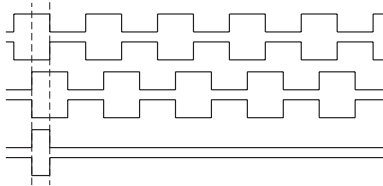


Play-free electronic switching cam encoder with electromagnetic rotary encoder

Model NOCI / S3 - SIL2 / incremental interface



- **Play-free version for use instead of electromechanical switching cam encoders**
- **For use in stationary and mobile machines and systems, especially for power plants, wind power plants, cranes, etc.**
- **Up to four electronically controlled safety SIL2 switching outputs (relays)**
- **Integrated multiturn SIL2 rotary encoder with standard incremental interface**
- **Switching outputs can be preset via preset input**
- **Internal position resolution up to 15 bits**
- **High vibration and shock resistance thanks to robust design**

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Design

Robust aluminium (AlMgSi1) or stainless steel (1.4305 or 1.4404) housing in dual-chamber design. Shaft with shaft seal and ball bearing mounted in pre-chamber. Electronics housed in sealed main chamber.

Ø 79 mm with short design length

Shaft diameter 12 mm. Electrical connection for voltage supply, switching outputs and incremental position data via M12 connector or cable. The number of connectors or cables varies depending on design or customer specification.

The **4 SIL2 safety switching contacts** are each designed with 2 relays connected in series to guarantee reliable contact separation (no contact sticking). All contacts are galvanically separated and suitable for **use in the safety chain**.

The switching contacts are closed during normal operation, and therefore establish a conductive connection - the relay coils are live. If the limit values are reached, the respective contact is opened. They are also opened when the switching cam encoder is not connected to the voltage supply or a fault is detected in the NOCI through self-diagnosis.

At each point in time, the integrated relay monitoring function compares whether the specified ON/OFF switching status of each switching contact is correct (nominal/actual comparison). If a deviation is detected due to a relay fault, failsafe status is assumed.

Electronic switching cam encoder - model NOCI / S3

Description

General functional principle

This involves a play-free electronic switching cam encoder (abbreviated to: NOCI) with a maximum of four galvanically separated¹⁾ SIL2 switching outputs that can be set by the customer, and which are activated or deactivated depending on the respective position of the drive shaft. A parameterisable multivolt absolute encoder with incremental interface as well as the four switching outputs are integrated in the compact housing. The switching outputs can be preset.

A special shaft design appropriate to the play-compensating measurement gear ZRS is available.

The supply voltage, incremental signal and switching contacts are each galvanically separated from one another¹⁾.

Rotary encoder

The rotary encoder has an incremental interface with 512 pulses with a measuring range of max. 4096 revolutions. Tracks A+, A-, B+ and B- can be output. A null signal Z+ / Z- is available (1 pulse per revolution).

The standard measurement accuracy is $\pm 0.25\%$ / 360° . A value of $\pm 0.1\%$ / 360° can be optionally implemented.

The standard measuring range is 4096 revolutions. Optionally, 16 or 256 revolutions are possible as the measuring range.

Switching outputs (cams)

The electronically activated cams can be used to control potential-free, galvanically separated¹⁾ switching processes.

The switching outputs are implemented using relays with a long service life. Each of the 4 contacts that are routed outwards consists of 2 relays connected in series. These two relays switch with a brief offset (in the millisecond range). This measure guarantees reliable contact separation - even if there is a risk of contact sticking due to high applied vol-

tages and currents. A separate controller unit monitors the function and the switching status of the switching outputs. If incorrect switching is ascertained, this is detected as a fault: all relays shut off and cannot be switched on again until the fault has been eliminated.

The SIL2 switching contacts are normally open contacts (NO). In normal operating state - without the limits having triggered - the contacts are closed and the relay coils are live. They open when the position limits are reached. All relays open when a fault is ascertained via self-diagnosis and the NOCI's supply voltage is too low or if the NOCI is shut off completely.

Within the measuring range, **one** switch-on and off process per switching output is possible. Customer-specific switching procedures can also be implemented in the factory.

The switching information for the cams is taken from the absolute rotary encoder signal. This signal is subsequently transformed into the incremental signal. The switching outputs are activated and deactivated without play, electronically and wear-free in comparison with an electromechanical switching cam encoder.

