

Data sheet STAWDG generation 2

(STAWDG = SingleTurn-AbsolutWertDrehGeber,
the German for single-turn absolute value rotary encoder)

Data sheet revision: 1.4

Article number	Plug connector	Interface
05442020	Mate-N-Lok compatible plug connector	RS485
05442021	RJ45 plug connector	RS485 and analogue output

Rotary encoders are an important link between mechanics and control electronics in automation. They detect angles and positions of shafts. The single-turn absolute value rotary encoder assigns each position within one revolution to a coded absolute position value. From this, the speed and acceleration of the shaft can be calculated for controlling applications.



Article number: 05442020



Article number: 05442021

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1 Technical data

1.1 General information

Angle detection range:	360° (single-turn)
Physical resolution:	0.0879°/step (12-bit = 4096 steps over 360°)
Nominal number of cycles:	1,000,000 cycles
Maximum rotational speed:	160°/s
Maximum current consumption:	< 50 mA
Time until ready for operation:	< 50 ms
Temperature range:	
5 V to 11 V:	-20 to +80 °C
11V to 24:	-20 to +70 °C
Protection class:	IP20
Safety level:	Performance Level C cat. 2 according to EN13849-1
Safety level of software:	Class B (EN60730-1 / EN 60335-1)
MTTF	see chapter 1.2 or 1.3 as dependent on operating mode
DC	>= 90.0%
CCF	68 (according to point method EN ISO 13849-1 Annex F)
Classification of emitted interference:	Group 1 class B device according to EN 61326-1 / EN 55011:2016
Classification of immunity:	For use in industrial electromagnetic environment (Table 2 from EN 61326-1)

Note: For the immunity tests, cable lengths <30 m were assumed.

Note on accuracy in the application:

The encoder is mainly intended for applications that require a high repeatability and only a lower absolute accuracy.

The final accuracy is largely based on the eccentricity of the encoder and mechanical shaft arrangement. It is therefore massively dependent on the tolerances of the final setup.

1.2 RS485 operation (article number: 05442020 and article number: 05442021)

Input voltage for RS485 operation (U _v):	5 to 24 V
Value range for RS485 operation:	0...8191 for 0...360°
Update rate for RS485 operation:	312.5 Hz
Detected angle change for RS485 operation:	<= 0.1°
Angular accuracy over one revolution for RS485 operation:	0.9° (or 20 digits)
Repeatability for RS485 operation:	better than +/-0.2°
Maximum deviation in digits for repetition: (0.2 ° corresponds to 4.55 digits in with 8192 digits /360°)	less than +/- 4 bits
Note: This applies with an unchanged mechanical arrangement.	

MTTF value: 109.9 years

1.3 Analogue operation (only article number: 05442021)

Input voltage for analogue operation (U _v):	12.5 to 24 V
Value range for Analog1:	1...10 V for 0...360°
Value range for Analog2:	10...1 V for 0...360°
Update rate for analogue operation:	100 Hz
Detected angle change for analogue operation:	<= 0.85°
Angular accuracy over one revolution for analogue operation:	better than +/- 1°
Repeatability for analogue operation:	better than +/- 1°
Resolution for analogue operation:	0.85°

MTTF value: 108.8 years

Note: Mapping the angle of 360° to the range of 9 V corresponds to a value change of 25 mV/°. A higher resolution, as is to be realised with digital transmission via RS485, is not considered appropriate in view of the analogue transmission.

1.4 Dimensioning

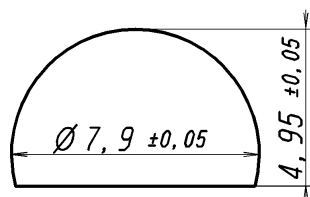
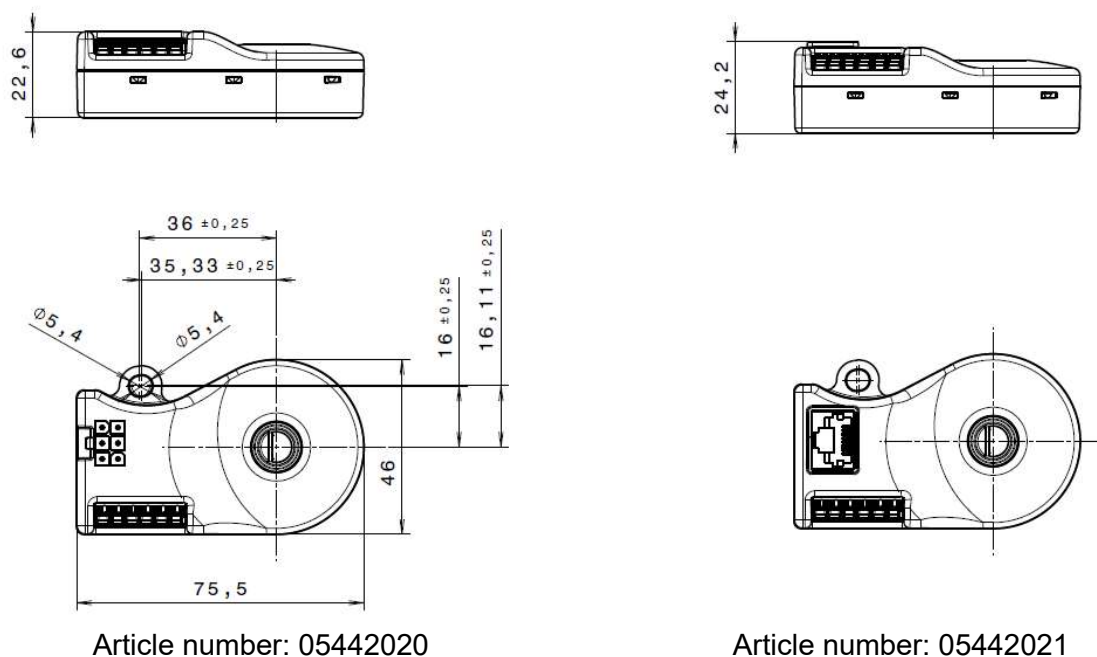


