Multi-turn actuators

TIGRON

TR-M30X – TR-M1000X

Modbus RTU

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

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

Table of contents

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 multi-turn actuators are designed for the operation of industrial valves, e.g. globe valves, gate valves, butterfly valves, and ball valves.

Other applications require explicit (written) confirmation by the manufacturer.

No liability can be assumed for inappropriate or unintended use.

Observance of these instructions and the 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).

⚠ DANGER	**Indicates an imminently hazardous situation with a high level of risk. Failure to observe this warning results in death or serious injury.**
⚠ WARNING	**Indicates a potentially hazardous situation with a medium level of risk. Failure to observe this warning could result in death or serious injury.**
⚠ CAUTION	**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.**
NOTICE	**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)

➥ **Result of a process step**

Describes the result of a preceding process step.

2. General information about Modbus

For exchange of information among automation systems and the connected decentralised field devices, the use of serial fieldbus systems for communication 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, those implemented 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 most suitable product at the most competitive price.

Modbus is an open fieldbus system used successfully throughout the world. The first Modbus solution was initiated as early as 1979. Since then, Modbus has developed into a de-facto standard. Meanwhile, Modbus has been standardised by the IEC 61158 and IEC 61784 standards. This standardization ensures that the investments by manufacturers and users are protected to the best possible degree and the user no longer depends on one manufacturer. The application range includes automation in the areas of manufacturing, processing, and building.

2.1. Basic characteristics

Modbus defines the technical and functional features of a serial fieldbus system used for interconnecting distributed digital automation devices. Modbus distinguishes between master and slave devices.

Master devices Master devices control data traffic on the bus. A master is allowed to send messages without an external request. Masters are also called "active devices" in the Modbus protocol.

Slave device Slave devices such as AUMA Modbus actuators are peripheral devices. Typical slave devices are input/output devices, valves, actuators, and measuring transducers. They do not have bus access rights, i.e. they may only acknowledge received messages or, at the request of a master, transmit messages to that master. Slaves are also called ‘passive devices’.

2.2. Modbus basic functions

Modbus uses a master-slave technique where only the master can initiate a transaction. The slaves respond by supplying the requested data in a response message or by executing the action requested in the query.

The Modbus telegram from the master contains the slave address, a function code defining the requested action, a data field, and a CRC field. The Modbus slaves’ response message contains fields confirming the requested action and possibly the requested data as well as a CRC field.

If an error occurs during reception of the telegram or if the slave is unable to perform the requested action, the slave will generate an error telegram and send it as response to the master.

2.3. Transfer mode

- RS-485 twisted wire pair or fibre optic cable
- AUMA actuators support baud rates up to 115.2 kbits/s.

2.4. Fieldbus access

- Master-slave technique
- Mono-master system
- Master and slave devices: max. 247 devices at one bus, without repeater max. 32 devices.

2.5. Communication

- Master-slave data exchange via request-response cycle (polling procedure).
- Modbus RTU protocol

2.6. Protective functions

- Parity check for each telegram byte
- CRC check for each telegram
- Watchdog for AUMA actuators with adjustable failure behaviour.
- Request-response cycle monitoring with configurable timer interval at the master.

2.7. Modbus RTU mode

Data format for a byte

Coding system:

- 8 bit binary, hexadecimal 0-9, A-F
- hexadecimal characters contained in each 8 bit field of the telegram

Bits pro Byte:

- 1 start bit
- 8 data bits; least significant bit sent first
- 1 bit for even/odd parity, no bit for no parity
- 1 stop bit if parity is used, 1 or 2 stop bits if no parity is used.

3. Commissioning

3.1. Introduction

To commission a Modbus slave, a special configuration of the master using a configuration file is usually not required.

Modbus RTU transmission is based on a simple protocol containing the slave address, a function code with offset address, the process data, and a checksum.

3.1.1. Modbus function overview

3.1.1.1. Functions for data transmission

Function	Function code (decimal)	Description
Force Single Coil	05	Sets an individual bit in the slave to ON or OFF.
Force Multiple Coils	15	Sets several consecutive bits in the slave to ON or OFF.
Read Coil Status	01	Reads out the status of individual pieces of output bit information from the slave.
Read Input Status	02	Reads out the status of individual pieces of input bit information from the slave.
Preset Single Register	06	Writes data to individual Holding Registers (16 bit) of the slave.
Preset Multiple Register	16	Writes data into consecutive Holding Registers.
Read Input Register	04	Reads out the contents of the Input Data Registers (16 bit) from the slave
Read Holding Register	03	Reads out the contents of the Holding Registers.

3.1.1.2. Diagnostic functions

Function	Function code (decimal)	Description
Diagnostics	08	Reads diagnostic data. • 00 00 Loopback • 00 10 (0AHex) Clear Counters and Diagnostic Register • 00 11 (0BHex) Return Bus Message Count • 00 12 (0CHex) Return Bus Communication Error Count • 00 13 (0DHex) Return Bus Exception Error Count • 00 14 (0EHex) Return Slave Message Count • 00 15 (0FHex) Return Slave No Response Count • 00 16 (10Hex) Return Slave NAK Count • 00 17 (11Hex) Return Slave Busy Count • 00 18 (12Hex) Return Character Overrun Count
Report Slave ID	17	Reads the device-specific data from the slave. • Byte 1: Slave Address • Byte 2: 0x11 (Function Code) • Byte 3: Byte Count = 97 • Byte 4: 0x01 (Ident Code) • Byte 5: 0x00 = Not ready REMOTE, 0xFF = Ready REMOTE • from byte 6 (vendor, 18 bytes): AUMA Riester GmbH • from byte 24 (actuator controls order number, 18 bytes) • from byte 42 (firmware version, 13-byte ASCII string) • from byte 55 (device tag, 20-byte ASCII string) • from byte 75 (actuator controls serial number, 13-byte ASCII string) • from byte 88 (actuator controls serial number, 13-byte ASCII string)

3.1.2. Modbus function and pertaining offset addresses

Action	Permissible function/function code (decimal)	Permissible offset addresses (decimal)	Permissible offset addresses (hexadecimal)
Read or write process representation output data (master outputs)	Force Single Coil (05) Force Multiple Coils (15) Read Coil Status (01)	0 to 511	0x0000 to 0x01FF
	Preset Single Register (06) Preset Multiple Register (16) Read Holding Register (03)	1,000 to 1,031	0x03E8 to 0x0407
Read process representation input data (master inputs)	Read Input Status (02)	0 to 511	0x0000 to 0x01FF
	Read Input Register (04)	1,000 to 1,031	0x03E8 to 0x0407
	Read Holding Register (03)	1,032 to 1,063	0x0408 to 0x0427
Read or write parameters of actuator controls	Preset Multiple Register (16) Read Holding Register (03)	View Objects: 1,200 to 1,499 (refer to <Parameters>) Individual parameter requests from 2,000	0x04B0 to 0x05DB

3.1.3. Operation parameters of the actuator

Parameters and notes on the parametrisation via Modbus RTU (Modbus function codes, offset addresses, parameter descriptions as well as the read/write access codes) are described in the appendix.

Functions to be used

Parameters of the actuator can be written or read using the following functions:

- Preset Multiple Register (16)
- Read Holding Register (03)

4. Description of the data interface

4.1. Input data – signals

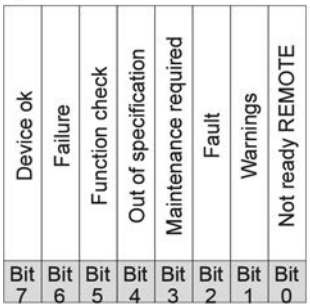
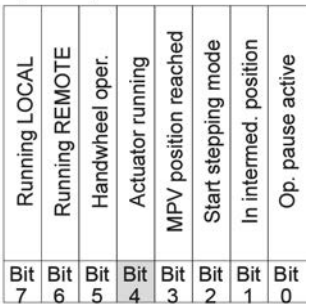
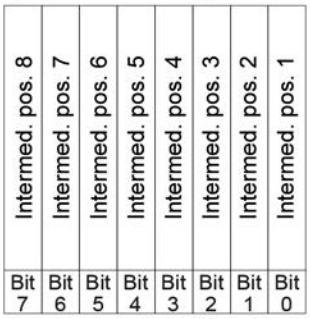
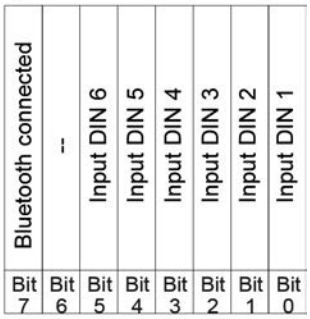
The master (controls) can read the state of the slave (actuator) by means of the input data.

