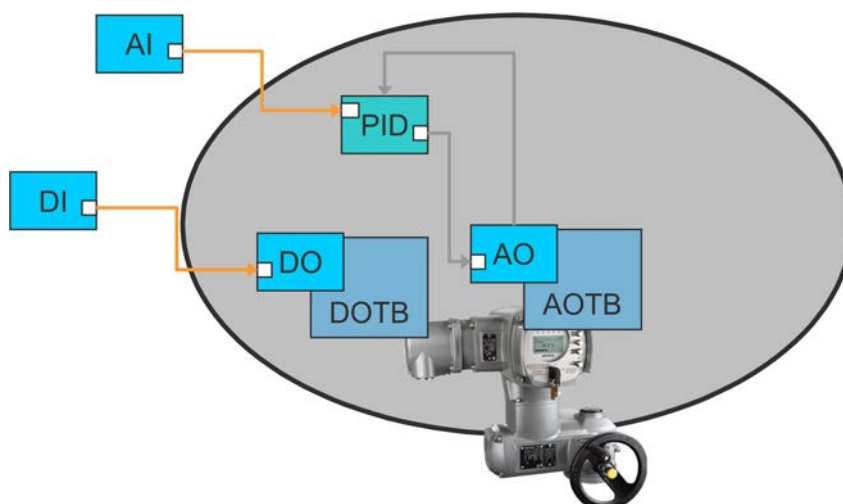
provide additional information on the actual position and the actuator status and therefore on the availability of the AO, when using the backward path (BKCAL_OUT).

Figure 9: Typical control via Analog Output function block



As an alternative, the setpoint signal can also be sent via the Analog Output transducer block. An additional Discrete Output function block then controls the change-over between setpoint operation command and binary OPEN - CLOSE commands. When using the above configuration, the AO will only provide the received setpoint via its backward path (BKCAL_OUT), but no further feedback on actuator position or actuator status.

Figure 10: Alternative control via Analog Output function block with operation command change-over via Discrete Output function block



Operation commands via Discrete Output function block

For binary control using a Discrete Output function block (DO), binary 8-bit operation commands are typically also forwarded to the Positioner Transducer Block. In this case, the DO provides the received operation commands via its backward path (BKCAL_OUT_D), but also additional feedback on the actuator status and therefore on the availability of the DO.

Figure 11: Discrete Output function block

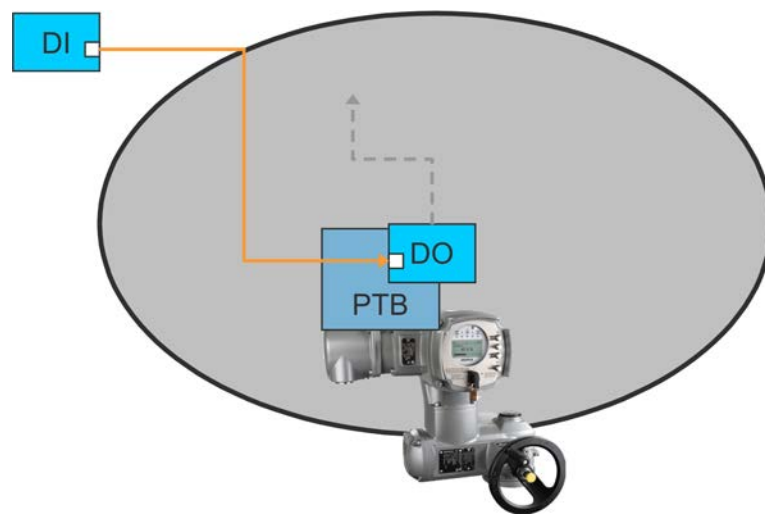
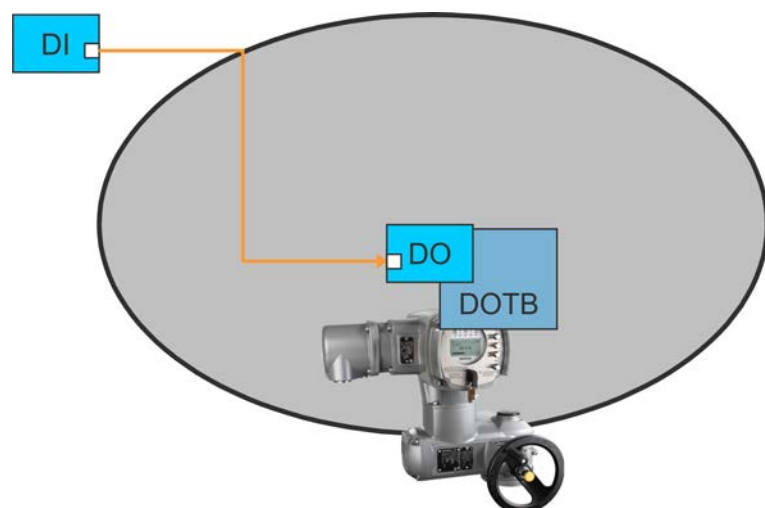


Table 2: Coding of 8-bit operation commands to the Positioner Transducer Block

Discrete State	Operation command	Description
0	Fieldbus CLOSE	Running CLOSE
1	Fieldbus OPEN	Running OPEN
2	Stop	Actuator stops
3	Stop	Actuator stops
4 – 7	Reserved	–
8	Fieldbus intermediate position 1	Run to intermediate position 1.
9	Fieldbus intermediate position 2	Run to intermediate position 2.
10	Fieldbus intermediate position 3	Run to intermediate position 3.
11	Fieldbus intermediate position 4	Run to intermediate position 4.
12	Fieldbus intermediate position 5	Run to intermediate position 5.
13	Fieldbus intermediate position 6	Run to intermediate position 6.
14	Fieldbus intermediate position 7	Run to intermediate position 7.
15	Fieldbus intermediate position 8	Run to intermediate position 8.
16 – 255	Reserved	–

As an alternative, Discrete Output function blocks (DO) can also forward operation commands OPEN or CLOSE as well as further binary control commands using a single bit format to the Discrete Output transducer block. When using this single bit configuration, DO will only provide the received binary signals via its backward path (BKCAL_OUT_D), but no further feedback on the actuator status.

Figure 12: Discrete Output function block



- Information**
- Selection of the single-bit format requires several DO function blocks as well as several external VCRs, as just one operation command can be sent per connection (e.g. either operation command OPEN or operation command CLOSE). Value 0x00 is interpreted as logical 0, all other values as logical 1 (the same applies when using the INVERT function)!
 - When selecting the 8-bit format, several operation commands (e.g. operation commands OPEN or CLOSE or intermediate position operation commands) can be transmitted using just one external VCR to a DO function block.
 - To avoid conflicting commands, operation commands or control signals must not be transmitted over several channels, using different formats to the DO function blocks.

3.3.2. Feedback signals from actuator controls

The actuator controls are able to indicate the own status by means of several different function blocks. The Analog Input function blocks (AI) are used to transmit analogue values, the Discrete Input function blocks (DI) are used to transmit binary information.

Feedback signals via the Analog Input function blocks

Actuator controls are equipped with 4 Analog Input function blocks (AI). Depending on the channel selection (CHANNEL parameter), the following analogue feedback signals can be transmitted:

- Actual actuator position (0.0 – 100.0%)
- Input AIN 1 (optional external analogue 0 – 20 mA input, connection terminals AIN1+/AIN1–)
- Actuator torque (0.0 – 100.0 %; value 0.0 % corresponds to 127 % of the nominal torque in direction CLOSE, 100.0 % corresponds to 127 % of the nominal torque in direction OPEN)
- Input AIN 2 (optional external analogue 0 – 20 mA input, connection terminals AIN2+/AIN2–)

For the Analog Input function blocks (AI), there is a common Analog Input Transducer Block (AITB) providing additional configuration options.

Feedback signals via Discrete Input function blocks

Actuator controls are equipped with 10 Discrete Input function blocks (DI). Depending on the channel selection (CHANNEL parameter), they can be used for different binary feedback signals in single-bit or 8-bit format. For the Discrete Input function blocks (DI), there is a common Discrete Input Transducer Block (DITB) providing additional configuration options.

3.3.3. Multiport valve

For multiport valve product variant, the Discrete Output function block is connected to the Positioner Transducer Block. Parameter CHANNEL of Discrete Output function block is set to "Ch PTB operation commands [8 bit]". Multiport valve positions correspond to a value of 8 (MPV position 1) through 15 (MPV position 8).

For Multiport valve command "Next position", two Discrete Output function blocks are required: Next position CW and next position CCW. The following parameters CHANNEL have to be selected

MPV Next position CW: DO_FB channel Ch_DOTB_Digital_Out_1

MPV next position CCW: DO_FB channel Ch_DOTB_Digital_Out_2

For this, refer to table "CHANNEL parameter setting for Discrete Output function block (DO)".

In addition, the Discrete Output Transducer Block must be configured:

MPV Next position CW: DOTB parameter CFG_DOUT_1 = Digital_Out_1 (Cfg)

MPV next position CCW: DOTB parameter CFG_DOUT_2 = Digital_Out_2 (Cfg)

For this, refer to table "Parameter Transducer Block".

To receive the feedback "Position reached", the parameter CHANNEL for a Discrete Input function block (DI) must be set as follows:

Ch DITB operation status [8 bit] = 26

Bit 3 stands here for "Position reached".

To indicate the current MPV position, the parameter CHANNEL for a Discrete Input function block (DI) must be set as follows:

Ch DITB intermediate positions [8 bit] = 25

The bits 0 – 7 received correspond to multiport valve positions 1 through 8.

For this, refer to table "CHANNEL parameter setting for Discrete Input function block (DI)".

3.3.4. Function block parameter setting

The following steps should be performed in the order as indicated to configure a basic function block application. Some parameter settings may depend on the type of application or the control system.

Uniform parameters for all blocks

All blocks contain six general parameters. They are: ST_REV, TAG_DESC, STRATEGY, ALERT_KEY, MODE_BLK and BLOCK_ERR:

ST_REV	Revision status of the static data associated with the function block. For better tracking of changes within the static parameter, the ST_REV of the associated blocks is incremented by one as soon as a static parameter attribute is changed. The ST_REV of the block is also incremented by one if static parameter attribute is written, however the value itself remains unchanged. The value is reset to 0 as soon as the RESTART resource parameter is described with "Defaults (3)".
TAG_DESC	This parameter can be used for describing the appropriate block application. The value is reset to factory settings as soon as the RESTART resource parameter is described with "Defaults (3)".
STRATEGY	The strategy field can be used to identify a grouping of blocks. The data is not checked or processed by the block but used by the higher ranking system to classify the function blocks.
ALERT_KEY	ID number of plant unit. A common ALERT_KEY can be assigned to all devices within a circuit or a plant segment to help the user to classify faults. Each block has its own ALERT_KEY transmitted with every block-specific alarm signal. The DCS can use this information to sort alarm signals, e.g. as code for identifying and classifying the source of the alarm signal. If the ALERT_KEY is not used, occurring fault signals cannot be sent to a certain user console. The ALERT_KEY defines the destination of the alarm signal transfer of this block (to which user console). The use of this parameter is strongly recommended!
MODE_BLK	This parameter includes the actual, target, permitted, and normal block operation modes. - TARGET: changes the block operation mode - ACTUAL: indicates the current block operation mode - PERMITTED: indicates the permissible operation modes - NORMAL: indicates the normal block operation mode Refer to appendix "Block operation modes" (contains detailed information about possible function block conditions).
BLOCK_ERR	This parameter reflects the fault state of hardware and software components associated with a block. It contains bit string, therefore several errors can be displayed at the same time.

Resource block (RESOURCE)

The resource block stores device hardware information related to all function blocks within a device (such as e.g. memory size) and controls the device hardware as well as the internal function blocks. Furthermore, it contains the device name, manufacturer, and serial number.

