Singleturn sin/cos rotary encoder

ENA58PL-H12DS5-0013SS2-RAA

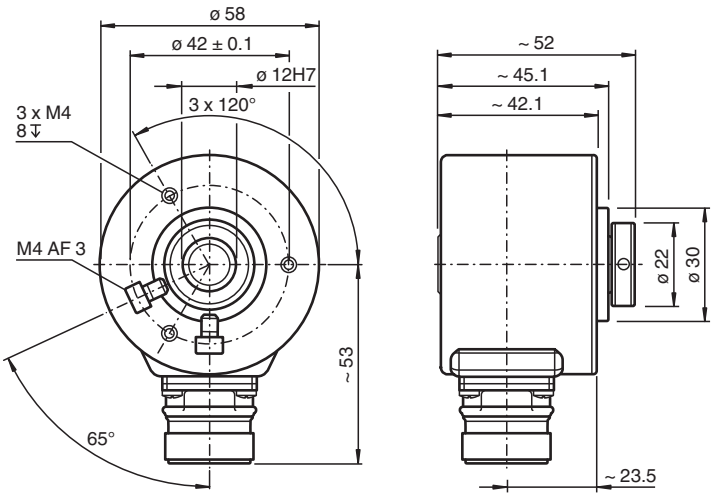
- Industrial standard housing Ø58 mm
- Suitable for SIL2/PId applications
- Absolute value data from SSI interface
- 13 Bit singleturn
- Incremental signals from sin/cos output

Function

This singleturn sin/cos rotary encoder transmits a position value corresponding to the shaft setting via the SSI interface (Synchronous Serial Interface). In addition to the postion values also sin/cos incremental signals are transmitted. Hearby a real time control of e. g. a motor is ensured.
The control module sends a clock bundle to the rotary encoder to obtain the position data. The rotary encoder then sends the position data synchronous to the cycles of the control module.
It is possible to select the following items with function inputs

- the counting direction and
- the zero-set function (preset value)

Dimensions



Technical Data

General specifications		
Detection type		photoelectric sampling
Device type		Singleturn absolute rotary encoder with incremental output (sin/cos)
Functional safety related parameters		
Safety Integrity Level (SIL)		SIL 2
Performance level (PL)		PL d
$MTTF_d$		1000 a
Mission Time (T_M)		20 a
PFH_d		4.6 E-10

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Technical Data

L_{10}		70 E+9 at 1.5 rpm
Diagnostic Coverage (DC)		99.7 %
Electrical specifications		
Operating voltage	U_B	24 V DC ± 25 %
No-load supply current	I_0	max. 100 mA
Time delay before availability	t_v	< 250 ms
Output code		Gray code
Code course (counting direction)		cw ascending (clockwise rotation, code course ascending)
Interface		
Interface type		SSI + incremental track (sin/cos)
Monoflop time		≤ 15 µs
Resolution		
Single turn		13 Bit
Overall resolution		13 Bit
Transfer rate		max. 500 kBit/s
Standard conformity		RS 422
Input 1		
Input type		Selection of counting direction (cw/ccw)
Signal voltage		
High		4.5 ... 24 V
Low		0 ... 2 V
Input current		< 6 mA
Switch-on delay		< 20 ms
Input 2		
Input type		zero-set (PRESET 1)
Signal voltage		
High		4.5 ... 24 V
Low		0 ... 2 V
Input current		< 6 mA
Signal duration		min. 10 ms
Switch-on delay		< 20 ms
Output		
Output type		sine / cosine
Pulses		2048
Amplitude		1 V_{ss} ± 10 %
Load current		max. per channel 10 mA , conditionally short-circuit proof (not with U_b), reverse polarity protected
Output frequency		max. 200 kHz (3 dB limit)
Connection		
Connector		type 9416L (M23), 12-pin
Standard conformity		
Degree of protection		DIN EN 60529, IP65
Climatic testing		DIN EN 60068-2-3, no moisture condensation
Salt spray test		DIN EN 60068-2-52 , 672 h
Emitted interference		EN IEC 61000-6-4:2019
Noise immunity		EN IEC 61000-6-2:2019
Shock resistance		DIN EN 60068-2-27, 100 *g*, 6 ms
Vibration resistance		DIN EN 60068-2-6, 10 *g*, 10 ... 2000 Hz
Functional safety		IEC/EN 61508:2010 EN 62061/A2:2015 EN 61326-3-1:2008 EN 61800-5-2:2016 Suitable up to SIL 2, PL d, see leaflet.
Approvals and certificates		
TÜV approval		Cert. no. Z10 17 03 68273 002