4.1.1. Reading the input data from the actuator using register functions

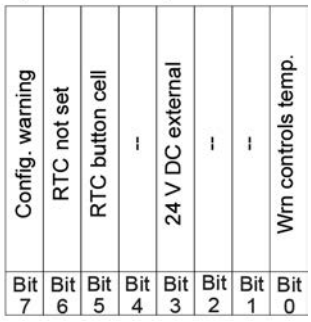
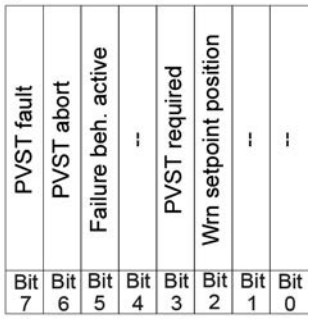
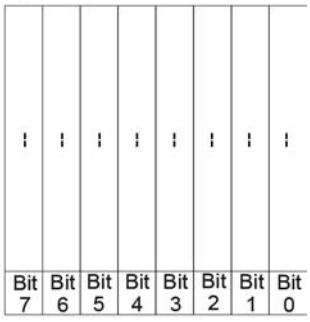
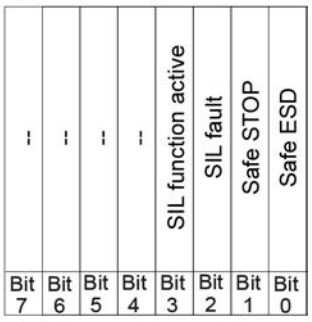
Functions to be used: Read Input Register (04)

When using the Read Holding Register (03) function, an additional offset of 32 has to be addressed (1032 – 1063 or 0x0408 – 0x0472).

Grey bits are collective signals. They contain the results of a disjunction (OR operation) of other information.

Offset (hexadecimal)	Offset (decimal)	Register contents
0x03E8	1000	Byte1: Logical signals  Byte 2: Actuator signals 
0x03E9	1001	Byte 3: Actual position high byte (position transmitter) Byte 4: Actual position low byte (position transmitter)
0x03EA	1002	Byte 5: Device status  Byte 6: Operation status 
0x03EB	1003	Byte 7: Intermediate positions  Byte 8: Discrete inputs 
0x03EC	1004	Byte 9: Input AIN 1 (high byte) Byte 10: Input AIN 1 (low byte)
0x03ED	1005	Byte 11 Torque (high byte) Byte 12: Torque (low byte)

Offset (hexadecimal)	Offset (decimal)	Register contents
0x03EE	1006	Byte 13: Not ready REMOTE 1 Bit 7: I/O interface Bit 6: FailState fieldbus Bit 5: EMCY behav.act. Bit 4: EMCY STOP act. Bit 3: Local STOP Bit 2: Interlock active Bit 1: Sel. sw. not REMOTE Bit 0: Incorrect op.cmd Byte 14: Not ready REMOTE 2 Bit 7: Handwheel active Bit 6: Service active Bit 5: PVST active Bit 4: Interlock by-pass Bit 3: Disabled Bit 2: SIL function active Bit 1: -- Bit 0: --
0x03EF	1007	Byte 15: Fault 1 Bit 7: No reaction Bit 6: Internal error Bit 5: Torque fault CLOSE Bit 4: Torque fault OPEN Bit 3: Phase failure Bit 2: Thermal fault Bit 1: Mains quality Bit 0: Configuration error Byte 16: Fault 2 Bit 7: Incorrect phase seq Bit 6: Config. error REMOTE Bit 5: Incorrect dir. rotation Bit 4: -- Bit 3: -- Bit 2: -- Bit 1: -- Bit 0: --
0x03F0	1008	Byte 17: Warnings 1 Bit 7: Wrn no reaction Bit 6: SIL fault Bit 5: Torque wrn OPEN Bit 4: Torque wrn CLOSE Bit 3: -- Bit 2: -- Bit 1: -- Bit 0: Maintenance required Byte 18: Warnings 2 Bit 7: Config. warning Bit 6: RTC not set Bit 5: RTC button cell Bit 4: -- Bit 3: 24 V DC external Bit 2: -- Bit 1: -- Bit 0: Wrn controls temp.
0x03F1	1009	Byte 19: Warnings 3 Bit 7: Op. time warning Bit 6: Wrn on time running Bit 5: Wrn on time starts Bit 4: Internal warning Bit 3: Wrn input AIN 1 Bit 2: Wrn input AIN 2 Bit 1: -- Bit 0: -- Byte 20: Warnings 4 Bit 7: PVST fault Bit 6: PVST abort Bit 5: Failure beh. active Bit 4: -- Bit 3: PVST required Bit 2: Wrn setpoint position Bit 1: -- Bit 0: --
0x03F2	1010	Byte 21: Input AIN 2 (high byte) Byte 22: Input AIN 2 (low byte)
0x03F3	1011	Byte 23: Failure Bit 7: Fault Bit 6: -- Bit 5: -- Bit 4: -- Bit 3: -- Bit 2: -- Bit 1: -- Bit 0: -- Byte 24: Maintenance required Bit 7: -- Bit 6: -- Bit 5: -- Bit 4: Maintenance interval Bit 3: Maintenance contactors Bit 2: Maintenance lubricant Bit 1: Maintenance seals Bit 0: Maintenance mechanics

Offset (hexadecimal)	Offset (decimal)	Register contents
0x03F4	1012	Byte 25: Out of specification 1  Byte 26: Out of specification 2 
0x03F5	1013	Byte 27: Out of specification 3  Byte 28: Out of specification 4 
0x03F6	1014	Byte 29: Function check 1  Byte 30: Function check 2 
0x03F7	1015	Byte 31: Status fieldbus  Byte 32: SIL signals 
0x03F8 – 0x03FB	1016 – 1019	Byte 33 to byte 40: Reserve

4.1.2. Description of the input data

Byte 1: Logic signals

Bits 3, 6, and 7 are collective signals.

Bits 5 and 4 of the logical signals (byte1) indicate a logical operation of the actuator, i.e. they are set when the actuator has received the command for an electrical operation (also active when e.g. the actuator is in a stepping pause during stepping mode or waiting for the end of the dead time).

Table 1: Byte 1: Logic signals

Bit	Designation (process representation)	Value	Description
0	End position OPEN	1	For limit seating: Limit switch operated in direction OPEN. For torque seating: Torque switch and limit switch operated in direction OPEN.
		0	No signal.
1	End position CLOSED	1	For limit seating: Limit switch operated in direction CLOSE. For torque seating: Torque switch and limit switch operated in direction CLOSE.
		0	No signal.
2	Setpoint pos.reached	1	The position setpoint is within max. error variable (outer dead band). Is only signalled if Modbus master has set the Fieldbus SETPOINT bit (process representation output).
		0	No signal.
3	Not ready REMOTE	1	Collective signal 04: Contains the result of a disjunction (OR-operation) of all bits comprised in bytes 13 and 14 (Not ready REMOTE 1 and Not ready REMOTE 2). The actuator cannot be operated from REMOTE. The actuator can only be operated via the local controls.
		0	In bytes 13 and 14, no signals are active (all bits are set to 0).
4	Running OPEN	1	An operation command via the local controls or via fieldbus in direction OPEN is performed: Fieldbus OPEN or Fieldbus SETPOINT (process representation output). This bit remains also set during operation pauses (e.g. due to the dead time or the reversing prevention time).
		0	Operation in direction OPEN via fieldbus is not executed.
5	Running CLOSE	1	An operation command via the local controls or via fieldbus in direction CLOSE is performed: Fieldbus CLOSE or Fieldbus SETPOINT (process representation output). This bit remains also set during operation pauses (e.g. due to the dead time or the reversing prevention time).
		0	Operation in direction CLOSE via fieldbus is not executed.
6	Warning	1	Collective signal 02: Contains the result of a disjunction (OR-operation) of all bits of bytes 17 to 20 (Warning 1 to Warning 4).
		0	In bytes 17 and 20, no warnings are active (all bits are set to 0).
7	Fault	1	Collective signal 03: Contains the result of a disjunction (OR-operation) of all bits of bytes 15 and 16 (Fault 1 and Fault 2). The actuator cannot be operated.
		0	In bytes 15 and 16, no faults are active (all bits are set to 0).

Byte 2: Actuator signals

Table 2: Byte 2: Actuator signals

Bit	Designation (process representation)	Value	Description
0	Thermal fault	1	Motor protection tripped.
		0	No signal.
1	Phase fault	1	• When connecting to a 3-phase AC system and with internal 24 V DC supply of the electronics: Phase 2 is missing. • When connecting to a 3-phase or 1-phase AC system and with external 24 V DC supply of the electronics: One of the phases L1, L2 or L3 is missing.
		0	All phases are available.
2	Selector sw. REMOTE	1	Selector switch is in position REMOTE.
		0	Selector switch is not in position REMOTE.
3	Selector sw. LOCAL	1	Selector switch is in position LOCAL.
		0	Selector switch is not in position LOCAL.
4	Limit switch OPEN	1	Limit switch operated in direction OPEN.
		0	No signal.
5	Limit switch CLOSED	1	Limit switch operated in direction CLOSE.
		0	No signal.

Bit	Designation (process representation)	Value	Description
6	Torque sw. OPEN	1	Torque switch operated in direction OPEN.
		0	No signal.
7	Torque sw. CLOSED	1	Torque switch operated in direction CLOSE.
		0	No signal.