If they are to deviate from the standard setting, the switching flanks of the individual switching outputs are programmed in the factory as per the customer's specifications (see *cam diagram* illustrations). The measuring range point at which the NOCI is to switch the switching outputs can be set using the preset input.

Direct and alternating voltage can be switched with all switching outputs. Different connector assignments are possible at the customer's request.

The cams do not switch if there is no operating voltage. In this case, all switching contacts are open. The current is interrupted.

¹⁾ Due to relay monitoring, the contacts have a high-impedance connection to the supply voltage in low-frequency and high-frequency terms. See circuit diagram on page 3. A sensitive input card may indicate a short-circuit on the control system side. In this case, contact our technicians for a solution.

Safety parameters

Data to follow

Standard EN 13849-1:2015

- Category:
- MTTFd (years):
- CCF:
- DC [%]:
- PL: d

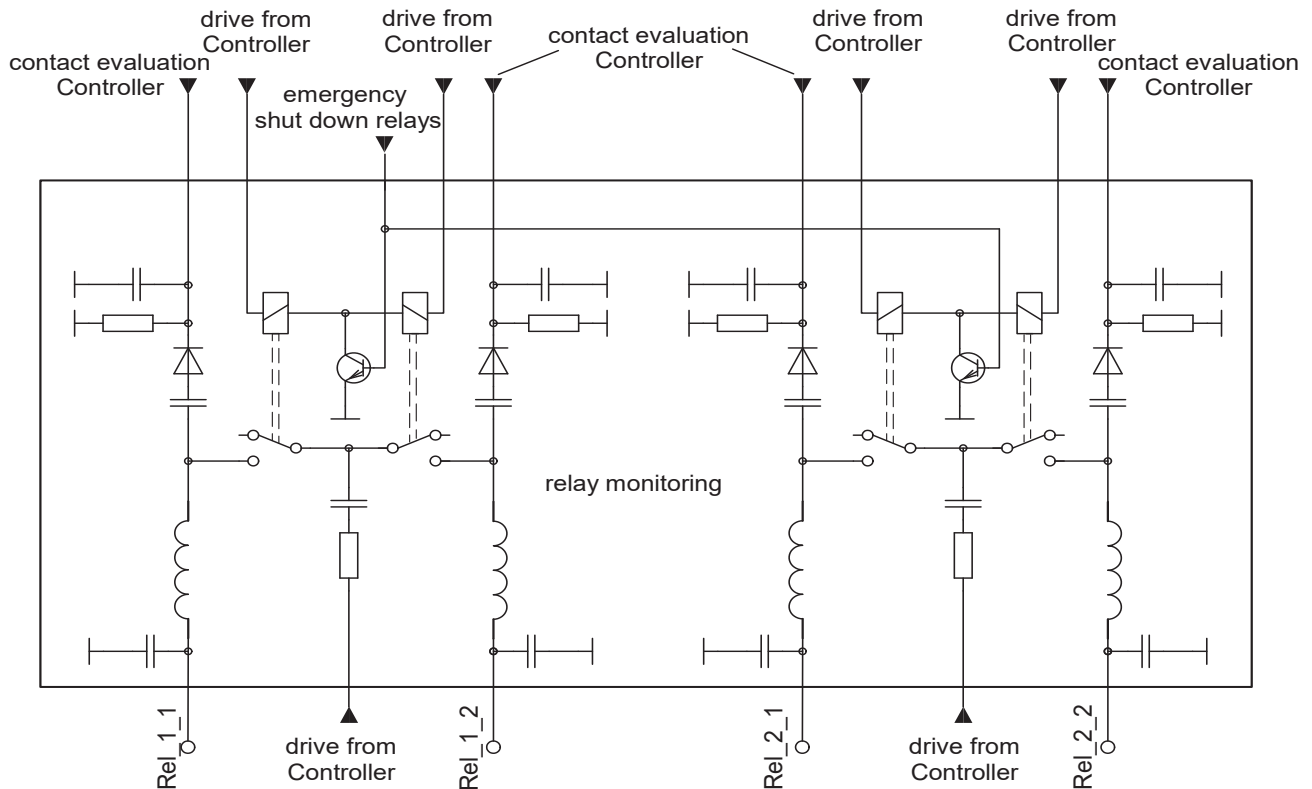
Standards EN 61508:2010 and EN 62061

- HFT:
- T1[s]:
- SFF [%]:
- PFH [1/h]:
- SIL: 2

Electronic switching cam encoder - model NOCI / S3

Principle circuit diagram

2 contacts shown. A total of 4 available



Technical data

Mechanical data

- Operating speed: 1000 rpm max. (higher rotational speeds possible on request)
- Angular acceleration: 10^5 rad/s^2 max.
- Moment of inertia (rotor): 20 gcm^2
- Operating torque: $\leq 8 \text{ Ncm}$ (with rotational speed 500 rpm)
- Starting torque: $\leq 4 \text{ Ncm}$
- Perm. shaft load: 250 N axially, 250 N radially
- Bearing service life: $\geq 10^9$ Revolutions
- Weight: Approx. 0.75 kg

