R67048.0002 - 2

Manual

Encoders with Modbus interface

pulses for automation

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1 Document

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2 General Information

Please read this document carefully before working with the product, mounting it or starting it up.

2.1 Target Group

The device may only be planned, mounted, commissioned and serviced by persons having the following qualifications and fulfilling the following conditions:

- Technical training.
- Briefing in the relevant safety guidelines.
- Constant access to this documentation.
- In case of electrical equipment for potentially explosive atmospheres, the specialized personnel needs knowledge about the ignition protection category concept.
- For facilities in potentially explosive atmospheres, the authorized person must comply with the applicable country-specific regulations.

2.2 Symbols used / Warnings and Safety instructions

⚠ DANGER	**Classification:** This symbol, together with the signal word **DANGER**, warns against immediately imminent threat to life and health of persons. The non-compliance with this safety instruction will lead to death or severe adverse health effects.
⚠ WARNING	**Classification:** This symbol, together with the signal word **WARNING**, warns against a potential danger to life and health of persons. The non-compliance with this safety instruction may lead to death or severe adverse health effects.
⚠ CAUTION	**Classification:** This symbol, together with the signal word **CAUTION**, warns against a potential danger for the health of persons. The non-compliance with this safety instruction may lead to slight or minor adverse health effects.
ATTENTION	**Classification:** The non-compliance with the **ATTENTION** note may lead to material damage.

NOTICE	**Classification:** Additional information relating to the operation of the product, and hints and recommendations for efficient and trouble-free operation.

3 Product Description

3.1 Technical Data Sendix F58xx

Sendix F58xx

The encoder Sendix F58 with the patented Intelligent Scan Technology™ is a high-resolution gearless optical multiturn encoder with 100 % insensitivity to magnetic interference.

Absolute encoder system	Singleturn with optical disk Multiturn with backup battery
Interface	Modbus protocol RTU
Communication	Default: 9600 bauds, 8 data bits, no parity, 1 stop bit
Display	LED
Interface	RS485 for Modbus
Type of connection	1 x or 2 x M12
Sensor	contactless optical interface
Singleturn resolution (MUR)	Max. 16 bits (default 16 bits) 65536 steps/per revolution
Multiturn resolution (NDR)	Max. 16 bits - 65536 revolutions
Total resolution (TMR)	Max. 32 bits (default 32 bits scaling disabled)
Supply voltage	10 … 30 V DC max. 80 mA
Temperature range	-40°C … +80°C

4 Installation

4.1 Electrical Installation

4.1.1 General Information for the Connection

ATTENTION	**Destruction of the device** Before connecting or disconnecting the signal cable, always disconnect the power supply and secure it against switching on again.
NOTICE	**General safety instructions** Make sure that the whole plant remains switched off during the electrical installation. • Make sure that the operating voltage is switched on or off simultaneously for the device and the downstream device.
NOTICE	**Traction relief** Always mount all cables with traction relief.
NOTICE	**Interference susceptibility** Proceed as follows: • Connect the shield to the device housing. • Comply with the maximum cable length for stub lines and for the total length of the bus network. • Check the maximum supply voltage on the device.
ATTENTION	**Wear of the memory module** Avoid too frequent writing of the EEPROM. It is used e.g. when setting a preset value. The memory module is designed for approximately 500,000 write cycles. If the maximum number of write cycles is exceeded, single memory areas may be damaged and errors may occur.

4.1.2 Information for EMC-Compliant Installation

Requirements for cables

- Use exclusively shielded twisted-pair cables to connect the device.
- Comply with the maximum permissible connection cables length.

EMC acc. to EN 61326-1	Criterion A The device operates trouble-free, user data transmission proceeds without disturbance, internally stored data and configurations remain preserved	Criterion B During a failure, a disturbed transmission of the user data is allowed, internally stored data and configurations remain preserved
Interference immunity	Is achieved with a shielded line	Is not achieved with a shielded line
	Class A Industrial environment The device has a radiation according to Class A	Class B Living area The device has a radiation according to Class B
Radiation	Is not achieved with a shielded line	Is achieved with a shielded line

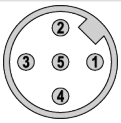
Shielding and equipotential bonding

- Apply the cable shield on a large contact area - ideally 360°. Use e. g. a shield terminal to this purpose.
- Pay attention to proper cable shield fastening.
- Preferably connect the shield on both sides with low impedance to the protective earth (PE), e.g.on the device and/or on the evaluation unit. In the event of potential differences, the shield must only be applied on one side.
- If shielding is not possible, appropriate filtering measures must be taken.
- If the protective earth should be connected to the shield on one side only, it must be made sure that no short-time overvoltages can appear on the signal and supply voltage lines.

Kübler offers a wide range of connection cables in various versions and lengths, see www.kuebler.com/connection technology.

Kübler offers various solutions for EMC-compliant installation, e.g. shield terminals for the electrical cabinet, see www.kuebler.com/accessories.