Apart from the diagnostic signals in accordance with NAMUR recommendation NE 107 as well as the representation of these signals in accordance with FF Specification Field Diagnostics Profile, FF-912.pdf, the resource block additionally contains essential information of the specific electronic name plate of the actuator controls:

Resource Block parameters	Explanations
IDENTIFICATION	
IDENT_DEVICE_DESIGNATION	Device description
IDENT_DEVICE_TAG	Device tag
IDENT_PROJECT_NAME	Project name
CONTROLS_IDENTIFIER	
CTRLS_COMMISSION_NO	Controls commission number
CTRLS_WORKS_NO	Controls works number
CTRLS_WIRING_DIAGRAM	Controls wiring diagram
CTRLS_DATE_OF_MANUFACTURE	Production date
ACTUATOR_IDENTIFIER	
ACT_COMMISSION_NO	Actuator commission number
ACT_WORKS_NO	Actuator works number
ACT_WIRING_DIAGRAM	Actuator wiring diagram

Commissioning:

1. Lock/unlock write protection:
Parameters: WRITE_LOCK
 - LOCKED = Write protection activated (no writing access possible to any changeable parameters)
 - NOT LOCKED = Write protection deactivated (factory setting)
2. Enter or change block name (if required):
Factory setting = "Resource ItemNo-SerialNoFF"
3. Set operation mode in MODE_BLK parameter group (TARGET parameter) to OOS (Out_Of_Service).
4. To delete a possibly existing function block application, write RESTART parameter with "Defaults (3)". Trend, link and alert objects will be deleted, function blocks will be reset to their default values. Device address and tags will be retained (for further details on the RESTART parameter, refer to appendix).

5. Verify and adapt settings of NAMUR recommendation NE 107 Field Diagnostics, if required. The following parameters may be used for configuration of the indications.

Field Diagnostics parameters	Factory setting
FD_FAIL_ACTIVE	-
FD_OFFSPEC_ACTIVE	-
FD_MAINT_ACTIVE	-
FD_CHECK_ACTIVE	-
FD_FAIL_MAP	0xFFC2 0001
FD_OFFSPEC_MAP	0x003D F901
FD_MAINT_MAP	0x0000 0401
FD_CHECK_MAP	0x0000 02FF
FD_FAIL_MASK	0
FD_OFFSPEC_MASK	0
FD_MAINT_MASK	0
FD_CHECK_MASK	0
FD_FAIL_ALM	Uninitialized
FD_OFFSPEC_ALM	Uninitialized
FD_MAINT_ALM	Uninitialized
FD_CHECK_ALM	Uninitialized
FD_FAIL_PRI	0
FD_OFFSPEC_PRI	0
FD_MAINT_PRI	0
FD_CHECK_PRI	0
FD_SIMULATE	0/0/Disable
FD_RECOMMEND_ACT	Not Initialized
FD_EXTENDED_ACTIVE_1	-
FD_EXTENDED_ACTIVE_2	-
FD_EXTENDED_ACTIVE_3	-
FD_EXTENDED_ACTIVE_4	-
FD_EXTENDED_ACTIVE_5	-
FD_EXTENDED_MAP_1	0x0000 1FFB
FD_EXTENDED_MAP_2	0x0000 0100
FD_EXTENDED_MAP_3	0xC000 0003
FD_EXTENDED_MAP_4	0x0000 0080
FD_EXTENDED_MAP_5	0x0000 0000

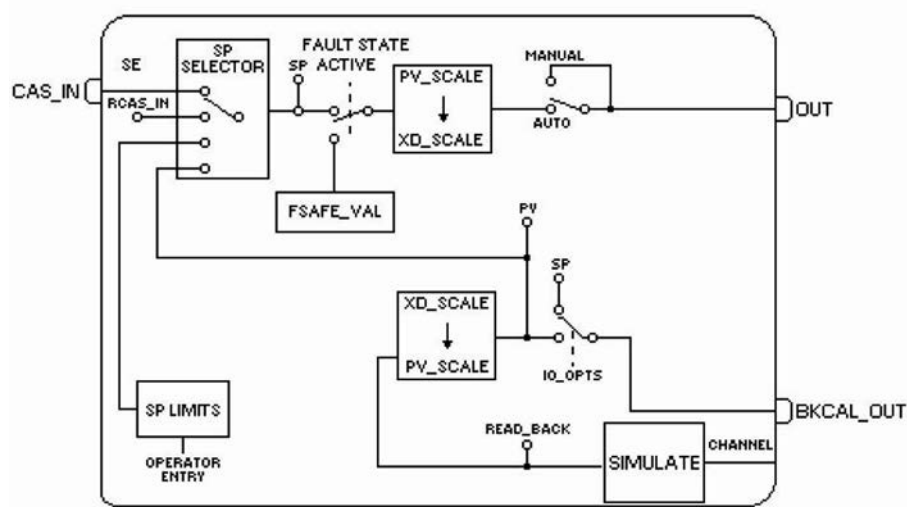
6. Set operation mode in MODE_BLK parameter group (TARGET parameter) to AUTO. Since the Resource Block contains the general operation mode of a Foundation Fieldbus device, the MODE_BLK parameter must be set to AUTO to allow commissioning of one of the other actuator controls' function blocks during operation.

Analog Output function block (AO)

The AO receives an analogue signal from an upstream block and passes it on either as setpoint operation command to the Positioner Transducer Block (PTB) or as general analogue signal to the Analog Output Transducer Block (AOTB). The main functions of the AO function block comprise:

- Scaling
- Value limiters – for both the value and change rate
- Simulation
- Actions upon deviations of upstream blocks

Figure 13: Analog Output function block



The AO performs bi-directional signal processing:

Main function:

Transmission of an analogue value from CAS_IN input via OUT output to PTB or AOTB (forward direction, controlled via CHANNEL parameter).

Secondary function:

Feedback to the upstream function block via BKCAL_OUT output (backward direction). The contents of this feedback signal depend on the channel selected (CHANNEL parameter) and the Use PV for BKCAL_OUT option of the IO_OPTS parameter.

Commissioning:

1. Enter or change block name (if required):
Factor setting = "AO_x ItemNo-SerialNoFF"
2. Set operation mode in MODE_BLK parameter group (TARGET parameter) to OOS (Out_Of_Service).
3. Set CHANNEL parameter according to desired use.
Refer to "CHANNEL parameter settings for Analog Output function block (AO)" table at the end of this section.
4. It is recommended to activate the following options for the IO_OPTS parameter:
 - SP-PV Track in Man
 - SP-PV Track in LO
 - SP Track retained target (SP tracks RCas or Cas if LO or Man)
 - and, if applicable, when using the PTB: Use PV for BKCAL_OUT

Refer to appendix: IO_OPTS, availability and description

Information: A torque fault causes the AO to enter IMan operation mode. To eliminate this torque fault by issuing an AO counter command, 'SP Track retained target' must be set; Otherwise, the actuator may only be operated into the opposite position using the operation commands of the local controls. If the current torque is lower than the preset tripping torque, the torque fault can be reset as follows:

- Either on the local controls using push button Reset (in selector switch position LOCAL).
 - Or via FF using a DO with CHANNEL = Ch DOTB fieldbus RESET.
5. The following option of the SHED_OPT parameter should be activated:
 - NormalShed_NormalReturn
 6. Further AO parameters can now be configured or changed (if required).
 7. Set operation mode in MODE_BLK parameter group (TARGET parameter) to CASCADE.

8. Check/ perform configuration of the respective transducer blocks (refer to section Positioner Transducer Block (PTB) or Analog Output Transducer Block (AOTB)).

Information 'Ch PTB setpoint position' channel can only be selected once and excludes the use of 'Ch PTB operation commands [8 bit]' as well as 'Ch DOTB fieldbus OPEN', 'Ch DOTB fieldbus CLOSE' and 'Ch DOTB fieldbus STOP' channels of the DO.

Table 3: CHANNEL parameter settings for Analog Output function block (AO)

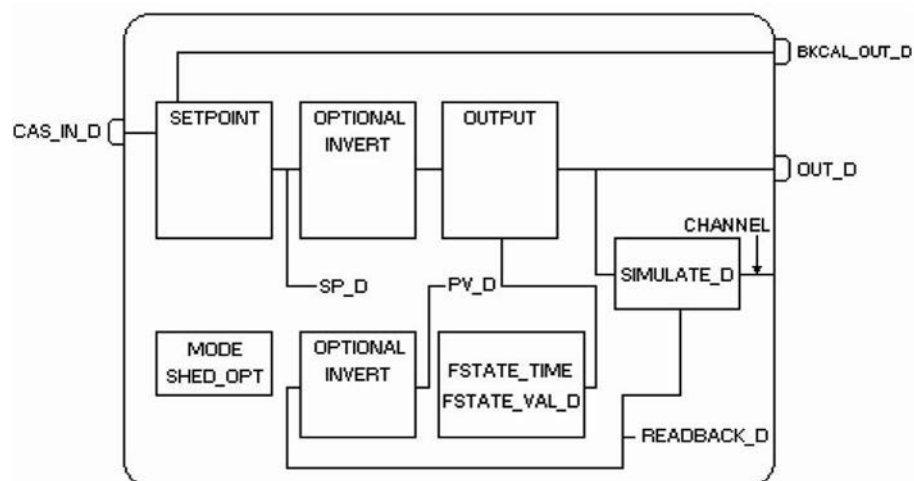
CHANNEL parameter	Value	Used Transducer Block	Explanation	AO.READBACK parameter
Ch not used	0	-	Not used (factory setting)	
Ch PTB setpoint position	1	PTB	Fieldbus setpoint position	Value and status: PTB.PRIMARY_VALUE_ACTUAL_POSITION
Ch PTB speed	3	PTB	Reserved for future extensions	Value and status: PTB.FINAL_VALUE_TARGET_SPEED
Ch AOTB Analog_Out 1	20	AOTB	Analog_Out 1 (Verify/perform further settings in AOTB parameter CFG_AOUT_1)	Value and status: AOTB.FINAL_VALUE_ANALOG_OUT_1
Ch AOTB Analog_Out 2	21	AOTB	Analog_Out 2 (Verify/perform further settings in AOTB parameter CFG_AOUT_2)	Value and status: AOTB.FINAL_VALUE_ANALOG_OUT_2

Discrete Output function block (DO)

The DO receives a binary signal from an upstream block and passes it on either as operation command to the Positioner Transducer Block (PTB) or as general binary control signal to the Discrete Output Transducer Block (DOTB). The main functions of the DO function block comprise:

- Simulation
- Actions upon deviations of upstream blocks
- Signal inversion
- Feedback signal via backward path (BKCAL_OUT_D)

Figure 14: Discrete Output function block (DO)



The DO also performs bi-directional signal processing:

Main function:

Transmission of a binary value from CAS_IN_D input via OUT_D output to PTB or DOTB (forward direction, controlled via CHANNEL parameter).

Secondary function:

Feedback signal to the upstream function block via BKCAL_OUT_D output (backward direction). The contents of this feedback signal depend on the channel selected (CHANNEL parameter) and the Use PV for BKCAL_OUT option of the IO_OPTS parameter.

Commissioning:

1. Enter or change block name (if required):
Factory setting = "DO_x ItemNo-SerialNoFF"
2. Set operation mode in MODE_BLK parameter group (TARGET parameter) to OOS (Out_Of_Service).
3. Set CHANNEL parameter according to desired use.
Refer to "CHANNEL parameter settings for Discrete Output function block (DO)" table at the end of this section.
Information: Conflicting operation commands or control signals are not permitted. For this reasons operation commands or control signals must not be transmitted several times using several DO function blocks and different channels.
4. It is recommended to activate the following options for the IO_OPTS parameter:
 - SP-PV Track in Man
 - SP-PV Track in LO
 - SP Track retained target (SP tracks RCas or Cas if LO or Man)
 - and, if applicable, when using the PTB: Use PV for BKCAL_OUT
 Refer to appendix: IO_OPTS, availability and description
Information: A torque fault causes the DO to enter IMan operation mode. To eliminate this torque fault by issuing a DO counter command, 'SP Track retained target' must be set; Otherwise, the actuator may only be operated into the opposite position using the operation commands of the local controls.
 If the current torque is lower than the preset tripping torque, the torque fault can be reset as follows:
 - Either on the local controls using push button Reset (in selector switch position LOCAL).
 - Or via FF using a DO with CHANNEL = Ch DOTB fieldbus RESET.
5. The following option of the SHED_OPT parameter should be activated:
 - NormalShed_NormalReturn
6. Further DO parameters can now be configured or changed (if required).
7. Set operation mode in MODE_BLK parameter group (TARGET parameter) to CASCADE.
8. Check/perform configuration of the respective transducer block (refer to section Positioner Transducer Block (PTB) or Discrete Output Transducer Block (DOTB)).