Bytes 3 and 4: Actual position

Byte 3 = high byte, byte 4 = low byte.

If a position transmitter is installed in the actuator, bytes 3 and 4 are used to transmit the current actuator position. The value is transmitted in per mil (value: 0 – 1,000).

Byte 5: Device status

Table 3: Byte 5: Device status

Bit	Designation (process representation)	Value	Description
0	Not ready REMOTE	1	Collective signal 04: Contains the result of a disjunction (OR-operation) of all bits comprised in bytes 13 and 14 (Not ready REMOTE 1 and Not ready REMOTE 2). The actuator cannot be operated from REMOTE. The actuator can only be operated via the local controls.
		0	In bytes 13 and 14, no signals are active (all bits are set to 0).
1	Warning	1	Collective signal 02: Contains the result of a disjunction (OR-operation) of all bits of bytes 17 to 20 (Warning 1 to Warning 4).
		0	In bytes 17 and 20, no warnings are active (all bits are set to 0).
2	Fault	1	Collective signal 03: Contains the result of a disjunction (OR-operation) of all bits of bytes 15 and 16 (Fault 1 and Fault 2). The actuator cannot be operated.
		0	In bytes 15 and 16, no faults are active (all bits are set to 0).
3	NAMUR mainten. req.	1	Collective signal 09: Indication according to NAMUR recommendation NE 107 Recommendation to perform maintenance. Contains the result of a disjunction (OR-operation) of all bits of byte 24 (Maintenance required).
		0	In all bits of byte 24, no signals are active (all bits are set to 0).
4	NAMUR out of spec.	1	Collective signal 07: Indication according to NAMUR recommendation NE 107 Actuator is operated outside the normal operation conditions. Contains the result of a disjunction (OR-operation) of all bits of bytes 25 to 28 (Out of specification 1 to 4).
		0	In bytes 25 and 28, no signals are active (all bits are set to 0).
5	NAMUR funct. check	1	Collective signal 08: Indication according to NAMUR recommendation NE 107 The actuator is being worked on; output signals are temporarily invalid. Contains the result of a disjunction (OR-operation) of all bits of bytes 29 and 30 (Function check 1 and 2).
		0	In bytes 29 and 30, no signals are active (all bits are set to 0).
6	NAMUR failure	1	Collective signal 10: Indication according to NAMUR recommendation NE 107 Actuator function failure, output signals are invalid. Contains the result of a disjunction (OR-operation) of all bits of byte 23 (Failure).
		0	In all bits of byte 23, no signals are active (all bits are set to 0).
7	Device ok	1	Collective signal 05: The device is ready for remote control. No AUMA warnings, AUMA faults or signals according to NAMUR are present. Bit 7 is set if bits 0 to 6 are deleted.
		0	Contains the result of a disjunction (OR-operation) of bits 0 to 6 (device status).

Byte 6: Operation status

They include information about the actuator movement.

Table 4: Byte 6: Operation status

Bit	Designation (process representation)	Value	Description
0	Operation pause active	1	The actuator is in off-time (e.g. reversing prevention time).
		0	No signal.
1	In intermediate pos.	1	The actuator is in an intermediate position e.g. neither in end position OPEN nor in end position CLOSED.
		0	No signal.
2	Start stepping mode	1	The actuator is within the set stepping range.
		0	The actuator is outside the set stepping range.
3	—		No signal (reserved).
4	Actuator running	1	Actuator is running (output drive is moving) Hard wired collective signal consisting of signals: • (26) Running LOCAL • (27) Running REMOTE • (28) Handwheel oper.
		0	No signal.
5	Handwheel oper.	1	Output drive rotates without electric operation command.
		0	No signal.
6	Running REMOTE	1	Output drive rotates due to operation command from REMOTE.
		0	No signal.
7	Running LOCAL	1	Output drive rotates due to operation command from LOCAL.
		0	No signal.

Byte 7: Intermediate positions

Table 5: Byte 7: Intermediate positions

Bit	Designation (process representation)	Value	Description
0	Intermediate pos. 1	1	Intermediate position 1 reached.
		0	No signal.
1	Intermediate pos. 2	1	Intermediate position 2 reached.
		0	No signal.
2	Intermediate pos. 3	1	Intermediate position 3 reached.
		0	No signal.
3	Intermediate pos. 4	1	Intermediate position 4 reached.
		0	No signal.
4	Intermediate pos. 5	1	Intermediate position 5 reached.
		0	No signal.
5	Intermediate pos. 6	1	Intermediate position 6 reached.
		0	No signal.
6	Intermediate pos. 7	1	Intermediate position 7 reached.
		0	No signal.
7	Intermediate pos. 8	1	Intermediate position 8 reached.
		0	No signal.

Byte 8: Discrete inputs

Table 6: Byte 8: Discrete inputs

Bit	Designation (process representation)	Value	Description
0	Input DIN 1	1	A high signal (+24 V DC) is present at digital input 1.
		0	No signal.
1	Input DIN 2	1	A high signal (+24 V DC) is present at digital input 2.
		0	No signal.
2	Input DIN 3	1	A high signal (+24 V DC) is present at digital input 3.
		0	No signal.
3	Input DIN 4	1	A high signal (+24 V DC) is present at digital input 4.
		0	No signal.
4	Input DIN 5	1	A high signal (+24 V DC) is present at digital input 5.
		0	No signal.
5	Input DIN 6	1	A high signal (+24 V DC) is present at digital input 6.
		0	No signal.
6	—		No signal (reserved).
7	Bluetooth connected	1	The Bluetooth interface is connected.
		0	No signal.

Bytes 9 and 10: Input AIN 1

Byte 9 = high byte, byte 10 = low byte.

Byte 9 and byte 10 transmit the value of the first additional free analogue current input of the Modbus interface. The start and end values can be set via the display. (For operation, please refer to the respective operation instructions for the actuator.)

If the measuring values are 0.3 mA below the initial value, a signal loss is indicated.

The value is transmitted in per mil (value: 0 – 1,000).

Bytes 11 and 12: Torque

Byte 11 = high byte, byte 12 = low byte.

The current actuator torque is transmitted in byte 11 and byte 12.

The value transmitted is the current torque in percent or per mil of the nominal actuator torque.

The value is transmitted in per mil (value: 0 – 1,000).

- The value 1,000 corresponds to 127.0 % torque in direction OPEN.
- The value 500 is the torque zero point.
- The value 0 corresponds to 127.0 % torque in direction CLOSE.

Byte 13: Not ready REMOTE 1

Table 7: Byte 13: Not ready REMOTE 1

Bit	Designation (process representation)	Value	Description
0	Wrong oper. cmd	1	Wrong operation command Indicates that several operation commands were received simultaneously via Modbus (e.g. Remote OPEN and Remote CLOSE simultaneously or Remote CLOSE/Remote OPEN and Remote SETPOINT simultaneously) or that the max. value for a setpoint position has been exceeded (setpoint position > 1,000).
		0	Operation commands are ok.
1	Sel. sw. not REMOTE	1	Selector switch is in position **LOCAL** or **OFF**:
		0	Selector switch is in position **REMOTE**.
2	Interlock active	1	Actuator is locked.
		0	No signal.

Bit	Designation (process representation)	Value	Description
3	Local STOP	1	Local controls: STOP is operated.
		0	No signal.
4	EMCY stop active	1	Operation mode EMERGENCY stop is active (EMERGENCY stop button has been pressed).
		0	EMERGENCY stop button not pressed (normal operation).
5	EMCY behav. active	1	Operation mode EMERGENCY behaviour is active (EMERGENCY signal was sent).
		0	No signal.
6	FailState fieldbus	1	No valid communication via fieldbus (despite available connection)
		0	Communication via fieldbus is ok.
7	I/O interface	1	The actuator is controlled via the I/O interface (parallel).
		0	The actuator is controlled via the fieldbus.

Byte 14: Not ready REMOTE 2

Table 8: Byte 14: Not ready REMOTE 2

Bit	Designation (process representation)	Value	Description
0	—		No signal.
1	—		No signal.
2	SIL function active[1)]	1	The safety function of the SIL sub-assembly is active.
		0	No signal.
3	Disabled	1	The actuator is in operation mode Disabled.
		0	No signal.
4	Interlock by-pass	1	Bypass of interlock function is active.
		0	No signal.
5	PVST active	1	Partial Valve Stroke Test (PVST) is active.
		0	No signal.
6	Service active	1	Operation mode Service is active.
		0	No signal.
7	Handwheel active	1	Manual operation is active (handwheel is engaged); optional signal
		0	No signal.

1) The safety function indications via fieldbus are for information only and must not be used as part of a safety function. The digital I/O signals of the SIL module must be used for this purpose.

Byte 15: Fault 1

The fault signals contain the causes why the actuator cannot be operated.

