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DATA SHEET
ABSOLUTE ROTARY ENCODER
CANOPEN SAFETY

Main Features

- Compact and heavy-duty industrial design
- Interface: CANopen / CANopen safety
- Housing: 25 mm ∅, 58 mm ∅
- Solid shaft: 6 mm ∅,10 mm ∅, flattened 21 mm with two M5 thread
- Resolution max. 4096 steps per revolution (12 Bit)
- Single-Turn
- Redundant 2 axis Hall – IC for position measurement

Software Features Non Safety

- Emergency Messages
- Heartbeat
- LSS for baud rate and node setting
- SDO for baud rate and node setting

Software Features Safety

- Direction of rotation (complement)
- Resolution per Revolution
- Total Resolution
- Preset value
- Position via SRDO-CP according to EN 50325-5 with specific protocol modification

Mechanical Structure

- Aluminium flange
- Zinc-Nickel-plated steel housing
- Stainless steel shaft
- Optional: Stainless steel flange
- Precision ball bearings with sealing or cover rings

Electrical Features

- Polarity inversion protection
- Over-voltage-peak protection
- CANopen and CANopen Safety interface with specific protocol modification

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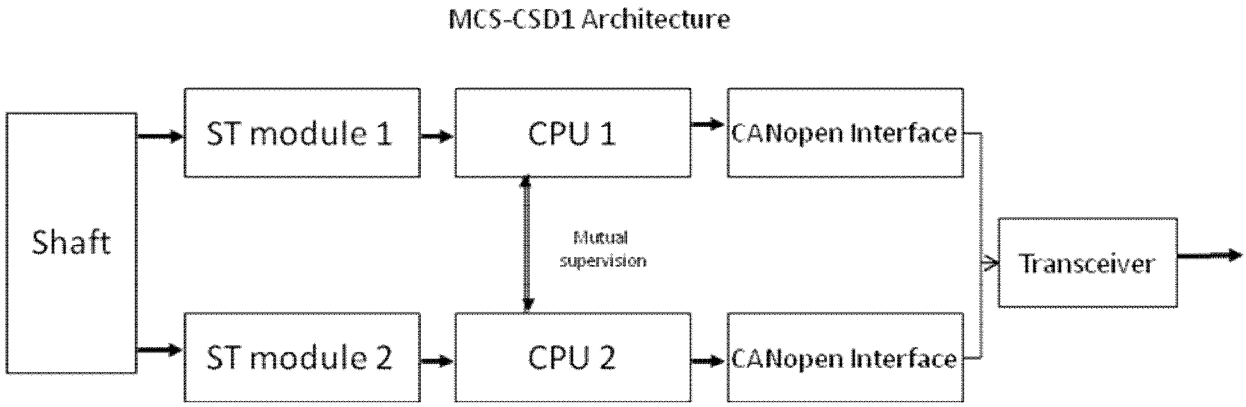
CANOPEN SAFETY

Function Principle



For safety-related applications this encoders shall be used in combination with a safety-related master (PLC). This PLC shall compare the position values of both channels to each other and on deviations greater than 1 % of the measuring range the PLC shall transit the machine into inherent safe state.

The encoder is built up by the following parts:

- Shaft is containing a magnet for position measurement. High mechanical load is achieved with double ball bearings.
- ST (Single-Turn) module to measure the resolution per revolution by a redundant Hall sensor element.
- CPU module is needed for signal conditioning and CANopen, CANopen Safety stack handling.
- CANopen interface: Fieldbus controller for CAN network
- Transceiver is transmitting and receiving messages from CANopen Interface 1 and 2.

As shown in the block diagram above the encoder is built up redundant in. A microcontroller (CPU) reads in the position value from a HALL sensor and transmits via a full CAN controller and one transceiver the information to the CANopen safety network. So only one CAN interface to the outer CAN network is needed. Regarding communication protocol standards CANopen and CANopen Safety with protocol modification is supported whereby both can be used at the same time.