- Information**
- Ch PTB operation commands [8 bit]' channel can only be selected once and excludes the use of 'Ch DOTB fieldbus OPEN', 'Ch DOTB fieldbus CLOSE' and 'Ch DOTB fieldbus STOP' channels. In this case, 'Ch PTB setpoint position' channel of the AO is also excluded.
 - Channels 'Ch DOTB fieldbus OPEN', 'Ch DOTB fieldbus CLOSE' and 'Ch DOTB fieldbus STOP' can be selected once each and exclude the use of the 'Ch PTB operation commands [8 bit]' channel. In this case, 'Ch PTB setpoint position' channel of the AO is also excluded.

Table 4: CHANNEL parameter settings for Discrete Output function block (DO)

CHANNEL parameter	Value	Used Transducer Block	Explanation	DO.READBACK_D parameter
Ch not used	0	-	Not used (factory setting)	
Ch PTB operation commands [8 bit]	2	PTB	Operation commands: Value 0: Fieldbus CLOSE Value 1: Fieldbus OPEN Value 2: Stop Value 3: Stop Values 4 – 7 Reserved Value 8: Fieldbus intermediate position 1 Value 9: Fieldbus intermediate position 2 Value 10: Fieldbus intermediate position 3 Value 11: Fieldbus intermediate position 4 Value 12: Fieldbus intermediate position 5 Value 13: Fieldbus intermediate position 6 Value 14: Fieldbus intermediate position 7 Value 15: Fieldbus intermediate position 8 Values 16 – 255: Reserved	Value: PTB.FINAL_VALUE_COMMANDS Status: PTB.PRIMARY_VALUE_ACTUAL_POSITION
Ch DOTB digital output [8 bit]	4	DOTB	Digital outputs: Bit 0: Fieldbus DOUT 1 Bit 1: Fieldbus DOUT 2 Bit 2: Fieldbus DOUT 3 Bit 3: Fieldbus DOUT 4 Bit 4: Fieldbus DOUT 5 Bit 5: Fieldbus DOUT 6 Bits 6 and 7: Reserved	Value and status: DOTB.FINAL_VALUE_DIGITAL_OUTPUTS
Ch DOTB additional commands [8 bit]	5	DOTB	Additional commands: Bit 0: Fieldbus enable LOCAL Bit 1: Fieldbus Interlock OPEN Bit 2: Fieldbus Interlock CLOSE Bit 3: Reserved Bit 4: Fieldbus channel 1 Bit 5: Fieldbus channel 2 Bit 6: Fieldbus EMCY Bit 7: PVST	Value and status: DOTB.FINAL_VALUE_ADDITIONAL_COMMANDS
Ch DOTB fieldbus OPEN	6	DOTB	Fieldbus OPEN	Value and status: DOTB.FINAL_VALUE_FIELDBUS_OPEN
Ch DOTB fieldbus CLOSE	7	DOTB	Fieldbus CLOSE	Value and status: DOTB.FINAL_VALUE_FIELDBUS_CLOSE
Ch DOTB fieldbus STOP	8	DOTB	Fieldbus STOP	Value and status: DOTB.FINAL_VALUE_FIELDBUS_STOP
Ch DOTB fieldbus EMERGENCY	9	DOTB	Fieldbus EMCY	Value and status: DOTB.FINAL_VALUE_FIELDBUS_EMCY
Ch DOTB fieldbus RESET	10	DOTB	Fieldbus RESET	Value and status: DOTB.FINAL_VALUE_FIELDBUS_RESET
Ch DOTB fieldbus enable OPEN	11	DOTB	Fieldbus Interlock OPEN	Value and status: DOTB.FINAL_VALUE_FIELDBUS_ENABLE_OPEN
Ch DOTB fieldbus enable CLOSE	12	DOTB	Fieldbus Interlock CLOSE	Value and status: DOTB.FINAL_VALUE_FIELDBUS_ENABLE_CLOSE
Ch DOTB fieldbus enable LOCAL	13	DOTB	Fieldbus enable LOCAL	Value and status: DOTB.FINAL_VALUE_FIELDBUS_ENABLE_LOCAL

CHANNEL parameter	Value	Used Transducer Block	Explanation	DO.READBACK_D parameter
Ch DOTB Digital_Out 1	14	DOTB	Digital_Out 1 (Verify/perform further settings in DOTB parameter CFG_DOUT_1)	Value and status: DOTB.FINAL_VALUE_FF_OUT1
Ch DOTB Digital_Out 2	15	DOTB	Digital_Out 2 (Verify/perform further settings in DOTB parameter CFG_DOUT_2)	Value and status: DOTB.FINAL_VALUE_FF_OUT2
Ch DOTB Digital_Out 3	16	DOTB	Digital_Out 3 (Verify/perform further settings in DOTB parameter CFG_DOUT_3)	Value and status: DOTB.FINAL_VALUE_FF_OUT3
Ch DOTB Digital_Out 4	17	DOTB	Digital_Out 4 (Verify/perform further settings in DOTB parameter CFG_DOUT_4)	Value and status: DOTB.FINAL_VALUE_FF_OUT4
Ch DOTB Digital_Out 5	18	DOTB	Digital_Out 5 (Verify/perform further settings in DOTB parameter CFG_DOUT_5)	Value and status: DOTB.FINAL_VALUE_FF_OUT5
Ch DOTB Digital_Out 6	19	DOTB	Digital_Out 6 (Verify/perform further settings in DOTB parameter CFG_DOUT_6)	Value and status: DOTB.FINAL_VALUE_FF_OUT6

Transducer blocks

Transducer blocks decouple standardised FF function blocks from specific input and output functions of an FF field device.

Output Transducer Blocks of the actuator controls, i.e. PTB, AOTB and DOTB, additionally offer the MAN (Manual) operation mode apart from the typical operation modes OSS (Out_Of_Service) and AUTO (Automatic). In the MAN (Manual) operation mode, the user can operate the actuator manually without using possibly activated and connected function blocks.

Furthermore, output transducer blocks are equipped with a backward path for transmission of a value including status to the READBACK or READBACK_D parameters of the upstream function blocks AO or DO.

Positioner Transducer Block (PTB)

Among others, the Positioner Transducer Block (PTB) contains XD_ERROR and XD_ERREXT error variables (for details on the error codes, refer to appendix) as well as the ACTIVE_CHANNEL parameter of the currently used channel (for details, refer to appendix).

Depending on the channel used, different value and status information is sent as feedback to the AO.READBACK or the DO.READBACK_D parameters:

CHANNEL	Value	Explanation	READBACK / READBACK_D parameters
Ch PTB set-point position	1	Analogue set-point position	Value and status AO.READBACK = PTB.PRIMARY_VALUE_ACTUAL_POSITION
Ch PTB set-point position	2	Binary operation commands	Value DO_READBACK_D = PTB.FINAL_VALUE_COMMANDS Status DO_READBACK_D = PTB.PRIMARY_VALUE_ACTUAL_POSITION
Ch PTB speed	3	Reserved for future extensions	Value and status AO_READBACK = PTB.FINAL_VALUE_TARGET_SPEED

Commissioning:

1. Enter or change block name (if required): Factor setting = "Positioner_TB ItemNo-SerialNoFF".
2. Set operation mode in MODE_BLK parameter group (TARGET parameter) to OOS (Out_Of_Service).
Now, the PTB parameters can be configured or changed (if required).
3. Set operation mode in MODE_BLK parameter group (TARGET parameter) to AUTO.

Analog Output Transducer Block (AOTB)

Among others, the Analog Output Transducer Block (AOTB) contains XD_ERROR and XD_ERREXT error variables (for details on the error codes, refer to appendix) and offers additional configuration options for the analogue signals received via the channel of the AO function blocks.

Both value and status of the analogue signal received via the respective channel (FINAL_VALUE_ANALOG_OUT_1 or FINAL_VALUE_ANALOG_OUT_2) are sent as return values to the AO.READBACK parameter.

Commissioning:

1. Enter or change block name (if required): Factory setting = "AnalogOut_TB ItemNo-SerialNoFF".
2. Set operation mode in MODE_BLK parameter group (TARGET parameter) to OOS (Out_Of_Service).
3. Verify or adapt CFG_AOUT_1 or CFG_AOUT_2 parameter settings:

Transducer Block	CFG_AOUT_1 or CFG_AOUT_2 parameters	Value	Explanations
AOTB	Fieldbus setpoint position	0	Fieldbus setpoint position
	Fieldbus speed	1	Reserved for future extensions
	Fieldbus actual process value	2	Fieldbus actual process value (for optional internal PID controller function)
	Fieldbus output AOUT 1	3	Fieldbus output AOUT 1
	Fieldbus output AOUT 2	4	Fieldbus output AOUT 2
	Analog_Out 1 (Cfg)	11	Configurable analogue output 1 (for future extensions)
	Analog_Out 2 (Cfg)	12	Configurable analogue output 2 (for future extensions)

Factory settings:

CFG_AOUT_1 = Fieldbus output AOUT 1

CFG_AOUT_2 = Fieldbus output AOUT 2

4. Set operation mode in MODE_BLK parameter group (TARGET parameter) to AUTO.

Discrete Output Transducer Block (DOTB)

Among others, the Discrete Output Transducer Block (DOTB) contains XD_ERROR and XD_ERREXT error variables (for details on the error codes, refer to appendix) and offers additional configuration options for the binary signals received via the channels of the DO blocks.

Both value and status of the binary signals received via the respective channel are sent as return values to the DO.READBACK_D parameter.

Commissioning:

1. Enter or change block name (if required): Factory setting = "DiscreteOut_TB ItemNo-SerialNoFF".
2. Set operation mode in MODE_BLK parameter group (TARGET parameter) to OOS (Out_Of_Service).