Environmental data

- Operating temperature range: -40°C to $+85^\circ\text{C}$
Note: the safety parameters (page 2) apply from -40°C to $+70^\circ\text{C}$
- Storage temperature range: -45°C to $+85^\circ\text{C}$
- Resistance:
 - To shock: 250 m/s^2 , 6 ms, (DIN EN 60068-2-27) per 100 x in 3 axes
 - To vibration: 100 m/s^2 , 5 Hz ... 2000 Hz, (DIN EN 60068-2-6) per 1 h in 3 axes
- Protection type: IP67 (DIN EN 60529)

Electronic switching cam encoder - model NOCI / S3

Technical data

Electrical data

- Sensor system: Magnetic - redundant design
- Operating voltage range: 9 ... 30 VDC
- Power consumption: ≤ 3 W
- Switch-on current: ≤ 500 mA
- Position resolution: Up to 32,768 steps / 360° (15 bits)
- Pulse numbers: 512 pulses / 360° (other pulse numbers on request)
- Measuring range: 4096 revolutions (optionally 256 or 16 revs.)
- Duty cycle: 1 : 1
- Signal outputs (resistant to short-circuit): Channels A+, A-
Channels B+, B-
Channels Z+, Z- (null signal)
- Absolute accuracy: $\pm 0.25\%$ / 360° (optionally $\pm 0.1\%$ / 360°)
- Repeatability: $\pm 0.1\%$ / 360°
- EMC standards: Interference emission: EN 61000-6-4
Interference immunity: EN 61000-6-2
- Electrical connection: 3 x connector M12
Optional: cable

Electrical data of the switching relay outputs

- Maximum switching current: 0.5 A at 30 VDC / VAC
- Maximum switching voltage: 60 VDC / VAC (also depending on the choice of connectors that are used)
- Switching time: 20 ms (ON and OFF in each case)
- Switching hysteresis: $\sim 1^\circ$ shaft revolution. Set in the factory
- Maximum ON resistance: 0.5 ohm
- Protective capacitor on the contacts: $2 \times C = 4,7$ nF (different connection possible subject to consultation)
→ time constant τ for voltage drop after contact opening: $\tau = RC$ with
R = external resistor
Other capacitors C are available, if safety controller units, to which the contacts are connected to, show an error
(See remark 1 on page 2)

Overall system and safety

- On-time (rise time) of supply voltage: 500 ms (10% to 90%)
- Storage cycle time: 3 s per storage cycle
- Set-up time: ~ 2 s in the operating temperature range
- Time between detection of an error and output: 100 ms (voltage supply)
300 ms (relay check)
5 s (RAM test, all individual bits OK)
2 s (ROM test (within set-up time))
- Certificate number: To follow
- Safety standards: EN 61508, 1 - 7: 2011
EN 62061: 2005
EN ISO 13849-1: 2015
EN 60947-5-1: 2004 + A1: 2009
- Maximum usage duration: 20 years