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DATA SHEET
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CANOPEN SAFETY

General Description

Safety Integrity Level (EN 62061) Performance Level (EN ISO 13849-1) Safety Category (EN ISO 13849-1)	SIL CL 2 PL d Cat 3
MTTF (EN ISO 13849-1)	597 years
$MTTF_d$ (EN ISO 13849-1)	568 years
DC_{avg} (EN ISO 13849-1)	88.0 %
Intended Time of Usage (EN 62061)	20 years
PFH_d(EN 62061)	$4.5*10^{-9}$ 1/h; <1% of SIL 2 limit
PFD_{avg}(EN 62061)	$3.9*10^{-4}$; 4% of SIL 2 limit
SFF (EN 62061)	0.935
Logical Architecture	Redundant design
Physical Architecture	Redundant design
Internal Safety cycle	10 ms
Certification	Conducted by TUV Rheinland

Technical Data

Electrical Data

Interface	CANopen safety according to CiA EN 50325-5 with specific protocol modification, CANopen according to CiA DS-301, Transceiver according to ISO 11898 Transceiver protected against voltage level up to 24V DC
Transmission rate	max. 1 MBaud
Device addressing	Programmable via SDO telegrams or LSS following to CiA DS 305 with specific modifications. Address lines for setting offset for master and slave node number. Address lines protected against voltage level up to 35V DC and polarity inversion.
Supply voltage	9 – 35 V DC (absolute limits including voltage peaks) Only to subsequent electronics whose power supplies comply with EN 50178 (protective low voltage, PELV or SELV) or battery powered.
Current consumption	Singleturn: max. 80 mA with 9 V DC, max. 30 mA with 30 V DC
Power consumption	max. 0.8 Watt Single-Turn version
EMC	Emission: EN 61000-6-4, EN50121-3-2, EN 61000-6-3
	Immunity: EN61000-6-2, EN50121-3-2, EN61326-3-2

DATA SHEET
ABSOLUTE ROTARY ENCODER
CANOPEN SAFETY

Mechanical Data

Housing	Zinc-Nickel-plated steel housing, optional stainless steel
Lifetime	Dependent on shaft version and shaft loading – refer to table
Max. shaft loading	Axial 40 N, radial 50 N for flange version PF6 Axial 40 N, radial 110 N for flange version YF1 Axial 100 N, radial 250 N for flange version PPK
Inertia of rotor	≤ 30 gcm^2
Friction torque	≤ 3 Ncm (without shaft sealing)
RPM (continuous operation)	Singleturn: max. 6,000 RPM (non-safety application) max. 166 RPM (safety application)
Shock (EN 60068-2-27)	≤ 100 g (half sine, 6 ms) ≤ 20 g (half sine, 11 ms)
Shock (EN 61373, Cat. 1, Class B)	≤ 5 g (half sine, 30 ms)
Permanent shock (EN 60028-2-29)	≤ 10 g (half sine, 16 ms)
Vibration (EN 60068-2-6)	≤ 20 g (10 Hz ≤ f ≤ 2000 Hz) ≤ 2 g (5 Hz ≤ f ≤ 150 Hz)
Random vibration, long duration (EN 61373, Cat 1, Class B)	Frequency range: 5 - 150 Hz Effective acceleration: 7.9 m/s² Frequency spectrum: 5-20Hz 1.857 m²/s³ 20-150Hz 0.033 m²/s³
Random vibration, function test (EN 61373, Cat 1, Class B)	Frequency range: 5 - 150 Hz Effective acceleration: 1.0 m/s² Frequency spectrum: 5-20Hz 0.0298 m²/s³ 20-150Hz 0.0006 m²/s³
Weight (cable version)	25 mm ∅ housing: ≈ 520 g, flange PF6 25 mm ∅ housing: ≈ 600, flange PPK 58 mm ∅ housing: ≈ 650 g, flange YF1
Requirement for Coupling	
Minimum torque	< 3 Ncm (without shaft sealing)
Design	Positive locking with style of D-form for coupling ring or Two set screw in the coupling ring with usage of thread locking compound. Coupling internal screw thread and screw shall be cleaned before threadlocker is used! Both shaft sides of drive and encoder shall be flattened for positive locking! For the flange type PPK the shaft has 2 internal thread to realize a positive locking.