3. Verify or adapt CFG_DOUT_1 to CFG_DOUT_6 parameter settings:

Table 5: Parameter Transducer Block

Transducer Block	CFG_DOUT_1 to CFG_DOUT_6 parameters	Value	Explanations
DOTB	Not used	0	Not used
	Fieldbus SETPOINT	1	Run to setpoint; in this case, the setpoint must be transmitted via an AO with channel = Ch AOTB Analog Out 1 or Ch AOTB Analog Out 2.
	Fieldbus channel 1	2	Change over to fieldbus channel 1
	Fieldbus channel 2	3	Change over to fieldbus channel 2
	Fieldbus PVST	4	Execute (PVST) Partial Valve Stroke Test
	Fieldbus intermediate position 1	5	Operation command: Run to intermediate position 1.
	Fieldbus intermediate position 2	6	Operation command: Run to intermediate position 2.
	Fieldbus intermediate position 3	7	Operation command: Run to intermediate position 3.
	Fieldbus intermediate position 4	8	Operation command: Run to intermediate position 4.
	Fieldbus intermediate position 5	9	Operation command: Run to intermediate position 5.
	Fieldbus intermediate position 6	10	Operation command: Run to intermediate position 6.
	Fieldbus intermediate position 7	11	Operation command: Run to intermediate position 7.
	Fieldbus intermediate position 8	12	Operation command: Run to intermediate position 8.
	Fieldbus DOUT 1	13	Activate digital output 1
	Fieldbus DOUT 2	14	Activate digital output 2
	Fieldbus DOUT 3	15	Activate digital output 3
	Fieldbus DOUT 4	16	Activate digital output 4
	Fieldbus DOUT 5	17	Activate digital output 5
	Fieldbus DOUT 6	18	Activate digital output 6
	Digital_Out 1 (Cfg)	19	Configurable digital output 1 (for future extensions)
	Digital_Out 2 (Cfg)	20	Configurable digital output 2 (for future extensions)
	Digital_Out 3 (Cfg)	21	Configurable digital output 3 (for future extensions)
	Digital_Out 4 (Cfg)	22	Configurable digital output 4 (for future extensions)
	Digital_Out 5 (Cfg)	23	Configurable digital output 5 (for future extensions)
	Digital_Out 6 (Cfg)	24	Configurable digital output 6 (for future extensions)

Factory settings:

CFG_DOUT_1 = Not used	CFG_DOUT_4 = Not used
CFG_DOUT_2 = Not used	CFG_DOUT_5 = Not used
CFG_DOUT_3 = Not used	CFG_DOUT_6 = Not used

4. Set operation mode in MODE_BLK parameter group (TARGET parameter) to AUTO.

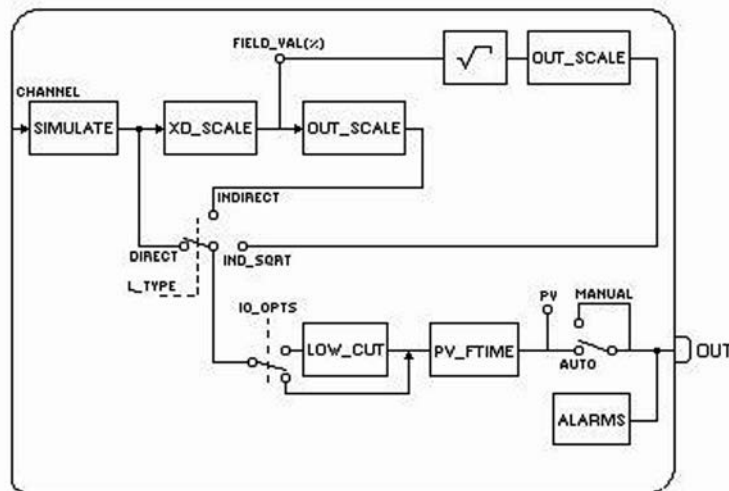
Analog Input function block (AI)

An AI receives an analogue signal from a transducer block of the field devices and makes the signal available to the other FF field devices as FF signal. The main functions of the AI function block comprise:

- Signal inversion
- Simulation

- Signal testing and alarm generation
- Scaling

Figure 15: Analog Input function block (AI)



All in all, actuator controls have four Analog Input function blocks (AI). Depending on the configuration (CHANNEL parameter), they may provide different feedback signals at the OUT output.

Commissioning:

1. Enter or change block name (if required): Factory setting = "AI_x ItemNo-SerialNoFF"
2. Set operation mode in MODE_BLK parameter group (TARGET parameter) to OOS (Out_Of_Service).
3. Set CHANNEL parameter according to desired use.
Refer to "CHANNEL parameter settings for Analog Input function block (AI)" table at the end of this section.
4. Use L_TYPE parameter to select the linearisation type for the input value (Direct, Indirect, Indirect Sq Root), recommendation: Direct
Information: For 'Direct' linearisation type, the configuration of the OUT_SCALE parameter group must correspond the configuration of the XD_SCALE parameter group; otherwise, the block operation mode cannot be set to AUTO. Incorrect configuration is indicated via the BLOCK_ERROR parameter ('Block Configuration Error').
5. If required, the following parameters can be used to define limit values for alarm and warning signals as well as the priorities of these signals (the limit values must be within the value range specified in the OUT_SCALE parameter group):
 - HI_HI_LIM
 - HI_LIM
 - LO_LIM
 - LO_LO_LIM
 - HI_HI_PRI
 - HI_PRI
 - LO_PRI
 - LO_LO_PRI
6. Set operation mode in MODE_BLK parameter group (TARGET parameter) to AUTO.
7. Set operation mode in MODE_BLK parameter group (TARGET parameter) to AUTO.

Table 6: CHANNEL parameter settings for Analog Input function block (AI)

CHANNEL	Value	Used Transducer Block	Explanation
Ch not used	0	–	Not used (factory setting)
Ch AITB Analog_In 1	67	AITB	Analog_In 1 (Verify/perform further settings in AITB paramet- er CFG_AIN_1, factory set- ting of CFG_AIN_1: Actual posi- tion of the actuator)
Ch AITB Analog_In 2	68	AITB	Analog_In 2 (Verify/perform further settings in AITB paramet- er CFG_AIN_2, factory set- ting of CFG_AIN_2: Input AIN 1)
Ch AITB Analog_In 3	69	AITB	Analog_In 3 (Verify/perform further settings in AITB paramet- er CFG_AIN_3, factory set- ting of CFG_AIN_3: actuator torque)
Ch AITB Analog_In 4	70	AITB	Analog_In 4 (Verify/perform further settings in AITB paramet- er CFG_AIN_4, factory set- ting of CFG_AIN_4: Input AIN 2)

Analog Input Transducer Block (AITB)

Apart from the analogue values of the actual position, the torques and the two optional inputs, the Analog Input Transducer Block (AITB) contains among others the XD_ERROR and XD_ERREXT error variables (for details on the error codes, refer to the appendix) and provides additional configuration options for the analogue signals to be transmitted to the AI function blocks via the channels.

Commissioning:

1. Enter or change block name (if required): Factory setting = "AnalogIn_TB ItemNo-SerialNoFF".
2. Set operation mode in MODE_BLK parameter group (TARGET parameter) to OOS (Out_Of_Service).

3. Verify or adapt CFG_AIN_1 to CFG_AIN_4 parameter setting:

CFG_AIN_1 to CFG_AIN_4 parameters	Value	Explanations
Actual position	0	Actual actuator position (0.0 – 100.0%)
Analogue input 1	1	Input AIN 1 (optional external analogue 0 – 20 mA input, connection terminals AIN1+/AIN1–)
Torque	2	Actuator torque (0.0 – 100.0 %; value 0.0 % corresponds to 127 % of the nominal torque in direction CLOSE, 100.0 % corresponds to 127 % of the nominal torque in direction OPEN)
Analogue input 2	3	Input AIN 2 (optional external analogue 0 – 20 mA input, connection terminals AIN2+/AIN2–)
Analog_In 1 (Cfg)	4	Configurable analogue input 1 (for future extensions)
Analog_In 2 (Cfg)	5	Configurable analogue input 2 (for future extensions)
Analog_In 3 (Cfg)	6	Configurable analogue input 3 (for future extensions)
Analog_In 4 (Cfg)	7	Configurable analogue input 4 (for future extensions)

Factory settings:

CFG_AIN_1 = Actual position

CFG_AIN_2 = Analogue input 1

CFG_AIN_3 = Torque

CFG_AIN_4 = Analogue input 2

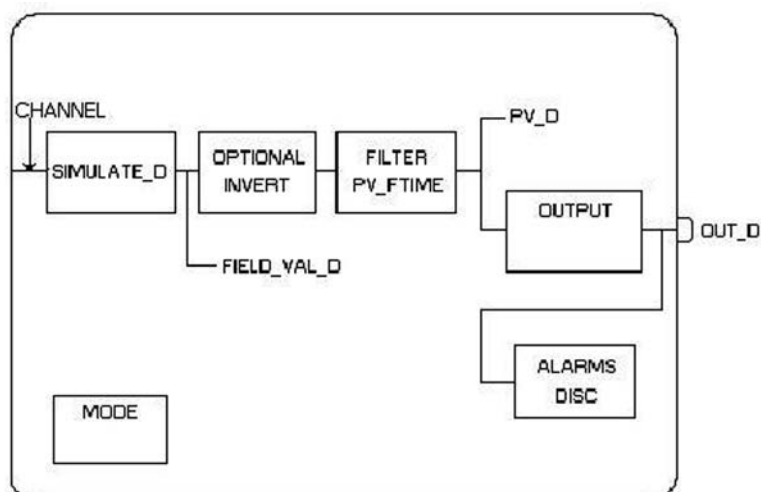
4. Set operation mode in MODE_BLK parameter group (TARGET parameter) to AUTO.

Discrete Input function block (DI)

A DI receives a binary signal from a transducer block of the field devices and makes the signal available to the other FF field devices as FF signal. The main functions of the DI function block comprise:

- Signal inversion
- Simulation
- Filtering (time delay)
- Generation of alarms

Figure 16: Discrete Input function block (DI)



Actuator controls are equipped all in all with ten Discrete Input function blocks (DI). Depending on the configuration (CHANNEL parameter), different binary feedback signals in single-bit or 8-bit format can be provided at output OUT_D.

Commissioning:

1. Enter or change block name (if required): Factory setting = "DI_x ItemNo-SerialNoFF"

2. Set operation mode in MODE_BLK parameter group (TARGET parameter) to OOS (Out_Of_Service).
3. Set CHANNEL parameter according to desired use.
Refer to table "CHANNEL parameter settings for Discrete Input function block (DI)" at the end of this section.
4. Set operation mode in MODE_BLK parameter group (TARGET parameter) to AUTO.
5. Verify or adapt configuration of the pertaining Discrete Input Transducer Block (refer to section below).

Table 7: CHANNEL parameter settings for Discrete Input function block (DI)

CHANNEL parameter	Value	Used Transducer Block	Explanation
Ch not used	0	-	Not used (factory setting)
Ch DITB logic signals [8 bit]	22	DITB	Logical signals Bit 0: End position OPEN Bit 1: End position CLOSED Bit 2: Setpoint position reached Bit 3: Not ready REMOTE Bit 4: Running OPEN Bit 5: Running CLOSE Bit 6: Warnings Bit 7: Fault
Ch DITB actuator signals [8 bit]	23	DITB	Actuator signals Bit 0: Thermal fault Bit 1: Phase failure Bit 2: Selector sw. REMOTE Bit 3: Selector sw. LOCAL Bit 4: Limit switch OPEN Bit 5: Limit switch CLOSED Bit 6: Torque switch OPEN Bit 7: Torque switch CLOSE
Ch DITB device status [8 bit]	24	DITB	Device status Bit 0: Not ready REMOTE Bit 1: Warnings Bit 2: Fault Bit 3: Maintenance required Bit 4: Out of specification Bit 5: Function check Bit 6: Failure Bit 7: Device ok
Ch DITB operation status [8 bit]	25	DITB	Operation status Bit 0: Op. pause active Bit 1: In intermed. position Bit 2: Start stepping mode Bit 3: MPV position reached Bit 4: Actuator running Bit 5: Handwheel oper. Bit 6: Running REMOTE Bit 7: Running LOCAL

Ch DITB intermediate positions [8 bit]	26	DITB	Intermediate positions
			Bit 0: Intermediate pos. 1
			Bit 1: Intermediate pos. 2
			Bit 2: Intermediate pos. 3
			Bit 3: Intermediate pos. 4
			Bit 4: Intermediate pos. 5
			Bit 5: Intermediate pos. 6
			Bit 6: Intermediate pos. 7
			Bit 7: Intermediate pos. 8
Ch DITB discrete inputs [8 bit]	27	DITB	Discrete inputs
			Bit 0: Input DIN 1
			Bit 1: Input DIN 2
			Bit 2: Input DIN 3
			Bit 3: Input DIN 4
			Bit 4: Input DIN 5
			Bit 5: Input DIN 6
			Bits 6, 7: -
Ch DITB not ready REMOTE 1 [8 bit]	28	DITB	Not ready REMOTE 1
			Bit 0: Wrong oper. cmd
			Bit 1: Sel. sw. not REMOTE
			Bit 2: Interlock active
			Bit 3: Local STOP
			Bit 4: EMCY STOP act.
			Bit 5: EMCY behav. active
			Bit 6: FailState fieldbus
Ch DITB not ready REMOTE 2 [8 bit]	29	DITB	Not ready REMOTE 2
			Bit 0.1: -
			Bit 2: SIL function active
			Bit 3: Disabled
			Bit 4: Interlock by-pass
			Bit 5: PVST active
			Bit 6: Service active
			Bit 7: Handwheel active
Ch DITB fault 1 [8 bit]	30	DITB	Fault 1
			Bit 0: Configuration error
			Bit 1: Mains quality
			Bit 2: Thermal fault
			Bit 3: Phase failure
			Bit 4: Torque fault OPEN
			Bit 5: Torque fault CLOSE
			Bit 6: Internal error
Ch DITB fault 2 [8 bit]	31	DITB	Bit 7: No reaction
			Fault 2
			Bit 0-5: -
			Bit 6: Config. error REMOTE
			Bit 7: Incorrect phase seq