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Technical Data

Ambient conditions		
Operating temperature		-40 ... 85 °C (-40 ... 185 °F)
Storage temperature		-40 ... 85 °C (-40 ... 185 °F)
Mechanical specifications		
Material		
Housing		3.2315 aluminum
Flange		3.2315 aluminum
Shaft		Stainless steel 1.4404 / AISI 316L
Mass		approx. 220 g
Rotational speed		max. 10 min $^{-1}$
Moment of inertia		≤ 80 gcm^2
Starting torque		< 10 Ncm
Shaft load		
Radial offset		max. 0.04 mm
Dimensions		
Length		52 mm
Diameter		58 mm

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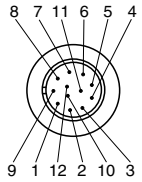
Connection

Signal	Connector 9416L, 12-pin	Explanation
GND (encoder)	1	Power supply
U_b (encoder)	2	Power supply
Clock (+)	3	Positive cycle line
Clock (-)	4	Negative cycle line
Data (+)	5	Positive transmission data
Data (-)	6	Negative transmission data
Preset	7	Zero-setting input
V/R	8	Input for selection of counting direction
A / Cos	9	Cosinus signal
$\overline{A}$ / $\overline{Cos}$	10	Inverted cosinus signal
B / Sin	11	Sinus signal
$\overline{B}$ / $\overline{Sin}$	12	Inverted sinus signal
		

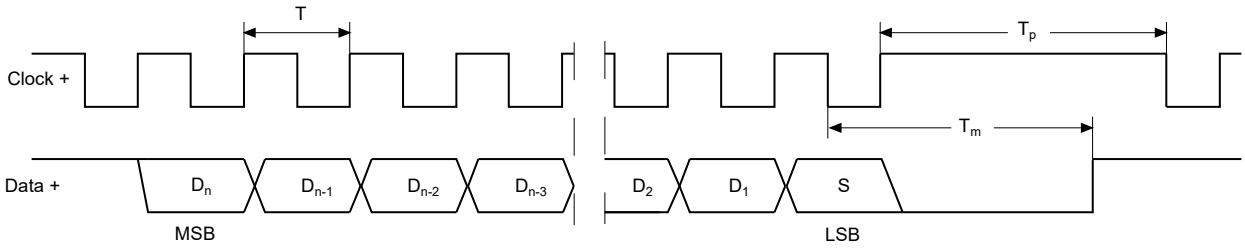
Interface

Description

The Synchronous Serial Interface was specially developed for transferring the output data of an absolute encoder to a control device. The control module sends a clock bundle and the absolute encoder responds with the position value.

Thus only 4 lines are required for the clock and data, no matter what the resolution of the rotary encoder is. The RS 422 interface is optically isolated from the power supply.