Flange	**Synchro (PF6)**	**Synchro (YF1)**	**Synchro positive locking (PPK)**
Shaft diameter	6 mm	10 mm	21 mm
Shaft length	10 mm	20mm	0,5 mm

DATA SHEET
ABSOLUTE ROTARY ENCODER
CANOPEN SAFETY

Minimum (mechanical) lifetime

Flange	Lifetime in 10^7 revolutions with F_a / F_r				
	20 N / 50 N	40 N / 110 N	40 N / 250 N	100 N / 250 N	250 N / 250 N
PPK (Synchro flange positive locking 21 x 0.5), Standard version	150	24	0.1	0.1	-
YF1 (Synchro flange 10 x 20)	1800	190	2.2	2.2	2.2
PF6 (Synchro flange 6 x 10)	150	24	0.1	0.1	-

Lifetime based on L10 with reliability of 90%.

Sensor Data

Technology	Magnetic redundant two axis Hall sensor
Single-Turn resolution	Up to 4096 steps / revolution (12 Bit)
Sensor element cycle time	< 1 ms
Measurement step deviation	±0.35° typical per channel ±0.5° additional statistical deviations per channel
Deviation between both channels	< 1% per 360°, < 3.6°

Environmental Conditions

Operating temperature	- 40 ... +60 °C
Storage temperature	- 30 ... +60 °C, Packing material constraint
Humidity	98 %, without liquid state
Protection class (DIN40050-9) (EN 60529)	Casing side: IP 69K (only for flange version YF1 and connection type CAW or xAW with x as number for cable length) Casing side: IP67 Shaft side: IP 64 (optional with shaft sealing: IP66)
Environmental and climate tests according to specifications	IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-14, IEC 60068-2-30
Salt spray test	IEC 60068-2-11, test grade Ka
Cable gland	- 40 ... +80 °C fixed installed cables
	- 30 ... +80 °C flexible installed cables
Cable material	PUR, black colored
Cable minimum bend radius	Flexible installation 53 mm Fixed installation 28 mm
External magnetic field (IEC 61000-4-8)	50 Hz / 60 Hz, 100 A/m
External static magnetic field	at 1 mT the measurement step deviation is less than 0.1% of 360° at 10 mT the measurement step deviation is less than 0.4% of 360° > 10 mT is not permitted

DATA SHEET
ABSOLUTE ROTARY ENCODER
CANOPEN SAFETY

Interface

Configuration

The standard configuration of the encoder in cable or connector version is: for master node number 47 and for slave node number 48. Pre-setting of baudrate is 250 KBaud. For adapting the encoder for a respective application the customer could use SDO telegrams or LSS, but only one configuration method shall be used. Valid baudrate range is 100 kBaud up to 1MBaud and for the node number from 1 to 64.

Electrical Interface

The POSITAL absolute rotary encoder with cable or connector exit were designed following to CiA normative DR303-1 Cabling and connector pin assignment. Shielded cables shall be used.

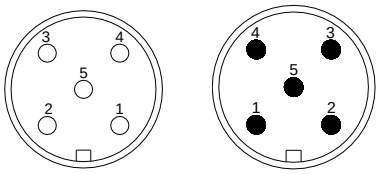
Absolute rotary encoders shall be connected only to subsequent electronics whose power supplies comply with EN 50178 (protective low voltage, PELV or SELV)

Be aware that for a connector exit version the address line signals are set internal to logical 1.

Signal	open cable
CAN Ground	Black
9-35 V supply voltage Battery powered or SELV/PELV supply	Red
0 V supply voltage	Blue
CAN High	Green
CAN Low	Yellow
Address Line Bit 1	White
Address Line Bit 2	Brown
Address Line Bit 3	Gray
Address Line Bit 4	Violet
Address Line GND	Pink

Signal	5 pin round connector pin number (male / female)
CAN Ground	1
9-35 V DC supply voltage Battery powered or SELV/PELV supply	2
0 V supply voltage	3
CAN High	4
CAN Low	5

5 pin M12 connector female/male



Setting of baudrate

The baudrate can be set by sending a CAN SDO telegram (see object 3001 h).