Electronic switching cam encoder - model NOCI / S3

Order number

NOCI	79	- KZ	A	4	-	512	BN	4096	S3	S3	D	01	→ Standard version
<p>Electrical and mechanical variants*</p> <p>01 Standard</p> <p>Output / signal level:</p> <p>D HTL - definition: see page 6</p> <p>U TTL - "</p> <p>Electrical connection:</p> <p>→ Combine type (S, T, K or L) and number (1, 2, 3)</p> <p>1 = 1 connection</p> <p>2 = 2 connections</p> <p>3 = 3 connections</p> <p>S Via device connector M12, radial</p> <p>T Via device connector M12, axial#</p> <p>K Via cable 1 m**, radial (# on request)</p> <p>L Via cable 1 m**, axial# (** other lengths possible)</p> <p>Safety profile:</p> <p>S3 Safety SIL2 version</p> <p>Measuring range (relevant for cams):</p> <p>16 Revolutions</p> <p>256 "</p> <p>4096 "</p> <p>Pulse tracks:</p> <p>BN A+, A-, B+ and B- as well as null signal Z+ and Z- (standard)</p> <p>AN A+, B+ as well as null signal Z+</p> <p>A A+ and B+</p> <p>B A+, A-, B+ and B-</p> <p>Resolution (pulses / 360°):</p> <p>512 512 pulses (other pulse numbers on request)</p> <p>Number of switching outputs:</p> <p>4 Up to 4 safe switching outputs (SIL2)</p> <p>Housing material:</p> <p>A Aluminium</p> <p>S Stainless steel 1.4305</p> <p>V Stainless steel 1.4404</p> <p>Flange and shaft:</p> <p>K Clamped flange Shaft 12 mm with flattened area</p> <p>KP Clamped flange Shaft 12 mm with feather key</p> <p>KZ Clamped flange Shaft 12 mm for measurement gear</p> <p>KN Clamped flange Clamped shaft, 12 mm inside diameter with groove</p> <p>S# Synchroniser flange Shaft 12 mm with flattened area</p> <p>SP# Synchroniser flange Shaft 12 mm with feather key</p> <p>SZ# Synchroniser flange Shaft 12 mm for measurement gear</p> <p>SN# Synchroniser flange Clamped shaft, 12 mm inside diameter with groove (# on request)</p> <p>Design form:</p> <p>79 Ø 79 mm</p>													
NOCI	Electronic switching cam encoder with incremental interface												

* The basic versions according to the data sheet bear the number 01. Deviations are identified with a variant number and are documented in the factory.

Electronic switching cam encoder - model NOCI / S3

Order number - mating connector

M12, 4-pin, socket: **STK4GS60**
 M12, 8-pin, socket: **STK8GS54**
 M12, 8-pin, connector: **STK8GP99**

Incremental interface

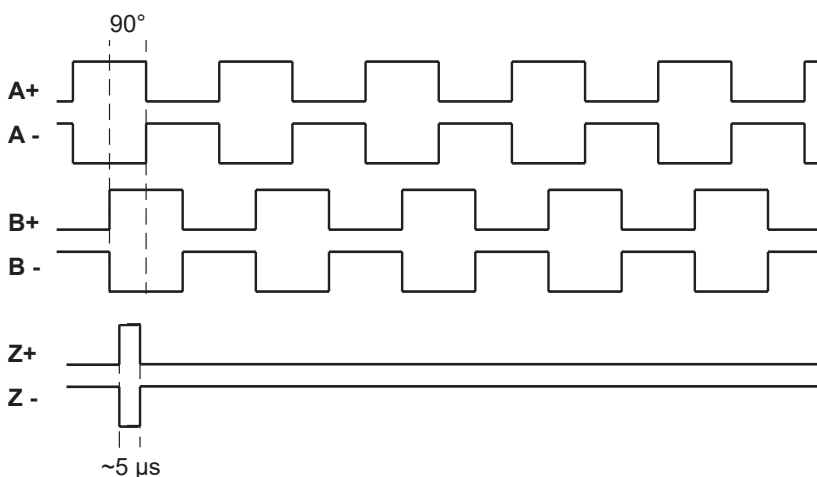
No safety transfer

Function

To register and output the angle or position of the shaft precisely, the contactless electromagnetic sensor system is equipped with an incremental interface so that the measured variable is available as digital data. The incremental signal is generated from the previously registered absolute position signal. This position signal, which corresponds to the precise position of the shaft, is also used to actuate the switching outputs.

This model's measuring range is set to 4096 revolutions in the factory (optionally 256 and 16 revs.). This is required to also actuate the switching outputs over several/many revolutions.