SSI signal course Standard



D_1, ..., D_n:	Position data	T = 1/f:	Duration of period of clock signal ≤ 1 MHz
S:	Special bit	T_m:	Monoflop time
MSB:	Most significant bit	T_p:	Clock pause ≥ monoflop time ($T_p \geq T_m$)
LSB:	Least significant bit		

SSI output format Standard

- At idle status signal lines "Data +" and "Clock +" are at high level (5 V).
- The first time the clock signal switches from high to low, the data transfer in which the current information (position data (D_n) and special bit (S)) is stored in the encoder is introduced.
- The highest order bit (MSB) is applied to the serial data output of the encoder with the first rising pulse edge.
- The next successive lower order bit is transferred with each following rising pulse edge.
- After the lowest order bit (LSB) has been transferred the data line switches to low until the monoflop time T_m has expired.
- No subsequent data transfer can be started until the data line switches to high again or the time for the clock pause T_p has expired.
- After the clock sequence is complete, the monoflop time T_m is triggered with the last falling pulse edge.
- The monoflop time T_m determines the lowest transmission frequency.

SSI output format ring slide operation (multiple transmission)

- In ring slide operation, multiple transmission of the same data word over the SSI interface makes it possible to offer the possibility of detecting transmission errors.

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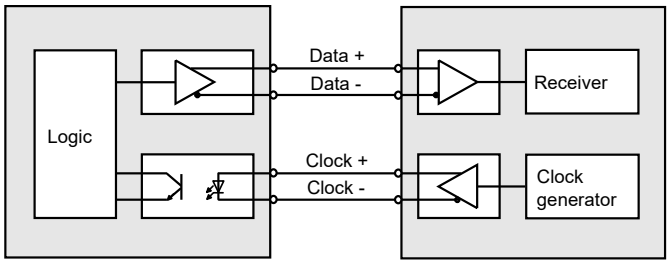
- In multiple transmission, 13 bits are transferred per data word in standard format.
- If the clock change is not interrupted after the last falling pulse edge, ring slide operation automatically becomes active. This means that the information that was stored at the time of the first clock change is generated again.
- After the first transmission, the 26th pulse controls data repetition. If the 26th pulse follows after an amount of time greater than the monoflop time T_m, a new current data word will be transmitted with the following pulses.

If the pulse line is exchanged, the data word is generated offset.
Ring slide operation is possible up to max. 13 bits.

Block diagram

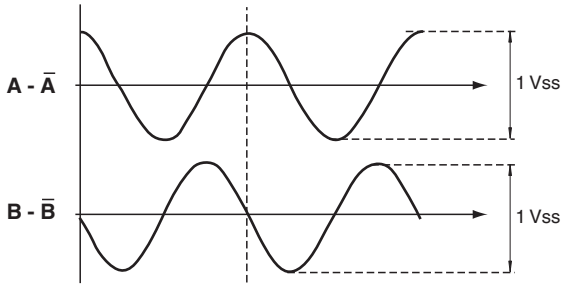


Line length

Line length in m	Baudrate in kHz
< 50	< 400

Operation

Signal outputs



mesuré en mode différence

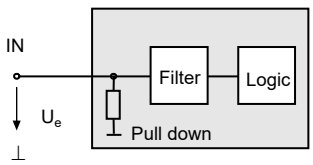
$0.5 \leq \sin^2 + \cos^2 \leq 1.5$
THD < 10 % (0 ... 200 kHz)

↻ cw - flange view

Configuration

Inputs

The selection of the counting direction input (cw/ccw) and the zero-set input (PRESET 1) are activated with 1-level.



Additional Information

Description

The rotary encoder ENA58PL is an electrical apparatus that converts rotation into electrical signals.

Functional safety

The rotary encoder has a safety function that correctly angles the shaft via an incremental and absolute output. The precision of the incremental safety function is 12 bits in the case of a signal delay of 1 ms, while the accuracy of 11-bit absolute safety function is 100 ms in the case of a signal delay. The safety function is available after an on delay of a maximum of 250 ms.

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Diagnostic options were implemented to ensure the correct safety function. Failure of the safety function is indicated by the following effects to be monitored during operation:

- $\sin^2 + \cos^2 \neq 1$ with a detection threshold of 0.5 … 1.5
- No SSI communication such as a constant level of SSI data and/or $\overline{\text{SSI data}}$ (stuck at behavior).
- Absolute value not plausible relative to the incremental value with regard to the direction of rotation, rotational speed, zero point position.