Table 9: Byte 15: Fault 1

Bit	Designation (process representation)	Value	Description
0	Configuration error	1	Incorrect configuration, i.e. the current setting of the actuator is invalid.
		0	Configuration is ok.
1	Mains quality	1	Due to insufficient mains quality, the controls cannot detect the phase sequence (sequence of phase conductors L1, L2 and L3) within the pre-set time frame provided for monitoring.
		0	No signal.
2	Thermal fault	1	Motor protection tripped.
		0	No signal.
3	Phase fault	1	• When connecting to a 3-phase AC system and with internal 24 V DC supply of the electronics: Phase 2 is missing. • When connecting to a 3-phase or 1-phase AC system and with external 24 V DC supply of the electronics: One of the phases L1, L2 or L3 is missing.
		0	No signal.

Bit	Designation (process representation)	Value	Description
4	Torque fault OPEN	1	Torque fault in direction OPEN
		0	No signal.
5	Torque fault CLOSE	1	Torque fault in direction CLOSE
		0	No signal.
6	Internal error	1	Collective signal 14: Internal error.
		0	No internal fault
7	Wrn no reaction	1	No actuator reaction to operation commands within the set reaction time.
		0	No signal.

Byte 16: Fault 2

The fault signals contain the causes why the actuator cannot be operated.

Table 10: Byte 16: Fault 2

Bit	Designation (process representation)	Value	Description
0	—		No signal (reserved).
1	—		No signal (reserved).
2	—		No signal (reserved).
3	—		No signal (reserved).
4	—		No signal (reserved).
5			No signal.
6	Config. error REMOTE	1	Config. error of REMOTE interface active.
		0	No signal.
7	Incorrect phase seq	1	The phase conductors L1, L2 and L3 are connected in the wrong sequence.
		0	Phase sequence is ok.

Byte 17: Warnings 1

The warning signals are for information only and do not interrupt or disable an operation (as opposed to faults).

Table 11: Byte 17: Warnings 1

Bit	Designation (process representation)	Value	Description
0	—		No signal (reserved).
1	—		No signal (reserved).
2	—		No signal (reserved).
3	—		No signal.
4	Torque wrn CLOSE	1	Warning: Limit value for torque warning in direction CLOSE exceeded.
		0	No signal.
5	Torque wrn OPEN	1	Warning: Limit value for torque warning in direction OPEN exceeded.
		0	No signal.
6	SIL fault[1)]	1	Warning: A SIL fault of the SIL sub-assembly has occurred.
		0	No signal.
7	Wrn no reaction	1	Warning: No actuator reaction to operation commands within the set reaction time.
		0	No signal.

1) The safety function indications via fieldbus are for information only and must not be used as part of a safety function. The digital I/O signals of the SIL module must be used for this purpose.

Byte 18: Warnings 2

Table 12: Byte 18: Warnings 2

Bit	Designation (process representation)	Value	Description
0	Wrn controls temp.	1	Warning: Temperature within actuator controls housing too high.
		0	No signal.
1	—		No signal (reserved).
2	—		No signal (reserved).
3	24 V DC external	1	The external 24 V DC voltage supply of the controls has exceeded the power supply limits.
		0	No signal.
4	—		No signal (reserved).
5	RTC voltage	1	Warning: Voltage of RTC button cell too low.
		0	No signal.
6	Time not set	1	The real time clock has not yet been set on the basis of valid values.
		0	No signal.
7	Config. warning	1	Warning: Configuration setting is incorrect. The device can still be operated with restrictions.
		0	No signal.

Byte 19: Warnings 3

Table 13: Byte 19: Warnings 3

Bit	Designation (process representation)	Value	Description
0	—	1	No signal (reserved).
1	—	1	No signal (reserved).
2	Wrn input AIN 2	1	Warning: Loss of signal analogue input 2
		0	No signal.
3	Wrn input AIN 1	1	Warning: Loss of signal analogue input 1
		0	No signal.
4	Internal warning	1	Collective signal 15: Internal warning
		0	No internal warning
5	Wrn op.mode starts	1	Warning: Max. number of motor starts (starts) exceeded
		0	No signal.
6	Wrn op.mode run time	1	Warning: Max. running time/h exceeded
		0	No signal.
7	Op. time warning	1	Warning: Max. permissible operating time for an operation (OPEN-CLOSE) exceeded
		0	No signal.

Byte 20: Warnings 4

Table 14: Byte 20: Warnings 4

Bit	Designation (process representation)	Value	Description
0	—		No signal (reserved).
1	—		No signal (reserved).
2	Wrn setpoint position	1	Warning: Signal loss of actuator setpoint position.
		0	No signal.
3	PVST required	1	Warning: A Partial Valve Stroke Test (PVST) should be performed.
		0	No signal.
4	—		No signal (reserved).
5	Failure behav. active	1	The failure behaviour is active.
		0	No signal.

Bit	Designation (process representation)	Value	Description
6	PVST abort	1	Partial Valve Stroke Test (PVST) was aborted or could not be started. Remedy: Perform RESET or restart PVST.
		0	No signal.
7	PVST fault	1	Partial Valve Stroke Test (PVST) could not be successfully completed.
		0	No signal.

Bytes 21 and 22: Input AIN 2

Byte 21 = high byte, byte 22 = low byte.

Byte 9 and 10 transmit the value of the second additional free analogue current input of the Modbus interface. The start and end values can be set via the display. (For operation, please refer to the respective operation instructions for the actuator.)

If the measuring values are 0.3 mA below the initial value, a signal loss is indicated.

The value is transmitted in per mil (value: 0 – 1,000).

Byte 23: Failure

Causes of the Failure signal in accordance with NAMUR recommendation NE 107.

Table 15: Byte 23: Failure

Bit	Designation (process representation)	Value	Description
0	—		No signal (reserved).
1	—		No signal (reserved).
2	—		No signal (reserved).
3	—		No signal (reserved).
4	—		No signal (reserved).
5	—		No signal (reserved).
6	—		No signal (reserved).
7	Fault	1	Collective signal 03: Contains the result of a disjunction (OR-operation) of all bits of bytes 15 and 16 (Fault 1 and Fault 2). The actuator cannot be operated.
		0	In bytes 15 and 16, no faults are active (all bits are set to 0).

Byte 24: Maintenance required

Causes of the Maintenance required signal in accordance with NAMUR recommendation NE 107.

Table 16: Byte 24: Maintenance required

Bit	Designation (process representation)	Value	Description
0	Mainten. mechanics	1	Mechanic maintenance requirement
		0	No signal.
1	Mainten. seals	1	Seal maintenance requirement
		0	No signal.
2	Mainten. lubricant	1	Lubricant maintenance requirement
		0	No signal.
3	Mainten. contactors	1	Contactor maintenance requirement
		0	No signal.
4	Mainten. interval	1	The set maintenance interval has expired.
		0	No signal.

Bit	Designation (process representation)	Value	Description
5	—		No signal (reserved).
6	—		No signal (reserved).
7	—		No signal (reserved).

Byte 25: Out of specification 1

Causes of the Out of specification signal in accordance with NAMUR recommendation NE 107.

Table 17: Byte 25: Out of specification 1

Bit	Designation (process representation)	Value	Description
0	—		No signal (reserved).
1	—		No signal (reserved).
2	—		No signal (reserved).
3	—		No signal.
4	Torque wrn CLOSE	1	Warning: Limit value for torque warning in direction CLOSE exceeded.
		0	No signal.
5	Torque wrn OPEN	1	Warning: Limit value for torque warning in direction OPEN exceeded.
		0	No signal.
6	SIL fault[1)]	1	Warning: A SIL fault of the SIL sub-assembly has occurred.
		0	No signal.
7	Wrn no reaction	1	Warning: No actuator reaction to operation commands within the set reaction time.
		0	No signal.

1) The safety function indications via fieldbus are for information only and must not be used as part of a safety function. The digital I/O signals of the SIL module must be used for this purpose.

Byte 26: Out of specification 2

Table 18: Byte 26: Out of specification 2

Bit	Designation (process representation)	Value	Description
0	Wrn controls temp.	1	Warning: Temperature within actuator controls housing too high.
		0	No signal.
1	—		No signal (reserved).
2	—		No signal (reserved).
3	24 V DC external	1	The external 24 V DC voltage supply of the controls has exceeded the power supply limits.
		0	No signal.
4	—		No signal (reserved).
5	RTC voltage	1	Warning: Voltage of RTC button cell too low.
		0	No signal.
6	Time not set	1	The real time clock has not yet been set on the basis of valid values.
		0	No signal.
7	Config. warning	1	Warning: Configuration setting is incorrect. The device can still be operated with restrictions.
		0	No signal.

Byte 27: Out of specification 3

Table 19: Byte 27: Out of specification 3

Bit	Designation (process representation)	Value	Description
0	—		No signal (reserved).
1	—		No signal (reserved).
2	Wrn input AIN 2	1	Warning: Loss of signal analogue input 2
		0	No signal.
3	Wrn input AIN 1	1	Warning: Loss of signal analogue input 1
		0	No signal.
4	Internal warning	1	Collective signal 15: Internal warning
		0	No internal warning
5	Wrn op.mode starts	1	Warning: Max. number of motor starts (starts) exceeded
		0	No signal.
6	Wrn op.mode run time	1	Warning: Max. running time/h exceeded
		0	No signal.
7	Op. time warning	1	Warning: Max. permissible operating time for an operation (OPEN-CLOSE) exceeded
		0	No signal.