Signal output on rotation CW (looking at the shaft)



Signal definitions

Signal forms	D	U
Pulses / revolution	512	
Operating voltage range U_B	9 to 30 VDC	9 to 30 VDC
Signal level	HTL	TTL (RS 422)
Signal current I_A	Max. 20 mA	Max. 20 mA
Signal level high	$\geq U_B - 3$ VDC	> 2.8 VDC
Signal level low	≤ 2 VDC	< 0.5 VDC
Max. pulse frequency	Max. 1 MHz (specification of driver)	
Duty cycle	1:1 \pm 15%	
Phase offset	$90^\circ \pm 25^\circ$	
Null pulse length	Time: $\sim 5 \mu\text{s}$ (irrespective of rotational speed) This pulse is always output when the position zero-axis crossing of single-turn registration takes place internally in the NOCI. In both directions.	
Direction of rotation	CW (standard): Edge A before B	

Function

The function of the switching outputs is implemented using relays. Two relays are connected in series per switching output. This measure significantly increases reliable separation of the contacts, even if one relay does not separate (contact sticking). In terms of operating voltage and the incremental output signal, the contacts are galvanically¹⁾ separated. The relay monitoring function detects whether a relay contact is open or closed as specified by the controller - i.e. whether it has the required switching status (ACTUAL status = NOMINAL status). If this is not the case, the NOCI79 switches to failsafe status and opens all contacts.

The information regarding when which relay is to pick up and drop off again is made available to the relay control system by the internal controller. It receives the shaft position data from the NOCI's absolute encoder.

The position signal, which is determined based on the shaft position in the NOCI, serves as the basis for the switching information (switching output switching flanks). This position signal determines the position of the switching contacts' switching flanks. It also forms the basis for the output pulses.

As the pulse output signal does not represent an absolute position signal, no recognisable, fixed output signal ↔ switching flank reference exists. Where the switching outputs' switching flanks lie cannot initially be recognised. By executing the *Cam Preset* function, however, all switching flanks assume the specified position relative to the shaft position in which this function was executed.

This preset point is located favourably in one of the following two positions:

- In the middle of the switching flank ensemble (4 units)
- On a switching flank (preferably Cam1)

In this regard, refer to the cam diagrams on the following pages. Corresponding data must be specified when ordering. The configuration/function *ascending flanks* or *descending flanks* can also be specified by the customer. See illustration.

The switching flanks of all switching outputs (of the ensemble) are set in the factory to a specific angle position with regard to the shaft, and are thus fixed in relation to one another. These positions are specified by the customer and set in the factory. Without this specification, the standard setting applies. Amongst other things, the standard setting means that two descending flanks are located in the shaft's direction of rotation *to the right* and two descending flanks in the shaft's direction of rotation *to the left*. Descending flank means that the respective switching output's contact opens - i.e. the relay drops off when the switching position is reached.

With the standard function, the switching contacts are closed (contact established - relay picked up - relay coil is live) in the NOCI working range (usually around the middle of the measuring range). On reaching the limits (switching flank positions), the contacts open (contact interrupted for the switching length L). The switching length L set in the factory is $4320^\circ = 12$ revolutions. The contacts are open for this length L.

The *Cam Preset* function is used to set the 4 cams simultaneously (en bloc) and thus adapt them to the application.

The cams cannot be preset individually.

To avoid undesired relay switching back and forth (flutter) when the shaft is stationary or due to slight shaft vibrations at the switching flank, a switching hysteresis of approx. 1° shaft revolution is programmed.

¹⁾ Due to relay monitoring, the contacts have a high-impedance connection to the supply voltage in low-frequency and high-frequency terms. See circuit diagram on page 3. A sensitive input card may indicate a short-circuit on the control system side. In this case, contact our technicians for a solution.

Electronic switching cam encoder - model NOCI / S3

Cam diagrams

Preset point: in the centre of the switching flanks

To define the position of the switching flanks, the **relative position of all cams to one another** must be specified for each switching cam on ordering (values a, b → e.g. in shaft revolutions). With the *Cam Preset* function, all switching flanks are shifted en bloc without changing their position relative to one another. The desired preset position in the switching flank ensemble is located at the current shaft position (in this example, the middle of the ensembles or, in the next example, the cam 1 switching flank). Depending on application, these two different positions may be favourable as the preset point for all switching contacts (shaft positions on the NOCI79). This should be defined as the *Cam Preset* function and ordered accordingly. See following examples.

- Designation example for the specification that the middle is to be the preset point: *Preset Middle*.
- Designation example for the specification that exactly the descending flank of Cam1 is to be the preset point: *Preset Cam1*.

The standard function of the switching contacts is such that 2 contacts open in the CW direction and 2 contacts in the CCW direction (limit switch function in both directions). The distance between one other is: a. They remain open for 12 revolutions, and then close again. The regular operating range of the NOCI ideally lies between Cam3/Cam4 and Cam1/Cam2.