Ch DITB warnings 1 [8 bit]	32	DITB	Warnings 1
			Bit 0-3: -
			Bit 4: Torque wrn CLOSE
			Bit 5: Torque wrn OPEN
			Bit 6: SIL fault
			Bit 7: Wrn no reaction
Ch DITB warnings 2 [8 bit]	33	DITB	Warnings 2
			Bit 0: Wrn controls temp.
			Bit 1.2: -
			Bit 3: 24 VDC external
			Bit 4: -
			Bit 5: RTC button cell
Ch DITB warnings 3 [8 bit]	34	DITB	Warnings 3
			Bit 0.1: -
			Bit 2: Warning input AIN 2
			Bit 3: Warning input AIN 1
			Bit 4: Internal warning
			Bit 5: Wrn on time starts
Ch DITB warnings 4 [8 bit]	35	DITB	Warnings 4
			Bit 0.1: -
			Bit 2: Wrn setpoint position
			Bit 3: PVST required
			Bit 4: -
			Bit 5: Failure behav. active
Ch DITB failure [8 bit]	36	DITB	Failure
			Bits 0 – 6: -
			Bit 7: Fault
Ch DITB maintenance required [8 bit]	37	DITB	Maintenance required
			Bits 0 – 6: -
			Bit 7: Maintenance required
Ch DITB out of specification 1 [8 bit]	38	DITB	Out of specification 1
			Bits 0 – 6: -
			Bit 7: Warnings
Ch DITB out of specification 2 [8 bit]	39	DITB	Out of specification 2
			Bit 0-7: -
Ch DITB out of specification 3 [8 bit]	40	DITB	Out of specification 3
			Bit 0-7: -
Ch DITB out of specification 4 [8 bit]	41	DITB	Out of specification 4
			Bit 0-7: -

Ch DITB function check 1 [8 bit]	42	DITB	Function check 1
			Bit 0: Local STOP
			Bit 1: Sel. sw. not REMOTE
			Bit 2: Service active
			Bit 3: Handwheel active
			Bit 4: EMCY STOP act.
			Bit 5: PVST active
			Bits 6 – 7: -
Ch DITB function check 2 [8 bit]	43	DITB	Function check 2
			Bit 0-7: -
Ch DITB fieldbus status [8 bit]	44	DITB	Status fieldbus
			Bit 0: Channel 1 active
			Bit 1: Channel 2 active
			Bit 2: Channel 1 DataEx
			Bit 3: Channel 2 DataEx
			Bit 4: Ch. 1 FailState Fieldb.
			Bit 5: Ch. 2 FailState Fieldb.
			Bit 6: Channel 1 activity
			Bit 7: Channel 2 activity
Ch DITB end position OPEN	45	DITB	End position OPEN
Ch DITB end position CLOSED	46	DITB	End position CLOSED
Ch DITB setpoint position reached	47	DITB	Setpoint position reached
Ch DITB not ready RE- MOTE	48	DITB	Not ready REMOTE
Ch DITB running OPEN	49	DITB	Running OPEN
Ch DITB running CLOSE	50	DITB	Running CLOSE
Ch DITB warnings	51	DITB	Warnings
Ch DITB fault	52	DITB	Fault
Ch DITB thermal fault	53	DITB	Thermal fault
Ch DITB phase fault	54	DITB	Phase failure
Ch DITB selector switch REMOTE	55	DITB	Selector sw. REMOTE
Ch DITB selector switch LOCAL	56	DITB	Selector sw. LOCAL
Ch DITB limit switch OPEN	57	DITB	Limit switch OPEN
Ch DITB limit switch CLOSED	58	DITB	Limit switch CLOSED
Ch DITB torque switch OPEN	59	DITB	Torque switch OPEN
Ch DITB torque switch CLOSED	60	DITB	Torque switch CLOSE
Ch DITB Digital In 1	61	DITB	Input DIN 1
Ch DITB Digital In 2	62	DITB	Input DIN 2
Ch DITB Digital In 3	63	DITB	Input DIN 3
Ch DITB Digital In 4	64	DITB	Input DIN 4
Ch DITB Digital In 5	65	DITB	Input DIN 5
Ch DITB Digital In 6	66	DITB	Input DIN 6

Ch DITB SIL status [8 bit]	71	DITB	SIL status
			Bit 0: Safe ESD
			Bit 1: Safe STOP
			Bit 2: SIL fault
			Bit 3: SIL function active
			Bit 4 – 7: –

Discrete Input Transducer Block (DITB)

Apart from the binary signals, the Discrete Input Transducer Block (DITB) contains among others the XD_ERROR and XD_ERREXT error variables (for details on the error code, refer to the appendix) and provides additional configuration options for the binary signals to be transmitted to the DI function blocks via the channels.

Commissioning:

1. Enter or change block name (if required): Factory setting = “DiscreteIn_TB ItemNo-SerialNoFF”.
2. Set operation mode in MODE_BLK parameter group (TARGET parameter) to OOS (Out_Of_Service).

3. Verify or adapt CFG_IN_1 to CFG_IN_6 parameter setting:

Parameters CFG_IN_1 to CFG_IN_6	Value	Explanations
Not used	0	-
Maintenance required	1	Maintenance required
Out of specification	2	Out of specification
Function check	3	Function check
Failure	4	Failure
Device ok	5	Device ok
Operation pause active	6	Op. pause active
In intermediate position	7	In intermed. position
Start stepping mode	8	Start stepping mode
Actuator running	9	Actuator running
Handwheel operation	10	Handwheel oper.
Running REMOTE	11	Running REMOTE
Running LOCAL	12	Running LOCAL
Intermediate position 1	13	Intermediate pos. 1
Intermediate position 2	14	Intermediate pos. 2
Intermediate position 3	15	Intermediate pos. 3
Intermediate position 4	16	Intermediate pos. 4
Intermediate position 5	17	Intermediate pos. 5
Intermediate position 6	18	Intermediate pos. 6
Intermediate position 7	19	Intermediate pos. 7
Intermediate position 8	20	Intermediate pos. 8
Input DIN 1	21	Input DIN 1
Input DIN 2	22	Input DIN 2
Input DIN 3	23	Input DIN 3
Input DIN 4	24	Input DIN 4
Input DIN 5	25	Input DIN 5
Input DIN 6	26	Input DIN 6
Wrong operation command	27	Wrong oper. cmd
Selector switch not REMOTE	28	Sel. sw. not REMOTE
Interlock active	29	Interlock active
Local STOP	30	Lokaler STOP
EMERGENCY stop active	31	EMCY STOP act.
EMERGENCY behaviour active	32	EMCY behav. active
FailState fieldbus	33	FailState fieldbus
I/O interface	34	I/O interface
SIL function active	35	SIL function active
Operation mode Disabled	36	Disabled
Interlock by-pass active	37	Interlock by-pass
PVST active	38	PVST active
Service active	39	Service active
Handwheel active	40	Handwheel active
Configuration error	41	Configuration error
Mains quality	42	Mains quality
Thermal fault	43	Thermal fault
Phase fault	44	Phase failure

Parameters CFG_IN_1 to CFG_IN_6	Value	Explanations
Torque fault OPEN	45	Torque fault OPEN
Torque fault CLOSE	46	Torque fault CLOSE
Internal fault	47	Internal error
No reaction	48	No reaction
Configuration error REMOTE	49	Config. error REMOTE
Incorrect phase sequence	50	Incorrect phase seq
Warning controls temperature	51	Wrn controls temp.
Warning gearbox temperature	52	-
Warning motor temperature	53	-
24 V DC external	54	24 VDC external
RTC button cell	55	RTC button cell
Warning RTC not set	56	RTC not set
Configuration warning	57	Config. warning
Warning input AIN 1	58	Warning input AIN 1
Warning input AIN 2	59	Warning input AIN 2
Internal warning	60	Internal warning
Warning on time starts	61	Wrn on time starts
Warning on time running	62	Wrn on time running
Operation time warning	63	Op. time warning
Warning setpoint position	64	Wrn setpoint position
Failure behaviour active	65	Failure behav. active
PVST abort	66	PVST abort
PVST fault	67	PVST fault
Fault	68	Fault
Warnings	69	Warnings
Channel 1 active	70	Channel 1 active
Channel 2 active	71	Channel 2 active
Channel 1 DataEx	72	Channel 1 DataEx
Channel 2 DataEx	73	Channel 2 DataEx
Channel 1 FailState fieldbus	74	Ch. 1 FailState Fieldb.
Channel 2 FailStae fieldbus	75	Ch. 2 FailState Fieldb.
Channel 1 activity	76	Channel 1 activity
Channel 2 activity	77	Channel 2 activity
Safe ESD	78	Safe ESD
Safe Stop	79	Safe Stop
SIL fault	80	SIL fault
Digital_In 1 (Cfg)	81	Configurable digital input 1 (for future extensions)
Digital_In 2 (Cfg)	82	Configurable digital input 2 (for future extensions)
Digital_In 3 (Cfg)	83	Configurable digital input 3 (for future extensions)
Digital_In 4 (Cfg)	84	Configurable digital input 4 (for future extensions)
Digital_In 5 (Cfg)	85	Configurable digital input 5 (for future extensions)
Digital_In 6 (Cfg)	86	Configurable digital input 6 (for future extensions)

Factory settings:

CFG_IN_1 = Input DIN 1

CFG_IN_2 = Input DIN 2

CFG_IN_3 = Input DIN 3

CFG_IN_4 = Input DIN 4

CFG_IN_5 = Input DIN 5

CFG_IN_6 = Input DIN 6

4. Set operation mode in MODE_BLK parameter group (TARGET parameter) to AUTO.

PID function block (PID)

The PID function block receives an input signal, performs the PID control computation and issues an output signal. In practice, it performs PID computation based on the deviation between the process setpoint and the actual process value and generates a value at the OUT output to decrease the calculated deviation. The PID block works together with other function blocks, like e.g. the AI and AO blocks.

Main functions of the PID:

- Filtering
- Setpoint limiters – for both the value and change rate
- Scaling Process Variables (PV), setpoint (SP), and output (OUT)
- PID control computations
- Control action bypass
- Feed-forward
- External output tracking
- Measured value tracking
- Output limiters
- Mode change in case of faults and alarm signals

Algorithm The PID block uses an algorithm for PID control; the basic form of the equation is shown below. The process control is possible by taking proportional, integral, and derivative counter-measures in response to characteristic changes of the control process, load changes, and the occurrence of faults.

Figure 17: Basic form of PID algorithm

$$\Delta MV_n = K \left\{ (SP_n - PV_n) + \frac{\Delta T}{Ti} (SP_n - PV_n) + \frac{Td}{\Delta T} [(SP_n - PV_n) - (SP_{n-1} - PV_{n-1})] \right\}$$

MV_n Changes at the control output

PV_n Actual process value (= IN)

SP_n Process setpoint (= CAS_IN)

ΔT Control time (period of execution in the Block Header, PERIOD_OF_EXECUTION parameter)

K Proportional gain (= GAIN)

Ti Reset time (=RESET)

Td Rate time (=RATE)

The output value is calculated based on control output changes: $OUT = BKCAL_IN - MV_n$

PID control parameters The table below shows the PID control parameters:

Parameters	Description	Scope
GAIN	Proportional gain Kp	0.01 to 100
RESET	Reset time Ti	0.1 to 60,000 (seconds)
RATE	Rate time Td	0 to 60,000 (seconds)

In case of an error variable, the P portion (GAIN) immediately (i.e. actively) changes the position value (proportionally to the error variable).