Figure 1: Dimensioning of the article variants

Notes:

- Concentricity tolerance of shaft according to DIN ISO 1101: Maximum 0.1 mm
- Forces in axial direction on the STAWDG: Not permitted
- Fastening of STAWDG with M4 flat head screw according to DIN ISO 1580 and washer according to DIN EN ISO 7089 recommended

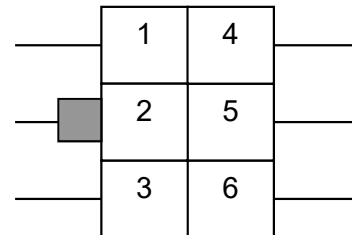
2 Connections

2.1 Article number: 05442020

Connection via a separate cable.

Assignment of Mate-N-Lok compatible:

Mate-N-Lok compatible	Designation
1	Safety chain input
2	RS485 B
3	GND
4	RS485 A
5	Safety chain output
6	Uv



2.2 Article number: 05442021

The use of standard patch cables is possible but not mandatory. A twisted pair cable for the RS485 signals A and B is strongly recommended.

Assignment of RJ45:

RJ45 contact	Designation	Wire pair
1	Safety chain input	Pair 3
2	Safety chain output	
3	GND	Pair 2
4	RS485 A	Pair 1
5	RS485 B	
6	Uv	Pair 2
7	Analog1: 1..10 V	Pair 4
8	Analog2: 10..1 V	

U_v can be reduced to 5 V_{DC} if the RS485 interface is used exclusively.

When using the analogue interfaces, at least 12.5 V_{DC} must be made available. If the input voltage is too low, the analogue signals are set together to ≤ 0.75V as an error message.

2.3 Clamping range of safety chain article number: 05442020 and article number: 05442021

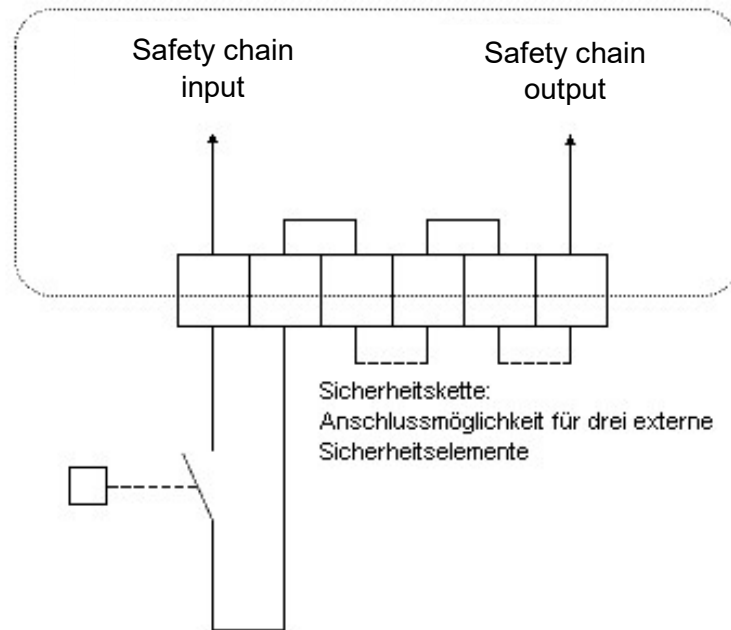


Figure 2: Terminal strip bar for safety chain

Note: The six-pole terminal strip is a pure terminal area for wiring the safety chain. The status of the individual elements cannot be queried via RS485 communication.