Recommended procedure for presetting the switching contacts:

- Approach respective position in the application (has been defined in advance and the NOCI set accordingly in the factory)
- Activate cam preset point specified in the factory with *Cam Preset*
- All four switching contacts are now set / adjusted.

If 3 or 4 switching contacts are to switch in the CW or CCW direction, and accordingly fewer contacts in the other direction, please speak to our technicians. Also if the cam length is to be more or fewer than 12 revolutions.

Illustration 1

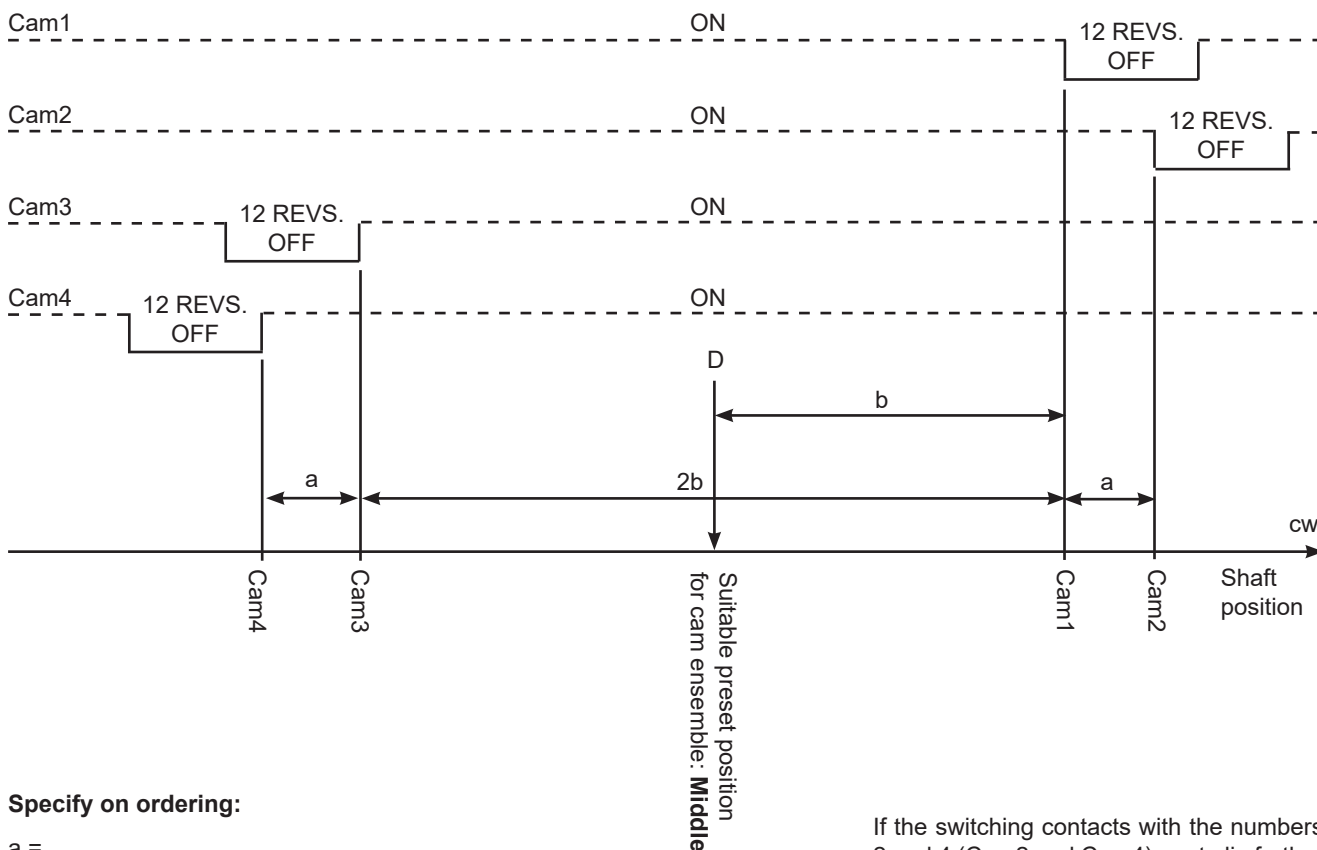
→ **Switching flanks lie symmetrically to the left and right of Cam Preset point D**

→ Values a and b are required - preset designation: *Preset Middle*

a = distance Cam1 ↔ Cam2 = distance Cam3 ↔ Cam4

b = distance Cam1 ↔ D = middle of switching edges

2b = distance Cam1 ↔ Cam3



Specify on ordering:

a = ...

b = ...

and cam preset = 'Middle'

If the switching contacts with the numbers 2 and 4 (Cam2 and Cam4) are to lie further inwards than Cam1 and Cam3, a < 0 (e.g. -5) must be selected.