Byte 28: Out of specification 4

Table 20: Byte 28: Out of specification 4

Bit	Designation (process representation)	Value	Description
0	—		No signal (reserved).
1	—		No signal (reserved).
2	Wrn setpoint position	1	Warning: Signal loss of actuator setpoint position.
		0	No signal.
3	PVST required	1	Warning: A Partial Valve Stroke Test (PVST) should be performed.
		0	No signal.
4	—		No signal (reserved).
5	Failure behav. active	1	The failure behaviour is active.
		0	No signal.
6	PVST abort	1	Partial Valve Stroke Test (PVST) was aborted or could not be started. Remedy: Perform RESET or restart PVST.
		0	No signal.
7	PVST fault	1	Partial Valve Stroke Test (PVST) could not be successfully completed.
		0	No signal.

Byte 29: Function check 1

Causes of the Function check signal in accordance with NAMUR recommendation NE 107.

Table 21: Byte 29: Function check 1

Bit	Designation (process representation)	Value	Description
0	Local STOP	1	Local controls: STOP is operated.
		0	No signal.
1	Sel. sw. not REMOTE	1	Selector switch is in position **LOCAL** or **OFF**:
		0	Selector switch is in position **REMOTE**.
2	Service active	1	Operation mode Service is active.
		0	No signal.

Bit	Designation (process representation)	Value	Description
3	Handwheel active	1	Manual operation is active (handwheel is engaged); optional signal
		0	No signal.
4	EMCY stop active	1	Operation mode EMERGENCY stop is active (EMERGENCY stop button has been pressed).
		0	EMERGENCY stop button not pressed (normal operation).
5	PVST active	1	Partial Valve Stroke Test function (PVST) is active.
		0	No signal.
6	—		No signal (reserved).
7	—		No signal (reserved).

Byte 30: Function check 2

The contents are reserved for further Function check signals in accordance with NAMUR recommendation NE 107.

Byte 31: Status fieldbus

Information on the fieldbus status.

Table 22: Byte 31: Status fieldbus

Bit	Designation (process representation)	Value	Description
0	Channel 1 active	1	Channel 1 is the active operation command channel.
		0	No signal.
1	Channel 2 active	1	Channel 2 is the active operation command channel.
		0	No signal.
2	Channel 1 DataEx	1	Channel 1 is in the data exchange state (DataEx).
		0	No signal.
3	Channel 2 DataEx	1	Channel 2 is in the data exchange state (DataEx).
		0	No signal.
4	Ch.1 FailState Fieldb.	1	No valid fieldbus communication via channel 1 (application does not communicate with the DCS).
		0	No signal.
5	Ch.2 FailState Fieldb.	1	No valid fieldbus communication via channel 2 (application does not communicate with the DCS).
		0	No signal.
6	Channel 1 activity	1	Fieldbus communication available on channel 1.
		0	No signal.
7	Channel 2 activity	1	Fieldbus communication available on channel 2.
		0	No signal.

Byte 32: SIL signals

Detailed signals of an optional SIL sub-assembly.

Table 23: Byte 32: SIL signals

Bit	Designation (process representation)	Value	Description
0	Safe ESD[1)]	1	Safe ESD (Emergency Shut Down) safety function of the SIL sub-assembly is active.
		0	No signal.
1	Safe Stop[1)]	1	Safe STOP safety function of the SIL sub-assembly is active.
		0	No signal.
2	SIL fault[1)]	1	Collective signal Warning: A SIL fault of the SIL sub-assembly has occurred.
		0	No signal.

Bit	Designation (process representation)	Value	Description
3	SIL function active[1)]	1	A safety function of the SIL sub-assembly is active.
		0	No signal.
4	—		No signal (reserved).
5	—		No signal (reserved).
6	—		No signal (reserved).
7	—		No signal (reserved).

1) The safety function indications via fieldbus are for information only and must not be used as part of a safety function. The digital I/O signals of the SIL module must be used for this purpose.

Byte 33 to byte 40: Reserve

The contents are reserved for future extensions.

4.1.3. Reading the feedback signals from the actuator using status functions

Functions to be used: Read Input Status (02)

Offset (hexa-decimal)	Offset (decimal)	Contents (for details refer to <Description of the input data>)
0x0000	0	End position OPEN (byte 1)
0x0001	1	End position CLOSED (byte 1)
0x0002	2	Setpoint pos.reached (byte 1)
0x0003	3	Not ready REMOTE (Byte 1, collective signal 04)
0x0004	4	Running OPEN (byte 1)
0x0005	5	Running CLOSE (byte 1)
0x0006	6	Warning (Byte 1, collective signal 02)
0x0007	7	Fault (Byte 1, collective signal 03)
0x0008	8	Thermal fault (byte 2)
0x0009	9	Phase fault (byte 2)
0x000A	10	Selector sw. REMOTE (byte 2)
0x000B	11	Selector sw. LOCAL (byte 2)
0x000C	12	Limit switch OPEN (byte 2)
0x000D	13	Limit switch CLOSED (byte 2)
0x000E	14	Torque sw. OPEN (byte 2)
0x000F	15	Torque sw. CLOSED (byte 2)
0x0010 – 0x0017	16 to 23	Actual position high byte (position transmitter) – (byte 3)
0x0018 – 0x001F	24 to 31	Actual position low byte (position transmitter) – (byte 4)
0x0020	32	Not ready REMOTE (Byte 5, collective signal 04)
0x0021	33	Warning (Byte 5, collective signal 02)
0x0022	34	Fault (Byte 5, collective signal 03)
0x0023	35	NAMUR mainten. req. (Byte 5, collective signal 09)
0x0024	36	NAMUR out of spec. (Byte 5, collective signal 07)
0x0025	37	NAMUR funct. check (Byte 5, collective signal 08)
0x0026	38	NAMUR failure (Byte 5, collective signal 10)
0x0027	39	Device ok (Byte 5, collective signal 05)
0x0028	40	Operation pause active (byte 6)
0x0029	41	In intermediate pos. (byte 6)
0x002A	42	Start stepping mode (byte 6)
0x002B	43	—
0x002C	44	Actuator running (byte 6)
0x002D	45	Handwheel oper. (byte 6)
0x002E	46	Running REMOTE (byte 6)
0x002F	47	Running LOCAL (byte 6)

Offset (hexa-decimal)	Offset (decimal)	Contents (for details refer to <Description of the input data>)
0x0030	48	Intermediate pos. 1 (byte 7)
0x0031	49	Intermediate pos. 2 (byte 7)
0x0032	50	Intermediate pos. 3 (byte 7)
0x0033	51	Intermediate pos. 4 (byte 7)
0x0034	52	Intermediate pos. 5 (byte 7)
0x0035	53	Intermediate pos. 6 (byte 7)
0x0036	54	Intermediate pos. 7 (byte 7)
0x0037	55	Intermediate pos. 8 (byte 7)
0x0038	56	Input DIN 1 (byte 8)
0x0039	57	Input DIN 2 (byte 8)
0x003A	58	Input DIN 3 (byte 8)
0x003B	59	Input DIN 4 (byte 8)
0x003C	60	Input DIN 5 (byte 8)
0x003D	61	Input DIN 6 (byte 8)
0x003E	62	—
0x003F	63	—
0x0040 – 0x0047	64 – 71	Input AIN1 (high-byte) – (byte 9)
0x0048 – 0x004F	72 – 79	Input AIN1 (low-byte) – (byte 10)
0x0050 – 0x0057	80 – 87	Torque (high byte) – (byte 11)
0x0058 – 0x005F	88 – 95	Torque (low byte) – (byte 12)
0x0060	96	Wrong oper. cmd (byte 13)
0x0061	97	Sel. sw. not REMOTE (byte 13)
0x0062	98	Interlock active (byte 13)
0x0063	99	Local STOP (byte 13)
0x0064	100	EMCY stop active (byte 13)
0x0065	101	EMCY behav. active (byte 13)
0x0066	102	FailState fieldbus (byte 13)
0x0067	103	I/O interface (byte 13)
0x0068	104	—
0x0069	105	—
0x006A	106	SIL function active (byte 14)
0x006B	107	Disabled (byte 14)
0x006C	108	Interlock by-pass (byte 14)
0x006D	109	PVST active (byte 14)
0x006E	110	Service active (byte 14)
0x006F	111	Handwheel active (byte 14)
0x0070	112	Configuration error (byte 15)
0x0071	113	Mains quality (byte 15)
0x0072	114	Thermal fault (byte 15)
0x0073	115	Phase fault (byte 15)
0x0074	116	Torque fault OPEN (byte 15)
0x0075	117	Torque fault CLOSE (byte 15)
0x0076	118	Internal error (byte 15)
0x0077	119	Wrn no reaction (byte 15)
0x0078	120	— (reserved for further fault signals)
0x0079	121	— (reserved for further fault signals)
0x007A	122	— (reserved for further fault signals)
0x007B	123	— (reserved for further fault signals)
0x007C	124	— (reserved for further fault signals)
0x007D	125	— (reserved for further fault signals)
0x007E	126	Config. error REMOTE (byte 16)