4.1.3 Terminal Assignment

Interface	Type of connection	M12 connector, 5-pole						Connector
			Bus IN					
6	E	Signal	+V	0V	D0	D1	TG	
		Pin	2	3	5	4	1	

+V: Supply voltage +V DC

0V: Ground GND (0V)

D0: non-inverted signal

D1: inverted signal

TG: Terminal Ground

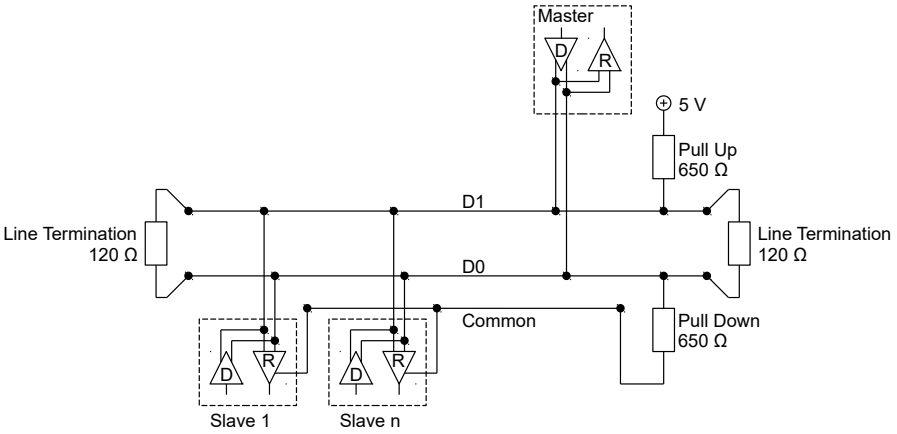
4.1.4 Network topology

Modbus is a 2-wire bus system in which all participants are connected in parallel (that is to say with short stub lines up to 30 cm). MODBUS uses serial lines based on an electrical "two-wire" interface. It is oriented on the EIA/TIA-RS485 standard.

The special RS485 transceiver can control up to 63 nodes with a transmission rate reaching 19.2 kBd. Thee address range (theoretical maximal number of network participants) is 0 … 247.

In order to prevent reflections, the bus must be terminated at each end with a 120 (or 121) ohm terminating resistor. This is necessary even in case of very short line lengths.

Termination at both ends of the main line.



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NOTICE	**Selection of the BUS termination**
	BUS termination can be configured by means of a register. A 120 ohm resistor can be connected to this purpose.

5 Commissioning and Operation

5.1 Function and Status LED

A 2-color LED signals the operating and error status of the Modbus.

Display	LED	Meaning
RUN		The RUN LED displays the current status of the Modbus sensor
ERROR		On in the event of a fault.

Display	LED	Meaning	Error cause	Addition
(All) LEDs off		No connection to the master	Data line interruption Wrong baud rate Interchanged data line No voltage	Observe the combination with the ERR LED. When the ERR LED is also off, ensure the voltage supply
RUN flashing about 1 ms		Device ready for operation		Communication is active
ERR off		Device operates error-free		
RUN flashing < 1 ms		Modbus transmission active	Combination with Bus state	RUN LED flashing green Transmission in progress
ERR flashing		Error	Modbus signaled a system error	Can also alternate with the green LED when transmission is in progress

5.2 Quick Start Guide

5.2.1 Changing the parameters

Modifying and reading device-specific parameters requires commands that are (can be) generated by means of the following function codes:

Function code (dec)	Function code (hex)	Name	Meaning
03	0x03	Read Holding Register	Reads the binary content of the holding registers (4XXXX references)
16	0x10	Preset Multiple Registers	Writes the binary content of the holding registers (4XXXX references)
17	0x11	Report Slave ID	Returns a description and device-specific information

The function codes can be sent to the device via a control or a parameterization software.

5.2.2 Not supported Modbus function codes

Code Decimal	Code Hexadecimal	Name
01	(0x01)	Read Coil Status
02	(0x02)	Read Input Status
04	(0x04)	Read Input Registers
05	(0x05)	Force Single Coil
06	(0x06)	Preset Single Register
07	(0x07)	Read Exception Status
11	(0x0B)	Fetch Comm Event Ctr
12	(0x0C)	Fetch Comm Event Log
15	(0x0F)	Force Multiple Coils
20	(0x14)	Read General Reference
21	(0x15)	Write General Reference
22	(0x16)	Mask Write 4X Register
23	(0x17)	Read/Write 4X Registers
24	(0x18)	Read FIFO Queue

5.2.3 Default settings

The default values are listed in the following table:

NOTICE	**Serial Number, Serial Update, Sensor Diagnosis**
	All additional holding registers have an additional functionality and are not intended for general use.

Register	Int. register	Data name	Sequence	Default
40257	256	Baud Rate	MSB	0x01
40258	257	Number Data	MSB	0x02
40259	258	Parity	MSB	0x01
40260	259	Stop Bits	MSB	0x01
40261	260	Comm Update	MSB	0x00
40262	261	Node Address	MSB	0x3F
40263	262	Node Update	MSB	0x00
40264	263	Preset Value	MSB	-
40265	264	Preset Value	LSB	-
40266	265	Preset Update	MSB	0x00
40267	266	Count Direct	MSB	0x02
40268	267	Count Update	MSB	0x00
40269	268	Termination	MSB	0x00
40270	269	Term Update	MSB	0x00

40271	270	Serial Number	MSB	-
40272	271	Serial Number	LSB	-
40273	272	Serial Update	MSB	0x00
40274	273	Sensor Diag	MSB	0x00
40275	274	Lower Limit	MSB	0x00
40276	275	Upper Limit	MSB	0x1C
40277	276	Compare Activ.	MSB	0x00
40278	277	MUR	MSB	0x0001
40279	278	MUR	LSB	0x0000
40280	279	TMR	MSB	0x1000
40281	280	TMR	LSB	0x0000
40282	281	Scaling Function	MSB	0x00
40283	282	Delay Prescaler	MSB	0x01

5.3 Protocol Features

5.3.1 Structure of the Modbus RTU frames

To carry out changes in the device, the respective Modbus registers must be addressed through the telegram. The basic structure of a Modbus telegram is shown below:

Start	Address	Function	Data	CRC	Stop
3.5 bytes	**1 byte**	1 byte	N x 8 bits	2 bytes	3.5 bytes

The data range has a different structure depending on whether the telegram is a query or a response and on the used function code.