If a small error variable is supposed to already generate a major valve position adjustment, the proportional gain Kp must be set.

The reset time (RESET) determines the I portion of the controller. The more inert a system, the higher this value should be set.

The rate time (RATE) determines the D portion of the controller. Typically, no setting is required here (= 0), since actuator and valve – due to the operating time – cannot react abruptly to a sudden occurrence of an error variable.

Commissioning when using the PID:

1. Enter or change block name (if required):
Factory setting = "PID_1 ItemNo-SerialNoFF"
2. Set operation mode in MODE_BLK parameter group (TARGET parameter) to OOS (Out_Of_Service).
3. Set BYPASS parameter to Off.
4. Now, the PID parameters can be configured or changed, if required.

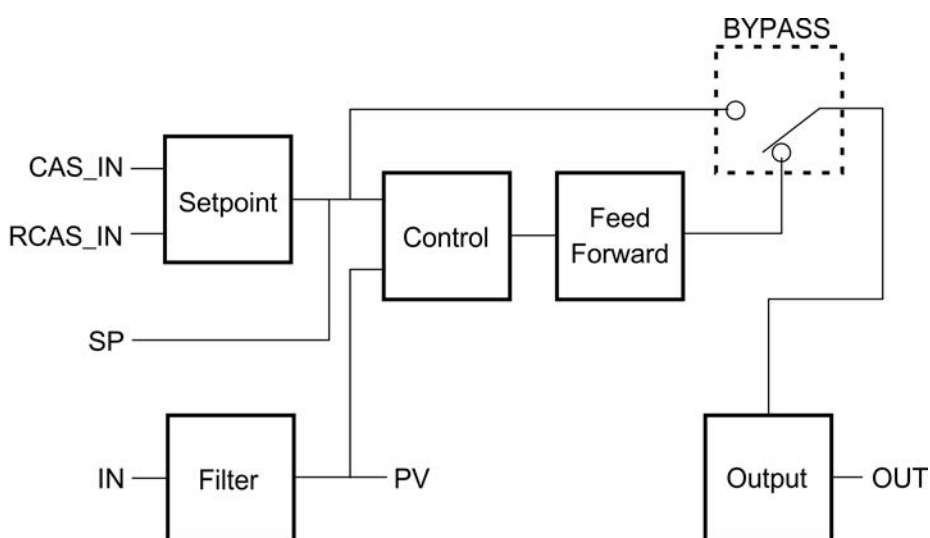
Proceeding for process controller setting

The setting of the process controller largely depends on the area of controller application. A PI controller suffices for most applications.

1. Operate the controller as P controller first, i.e. set the parameters as follows:
 - GAIN (Proportional gain K_p) = 1
 - RESET (Reset time T_i) = 1000 s
 - RATE (Rate time T_d) = 0
2. Double GAIN until the control loop starts to oscillate.
3. Reduce GAIN to 60 % of the set value.
4. Decrease RESET until the error variable equals zero.
5. The direction of the control action can be defined by activating the Direct Acting within the CONTROL_OPTS parameter.

Direct Acting	Description
True	Initial value increases if the input process variable exceeds setpoint SP.
False	Initial value decreases if the input process variable exceeds setpoint SP.

6. If required, bypass PID computation.
Bypass PID computation = activate Bypass_Enable option via CONTROL_OPTS parameter (directly connect SP to output OUT).
Activate PID computation = deactivate Bypass_Enable.



7. Further settings can be performed using the CONTROL_OPTS and the STATUS_OPTS parameters.
8. The option 'NormalShed_NormalReturn' should be activated in the SHED_OPT parameter.

9. Set operation mode in the MODE_BLK parameter group (TARGET parameter) to CASCADE (e.g. for by-passed PID calculation to AUTO).

4. Corrective action

4.1. Troubleshooting

In case of problems with fieldbus communication, AUMATIC provides important information on troubleshooting via the display (menu **DiagnosticsM0022**).

5. Technical data

Information The following tables include standard and optional features. For detailed information on the customer-specific version, refer to the order-related data sheet. The technical data sheet can be downloaded from the Internet in both German and English at <http://www.auma.com> (please state the order number).

5.1. Foundation Fieldbus interface

Settings/programming the Foundation Fieldbus interface

Setting the fieldbus address	The address is set via Foundation Fieldbus while using the provided system management services and a configuration software for Foundation Fieldbus (e.g. NI-FBUS).
Configurable feedback signals	The feedback signals of the "Analog Input" (AI) and "Discrete Input" (DI) function blocks may be configured according to the requirements using channels and the appropriate transducer blocks. Configuration is made via Foundation Fieldbus while using the device description and a configuration software for Foundation Fieldbus (e.g. NI-FBUS).
Programming of user functions	User functions (e.g. stepping mode, intermediate positions, ...) may either be programmed via display or via Foundation Fieldbus using the device description and a configuration software for Foundation Fieldbus (e.g. NI-FBUS).

General data of the Foundation Fieldbus interface

Communication protocol	Foundation Fieldbus H1 (31.25 kbit/s) in accordance with IEC 61158 and IEC 61784-1
Physical Layer	Separate supply, standard data transmission
Network topology	Line, star and tree structures (trunks combined with spurs) are supported. Internal drop line length of the actuator controls is 0.27 m.
Transmission medium	Two-wire copper cable with data transmission and voltage supply on the same wire pair in accordance with: - ISA S50.02-1992 ISA Physical Layer Standard or - IEC 61158-2:2000 (ed. 2.0), Fieldbus standard for use in industrial control systems, Part 2: Physical Layer specification and service definition Recommendation: Use cable type A (screened and twisted)
Current consumption	approx. 13 mA at +24 V DC
Transmission rate	31.25 kbit/s
Cable length	Max. 1,900 m (only when using the recommended A type cable); with repeaters (4 units max.) expandable up to a max. of 9.5 km
Number of devices	- Max. 32 devices per segment; altogether max. 240 devices can be addressed. - Typical number of devices: approx. 6 – 15 devices per segment
Communication services	- Publisher/subscriber communication for the transmission of process data - Client/server communication for programming and configuration - Report Distribution for transmission of alarm signals
Supported Foundation Fieldbus functions	Actuator controls are a Link Master device. Link Master devices can take over the Link Active Scheduler (LAS) function for bus communication coordination.
Permissive connection	Actuator controls offer an automatic polarity detection and correction of the Foundation Fieldbus cable polarity.

Function blocks of Foundation Fieldbus interface

Function blocks For output signals	8 Discrete Output (DO) function blocks for discrete output signals, e.g.: - OPEN, STOP, CLOSE - RESET - EMERGENCY - Interlock OPEN/CLOSE - Enable Local - Intermediate positions - Digital customer outputs 2 Analog Output (AO) function blocks for analogue output signals, e.g.: - Setpoint position - Analogue customer outputs
Function blocks For input signals	10 Discrete Input (DI) function blocks for discrete feedback signals, e.g.: - End positions OPEN/CLOSED - Selector switch in position LOCAL/REMOTE - Running indication (directional) - Torque switch OPEN, CLOSED - Limit switch OPEN, CLOSED - Manual operation by handwheel or via local controls - Intermediate positions - Digital customer inputs 4 Analog Input (AI) function blocks for analogue output signals, e.g.: - Actual position - Torque - Analogue 0 – 20 mA customer inputs
Further function blocks	1 Signal Characterizer function block (SC) for conversion of analogue signals 1 Input Selector (IS) function block for the selection of analogue input signals 1 Process controller (PID) block as function block for modulating applications - Resource Block (RB) for definition of characteristic Foundation Fieldbus device data 4 Transducer Blocks (AOTB, DOTB, AITB, DITB) as connection blocks of discrete and analogue input and output signals 1 Transducer Block (PTB) as connection block for control 1 Transducer Block (AUMACTB) for configuration and programming 1 Transducer Block (AUMADTB) for monitoring and diagnostics

Special features of the AUMATIC Foundation Fieldbus interface

Manufacturer ID	0x0A01FF
Device type	0x0001
Device revision	0x01 or 0x02
Device ID	0A01FF0001-(AC 01.2-xACExC 01.2-x serial number)-(FF module serial number)
Baud rate	31.25 kbit/s
Polarity	No polarity (automatic polarity detection and correction)
Segment information	
Standard	FF H1
Link master (LAS) function	Yes
Current consumption	13 mA
FF supply current	< 20 mA
Device voltage min/max	9 – 32 V DC
FISCO ic characteristics	FF capacity: $C_i < 5 \text{ nF}$, FF inductivity: $L_i < 10 \text{ } \mu\text{H}$, Minimum input current: $I_i = 380 \text{ mA}$, Minimum input voltage: $U_i = 17.5 \text{ V}$, Minimum input power: $P_i = 5.32 \text{ W}$
Jitter tolerance range	< $\pm 8 \text{ } \mu\text{s}$
Min. transmission level (V_p -t-p)	> 0.75 V
Available server VCRs	23
Available source VCRs	23

Special features of the AUMATIC Foundation Fieldbus interface

Available publisher VCRs	23
Available subscriber VCRs	23
DD revision	0x01
CFF revision	020101
ITK revision	6.1.2

Available channels

Analog Output (AO) function blocks	0, 1, 3, 20, 21
Discrete Output (DO) function blocks	0, 2, 4 – 19
Analog Input (AI) function blocks	0, 67, 68, 69, 70
Discrete Input (DI) function blocks	0, 22 – 66, 71

Number of function blocks with their respective execution times [ms]

8 Discrete Output (DO) function blocks	30 ms
2 Analog Output (AO) function blocks	30 ms
10 Discrete Input (DI) function blocks	20 ms
4 Analog Input (AI) function blocks	30 ms
1 Signal Characterizer (SC) function block	40 ms
1 Input Selector (IS) function block	30 ms
1 Proportional/Integral/Differential (PID) function block	40 ms

6. Appendix

6.1. Status signals of the transducer blocks including XD_ERROR und XD_ERREXT error variable coding

Transducer	Parameters	Value	XD_ERROR	XD_ERROR_EXT	Possible display indications or causes
PTB	PRIMARY_VALUE_ACTUAL_POSITION.Status =	Bad / Device Failure	Electronics failure 0x14 hex 20 dec	Device fault 0x40000000 hex 1073741824 dec	Internal error
DITB	PRIMARY_VALUE_x.Status =	Bad / Device Failure			
AITB	PRIMARY_VALUE_x.Status =	Bad / Device Failure			
PTB	PRIMARY_VALUE_ACTUAL_POSITION.Status =	Bad / Device Failure	Configuration error 0x13 hex 19 dec	Configuration error 0x00002000 hex 8192 dec	Configuration error
DITB	PRIMARY_VALUE_x.Status =	Bad / Device Failure			
AITB	PRIMARY_VALUE_x.Status =	Bad / Device Failure			
PTB	PRIMARY_VALUE_ACTUAL_POSITION.Status =	Bad / Device Failure	Electronics failure 0x14 hex 20 dec	Device lost 0x80000000 hex 2147483648 dec	FF module cannot access the process data of the AC .2 (internal connection between FF module and FF sub-assembly or FF sub-assembly and logic not available).
PTB	FINAL_VALUE_x.Status =	Bad / Device Failure			
DITB	PRIMARY_VALUE_x.Status =	Bad / Device Failure			
AITB	PRIMARY_VALUE_x.Status =	Bad / Device Failure			
PTB	PRIMARY_VALUE_ACTUAL_POSITION.Status =	Bad / Sensor Failure	Electronics failure 0x14 hex 20 dec	Feedback E2 loss 0x00010000 hex 65536 dec	Wrn sign.loss act.pos. for AITB only for setting the AITB.CFG_AIN_x = Actual position parameter
AITB	PRIMARY_VALUE_x.Status =	Bad / Sensor Failure			
PTB	PRIMARY_VALUE_ACTUAL_POSITION.Status =	Bad / Sensor Failure	Calibration error 0x12 hex 18 dec	Calibration 0x00001000 hex 4096 dec	Wrn sign.loss act.pos., Wrn ref.actual position. For AITB only for setting the AITB.CFG_AIN_x = Actual position parameter
AITB	PRIMARY_VALUE_x.Status =	Bad / Sensor Failure			
AITB	PRIMARY_VALUE_x.Status =	Bad / Sensor Failure	No error 0x00 hex 0 dec	No error 0x00000000 hex 0 dec	Wrn input AIN 1, Wrn input AIN 2, only for setting the AITB.CFG_AIN_x = Analogue input 1 or Analogue input 2 parameter
PTB	PRIMARY_VALUE_ACTUAL_POSITION.Status =	Good_Cascade / Local Override	General error 0x11 hex 17 dec	Loss of phase 0x00000100 hex 256 dec	Phase failure, Incorrect phase seq, Mains quality
PTB	PRIMARY_VALUE_ACTUAL_POSITION.Status =	Good_Cascade / Local Override	General error 0x11 hex 17 dec	Thermal fault 0x00000200 hex 512 dec	Thermal fault
PTB	PRIMARY_VALUE_ACTUAL_POSITION.Status =	Good_Cascade / Local Override	General error 0x11 hex 17 dec	Torque fault OPEN 0x00000001 hex 1 dec	Torque fault OPEN