Baudrate in kBit/s	Values Object 3001h
100	2
125	3
250	4
500	5
800	6
1000	7

DATA SHEET
ABSOLUTE ROTARY ENCODER
CANOPEN SAFETY

Within the Safety encoder a safety and non safety function is integrated, which can be used in the same time. Both functions are strictly divided from each other and do not interact. In the following sections both functions with their corresponding parameters are explained.

General Safety Definitions

Safety Function	Measurement of the position angle with a resolution of 4096 steps per revolution (12 bits) for each channel with an overall measurement step deviation of ±1.8° per channel. The deviation between both channel shall never exceed 1% per 360° = 3.6°.
Failure reaction function	In case of any failure the transmission of SRDO-CP shall be stopped.
Safety state	Within the safety state the encoder stopped the communication of SRDO – CP data.
Intended usage	The sensor shall be able to measure the physical angle of its shaft and converts this into a digital position value transmitted via the CAN bus to other field devices. This device function can be used for example in positioning tasks or length measurements. General applications could be: like cranes, construction machines, lifts, packing machines etc. For safety-related applications this encoders shall be used in combination with an safety-related master (PLC). This PLC shall compare the position values of both channels to each other and on deviations greater than 1 % the PLC shall transit the machine into inherent safe state.

Safety Function Programmable Encoder - Parameter

Operating Parameters	This parameter determines the counting direction, in which the output code increases or decreases.
Preset Value	The preset value is the desired position value, which should be reached at a certain physical position of the axis. The position value is set to the desired process value by the parameter preset.
Position Value	The safety position value has a resolution of up to 12 Bit per revolution. Within the SRDO-CP communication the position value is transmitted as a normal value from one channel and additional an inverted value from the second channel. The protocol is following to the definition of SRDO communication in the CANopen Safety profile EN 50325-5.
Resolution per Revolution	The parameter resolution per revolution is used to program the desired number of steps per revolution.
Total Resolution	This parameter shall be identical with parameter Resolution per Revolution for a single-turn encoder.

Programmable SRDO Parameter (according to standard EN 50325-5)

SRDO communication parameter	Configuration of SRDO communication transmit parameters defined in object 1301 hex, like information direction, refresh time, transmission type and COB-ID. Additional adaption for SRDO-CP data protocol.
Configuration valid	This object 13FE hex shall contain an acknowledgement flag for a valid configuration.
Safety configuration checksum	For the SRDO a safety configuration checksum is provided according to a polynomial defined in EN 50325-5 respectively in object 13FF hex.

Non Safety Programmable Encoder – Functions

LSS	With Layer Setting Services the encoder can be configured regarding node number and baud rate.
Node number	The parameter is used to program the desired node number of the master via SDO CANopen telegrams. LSS shall not be used at the same time.
Baud rate	The used baud rate of the node can be configured via SDO CANopen telegrams. LSS shall not be used at the same time.
Heartbeat producer	General functionality according to CANopen specification DS-301.
Emergency producer	General functionality according to CANopen specification DS-301. In case of a detected error the encoder is transmitting an error message with the corresponding error code.
UDS Bootloader	Via CAN bus a software update of the encoder software can be conducted by using the UDS protocol.