In RTU mode, the messages start with silent interval of at least 3.5 characters.

According to the baud rate set in the network, this interval is easiest implemented as a multiple of the duration of a character.

The first field subsequently transmitted is the device address in the range of 01…0xF7 (247) (248-255 are reserved for Modbus). Characters permissible for all fields: hexadecimal 0–9, A–F.

The networked devices constantly monitor the network bus - also during the 'silent' intervals. When the first field (address field) is received, the sensor decodes it to determine whether the message is directed to it.

After the last transmitted character, an identical interval of at least 3.5 characters indicates the end of the message. A new message can start after this interval.

The complete message frame must be transmitted as a continuous data stream. In the event of a silent interval of more than 1.5 characters before the end of the frame, the receiver device erases the message and assumes that the following byte is the address of a new message.

Likewise, if a new message starts before the end of the silent interval of 3.5 characters, the receiver device considers this new message as the continuation of the previous message. This will trigger a fault, as the value in the final CRC field will not be valid for the combined messages.

5.3.2 Function codes

Read Holding Register (function code 0x03)

Request

	Address	Function	Data		CRC
Bytes	**1 byte**	1 byte	2 bytes	2 bytes	2 bytes
Description	Slave address (sensor)	Function code (Read holding register)	Address of the first requested register (e.g. register 40002)	Number of requested registers (e.g. 40002 to 40003)	For error detection
Example	0x3F	0x03	0x0001	0x0002	

Response

	Address	Function	Data			CRC
Bytes	**1 byte**	1 byte	1 byte	2 bytes	2 bytes	2 bytes
Description	Slave address (sensor)	Function code (Read holding register)	Number of the following data bytes (2 registers with each 2 bytes = 4 bytes)	Content of the register (e.g. register 40002)	Content of the register (e.g. 40002 to 40003)	For error detection
Example	0x3F	0x03	0x02			

Preset multiple registers (function code 0x10)

Request

	Address	Function	Data				CRC
Bytes	**1 byte**	1 byte	2 bytes	2 bytes	1 byte	2 bytes	2 bytes
Description	Slave address (sensor)	Function code (preset multiple registers)	Address of the first register to be written (e.g. register 40269)	Number of registers to be written	Number of the following data bytes (1 register with 2 bytes = 2 bytes)	Value for the register (e.g. register 40269)	For error detection
Example	0x3F	0x10	0x010C	0x0001	0x02		

Response

	Address	Function	Data		CRC
Bytes	**1 byte**	1 byte	2 bytes	2 bytes	2 bytes
Description	Slave address (sensor)	Function code (Read holding register)	Address of the first register to be written (e.g.register 40269)	Number of registers written	For error detection
Example	0x3F	0x10	0x010C	0x0001	

Report Slave ID (function code 0x11)

NOTICE	**Slave ID**
	Slave ID does not mean the node address of the sensor. In this case, the Slave ID identifies the sensor type. Function code 17 - Query of Device-Specific Information [▶ 22]

Request:

	Address	Function	CRC
Bytes	**1 byte**	1 byte	2 bytes
Description	Slave address (sensor)	Function code (preset multiple registers)	For error detection
Example	0x3F	0x11	

Response

	Address	Function	Data					CRC
Bytes	1 byte [1]	1 byte [2]	1 byte [3]	1 byte [4]	1 byte [5]	23 bytes [6]	2 bytes [7]	2 bytes [8]
Example	0x3F	0x11	0x1A	0x02	0xFF	0x46353836384D544B75656 26C657256322E3034525455		

1) Slave address (Sensor)
2) Function code (Read holding register)
3) Number of the following data bytes (generally 26 bytes)
4) Sensor slave ID
5) Status (e.g. ready for operation)
6) Slave version in the ASCII format (e.g. "F5868MTKueblerV2.04RTU")
7) Errors counter
8) For error detection

5.3.3 LRC check

In ASCII mode, the messages are subjected to an error check based on a longitudinal redundancy check.

The check calculation (LRC) follows the content of the message without the initial 'colon' and the two final CRLF characters. The LRC check takes place regardless of the parity check method used.

The LRC field has a one-byte length and contains a 8-bit binary value. The LRC value is calculated by the transmitter and attached to the message. On receipt of the message, the receiver calculates a LRC and compares this calculated value with the value contained in the LRC field. If both values are not equal, an error is triggered.

The LRC is formed by adding successive 8-bit blocks of the message. Possible carries are ignored. Then the two's complement of the result is formed. The calculation is performed with the bytes of the message, before the coding of every byte in the two ASCII characters that correspond to the hexadecimal representation of every nibble. It considers neither the 'colon' at the beginning of the message nor the two CRLF characters at its end.

5.3.4 Data Addresses

Modbus bases its data model on a series of tables with characteristic features. The four primary tables are:

Main tables	Object type	Type	Description
Discrete input	Single bit	Read-only	This data type can be provided by an I/O system
Coils	Single bit	Read-write	This data type can be modified by an application
Input register	16-bit word	Read-only	This data type can be provided by an I/O system
Read holding register	16-bit word	Read-write	This data type can be modified by an application

The distinctions between inputs and outputs and between bit-addressable and word-addressable data elements have no influence on the behavior of the application.

All data addresses in Modbus messages are zero-based.

- Holding register 40001 is addressed as Register 0001 in the data address field of the message. The function code field already defines a 'holding register' operation.
  Therefore reference '4XXXX' is implied.
- Holding register 40014 is addressed as register 0x0D (14 decimal).

5.4 Function code 03 - Reading the Holding Register

Read Holding Registers function code 03 (0x03)

Reads the binary content of the holding registers (4XXXX references) in the slave.