Transducer	Parameters	Value	XD_ERROR	XD_ERROR_EXT	Possible display indications or causes
PTB	PRIMARY_VALUE_ACTUAL_POSITION.Status =	Good_Cascade / Local Override	General error 0x11 hex 17 dec	Torque fault CLOSE 0x00000002 hex 2 dec	Torque fault CLOSE
PTB	PRIMARY_VALUE_ACTUAL_POSITION.Status =	Good_Cascade / Local Override	General error 0x11 hex 17 dec	Not ready indication 0x00000010 hex 16 dec	Not ready REMOTE

6.2. Selection for RESTART parameter of Resource Block

Selection	Consequence	Value (dec)	Value (hex)
Run	No consequences	1	0x01
Resource	No consequences	2	0x02
Defaults	FF function block application will be deleted (i.e. the trend, link and alert objects will be deleted, function blocks will be reset to their default values). Device address and tags will be retained.	3	0x03
Processor	Both AC controls and FF interface will be rebooted	4	0x04
Factory Defaults	Factory settings of AC controls will be restored; the FF interface will then rebooted	5	0x05
Restore device defaults	Factory settings of AC controls will be restored and the FF function block application will be deleted (i.e. the trend, link and alert objects will be deleted, function blocks will be reset to their default values) and the FF interface will be rebooted. Device address and tags will be retained.	6	0x06
Reset operating data	Reset operating data	13	0x0D
Reset characteristic curves	Reset torque curves	14	0x0E

6.3. Block operation modes

All blocks express their operation modes via the MODE_BLK parameter. It is a record consisting of four components:

Target, Actual, Permitted, and Normal.

- **Target** is the mode into which the user wants to bring this block. This parameter is writable.
- **Actual** indicates the actual block operation mode and can only be read. If the required condition is fulfilled, Target and Actual mode are identical. However, it is possible the Actual and Target mode differ for a definite reason.
- **Permitted** indicates which mode is allowed as Target for this function block.
- **Normal** indicates the normal mode.

The Permitted and Normal modes are writable, however, should not be changed without reason.

Possible operation modes are OOS, IMan, Man, LO, Auto, Cas, Rcas, and ROut:

- **Out_of_Service (OOS)**. This block does not function, the block execution has been interrupted and all output parameter contain the "BAD" status: Out_Of_Service.
- **Initialization Manual (IMan)**. The block is just about to initialise a cascade. This state is used for upstream control blocks to perform a smooth transition to automatic mode.
- **Local Override (LO)**. Fault state or Interlock are active and override the block output value. This is not a valid Target mode but merely a valid actual mode.
- **Manual (Man)**. The block output value is set by the user.
- **Auto (Auto)**. The block output value is set by the block algorithm, whereby the block uses a local value as setpoint.

- **Cascade (Cas).** The block setpoint is taken out of the CAS_IN parameter which is normally connected to the output of another block. Diese Betriebsart kann erst nach der Kaskaden- Initialisierung verwendet werden. If Cascade shall be used as Target mode, the Auto Bit within Target is also set.
- **Remote Cascade (RCas).** Like for the Cascade mode, the Remote Cascade setpoint is supplied by an external data source. Contrary to Cascade, in Remote Cascade mode the block receives the setpoint from the RCAS-IN parameter which has been written by a host application and not by another function block.
- **Remote Output (ROut).** The Remote Output mode is identical to the Remote Cascade mode, except that the host application directly sets the block output and not the setpoint. Thus, the setpoint range and the absolute limitation is bypassed for an analogue output block.

Depending on the status of a downstream block or in case of local operation, the Actual mode of function blocks for Output or Control can take the status IMan (Initialization Manual) or LO (Local Override).

Only operation modes OOS and AUTO are available for the resource block. The operation modes OOS, MAN, and AUTO are available for transducer blocks.

6.4. IO_OPTS, availability and description

Bit	Signification	AI	DI	AO	DO	Description
0	Invert		X		X	Indicates whether the discrete input value should be logically inverted before it is stored in the process variable. A discrete value of zero (0) will be considered to be a logical zero (0) and a non-zero discrete value will be considered to be a logical (1). When selecting invert, the PV value is inverted.
1	SP-PV Track in Man			X	X	Allows the setpoint to track the process variable, if the target mode of the block is Man.
2	Reserved				X	
3	SP-PV Track in LO			X	X	Allows the setpoint to track the process variable if the actual mode of the block is LO.
4	SP Track retained target			X	X	Allows the setpoint to track the RCas or Cas parameters based on the retained target mode, if the actual mode of the block is LO or Man. Once SP-PV track options are enabled, the SP track retain target will have precedence in the selection of the value to track if the actual mode is Man and LO.
5	Increase to close			X	X	Defines whether the output value should be inverted before it is communicated to the I/O channel.
6	Fault State to value			X	X	Measures to take in the event of a fault (0: freeze value, 1: accept preset value).
7	Use Fault State value on restart			X	X	Use the FSTATE_VAL(_D) parameter value, other use the non-volatile value. The reaction does not depend on the Fault state function, only the FSTATE_VAL(_D) is used.
8	Target to Man if Fault State activated			X	X	Set target mode to Man when enabling the fault state; the initial target value is lost. This puts the output block in manual mode.
9	Use PV for BKCAL_OUT			X	X	Usually, the BKCAL_OUT value is the active setpoint (SP). This option changes it to the process variable (PV).
10	Low cutoff	X				The AI Low Cutoff algorithm is enabled.
11	Reserved					
12	Units conversion	X				Device will perform units conversion on the channel value so that it will match the units set in XD_SCALE. If the units of XD_SCALE are set to a value not supported by the device then the block will remain in O/S after being configured.
13 – 15	Reserved					

6.5. CONTROL_OPTS, availability and description

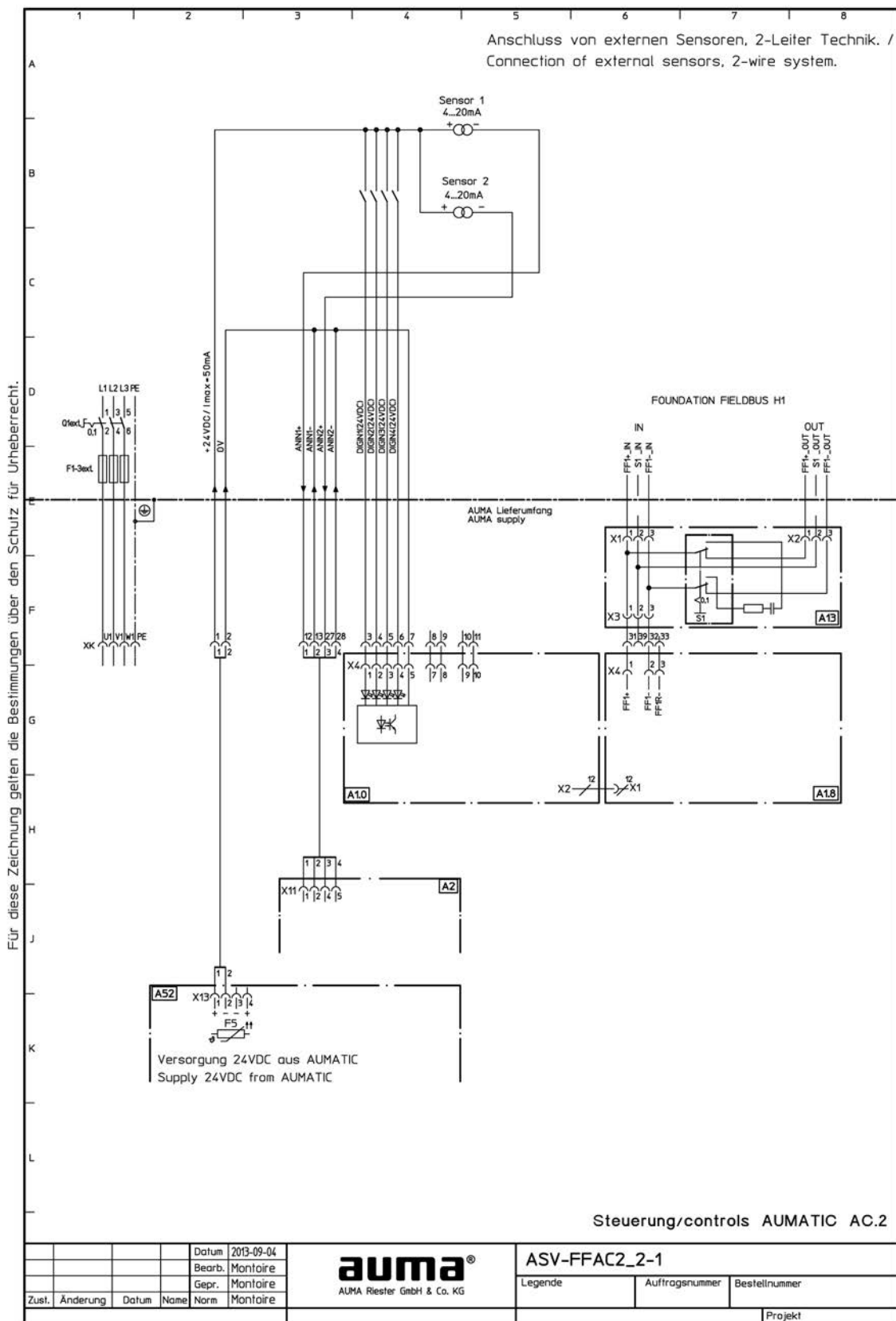
Bit	Signification	PID	Description
0	Bypass Enable	X	This setting can be used to enable the BYPASS function. Some control application cannot provide closed loops if BYPASS is enabled.
1	SP-PV Track in Man	X	Allows the setpoint to track the process variable, if the target mode of the block is MAN.
2	SP-PV Track in Rout	X	Allows the setpoint to track the process variable, if the target mode of the block is ROut.
3	SP-PV Track in LO or IMan	X	Allows the setpoint to track the process variable, if the target mode of the block is LO or IMan.
4	SP Track retained target	X	Allows the setpoint to track the RCas or Cas parameters based on the retained target mode, if the actual mode of the block is IMan, LO, Man, or Rout. If the SP-PV track options are enabled, the SP track retain target will have precedence in the selection of the value to track if the actual mode is Man, IMan, Rout, or LO.
5	Direct Acting	X	Defined the relationship between a change in the process variable and the respective output change. If Direct has been selected, a process variable increase results in an output increase.
6	Reserved	X	
7	Track Enable	X	This enables the external tracking function. When enabled, the value in TRK_VAL replaces the OUT value if TRK_IN_D is set and the target mode is not Man.
8	Track in Manual	X	When enabled, the TRK_VAL value replaces the OUT value if TRK_IN_D is set. this allows TRK_VAL to replace the OUT value if the target mode is Man and TRK_IN_D applies. The actual mode is then LO.
9	Use PV for BKCAL_OUT	X	The BKCAL_OUT and RCAS_OUT values are normally the active setpoints (SP). This option changes it into the process variable (PV) if the control cascade is closed.
10	Act on IR		If enabled, the setpoint is adapted within the setpoint limits after receipt of IR on the BKC-AL_IN, and when closing the control cascade, a bumpless transfer is guaranteed. If the setpoint required to provide a bumpless transfer is outside the setpoint limits, any adaptation to ensure bumpless transfer will be removed again within the BAL_TIME.
11	Use BKCAL_OUT with IN_1		Normally, BKCAL_OUT is used to initialise a downstream block providing CAS_IN. When this option is enabled, BKCAL_OUT is used for a downstream block providing IN_1. This option can be used in combination with the ratio and the bias/gain block to determine value and status, which must be made available in BKCAL_OUT for correct initialisation and for handshake.
12	Obey SP limits if Cas or RCas	X	Normally, the setpoint is not limited to the setpoint limit, except it is entered by a user. When this option is selected, the setpoint is subject to the absolute setpoint limits in Cas and RCas.
13	No OUT limits in Manual	X	OUT_HI_LIM or OUT_LO_LIM are not considered, if the target and actual modes are set to Man.
14 + 15	Reserved		