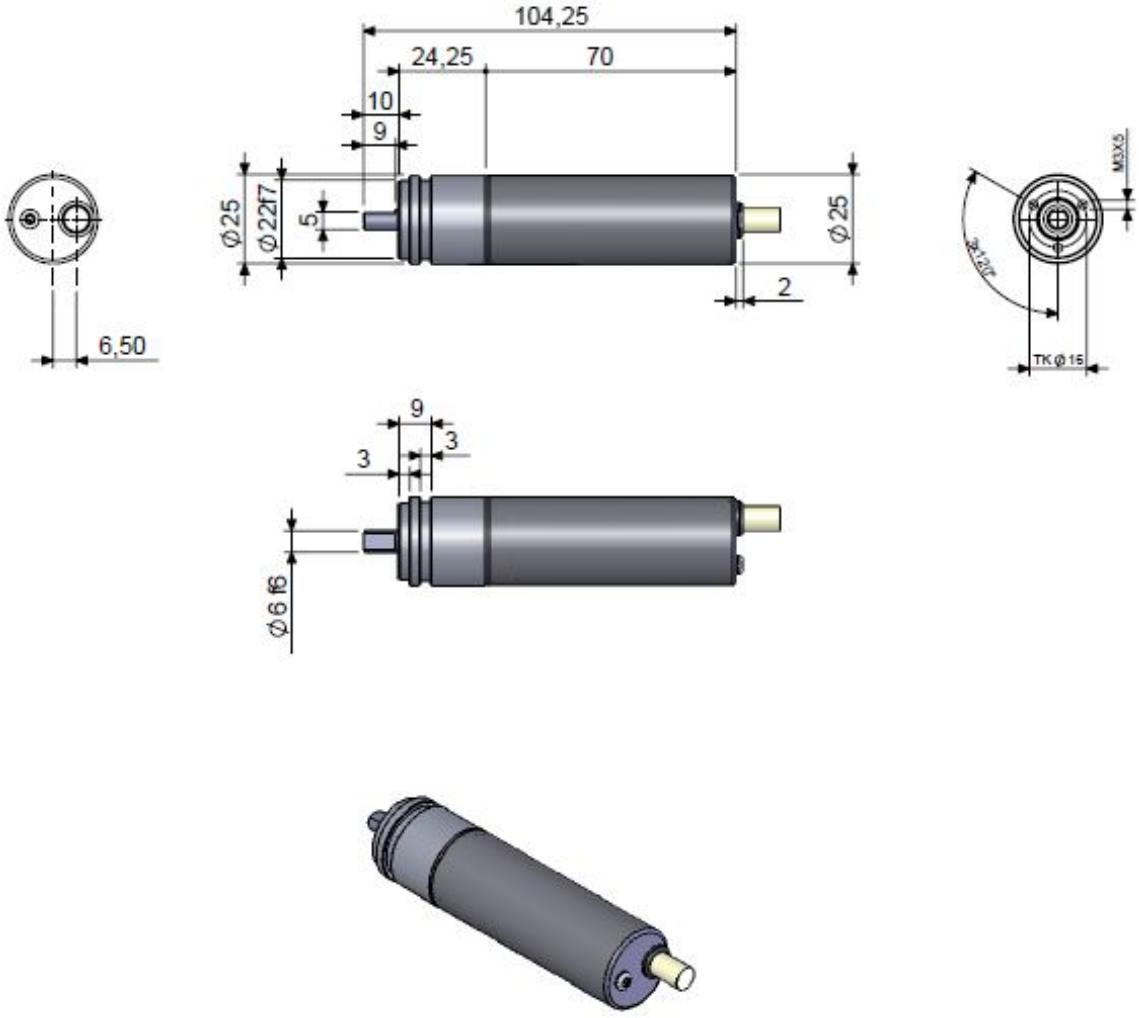
Programmable CAN Transmission Modes (according to DS-301)

Sync Mode	After receiving a sync telegram by the host, the absolute rotary encoder answers with the current process value via SRDO messages. If more than one node number (encoder) shall answer after receiving a sync telegram, the answer telegrams of the nodes will be received by the host in order of their identifiers. The programming of an offset-time is not necessary. If a node should not answer after each sync telegram on the CAN network, the parameter sync counter can be programmed to skip a certain number of sync telegrams before answering again.