NOTICE	**Broadcast function**
	Broadcast is not supported

Register	Int. Reg.	Data name	Se-quence	Data type	Value	Default (hex)	Manda-tory
40002	1	POSITION UPPER VALUE	MSB	I16	Position value Bit 17-32	-	Yes
40003	2	POSITION LOWER VALUE	LSB	I16	Position value Bit 1-16	-	Yes
40004	3	REVERSE STATE	MSB	I16	Count direction 1 = CCW 2 = CW	0x02	Yes
40005	4	TERMINATION STATE	MSB	U16	Termination 0 = off 1 = on	0x00	Yes
40006	5	COMMISION. DIAG.	MSB	U16	Diagnosis / Error result 0 = no error	0x00	No
40007	6	COMPARE STATE	MSB	U16	0 = within 1 < lower limit 2 > upper limit	0x00	No
40008	7	BATTERY VOLTAGE	MSB	U16	Current battery voltage in VDC	3,50 … 3,65 (dec.)	No
40009	8	SENSOR TEM-PERATURE	MSB	U16	Current sensor temper-ature °C	-	No
40010	9	MEASURING UNITS (MUR)	MSB	U16	Measuring steps / revolution	0x0002	No
40011	10	MEASURING UNITS (MUR)	LSB	U16	Measuring steps / revolution	0x0000	No
40012	11	TOTAL MEASUR-ING RANGE	MSB	U16	Total measuring range	0x0002	No
40013	12	TOTAL MEASUR-ING RANGE	LSB	U16	Total measuring range	0x0000	No
40014	13	SCALING FUNCTION	MSB	F32	Scaling 0 = off 1 = on	0x00	No
40015	14	SERIAL NUMBER	MSB	U32	Serial number	-	No
40016	15	SERIAL NUMBER	LSB	U32	Format YYDDNNNNN	-	No
40017	16	FIRMWARE	MSB	U16	Firmware check sum	0xXXXX	No

Query

The query message contains the starting register and the number of registers to be read. The registers are addressed as from 0. Registers 1–16 are addressed as 0–15.

Example of a read query for registers 40108–40110 of the slave device:

QUERY

Field Name	Example (Hex)
Slave Address	11
Function	03
Starting Address Hi	00
Starting Address Lo	6B
No. of Points Hi	00
No. of Points Lo	03
Error Check (LRC or CRC)	—

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LRC calculation LRC check [▷ 16]

Response

The response message contains the register data, two bytes per register. The binary content is right-justified in every byte. In every register, the first byte contains the high-order bits and the second byte the low-order bits. The response is transmitted when the data is fully compiled.

Example of a response to the above read query:

RESPONSE

Field Name	Example (Hex)
Slave Address	11
Function	03
Byte Count	06
Data Hi (Register 40108)	02
Data Lo (Register 40108)	2B
Data Hi (Register 40109)	00
Data Lo (Register 40109)	00
Data Hi (Register 40110)	00
Data Lo (Register 40110)	64
Error Check (LRC or CRC)	—

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5.5 Function Code 16 - Writing the Holding Register

Write Holding Register function code 16 (0x10)

Function code 16 (0x10) allows modifying the parameters.

Writing of the values in a sequence of holding registers (references 4XXXX). In the case of a broadcast, this function sets the same register references in all connected slaves.

NOTICE	**This function takes precedence over the encoder memory protection state.**
	The programmed values remain valid in the registers during the whole duty cycle and some functions are immediately taken over. Other require restarting the device.
	The register values are saved in a non-volatile memory, regardless of whether they are programmed in the PLC logic or not.

Register	Int. register	Data name	Sequence	Description	Default (hex)	Restart required
40257	256	Baud Rate	MSB	1 = 9600 2 = 19200 3 = 38400 4 = 57600 5 = 115200	0x01	Yes
40258	257	Number Data	MSB	Number of data bits 2 = 8 bits	0x02	Yes
40259	258	Parity	MSB	Parity 1 = none 2 = even 3 = odd	0x01	Yes
40260	259	Stop Bits	MSB	Stop bits 1 = 1 bits 3 = 2 bits	0x01	Yes
40261	260	Comm Update	MSB	Communication update 1 = Carry out	0x00	Yes
40262	261	Node Address	MSB	Node ID 1 … 247 = 1 … 0xF7	0x3F	Yes
40263	262	Node Update	MSB	Node ID update 1 = Carry out	0x00	Yes
40264	263	Preset Value	MSB	Preset high word MSB	-	
40265	264	Preset Value	LSB	Preset low word LSB	-	
40266	265	Preset Update	MSB	Preset update 1 = Carry out	0x00	
40267	266	Count Direct	MSB	Counting direction 1 = CCW 2 = CW	0x02	
40268	267	Count Update	MSB	Count direction update 1 = Carry out	0x00	
40269	268	Termination	MSB	Modbus termination 0 = off 1 = on	0x00	
40270	269	Term Update	MSB	Termination update 1 = Carry out	0x00	
40271	270	Serial Number	MSB	Serial number high word	-	
40272	271	Serial Number	LSB	Serial number low word	-	

Register	Int. register	Data name	Sequence	Description	Default (hex)	Restart required
40273	272	Serial Update	MSB	Serial no. update 1 = Carry out	0x00	
40274	273	Sensor Diag	MSB	Sensor diagnosis (internal register value)	0x00	
40275	274	Lower Limit	MSB	Lower limit value	0x00	
40276	275	Upper Limit	MSB	Upper limit value	0x1C	
40277	276	Compare Activ.	MSB	Comparison 0 = no comparison 1 = active	0x00	
40278	277	MUR	MSB	Measuring units / revolution MSB word	0x0001	
40279	278	MUR	LSB	Measuring units / revolution LSB word	0x0000	
40280	279	TMR	MSB	Total measuring range MSB word	0x1000	
40281	280	TMR	LSB	Total measuring range LSB word	0x0000	
40282	281	Scaling Function	MSB	Scaling 0 = off 1 = on	0x00	
40283	282	Delay Prescaler	MSB	Delay after t3.5 (1…32 * t3.5)	0x01	

NOTICE	**Updating the register values**
	Holding register 40257 - 40263 require a switch off-switch on cycle.