Reliability data

The rotary encoder is intended to determine the blade angle of a rotor blade in wind turbines with a high demand rate. In the event of device failure, the safety function is out of operation. In such cases, the user shall ensure the appropriate measures are taken.

- SIL2/PI d
- Device type B
- Overall error rate 171 FIT
- Safe failure fraction (SFF): > 99%
- Diagnostic coverage (DC): > 99%
- MTBF: 464a
- $MTTF_d$: > 1000a
- PFH: 4.60×10^{-10} 1/h

The specified values were determined based on the standards SN29500 and IEC62061 and apply for an operating time of up to 20 years at a maximum operating altitude of 3200 m. The device is subject to mechanical wear and tear. Mechanical considerations were not part of the TÜV SÜD certification.

The nominal service life of the device is set to $L_{10} = 70 \times 10^9$ revolutions at a rotational speed of 1.5 rpm.

The failure rates of other devices in the safety loop are also included in the calculation.

Required diagnostic capabilities in the user's control interface:

- $\sin^2 + \cos^2 = 1$ monitoring
- Plausibility check of incremental versus absolute value
  - cyclic querying of absolute value & incremental value (the sampling rate has to be selected in such a way, that in case of a detected malfunction there is sufficient time for reaction prior to entering a dangerous condition)
  - Direction of rotation
  - Rotational speed
  - Zero point position

Commissioning, installation, special conditions

The device must not be opened. The manufacturer data sheets and all laws and guidelines applicable for the use or the intended purpose must be observed.

The mechanical and electrical values (e.g., ambient temperature, rotational speed, mechanical load, max. supply voltage, etc.) of the acquired apparatus must not exceed the permitted values set out by the manufacturer.

The rated voltage of the apparatus is 24 volts and may be exceeded by a maximum of 25%. The rated voltage should only briefly be exceeded in order to ensure the lasting technical operation of the apparatus. Longer–lasting interferences that cause the rated voltage to be exceeded must be suppressed through appropriate measures on the part of the operator. In case of a fault, the supply voltage must also not exceed 60 volts and must be limited to 1 amp by a fuse.

The owner must ensure a slip-free connection of the apparatus to the drive. In addition, the bolts of the clamping ring for clamping the rotary encoder shaft on the drive shaft are to be tightened with a torque of 2.5 Nm, with a suitable thread-locking fluid for protection against loosening. Likewise, the screws for mounting the torque rest are to be tightened with a torque of 2.2 Nm and secured with a thread-locking fluid.

The apparatus must be protected from excessive heat due to mechanical or electrical overloads and also from strong electromagnetic fields. The sensor must not be mechanically damaged. The rotary encoder connection lines must be protected against tensile loads and torsional stress.

Impermissible electrostatic charging of the metal housing parts must be avoided. Hazardous electrostatic charging of metal housing parts can be prevented by grounding or integration into equipotential bonding, whereby very small metal-housing parts (e.g., screws) need not be considered.

Repair and maintenance

No maintenance work is required on ENA58PL rotary encoders. Regular adjustment or similar is not required. No changes are permitted to be made. Only the manufacturer may perform repair work.

Recommended receiver circuit for sine/cosine signals

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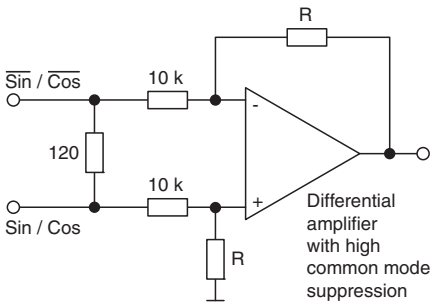

It is important to ensure that the load current does not exceed 10 mA at the output connection. The rotary encoder outputs are short-circuit proof.

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