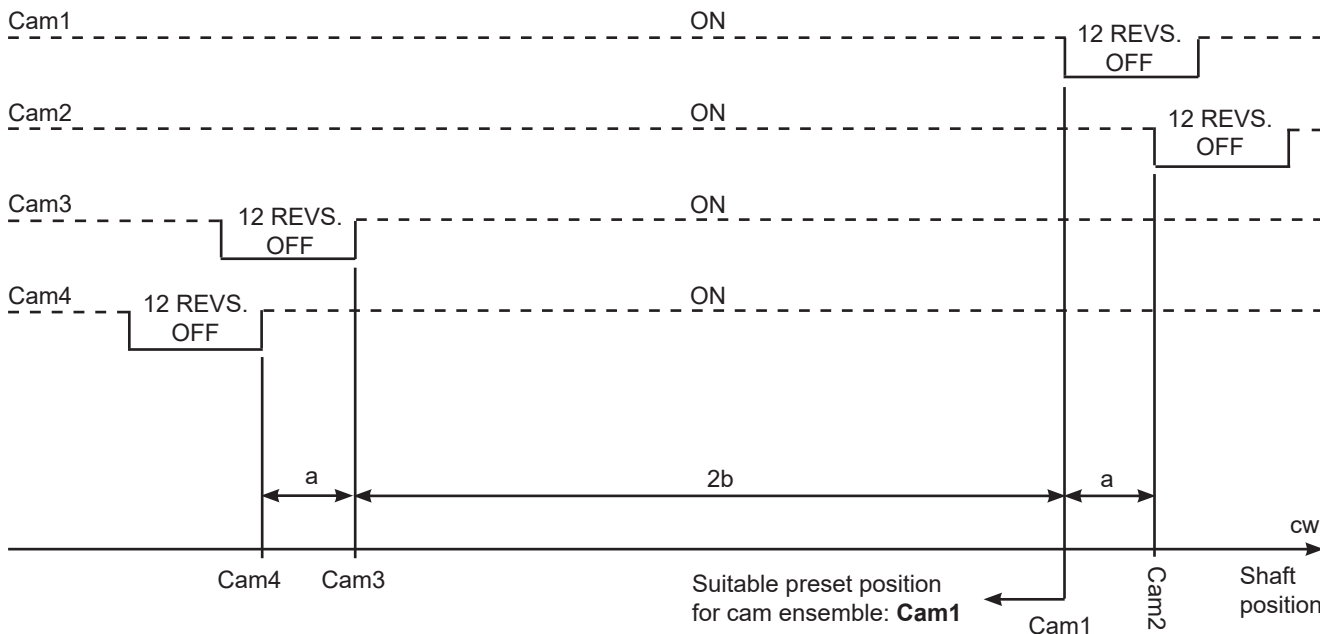
Electronic switching cam encoder - model NOCI / S3

Cam diagrams

Preset point: at Cam1 switching flank

Illustration 2

- Like illustration 1, but preset set to Cam1
- Values a and 2b are required. Preset designation: *Preset Cam1*
 - a = distance Cam1 ↔ Cam2 = distance Cam3 ↔ Cam4
 - 2b = distance Cam1 ↔ Cam3
- 0 = distance Cam1 ↔ preset point Cam1



Specify on ordering:

a = ...
 2b = ...
 and cam preset = 'Cam1'

If the switching contacts with the numbers 2 and 4 (Cam2 and Cam4) are to lie further inwards than Cam1 and Cam3, a < 0 (e.g. -5) must be selected.

Other configurations and preset options on request.

Electronic switching cam encoder - model NOCI / S3

Switching contacts: standard setting

The desired switching output default settings should always be specified when ordering the NOCI79. If no data are available from the customer, the following setting is supplied (variant 01. See illustration 1):

- Pulses: ▪ Configuration as described on page 6
- Switching flanks: ▪ 2 switching contacts (1 + 2) set to descending flank in shaft direction of rotation CW
▪ 2 switching contacts (3 + 4) set to descending flank in shaft direction of rotation CCW
▪ a = +5 revolutions
▪ b = 40 revolutions
▪ *Cam Preset* set to 'Middle'
▪ Cam length L = 12 revolutions

Teach-in function: *Cam Preset*

Safety teach function

Due to the SIL2 requirements, two multi-function pins (MFP) must be used for a preset / teach-in process instead of one → safety teach-in function.