Offset (hexa-decimal)	Offset (decimal)	Contents (for details refer to <Description of the input data>)
0x007F	127	Incorrect phase seq (byte 16)
0x0080 – 0x0083	128 – 131	— (reserved for further warnings)
0x0084	132	Torque wrn CLOSE (byte 17)
0x0085	133	Torque wrn OPEN (byte 17)
0x0086	134	SIL fault (byte 17)
0x0087	135	Wrn no reaction (byte 17)
0x0088	136	Wrn controls temp. (byte 18)
0x0089	137	— (reserved for further warnings)
0x008A	138	— (reserved for further warnings)
0x008B	139	24 V DC external (byte 18)
0x008C	140	— (reserved for further warnings)
0x008D	141	RTC voltage (byte 18)
0x008E	142	Time not set (byte 18)
0x008F	143	Config. warning (byte 18)
0x0090	144	— (reserved for further warnings)
0x0091	145	— (reserved for further warnings)
0x0092	146	Wrn input AIN 2 (byte 19)
0x0093	147	Wrn input AIN 1 (byte 19)
0x0094	148	Internal warning (byte 19)
0x0095	149	Wrn op.mode starts (byte 19)
0x0096	150	Wrn op.mode run time (byte 19)
0x0097	151	Op. time warning (byte 19)
0x0098	152	—
0x0099	153	—
0x009A	154	Wrn setpoint position (byte 20)
0x009B	155	PVST required (byte 20)
0x009C	156	— (reserved for further warnings)
0x009D	157	Failure behav. active (byte 20)
0x009E	158	PVST abort (byte 20)
0x009F	159	PVST fault (byte 20)
0x00A0 – 0x00A7	160 – 167	Input AIN2 (high-byte) – (byte 21)
0x00A8 – 0x00AF	168 – 175	Input AIN2 (low-byte) – (byte 22)
0x00B0 – 0x00B6	176 – 182	— (reserved for further Failure signals in accordance with NAMUR recommendation NE 107)
0x00B7	183	Fault (byte 23)
0x00B8	184	Mainten. mechanics
0x00B9	185	Mainten. seals
0x00BA	186	Mainten. lubricant
0x00BB	187	Mainten. contactors
0x00BC	188	Mainten. interval
0x00BD	189	— (reserved for further Maintenance required signals in accordance with NAMUR recommendation NE 107)
0x00BE	190	— (reserved for further Maintenance required signals in accordance with NAMUR recommendation NE 107)
0x00BF	191	— (reserved for further Maintenance required signals in accordance with NAMUR recommendation NE 107)
0x00C0 – 0x00C3	192 – 195	— (reserved for further warnings)
0x00C4	196	Torque wrn CLOSE (byte 25)
0x00C5	197	Torque wrn OPEN (byte 25)
0x00C6	198	SIL fault (Byte 25)[1)]
0x00C7	199	Wrn no reaction (byte 25)
0x00C8	200	Wrn controls temp. (byte 26)

Offset (hexa-decimal)	Offset (decimal)	Contents (for details refer to <Description of the input data>)
0x00C9	201	— (reserved for further Out of specification signals in accordance with NAMUR recommendation NE 107)
0x00CA	202	— (reserved for further Out of specification signals in accordance with NAMUR recommendation NE 107)
0x00CB	203	24 V DC external (byte 26)
0x00CC	204	— (reserved for further Out of specification signals in accordance with NAMUR recommendation NE 107)
0x00CD	205	RTC voltage (byte 26)
0x00CE	206	Time not set (byte 26)
0x00CF	207	Config. warning (byte 26)
0x00D0	208	— (reserved for further warnings)
0x00D1	209	— (reserved for further warnings)
0x00D2	210	Wrn input AIN 2 (byte 27)
0x00D3	211	Wrn input AIN 1 (byte 27)
0x00D4	212	Internal warning (byte 27)
0x00D5	213	Wrn op.mode starts (byte 27)
0x00D6	214	Wrn op.mode run time (byte 27)
0x00D7	215	Op. time warning (byte 27)
0x00D8	216	— (reserved for further Function check signals in accordance with NAMUR recommendation NE 107)
0x00D9	217	— (reserved for further Function check signals in accordance with NAMUR recommendation NE 107)
0x00DA	218	Wrn setpoint position (byte 28)
0x00DB	219	PVST required (byte 28)
0x00DC	220	— (reserved for further warnings)
0x00DD	221	Failure behav. active (byte 28)
0x00DE	222	PVST abort (byte 28)
0x00DF	223	PVST fault (byte 28)
0x00E0	224	Local STOP (byte 29)
0x00E1	225	Sel. sw. not REMOTE (byte 29)
0x00E2	226	Service active (byte 29)
0x00E3	227	Handwheel active (byte 29)
0x00E4	228	EMCY stop active (byte 29)
0x00E5	229	PVST active (byte 29)
0x00E6	230	— (reserved for further Function check signals in accordance with NAMUR recommendation NE 107)
0x00E7	231	— (reserved for further Function check signals in accordance with NAMUR recommendation NE 107)
0x00E8 – 0x00EF	232 – 239	— (reserved for further Function check signals in accordance with NAMUR recommendation NE 107)
0x00F0	240	Channel 1 active (byte 31)
0x00F1	241	Channel 2 active (byte 31)
0x00F2	242	Channel 1 DataEx (byte 31)
0x00F3	243	Channel 2 DataEx (byte 31)
0x00F4	244	Ch.1 FailState Fieldb. (byte 31)
0x00F5	245	Ch.2 FailState Fieldb. (byte 31)
0x00F6	246	Channel 1 activity (byte 31)
0x00F7	247	Channel 2 activity (byte 31)
0x00F8	248	Safe ESD (byte 32)[1)]
0x00F9	249	Safe Stop (byte 32)[1)]

Offset (hexa-decimal)	Offset (decimal)	Contents (for details refer to <Description of the input data>)
0x00FA	250	SIL fault (byte 32)[1)]
0x00FB	251	SIL function active (byte 32)[1)]
0x00FC – 0x0147	252 – 327	Reserve

1) The safety function indications via fieldbus are for information only and must not be used as part of a safety function. The digital I/O signals of the SIL module must be used for this purpose.

4.2. Output data – operation commands

The master (controls) can control the slave (actuator) via the process representation output.

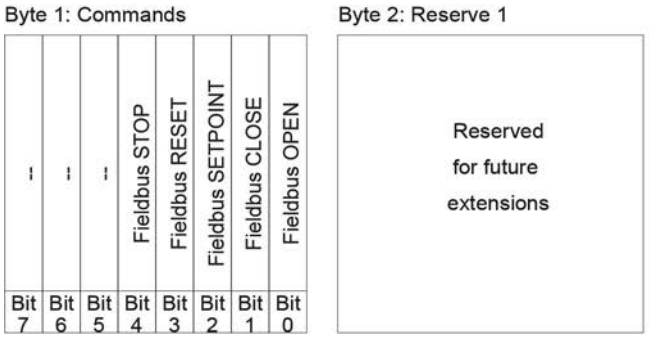
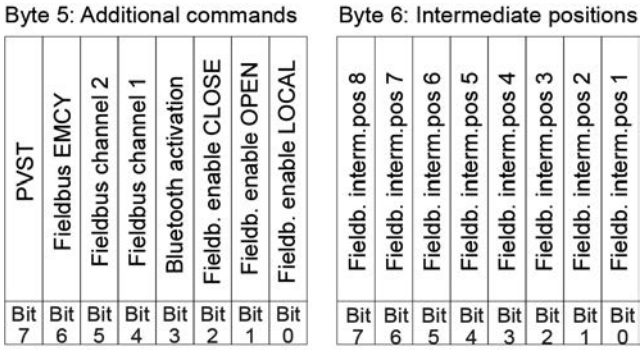
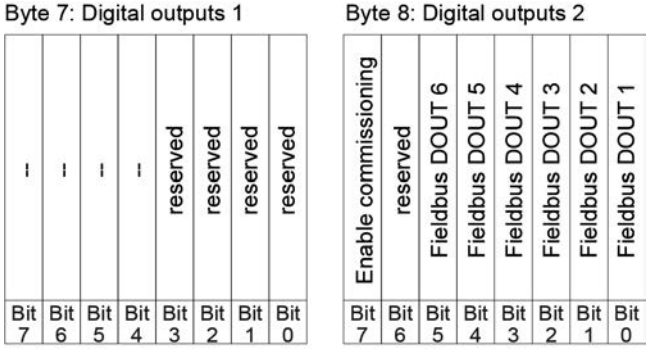
4.2.1. Transmitting or reading out operation commands from the actuator using register functions

Information

To perform remote operations, the selector switch must be in position **REMOTE** .