6.6. STATUS_OPTS, availability and description

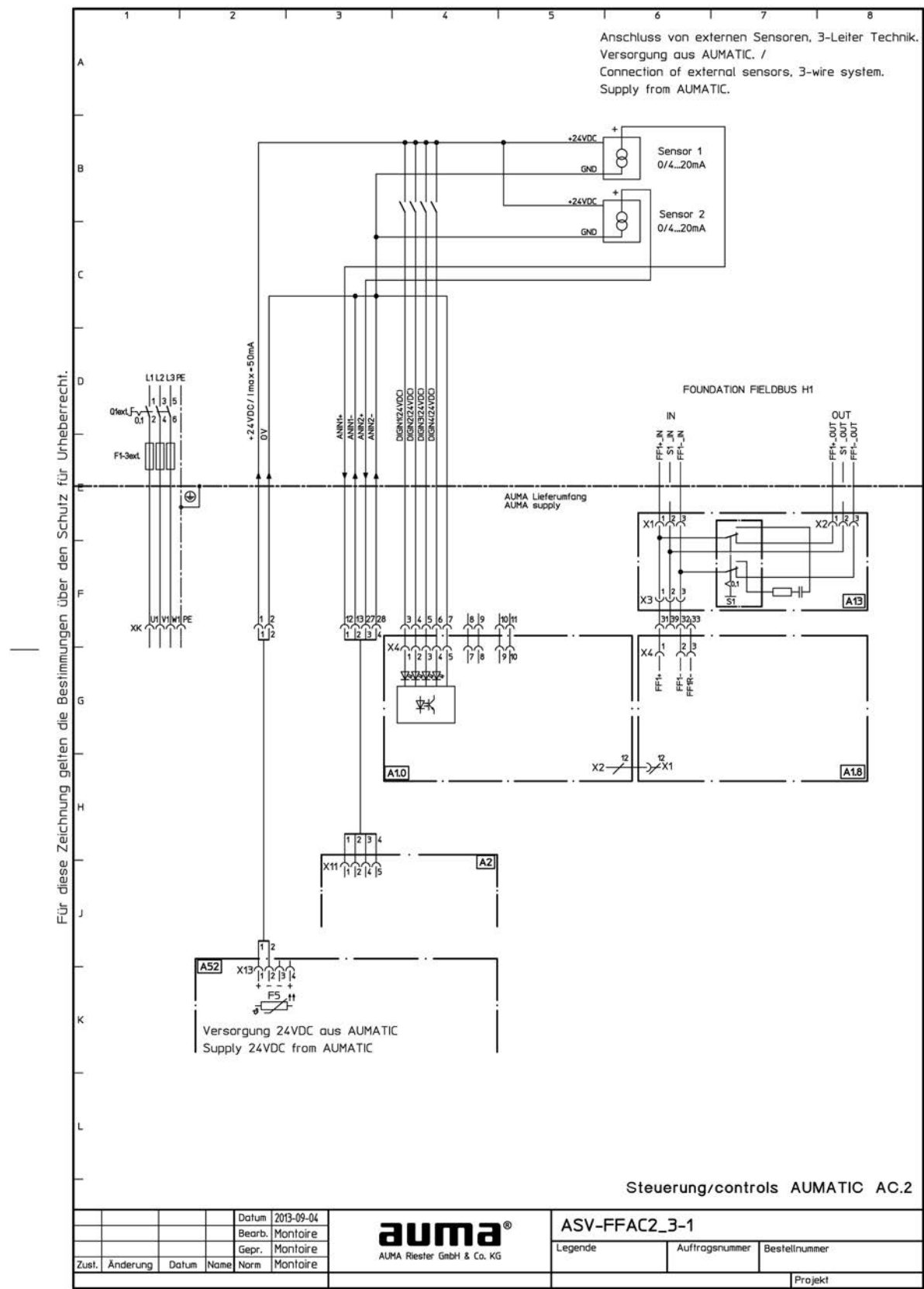
Bit	Signification	AI	DI	AO	DO	PID	Description
0	IFS if BAD IN					X	Activate initiate fault state status in OUT parameter if the IN parameter status is BAD.
1	IFS if BAD CAS_IN					X	Activate initiate fault state status in OUT parameter if the CAS_IN parameter status is Bad.
2	Use Uncertain as Good					X	If the IN parameter status is Uncertain, treat as if it were Good. Otherwise, treat as as Bad.
3	Propagate Fault Forward	X	X				If the sensor status is Bad, Device failure, Bad, or Sensor failure, transmit this status without issuing an alarm to the OUT parameter. This option allows the user to determine whether the alarm (sending an alert) is carried out by the block or transmitted to upstream blocks for alarm issue.
4	Propagate Fault Backward			X	X		If the status set by the actuator is Bad, Device failure, Fault State Active or Local Override Active, transmit this status as Bad, Device Failure or Good Cascade, Fault State Active or Local Override to BKCAL_OUT without generating an alarm. This option allows the user to determine whether the alarm (sending an alert) is carried out by the block or transmitted to an upstream block for alarm issue.

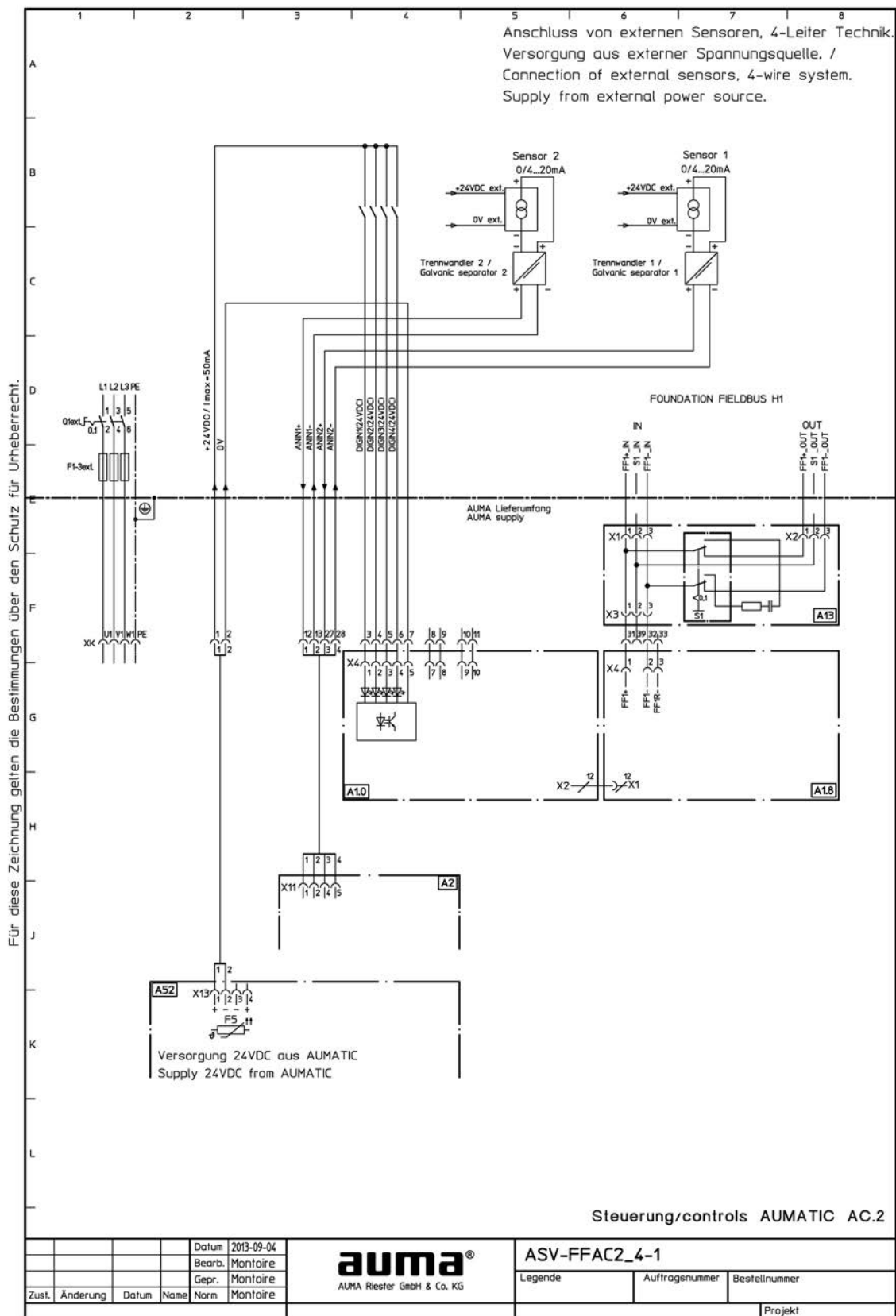
Bit	Signification	AI	DI	AO	DO	PID	Description
5	Target to Manual if BAD IN					X	Set target mode to Man, if the status of the IN parameter is Bad. This causes the switching of a PID block in Man status if the input should go to Bad.
6	Uncertain if Limited	X					Set the output status of an input or calculation block to Uncertain if the measured or calculated value is subject to a limit.
7	BAD if Limited	X					Set the output status to Bad if the sensor is at a High or Low Limit. Reference: Bad (if Limited) has preference before Uncertain (if Limited).
8	Uncertain if Man mode	X	X				Set the output status of an input or calculation block to Uncertain if the actual mode of the block is Man.
9	Target to next permitted mode if BAD CAS_IN						Set target mode to the next permitted mode if the target mode is CAS and the status of CAS_IN is Bad. This switches a control block within the next permitted mode, if CAS_IN is used for control and if the status changes to Bad.
10	Target to Man if BAD TRK_IN_D					X	Set the target to Man if the current target mode is not Out-of-Service and Man mode is permitted. This latches a control block into Man if the status goes bad.
11	IFS if BAD TRK_IN_D					X	Set Initiate Fault State Status in the OUT parameter if the status of the TRK_IN_D parameter is BAD.
12 – 15	Reserved						

6.7. Proposed wiring diagram for external sensors, 2-wire technology



6.8. Proposed wiring diagram for external sensors, 3-wire technology



6.9. Proposed wiring diagram for external sensors, 4-wire technology

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