2.4 Installation instructions

- Installation in a voltage-free state.
- Observe the connection assignment (incorrect connection may result in destruction).
- Connection via a separate cable.
- Moving parts of the sensor system must not be greased or oiled.

3 RS485 interface (article number: 05442020 and article number: 05442021)

Interface settings

Operating mode: Half-duplex
Start bit: 1
Data bit: 8
Stop bit: 1
Parity: Even

Supported baud rates*:

- 9,600 bps
- 19,200 bps
- 38,400 bps
- 57,600 bps

*with automatic detection and fixation after the first valid request
Baud rate determination starts at 38,400 bps

4 Analogue interface (only article number: 05442021)

At the "Analogue 1" output, the angle is mapped with a voltage of 25 mV/° to the voltage range 1...10V and at the "Analogue 2" output to the voltage range 10...1V, i.e. in the opposite direction.

$$U_1 = 1V + \alpha * 0.025V/^\circ \quad \text{where } \alpha = \text{set angle in } ^\circ$$

$$U_2 = 10V - \alpha * 0.025V/^\circ \quad \text{where } \alpha = \text{set angle in } ^\circ$$

The two analogue signals are designed in opposite directions so that a safety check can take place at the receiver. In the event of a detected internal error in the encoder, both channels are set to $\leq 0.75V$ simultaneously as an error message.

$$\text{Error state: } U_1, U_2 \leq 0.75V$$

The input resistance of the receiver should be as high as possible. It should never fall below a minimum value of 10k Ω per analogue voltage signal.

5 STAWDG communication protocols

The encoder supports various communication protocols. In order to avoid overlapping of the telegram contents, an automatic protocol lock is implemented from firmware version 02.13. After the first valid telegram of a supported protocol, both the protocol type and the baud rate are then frozen until the supply voltage is switched off. The encoder then only responds to telegrams of the associated protocol. After the first valid telegram, the baud rate or protocol can therefore only be changed by switching on the supply voltage again.

5.1 Protocol article number: 05442020 and article number: 05442021 (generation 2)

In order to ensure faultless communication when changing between send and receive mode of the RS485, the response telegram is delayed in a defined way.

The pause time between request and response telegram is at least 60µs for a "quick response" request. For a "slow response" request, the delay time is extended to at least 150µs.

5.1.1 Value telegrams

5.1.1.1 Request telegrams

Byte 1	Byte 2	Byte 3	Byte 4	Description
Address	Telegram length in bytes	Command code	XOR checksum	
0xXX	0x04	0xB1	0xXX	Absolute value request: Falling values with clockwise rotation
0xXX	0x04	0xB2	0xXX	Absolute value request: Increasing values with clockwise rotation
0xXX	0x04	0xB4	0xXX	Absolute value request with delay: Falling values with clockwise rotation
0xXX	0x04	0xB5	0xXX	Absolute value request with delay: Increasing values with clockwise rotation

When using the default address 0xAA				
Byte 1	Byte 2	Byte 3	Byte 4	Description
Default address = 0xAA	Telegram length in bytes	Command code	XOR checksum	
0xAA	0x04	0xB1	0x1F	Absolute value request: Falling values with clockwise rotation
0xAA	0x04	0xB2	0x1C	Absolute value request: Increasing values with clockwise rotation
0xAA	0x04	0xB4	0x1A	Absolute value request with delay: Falling values with clockwise rotation
0xAA	0x04	0xB5	0x1B	Absolute value request with delay: Increasing values with clockwise rotation

5.1.1.2 Response telegram

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Description
Address (Default = 0xAA)	Telegram length in bytes	Request identifier	Data H	Data L	XOR checksum	
0xXX	0x06	0xB1 / 0xB4	0xXX	0xXX	0xXX	Absolute value response: Falling values with clockwise rotation*
0xXX	0x06	0xB2 / 0xB5	0xXX	0xXX	0xXX	Absolute value response: Increasing values with clockwise rotation*

*The angle is mapped in the value range of 0...8191 digits with 0.0439° / digit.

Values >= 8192 are to be defined as an error state.

Byte 1	Byte 2	Byte 3	Byte 4	Description
Default address = 0xAA	Telegram length in bytes	Command code	XOR checksum	
0xXX	0x04	0xXX*	0xXX	Error telegram response

* Byte 3 can assume the following values:

0xF1	Supply voltage outside permissible limits
0xF2	Mechanical error in the sensor system

5.1.2 Parameterisation and data

Basically, the commands for parameterisation and data are only available under the standard address 0xAA.