NOTICE	**Plausibility check**
	All input values for communication and further functionalities are checked for plausibility. Exclusively the specified values are allowed. Other values trigger an error message.

Query

The query message contains the references of the registers to be set. The registers are addressed as from 0. Register 1 is addressed as 0.

Example of a query to set two registers beginning with 40002 in the slave device 17 (0x11) to 00 0A and 01 02 hex:

QUERY

Field Name	Example (Hex)
Slave Address	11
Function	10
Starting Address Hi	00
Starting Address Lo	01
No. of Registers Hi	00
No. of Registers Lo	02
Byte Count	04
Data Hi	00
Data Lo	0A
Data Hi	01
Data Lo	02
Error Check (LRC or CRC)	—

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Response

The normal response contains the slave address, the function code, the starting address and the number of registers set.

Example of a response to the above query:

RESPONSE

Field Name	Example (Hex)
Slave Address	11
Function	10
Starting Address Hi	00
Starting Address Lo	01
No. of Registers Hi	00
No. of Registers Lo	02
Error Check (LRC or CRC)	—

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5.6 Function code 17 - Query of Device-Specific Information

Report slave ID function code 17

NOTICE	Slave ID
	Slave ID DOES NOT mean the node address of the sensor. In this case, slave ID means the sensor type.

Description

Returns a description of the type (at the slave address) and other device-specific information.

NOTICE	Broadcast function
	Broadcast is not supported

Example

The ID and the state of the device with node ID 20 (0X14) are queried:

Command: 14 11 CE BC

QUERY

Field Name	Example (Hex)
Slave Address	11
Function	11
Error Check (LRC or CRC)	—

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Response

The format of a response is represented below. The data content depends on the respective sensor type. The data is visible below.

RESPONSE

Field Name	Contents
Slave Address	Echo of Slave Address
Function	11
Byte Count	Device Specific
Slave ID	Device Specific
Run Indicator Status	00 = OFF, FF = ON
Additional Data	Device Specific
. . .	
Error Check (LRC or CRC)	—

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Summary of the slave IDs:

1 = singleturn encoder

2 = multiturn encoder

Slave ID codes returned by the Kübler encoders in the first byte of the data field.

The Modbus encoder returns 31 bytes as described below:

Byte contents:	
1	Slave address
2	Function code
3	Byte length
4	Slave ID
5	Running indication status (0 = Modbus OFFline (diagnosis), 0xFF = Modbus ready for operation)
6 - 27	System information inclinometer type, company name, SW version (ASCII format) Example: For inclinometers: 02,FF, “IN88_MB_V103 IN88_V1.28” For encoders: „F5868MTKueblerV2.02MB“, or „F5868STKueblerV2.02MB“
28, 29	Errors counter
30, 31	CRC

5.7 Description of the Registers

5.7.1 Reading the Holding Register

5.7.1.1 Register 1 & 2 Position Value

Position values depending on the scaling set.

Singleturn resolution 16 bits	0 ... 0xFFFF (0...65535) CW
	0xFFFF … 0 CCW
Multiturn resolution 16 + 16 bits	0 … 2^32 CW
	2^32 … 0 CCW

Deterministic position delay	40µs
Position jitter	± 1µs
Total response delay for position values	40µs + response frame processing time
Estimated response delay for the position	100µs
Minimum cycle time for position update	2ms (timeout t3.5 + 300µs)

Practical calculation example:

Encoder speed: 1000 min^{-1}

Calculated position delay: 1000/60 sec. = 16.67 revolutions/second

Factor /100µs: 16.67 / 100 *10-6 = 0.001667

Total number of steps in 100µs with a 14-bit resolution 0.001667 * 16384 (14 bits) = 27 steps

Encoder speed: 100 min^{-1}

Total number of steps in 100µs with a 14-bit resolution 0.0001667 * 16384 (14 bits) = 3 steps

After the reading of the position value, the actual position has a deterministic delay that depends on the rotational speed of the encoder.

5.7.1.2 Register 3 Actual Reverse State

Permissible count direction values:

1 = counter-clockwise CCW

2 = clockwise CW

Estimated response delay for the count direction: 10µs + response frame processing time

Minimum cycle time for count direction update: 2ms

5.7.1.3 Register 4 Actual Bus Termination State

Permissible bus termination values:

Bus termination off = 0

Bus termination on = 1

Estimated response delay for the termination: 10µs + response frame processing time

Minimum cycle time for actual termination update: 2ms

5.7.1.4 Register 5 Actual Commissioning Diag State

Saved values: Actual result of the internal diagnosis test routines

COMM_NULL_ERR 0x0000

COMM_BATTERY_LOW 0x8001

COMM_INIT_FAULT 0x8002

COMM_ICLG_TEMP 0x8003

COMM_ICLG_OPTIC_FAIL 0x8004

COMM_FLASH_MODE 0x8005

Response delay after Diag execution command: 200µs

5.7.1.5 Register 6 Read Actual Compare State

Comparative values:

0 = within the values

1 < lower limit

2 > upper limit

Response delay after Compare execution command: 200µs

5.7.1.6 Register 7 Read Actual Battery Voltage of Encoder

Battery values: in volts DC

Default: 350 … 365 ⇒ 3.50 … 3.65 V DC

Singleturn: 0

Battery 1st warning level: 2,6 V DC

Battery critical level: 2,2 V DC

Singleturn value: 0

Update rate: 6 min.