DATA SHEET
ABSOLUTE ROTARY ENCODER
CANOPEN SAFETY

Mechanical drawings: Encoder with 25 mm ∅ housing

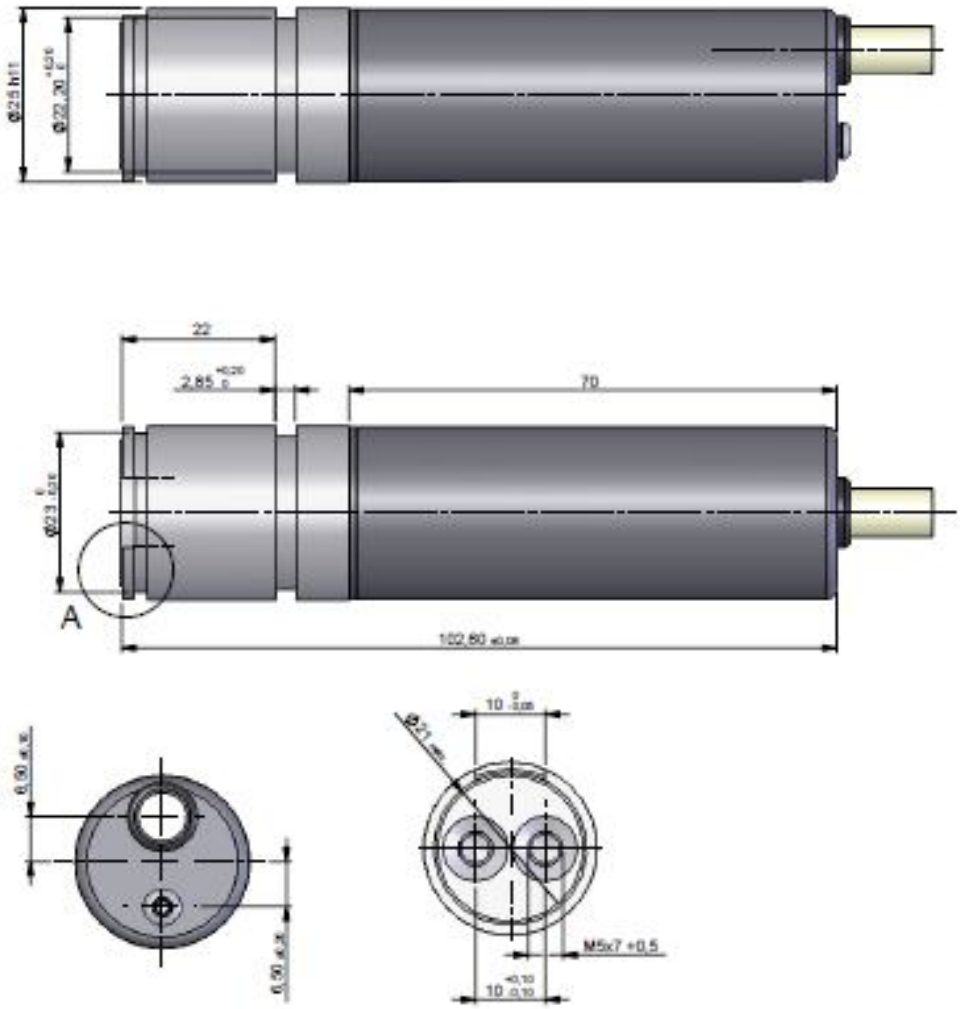
Synchro flange (PF6)



DATA SHEET
ABSOLUTE ROTARY ENCODER
CANOPEN SAFETY

Mechanical drawings: Encoder with 25 mm ∅ housing
Shaft with positive locking

Synchro flange (PPK)