Functions to be used:

- Preset Single Register (06)
- Preset Multiple Register (16)
- Read Holding Register (03)

Offset (hexadecimal)	Offset (decimal)	Register contents
0x03E8	1000	
0x03E9	1001	Byte 3: Setpoint position/process setpoint high byte Byte 4: Setpoint position/process setpoint low byte
0x03EA	1002	
0x03EB	1003	
0x03EC	1004	Byte 9: Actual process value (high byte) – option Byte 10: Actual process value (low byte) – option
0x03ED	1005	Byte 11 output AOUT 1 (high byte) Byte 12: Output AOUT 1 (low byte)
0x03EE	1006	Byte 13 output AOUT 2 (high byte) Byte 14: Output AOUT 2 (low byte)
0x03EF – 0x03F4	1007 – 1012	Byte 15 to byte 26: Reserve

4.2.2. Description of the output data

Byte 1: Commands

Table 24: Byte 1: Commands

Bit	Designation (process representation)	Value	Description
0	Fieldbus OPEN	1	Operation command in direction OPEN.
		0	No command
1	Fieldbus CLOSE	1	Operation command in direction CLOSE.
		0	No command

Bit	Designation (process representation)	Value	Description
2	Fieldbus SETPOINT	1	Run to setpoint. Setpoint is provided via bytes 3 and 4. In combination with a process controller, this bit is used to select between process controller operation and OPEN - CLOSE operation.
		0	No command
3	Fieldbus RESET	1	Certain indications of the actuator can be reset using this command in selector switch position **REMOTE** via fieldbus (e.g. PTC tripping device and torque fault).
		0	No command
4	Not used		Fieldbus STOP.
5	—		No command (reserved)
6	—		No command (reserved)
7	—		No command (reserved)

Bits 0, 1, 2 = operation commands

Bits 0 – 2 are used to transmit operation commands to the actuator. Only one of these bits may be set to 1 at any given time. If several bits are set, no operation is performed and the following signal is given: Wrong oper. cmd

For operation commands via bit 2 (Fieldbus SETPOINT):

- If the setpoint is 0 per mil, the actuator runs to end position CLOSED; it runs to end position OPEN for 1000 per mil .
- If the limit of 1,000 is exceeded, the actuator completely runs to end position OPEN.
- To avoid placing too much strain on the actuator mechanics, reversion of direction is delayed. The default setting in the factory for the reversing prevention time is 300 ms.

Bits 4, 5, 6, 7

Bits 4 through 7 are not used and must be set to 0.

Byte 2: Reserve

The contents are reserved for future extensions.

Bytes 3 and 4: Setpoint position/process setpoint

Byte 3 = high byte, byte 4 = low byte.

The setpoint position is transmitted via bytes 3 and 4 (value: 0 – 1,000), using the position controller.

- The value 1,000 corresponds to the maximum setpoint, e.g. end position OPEN.
- The value 0 corresponds to the minimum setpoint, e.g. end position CLOSED.

As an alternative, the process setpoint can be transmitted via bytes 3 and 4 (value 0...1,000), using a process controller (option). Value 1,000 corresponds to the maximum process setpoint, value 0 to the minimum process setpoint.

Byte 5: Additional commands

Table 25: Byte 5: Additional commands

Bit	Designation (process representation)	Value	Description
0	Fieldb. enable LOCAL	1	Actuator operation via local controls enabled.
		0	Actuator operation via local controls disabled.
1	Fieldb. enable OPEN	1	Enabling operation command in direction OPEN
		0	Operation command in direction OPEN disabled.
2	Fieldb. enable CLOSE	1	Enables operation command in direction CLOSE
		0	Operation command in direction CLOSE disabled.

Bit	Designation (process representation)	Value	Description
3	BluetoothActivDigIn	1	Activation of Bluetooth interface.
		0	Activation of Bluetooth interface disabled.
4	Fieldbus channel 1	1	Initiate change-over to channel 1
		0	No operation command
5	Fieldbus channel 2	1	Initiate change-over to channel 2
		0	No operation command
6	Fieldbus EMCY	1	EMERGENCY signal, triggers EMERGENCY behaviour.
		0	No command
7	PVST	1	Start Partial Valve Stroke Test (functional test)
		0	No operation command

Byte 6: Intermediate positions

Byte 6 is used for coding operation commands. Thus, 8 intermediate positions can be directly selected via fieldbus commands. Hereby, the selected intermediate position is approached directly, without stopping in another intermediate position.

In this case, the actuator continues running until the selected intermediate position has been reached. Example: Operation from position 5 to 7 without stopping at position 6.

Table 26: Byte 6: Operation commands for intermediate positions

Value	Behaviour
0x01	Position 1 is approached selecting the shortest travel.
0x02	Position 2 is approached selecting the shortest travel.
0x04	Position 3 is approached selecting the shortest travel.
0x08	Position 4 is approached selecting the shortest travel.
0x10	Position 5 is approached selecting the shortest travel.
0x20	Position 6 is approached selecting the shortest travel.
0x40	Position 7 is approached selecting the shortest travel.
0x80	Position 8 is approached selecting the shortest travel.

For further information, please refer to the Manual (Operation and setting).

Byte 7: Digital outputs 1

The digital outputs Fieldbus DOUT 1 – DOUT 6 of the fieldbus interface can be used as commands for the output contacts. For this, the outputs of the output contacts have to be assigned with the signals Fieldbus DOUT 1 – Fieldbus DOUT 6.

Table 27: Byte 7: Digital outputs 1

Bit	Designation (process representation)	Value	Description
0	—		No command (reserved)
1	—		No command (reserved)
2	—		No command (reserved)
3	—		No command (reserved)
4	—		No command (reserved)
5	—		No command (reserved)
6	—		No command (reserved)
7	—		No command (reserved)

Byte 8: Digital outputs 2

Table 28: Byte 8: Digital outputs 2

Bit	Designation (process representation)	Value	Description
0	Fieldbus DOUT 1	1	Digital output 1 is activated.
		0	Output is deactivated.
1	Fieldbus DOUT 2	1	Digital output 2 is activated.
		0	Output is deactivated.
2	Fieldbus DOUT 3	1	Digital output 3 is activated.
		0	Output is deactivated.
3	Fieldbus DOUT 4	1	Digital output 4 is activated.
		0	Output is deactivated.
4	Fieldbus DOUT 5	1	Digital output 5 is activated.
		0	Output is deactivated.
5	Fieldbus DOUT 6	1	Digital output 6 is activated.
		0	Output is deactivated.
6	—		No command (reserved)
7	Enable commissioningn	1	Digital output 7 is activated.
		0	Output is deactivated.

Bytes 9 and 10: Actual process value

Byte 9 = high byte, byte 10 = low byte.

Byte 9 and byte 10 in combination with a process controller (option) can be used to transmit the actual process value.

Bytes 11 and 12: Fieldbus output AOUT 1

Byte 11 = high byte, byte 12 = low byte.

Bytes 11 and 12 can be used to send an analogue value to the actuator.

The value is transmitted in per mil (value: 0 – 1,000).

The outputs "Fieldbus output AOUT 1" and "Fieldbus output AOUT 2" can be used as output values via the analogue outputs. For this, the outputs of the analogue outputs have to be assigned with the signals Fieldbus AOUT 1 or Fieldbus AOUT 2.

Bytes 13 and 14: Fieldbus output AOUT 2

Byte 13 = high byte, byte 14 = low byte.

Bytes 13 and 14 can be used to send a second analogue value to the actuator.

The value is transmitted in per mil (value: 0 – 1,000).

Byte 15 to byte 26: Reserve

The contents are reserved for future extensions.

4.2.3. Transmitting operation commands from the actuator using Coil functions

Functions to be used:

- Force Single Coil (05)
- Force Multiple Coil (15)
- Read Coil Status (01)

Offset (hexa-decimal)	Offset (decimal)	Contents (for details refer to <Description of the output data>)
0x0000	0	Fieldbus OPEN (byte 1)
0x0001	1	Fieldbus CLOSE (byte 1)
0x0002	2	Fieldbus SETPOINT (Byte 1
0x0003	3	Fieldbus RESET (byte 1)
0x0004 – 0x000F	4 – 15	—
0x0010 – 0x0017	16 to 23	Setpoint position high byte (position transmitter) – (byte 3)
0x0018 – 0x001F	24 to 31	Setpoint position low byte (position transmitter) – (byte 4)
0x0020	32	Fieldb. enable LOCAL (byte 5)
0x0021	33	Fieldb. enable OPEN (byte 5)
0x0022	34	Fieldb. enable CLOSE (byte 5)
0x0023	35	—
0x0024	36	Fieldbus channel 1 (byte 5)
0x0025	37	Fieldbus channel 2 (byte 5)
0x0026	38	Fieldbus EMCY (byte 5)
0x0027	39	PVST (byte 5)
0x0028	40	Fieldb. interm. pos. 1 (byte 6)
0x0029	41	Reset self-retaining (byte 6)
0x002A	42	Doub. Cmd CW MPV (byte 6)
0x002B	43	Doub. Cmd CCW MPV (byte 6)
0x002C	44	Fieldb. interm. pos. 5 (byte 6)
0x002D	45	MWG hall sensor3 fail (byte 6)
0x002E	46	IE MWG hall sensor (byte 6)
0x002F	47	Fieldb. interm. pos. 8 (byte 6)
0x0030	48	—
0x0031	49	—
0x0032	50	—
0x0033	51	—
0x0034	52	—
0x0035	53	—
0x0036	54	—
0x0037	55	—
0x0038	56	—
0x0039	57	—
0x003A	58	Fieldbus DOUT 6 (byte 8)
0x003B	59	Fieldbus DOUT 5 (byte 8)
0x003C	60	Fieldbus DOUT 4 (byte 8)
0x003D	61	Fieldbus DOUT 3 (byte 8)
0x003E	62	Fieldbus DOUT 2 (byte 8)
0x003F	63	Fieldbus DOUT 1 (byte 8)
0x0040 – 0x0047	64 – 71	Actual process value (high byte) – (byte 9)
0x0048 – 0x004F	72 – 79	Actual process value (low byte) – (byte 10)
0x0050 – 0x0057	80 – 87	Fieldbus output AOUT 1 (high byte) – (byte 11)
0x0058 – 0x005F	88 – 95	Fieldbus output AOUT 1 (low byte) – (byte 12)
0x0060 – 0x0067	96 – 103	Fieldbus output AOUT 2 (high byte) – (byte 13)
0x0068 – 0x006F	104 – 111	Fieldbus output AOUT 2 (low byte) – (byte 14)
0x0070 – 0x00C7	112 – 199	—