5.7.1.7 Register 8 Read Actual Sensor Temperature

Sensor temperature values: in °C

Default: 25°C (ambient temperature)

Temperature range: -40°C … 80°C [-40°F … 176°F]

Critical temperature threshold: 100°C

Response delay after update rate: 60 sec.

5.7.1.8 Register 9 & 10 MUR - Measuring Steps per Revolution

Position values depending on the scale factor set.

MUR 16 bits:

0..0xFFFF (0 ...65535) CW

0xFFFF…0 CCW

Deterministic position delay: 40µs

Position jitter: +/- 1µs

Total response delay for position values: 40µs + response frame processing time

Estimated response delay for the position: 100µs

Minimum cycle time for position update: 2ms (timeout t3.5 + 300µs)

5.7.1.9 Registers 11 & 12 TMR - Total Measuring Range

Position values depending on the scaling set.

TMR 16+16 bits:

0 … 2^32 CW

2^32 … 0 CCW

Deterministic position delay: 40µs

Position jitter: +/- 1µs

Total response delay for position values: 40µs + response frame processing time

Estimated response delay for the position: 100µs

Minimum cycle time for position update: 2ms (timeout t3.5 + 300µs)

5.7.1.10 Register 13 Scaling Active State

Scaling values:

0 = scaling off

1 = scaling on

Estimated response delay for scaling: 10µs + response frame processing time

Minimum cycle time for scaling update: 2ms

5.7.1.11 Registers 14 & 15 Serial Number

Permitted values:

Actual serial number in the following format:

0xYYDDDNNNNN

0xYY year (2 lst figures)

0xDDD day of the year (1...365)

Low word serial number 0xNNNNN consecutive number 1…65535

Response delay after SN update execution command:
15 ms (to be determined) required for the saving process

5.7.1.12 Register 16 Firmware

Saved values: Actual checksum of the firmware version

Default: 0xXXXX

Response delay after Firmware execution command: 200µs

5.7.2 Writing the Holding Register

5.7.2.1 Register 256 - 259 Write Communication Parameters

After a communication update, all communication parameters will be taken over only after completion of a switch off/switch on cycle. The new values are saved, but they will be taken over only after a new switch-on cycle.

Singleturn parameters: 9600 bauds, 8 data bits, no parity, 1 stop bit

Multiturn parameters: 9600 bauds, 8 data bits, no parity, 2 stop bits

NOTICE	**No parity**
	2 stop bits are necessary for the no parity and 115 kb setting.

The values are taken over with Execute communication parameters (Register 40261).

Response delay after Comm update execution command:
15 ms required for the saving process

5.7.2.2 Register 261 Write Node ID

Valid node IDs are in the range 0x01…0xF7 (0x00 is reserved for the PLC, 248...255 are reserved).

The new node ID is taken over with Write Node ID Update (register 40263)..

After a node ID update, the new node ID will be taken over only after completion of a switch off/ switch on cycle.

5.7.2.3 Register 263 & 264 Write Position Preset Value

The actual position of the encoder is set to the programmed preset value immediately after a valid update command. This allows for example setting the encoder position to the position of the application. The range is checked after the transmission of the preset values. Allowed only when the encoder is standing still.

Preset range singleturn 0…65535 (16 bits)

Preset range multiturn 0…2^32 -1 (32 bits)

Preset delay: 100µs

Position check after preset: yes (internal)

The value is taken over with Write position preset update (register 40266).

Response delay after Preset update execution command:
20ms required for the saving process

5.7.2.4 Register 266 Write Count Direction Update

Permissible count direction values:

1 = counter-clockwise CCW

2 = clockwise CW

The value is taken over with Write count direction update (register 40268).

Response delay after Reverse update execution command:
15 ms required for the saving process

5.7.2.5 Register 268 Write Termination Modbus

The bus termination is configured per software through register 40269. When the line has been looped through, it must be terminated at the end of the last encoder between D0 and D1.

Permitted values: Termination off = 0, Termination on = 1

Default multiturn termination on = 1 (on)

The value is taken over with Write termination update (register 40270).

Response delay after Termination update execution command:
15 ms required for the saving process

5.7.2.6 Register 274 Write Lower Limit Value

The actual position of the encoder is compared with the programmed limit value immediately after a valid update command. This allows for example comparing the encoder position with the position of the application. The range is checked after the transmission of the preset values.

Lower preset value 0x0000 … 0xFFFF

Preset delay: 100µs

Position check after preset: yes (internal)

Response delay after Preset update execution command:
15 ms required for the saving process

5.7.2.7 Register 273 Sensor Diagnosis

Register 273 is used exclusively for the internal diagnosis of the sensor inside the encoder. In the event of a fault, it allows the manufacturer to analyze the encoder.

5.7.2.8 Register 275 Write Upper Limit Value

The actual position of the encoder is compared with the programmed limit value immediately after a valid update command. This allows for example comparing the encoder position with the position of the application. The range is checked after the transmission of the preset values.

Upper preset value 0x0000 … 0xFFFF

Preset delay: 100µs

Position check after preset: yes (internal)

Response delay after Preset update execution command:
15 ms required for the saving process

5.7.2.9 Register 276 Write Compare Update

Comparison active

0 = off

1 = on

Delay: 100µs

Position check after preset: yes (internal)

Response delay after Preset update execution command:
15 ms required for the saving process

5.7.2.10 Registers 277 & 278 Write MUR Value

The actual position of the encoder is compared with the programmed limit value immediately after a valid update command. This allows for example comparing the encoder position with the position of the application. The range is checked after the transmission of the preset values.