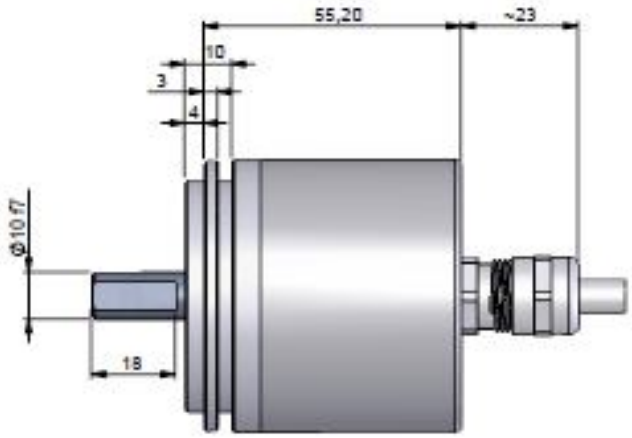


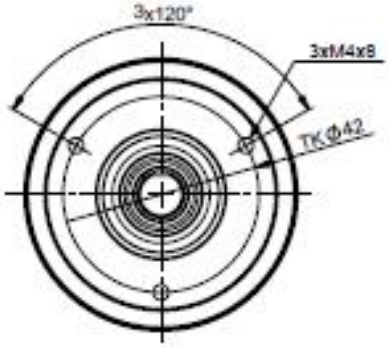
DATA SHEET
ABSOLUTE ROTARY ENCODER
CANOPEN SAFETY

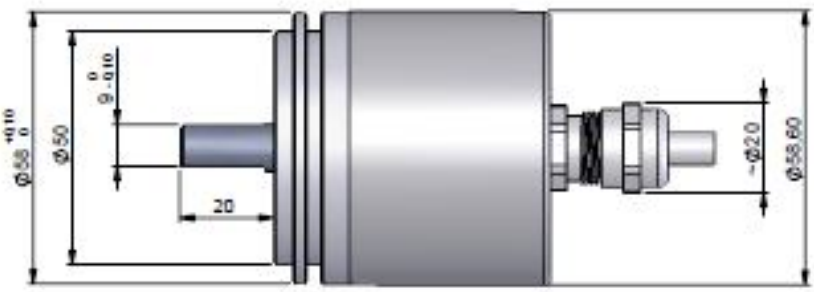
DATA SHEET
ABSOLUTE ROTARY ENCODER
CANOPEN SAFETY

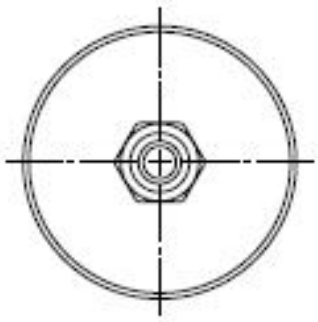
Mechanical drawings: Encoder with 58 mm ∅ housing

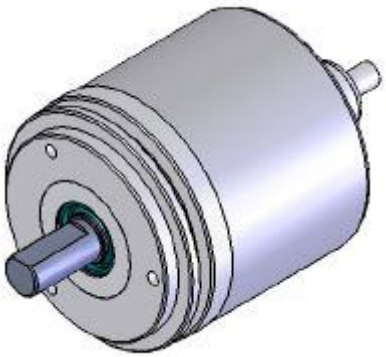
Synchro flange (YF1)











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DATA SHEET
ABSOLUTE ROTARY ENCODER
CANOPEN SAFETY

Models/Ordering Description

Description	**Type key**											
IXARC	**MCS-**	**CS**	**D 1**	**B -**	_ _	_ _ -	_	_ _	_-	_ _ _		
-Interface	CANopen safety	**CS**										
Performance level/			**D**									
Product Version			**1**									
Code	**Binary**			**B**								
Revolutions (Bits)	**Singleturn**				**00**							
Steps per revolution	**4096 (0,09°)**					**12**						
Flange / Shaft	**58 mm Synchro flange, 10 mm flat shaft**						**Y**	**F1**				
	25 mm Synchro flange, 6 mm flat shaft						**P**	**F6**				
	25 mm Synchro flange, 21 mm flat shaft						**P**	**PK**				
	Without								0			
	Shaft sealing (IP66)								**S**			
	Stainless steel version								V			
Mechanical options	Customized								C			
Connection												
	Cable exit 1m, axial, open wire ends										CAW	
	Cable exit 4m, axial, open wire ends										**4AW**	
	Connector exit, axial, 5 pin male M12										PAM	

This English version of document is the original version and was part of a type approval performed by TÜV Rheinland.
The “Original Instructions” is a set of documents containing data sheet, user manual, leaflet and declaration of EC conformity delivered on a CD with the product. The information can be also downloaded from the website or get in contact with the manufacturer FRABA AG or authorized distributors.

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DATA SHEET
ABSOLUTE ROTARY ENCODER
CANOPEN SAFETY

Document History

Version	Modifications
6	Date of release 02.10.2013, official released version
7	Date of release 03.01.2014 Changed footer with updated version and date information Added information about original instruction in the footer. This is the certified version in English language.
8	Date of release 05.02.2014 Changed footer Original Instruction into Original Instructions. Added information about the document set of “Original Instructions”.
9	Date of release 07.02.2014 Added information about maximum speed in RPM for safety and non safety application. Added remark PELV / SELV under technical data Removed unit for PFD and correction of % for PFHd.