5. Corrective action

5.1. Troubleshooting

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

Table 29: Troubleshooting table

			Causes and remedies
1.	Can the actuator be controlled via Modbus?	Yes	No fault
		No	→ Continue with 2
2.	Select menu: Diagnostics M0022		→ Continue with 3
3.	Select menu: for channel 1: Modbus MD1 M0241 for channel 2 (option): Modbus MD2 M0775	Channel 1 DataEx	Valid telegrams to the own address Modbus communication via channel 1 is ok. → Continue with 4
		Channel 2 DataEx	Valid telegrams to the own address Modbus communication via channel 2 is ok. → Continue with 4
		Channel 1 activity	Bus communication available on channel 1 Valid telegrams, however not sent to the own address Possible causes and remedies: • Incorrect slave address → Check slave address (MD1 slave address parameter) • Incorrect master configuration → Correct parameter data in master
		Channel 2 activity	Bus communication available on channel 2 Valid telegrams, however not sent to the own address Possible causes and remedies:
		Neither DataEx nor activity available	Possible causes and remedies: • Line interruption • Incorrect polarity • Master not available or switched off. → Check fieldbus wiring
4.	Operation via local controls possible?	Yes	Possible causes and remedies: • Master does not send an operation command. • Master sends wrong operation command. → Check program of DCS
		No	Possible causes and remedies: Faults such as torque, thermal or internal fault → Check logic board, motor control and motor. → Continue with 6

5.2. Diagnostics

Menu Diagnostics M0022 and the AUMA CDT software can be used to check the different states of the Modbus interface.

The <Information on Modbus 1> table shows the menus for the first Modbus interface.

In case a second, redundant Modbus interface is installed, this table may be used as well. In the menu, Modbus MD2 is displayed instead of Modbus MD1.

Table 30: Information on Modbus 1

Indication on display	Value and description
MD1 slave address M0412	Bus address (slave address)
Baud rate M0766	Baud rate
Channel 1 DataEx M0784	Channel 1 is in the data exchange state (DataEx).
Channel 1 activity M0767	Bus communication available on channel 1
Bus Message Count M0918	Number of valid messages received (including all addresses). Number of messages that the remote device has detected on the communications system since its last restart, clear counters operation, or power–up. Messages with bad CRC are not taken into account.

Indication on display	Value and description
Bus Com Err Count M0919	Number of messages with CRC or parity/block check/data loss error. Number of CRC errors recorded by the remote device since its last restart, clear counters operation, or power–up. In case of an error detected on the character level, (overrun, parity error), or in case of a message length < 3 bytes, the recipient is not able to perform the CRC test. In such cases, this counter is also incremented.
Slave Except Err Count M0920	Number of sent exceptions. Number of Modbus exceptions detected by the remote device since its last restart, clear counters operation, or power–up. It comprises also the error detected in broadcast messages even if an exception message is not returned in this case. Exception responses are described and listed in "MODBUS Application Protocol Specification" document.
Slave Message Count M0921	Number of messages received (including slave addresses). Number of messages addressed to the remote device, including broadcast messages, that the remote device has processed since its last restart, clearing of the diagnostic counters, or power-up.
Slave No Resp. Count M0922	Number of messages without response. Number of messages received by the remote device for which it returned no response (neither a normal response nor an exception response), since its last restart, clear counters operation, or power-up (number of broadcast messages received).
Slave NAK Count M0923	Number of messages answered with NAK. Number of messages addressed to the remote device for which it returned a Negative Acknowledge (NAK) exception response, since its last restart, clearing of the diagnostic counters, or power-up. Exception responses are described and listed in "MODBUS Application Protocol Specification" document.
Slave Busy Count M0924	Quantity of messages addressed to the remote device for which it returned a Slave Device Busy exception response, since the last reboot, the clearing of diagnostic counters or the power-up. Exception responses are described and listed in "MODBUS Application Protocol Specification" document.
Bus Char Overr Count M0925	Number of messages with data loss error. Quantity of messages addressed to the remote device that it could not be handled due to a character overrun condition, since its last restart, clearing of the diagnostic counters, or power-up. A character overrun is caused by data characters arriving at the port faster than they can be stored, or by the loss of a character due to a hardware fault.
Parity Error Count M0926	Number of parity errors

Table 31: Modbus details

Indication on display	Value and description
Channel 1 active	Modbus interface of channel 1 is used.
Channel 2 active	Modbus interface of channel 2 is used.

6. 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).

6.1. Modbus interface

Settings/programming the Modbus RTU interface	
Setting the Modbus RTU interface	Baud rate, parity and Modbus address are set via the display of actuator controls

General data of the Modbus RTU interface	
Communication protocol	Modbus RTU according to IEC 61158 and IEC 61784
Network topology	• Line (fieldbus) structure. When using repeaters, tree structures can also be implemented. • Coupling and uncoupling of devices during operation without affecting other devices is possible.
Transmission medium	Twisted, screened copper cable according to IEC 61158
Fieldbus interface	EIA-485 (RS-485)
Transmission rate/cable length	Redundant line topology: Baud rate (kbit/s) | Max. cable length (segment length) without repeater | Possible cable length with repeater (total network cable length) 9.6 – 115.2 | 1,200 m | approx. 10 km Redundant ring topology: Baud rate (kbit/s) | Max. cable length between actuators (without repeater) | Max. possible cable length of redundant loop 9.6 – 115.2 | 1,200 m | approx. 290 km
Device types	Modbus slave, e.g. devices with digital and/or analogue inputs/outputs such as actuators, sensors
Number of devices	32 devices in each segment without repeater, with repeaters expandable to 247
Fieldbus access	Polling between master and slaves (query response)
Supported Modbus functions (services)	01 Read Coil Status 02 Read Input Status 03 Read Holding Registers 04 Read Input Registers 05 Force Single Coil 15 (0FHex) Force Multiple Coils 06 Preset Single Register 16 (10Hex) Preset Multiple Registers 17 (11Hex) Report Slave ID 08 Diagnostics: • 00 00 Loopback • 00 10 (0AHex) Clear Counters and Diagnostic Register • 00 11 (0BHex) Return Bus Message Count • 00 12 (0CHex) Return Bus Communication Error Count • 00 13 (0DHex) Return Bus Exception Error Count • 00 14 (0EHex) Return Slave Message Count • 00 15 (0FHex) Return Slave No Response Count • 00 16 (10Hex) Return Slave NAK Count • 00 17 (11Hex) Return Slave Busy Count • 00 18 (12Hex) Return Character Overrun Count

Commands and signals of the Modbus RTU interface	
Process representation output (command signals)	OPEN, STOP, CLOSE, position setpoint, RESET, EMERGENCY operation command, enable LOCAL, Interlock OPEN/CLOSE
Process representation input (feedback signals)	• End positions OPEN, CLOSED • Actual position value • Actual torque value, requires MWG in actuator • Selector switch in position LOCAL/REMOTE • Running indication (directional) • Torque switches OPEN, CLOSED • Limit switches OPEN, CLOSED • Manual operation by handwheel or via local controls • Analogue (2) and digital (4) customer inputs
Process representation input (fault signals)	• Motor protection tripped • Torque switch tripped in mid-travel • One phase missing • Failure of analogue customer inputs
Behaviour on loss of communication	The behaviour of the actuator is programmable: • Stop in current position • Travel to end position OPEN or CLOSED • Travel to any intermediate position • Execute last received operation command

Index

AUMA Riester GmbH & Co. KG

P.O. Box 1362
DE 79373 Muellheim
Tel +49 7631 809 - 0
Fax +49 7631 809 - 1250
info@auma.com
www.auma.com

Y009.433/003/en/1.21