This parameter configures the desired resolution per revolution. The encoder then calculates internally the corresponding scaling. The calculated scaling MURF (by which the physical position value is multiplied) is determined according to the following formula.

MURF = Measuring steps per revolution (40278) = physical singleturn resolution (65536)

Values range: 1 … max. physical resolution (65536) 16 bits

Default setting: 65536 Multiturn

5.7.2.11 Registers 279 & 280 Write TMR Value

The actual position of the encoder is compared with the programmed limit value immediately after a valid update command. This allows for example comparing the encoder position with the position of the application. The range is checked after the transmission of the preset values.

This parameter configures the total number of singleturn and multiturn measuring steps. A factor is used for the maximum physical resolution This factor is always < 1. When reaching the defined number of measuring steps, the encoder resets itself back to zero (see Limitation).

Values range: TMR 1 … max. physical resolution (4294967296) 32 bits

Default setting: 33554432 (25 bits)

5.7.2.12 Register 281 Scaling Function

Scaling active

0 = off

1 = on, Default = off

Preset delay: 100µs

Position check after preset: yes (internal)

Response delay after Preset update execution command:
15 ms required for the saving process

5.7.2.13 Register 282 Write Delay Prescaler After Request From PLC

Permitted prescaler delay values 1 … 32

Preset delay:

1 = (1*t3.5) = 1750µs

2 = (2*t3.5) = 3.5ms

Max. delay 32 = (32*t3.5) = 56 ms for baud rate > 9600, 128 ms for baud rate 9600

Position check after preset: yes (internal)

Response delay after Preset update execution command:
15 ms required for the saving process

5.8 Modbus Exception Codes

Number	Code Name	Meaning
01	Illegal Function	The function code contained in the query does not correspond to a permitted action for the slave. If a Poll Program Complete command has been issued, this code indicates that this command has not been preceded by a program function.
02	Illegal Data Address	The data address contained in the query does not correspond to a permitted address for the slave.
03	Illegal Data Value	A value contained in the data field of the query is not permitted for the slave.
04	Slave Device Failure	Unrecoverable error while the slave tried to perform the required action.
05	Acknowledge	The slave accepted the query and is processing it, but it will require much time for this. This answer is intended to prevent a timeout error in the master. The master can then send a Poll Program Complete message to determine whether processing is finished.
06	Slave Device Busy	The slave is processing a program command that requires much time. The master must re-send the message later, when the slave will be free.
07	Negative Acknowledge	The slave cannot perform the programming functions. The master should request diagnosis or error information from the slave.
08	Memory Parity Error	The slave detected a parity error in the memory. The master can repeat the request. Servicing may however be necessary for the slave device.
10	Gateway Path Unavailable	Specialized for Modbus gateways. Indicates a wrong gateway configuration.
11	Gateway Target Device Failed to Respond	Specialized for Modbus gateways. Is sent when the slave does not answer.

5.9 Examples

5.9.1 Scaling Setting Example

Proceed as follows to parameterize the scaling (MUR/TMR):

Step	Register	Value	Note
Parameterizing MUR	277 + 278	0x0000 / 0x0FFF	for e.g. 4096 / 12 bits per revolution
Parameterizing TMR	279 + 280	0x01FF / 0xFFFF	for e.g. 33554432 / 25 bits total resolution
Scaling Function enable	281	0x01	on

Scaling only affects the position after writing register 267 (Update Direction).

The written registers can be read back immediately through the READ registers. No update command is required.

In particular the following commands are required (node address is default 36):

Parameterizing MUR

Address	Function	Data				
1 byte	1 byte	2 bytes	2 bytes	1 byte	2 bytes	2 bytes
		Address of the first register	Number of registers	Number of bytes to be written	Data re-gister 40278	Data register 40279
3F	**10**	**0115**	**0002**	**04**	**0000**	**0FFF**

Parameterizing TMR

Address	Function	Data				
1 byte	1 byte	2 bytes	2 bytes	1 byte	2 bytes	2 bytes
		Address of the first register	Number of registers	Number of bytes to be written	Data re-gister 40278	Data register 40279
3F	**10**	**0117**	**0002**	**04**	**01FF**	**FFFF**

Scaling Function enable

Address	Function	Data			
1 byte	1 byte	2 bytes	2 bytes	1 byte	2 bytes
		Address of the first register	Number of registers	Number of bytes to be written	Data register 40278
3F	**10**	**0119**	**0001**	**02**	**0001**

5.9.2 Count Direction Change Example

Proceed as follows to change the count direction:

Count direction parameterizing	266	0x02	CCW
Update Count Direction	267	0x01	Perform the update

Count direction parameterizing

Address	Function	Data			
1 byte	1 byte	2 bytes	2 bytes	1 byte	2 bytes
		Address of the first register	Number of registers	Number of bytes to be written	Data register 40278
3F	**10**	**010A**	**0001**	**02**	**0002**

Update Count Direction

Address	Function	Data			
1 byte	1 byte	2 bytes	2 bytes	1 byte	2 bytes
		Address of the first register	Number of registers	Number of bytes to be written	Data register 40278
3F	**10**	**010B**	**0001**	**02**	**0001**

5.9.3 Preset Setting Example

Proceed as follows to parameterize a preset value 0:

Step	Register	Value	Note
Position Preset Value	263 + 264	0x0000 / 0x0000	0 = Preset value
Position Preset Value Update	265	0x01	1 = Carry out

Position Preset Value

Address	Function	Data				
1 byte	1 byte	2 bytes	2 bytes	1 byte	2 bytes	2 bytes
		Address of the first register	Number of registers	Number of bytes to be written	Data register 40264	Data register 40265
3F	**10**	**0107**	**0002**	**04**	**0000**	**0000**

Position Preset Value Update

Address	Function	Data			
1 byte	1 byte	2 bytes	2 bytes	1 byte	2 bytes
		Address of the first register	Number of registers	Number of bytes to be written	Data register 40267
3F	**10**	**0109**	**0001**	**02**	**0001**

6 Maintenance

In harsh environments, we recommend regular inspections for firm seating and possible damages at the device. Repair work may only be carried out by the manufacturer, see chapter Contact [▷ 37].