5.1.2.1 Read access for serial number

Request:

Byte 1	Byte 2	Byte 3	Byte 4	Description
Address	Telegram length in bytes	Command code	XOR checksum	
0xAA	0x04	0xD4	0x7A	Requests the serial number

Response:

Byte 1	Byte 2	Byte 3	Byte 4 - 7	Byte 8	Description
Address	Telegram length in bytes	Command code	Serial number as 32 bit unsigned integer	XOR checksum	
0xAA	0x08	0xD4	0XXXXXXXX	0XX	Returns the stored serial number

5.1.2.2 Read access for firmware version

Request:

Byte 1	Byte 2	Byte 3	Byte 4	Description
Address	Telegram length in bytes	Command code	XOR checksum	
0xAA	0x04	0xD5	0x7B	Requests the firmware version

Response:

Byte 1	Byte 2	Byte 3	Byte 4 - 7	Byte 8	Description
Address	Telegram length in bytes	Command code	Firmware version as 4 bytes hexadecimal	XOR checksum	
0xAA	0x08	0xD5	0XXXXXXXX	0XX	Response to firmware version request

5.1.2.3 Write access for RS485 address for value telegrams

A change to the RS485 address only affects the value telegrams.

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Description
Address	Telegram length in bytes	Command code	New address	XOR checksum	
0xAA	0x05	0xD1	0xFF	0xFF	Change to RS485 address for value telegrams

5.1.3 Checksum calculation

The XOR checksum is used to protect the telegram content. As an example, a code example for calculating the checksum in programming language C is shown here:

```
uint8_t CalcXorChecksum (uint8_t * data, uint16_t length)
{
    uint8_t cs = 0;

    for(uint16_t i = 0; i < length; i++)
    {
        cs = cs ^ data[i];
    }
    return cs;
}
```

5.2 Compatibility mode STAWDG article number: 05442000 (generation 1)

5.2.1 Value telegrams

5.2.1.1 Request telegrams

Byte 1 High Nibble: Address of recipient

Byte 1 Low Nibble: Number of bytes of the entire telegram

Byte 2: Command code

In order to ensure faultless communication when changing between send and receive mode of the RS485, the response telegram is delayed in a defined way. The pause time between request and response telegram is at least 60 μ s for a fast response and at least 150 μ s for a slow response.

Request telegram, fast response

Byte 1		Byte 2	Description
High Nibble: Address	Low Nibble: Telegram length	Command code	
0xA2		0xB0	Installation location: Falling values with clockwise rotation
0xA2		0xB3	Installation location: Increasing values with clockwise rotation

Request telegram, delayed response

Byte 1		Byte 2	Description
High Nibble: Address	Low Nibble: Telegram length	Command code	
0xA2		0xB1	Installation location: Falling values with clockwise rotation
0xA2		0xB4	Installation location: Increasing values with clockwise rotation

5.2.1.2 Response telegrams for both request types

Byte 1 High Nibble: Address nibble 0xA

Byte 1 Low Nibble: Number of bytes of the entire telegram, fixed 3

Byte 2: Data high

Byte 3: Data low

The angle is mapped in the value range of 0...8191 digits with 0.0439° / digit.

Values >= 8192 are to be defined as an error state.

Response telegram

Byte 1		Byte 2	Byte 3	Description
High Nibble: Address	Low Nibble: Telegram length	Data H	Data L	
0xA3		0xFF	0xFF	Position data 0...8191
0xA3		0xFA	0xFA	Potentiometer mechanically defective
0xA3		0xFB	0xFB	Supply voltage error

6 Standards

Directive 2014/30/EU - Electromagnetic Compatibility (EMC)

Harmonised standards used

EN ISO 13849-1:2015	Safety of machinery - Safety-related parts of control systems - Part 1: General principles of design
EN ISO 13849-2:2012	Safety of machinery - Safety-related parts of control systems Part 2: Validation
EN 60335-1:2012+A1:2014 Annex R	Safety of household and similar electrical appliances - Part 1: General requirements
EN 61326-1:2013	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements

Standards applied for environmental audits

EN 60068-2-6:2008-02	Vibration
EN 60068-2-78:2001-10 / replaces EN 60068-2-3	Damp heat, steady state
DIN EN 60068-2-14:2010-04	Change in temperature test Na size (200 cycles)
DIN EN 60068-2-27:2010-02	Continuous shock test under the following conditions <ul style="list-style-type: none"> • Shock type: Half-sine • Acceleration: 25 g • Shock duration: 6 ms • Direction: x-, y- and z-axis • Number of shocks: 4,000 per direction

EMC tests according to EN 61326-1:2013 if applicable

EN 55011	Emitted interference
EN 61000-4-2	Electrostatic discharge (ESD)
EN 61000-4-3	Electromagnetic fields
EN 61000-4-4	Fast transients
EN 61000-4-5	Surge voltages
EN 61000-4-6	Conducted HF signals
EN 61000-4-8	Power-frequency magnetic fields
EN 61000-4-11	Voltage dip