Prior to the work

- Switch off the power supply and secure it against switching on again.
- Then disconnect the power supply lines physically.
- Remove operating and auxiliary materials and remaining processing materials from the measuring system.

7 Annex

7.1 Decimal / Hexadecimal conversion table

Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
0	*0*	51	*33*	102	*66*	153	*99*	204	*CC*
1	*1*	52	*34*	103	*67*	154	*9A*	205	*CD*
2	*2*	53	*35*	104	*68*	155	*9B*	206	*CE*
3	*3*	54	*36*	105	*69*	156	*9C*	207	*CF*
4	*4*	55	*37*	106	*6A*	157	*9D*	208	*D0*
5	*5*	56	*38*	107	*6B*	158	*9E*	209	*D1*
6	*6*	57	*39*	108	*6C*	159	*9F*	210	*D2*
7	*7*	58	*3A*	109	*6D*	160	*A0*	211	*D3*
8	*8*	59	*3B*	110	*6E*	161	*A1*	212	*D4*
9	*9*	60	*3C*	111	*6F*	162	*A2*	213	*D5*
10	*0A*	61	*3D*	112	*70*	163	*A3*	214	*D6*
11	*0B*	62	*3E*	113	*71*	164	*A4*	215	*D7*
12	*0C*	63	*3F*	114	*72*	165	*A5*	216	*D8*
13	*0D*	64	*40*	115	*73*	166	*A6*	217	*D9*
14	*0E*	65	*41*	116	*74*	167	*A7*	218	*DA*
15	*0F*	66	*42*	117	*75*	168	*A8*	219	*DB*
16	*10*	67	*43*	118	*76*	169	*A9*	220	*DC*
17	*11*	68	*44*	119	*77*	170	*AA*	221	*DD*
18	*12*	69	*45*	120	*78*	171	*AB*	222	*DE*
19	*13*	70	*46*	121	*79*	172	*AC*	223	*DF*
20	*14*	71	*47*	122	*7A*	173	*AD*	224	*E0*
21	*15*	72	*48*	123	*7B*	174	*AE*	225	*E1*
22	*16*	73	*49*	124	*7C*	175	*AF*	226	*E2*
23	*17*	74	*4A*	125	*7D*	176	*B0*	227	*E3*
24	*18*	75	*4B*	126	*7E*	177	*B1*	228	*E4*
25	*19*	76	*4C*	127	*7F*	178	*B2*	229	*E5*
26	*1A*	77	*4D*	128	*80*	179	*B3*	230	*E6*
27	*1B*	78	*4E*	129	*81*	180	*B4*	231	*E7*
28	*1C*	79	*4F*	130	*82*	181	*B5*	232	*E8*
29	*1D*	80	*50*	131	*83*	182	*B6*	233	*E9*
30	*1E*	81	*51*	132	*84*	183	*B7*	234	*EA*

Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
31	*1F*	82	*52*	133	*85*	184	*B8*	235	*EB*
32	*20*	83	*53*	134	*86*	185	*B9*	236	*EC*
33	*21*	84	*54*	135	*87*	186	*BA*	237	*ED*
34	*22*	85	*55*	136	*88*	187	*BB*	238	*EE*
35	*23*	86	*56*	137	*89*	188	*BC*	239	*EF*
36	*24*	87	*57*	138	*8A*	189	*BD*	240	*F0*
37	*25*	88	*58*	139	*8B*	190	*BE*	241	*F1*
38	*26*	89	*59*	140	*8C*	191	*BF*	242	*F2*
39	*27*	90	*5A*	141	*8D*	192	*C0*	243	*F3*
40	*28*	91	*5B*	142	*8E*	193	*C1*	244	*F4*
41	*29*	92	*5C*	143	*8F*	194	*C2*	245	*F5*
42	*2A*	93	*5D*	144	*90*	195	*C3*	246	*F6*
43	*2B*	94	*5E*	145	*91*	196	*C4*	247	*F7*
44	*2C*	95	*5F*	146	*92*	197	*C5*	248	*F8*
45	*2D*	96	*60*	147	*93*	198	*C6*	249	*F9*
46	*2E*	97	*61*	148	*94*	199	*C7*	250	*FA*
47	*2F*	98	*62*	149	*95*	200	*C8*	251	*FB*
48	*30*	99	*63*	150	*96*	201	*C9*	252	*FC*
49	*31*	100	*64*	151	*97*	202	*CA*	253	*FD*
50	*32*	101	*65*	152	*98*	203	*CB*	254	*FE*
								255	*FF*

8 Contact

You want to contact us:

Technical support

Kübler's worldwide applications team is available on site all over the world for technical advice, analysis or installation support.

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Repair service / RMA form

In case of returns, please package the product sufficiently and attach the completed "Returns form".

www.kuebler.com/rma

Please send your return to the address below.

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Glossary

CRC

Cyclic Redundancy Check

CRLF

Carriage Return - Line Feed

ERR

Error

HEX

Hexadecimal

LRC

Longitudinal Redundancy Check

LSB

Least Significant Bit

MSB

Most Significant Bit

PDU

Protocol Data Unit

RTU

Remote Terminal Unit

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