One pin serves to release the teach-in function: *Activate*. The other pin executes the preset function: *Cam Preset*. This second pin is called the "Function" pin in the sequence procedure below.

All functions must take place while the shaft is stationary (rotation during the process: $\leq 2^\circ$).

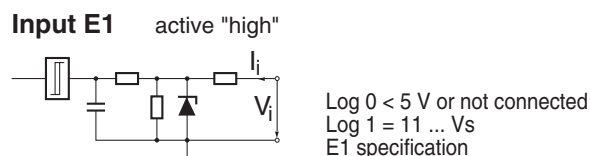
Step	Sequence procedure
1.	Set <i>Activate</i> pin to logical 1
2.	Wait for > 2 seconds
3.	Set "Function" pin to logical 1 ("Function" = <i>Cam Preset</i>)
4.	Wait for > 2 seconds
5.	Set "Function" pin to logical 0
6.	Wait for > 2 seconds
7.	Set <i>Activate</i> pin to logical 0
	Programming (teach-in) ended
	Normal operation: all MFP inputs open or logical 0

Logical 0 = $-U_B$ or open. Logical 1 = 11 VDC ... $+U_B$

The safety teach function is cancelled if this procedure, incl. the waiting times, is not adhered to. It must additionally be ensured that no contact bounce occurs during MFP contact establishment (logical 1) and contact breaking (logical 0). Otherwise, the sequence has to be started from the beginning again after a brief waiting time. The function is only taken over on completion of the entire procedure, and a further teach-in process can be commenced.

Input circuit for preset inputs: E1

(Pull-down resistor: 10 k Ω and 10 k Ω in series)



Electronic switching cam encoder - model NOCI / S3

Connector pin numbering

Pin configuration and numbering

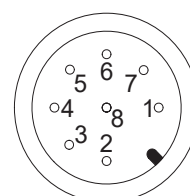
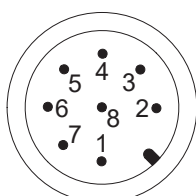
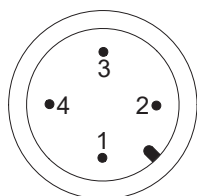
Viewed looking at the contact side of connectors / sockets installed in the NOCI.

Depending on customer specifications, the use of different M12 connectors with individual assignment is possible.

Please always note the connection assignment TY which is enclosed with each device.

In the case of M12, 8-pin, the recommended maximum voltage at the individual pins is 30 V.

4- and 8-pin connectors, A-coded, pins / socket



Connection assignment NOCI/S3 standard assignment

PIN	Connector S1 (pins)
1	Safety contact 1 / (13)
2	Safety contact 1 / (14)
3	Safety contact 2 / (23)
4	Safety contact 2 / (24)
5	Safety contact 3 / (33)
6	Safety contact 3 / (34)
7	Safety contact 4 / (43)
8	Safety contact 4 / (44)

PIN	Connector S2 (socket)
1	Channel A+
2	Channel A- (if available, otherwise not used)
3	Channel B+
4	Channel B- (if available, otherwise not used)
5	Channel Z+ (if available, otherwise not used)
6	Channel Z- (if available, otherwise not used)
7	MFP <i>Cam Preset</i>
8	MFP <i>Activate</i>

PIN	Connector S3 (pins)
1	Operating voltage + U_B
2	Not used
3	Operating voltage - U_B
4	Not used

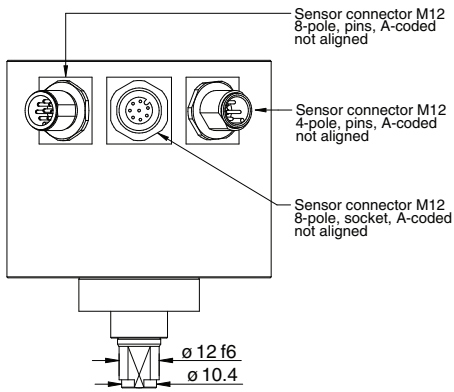
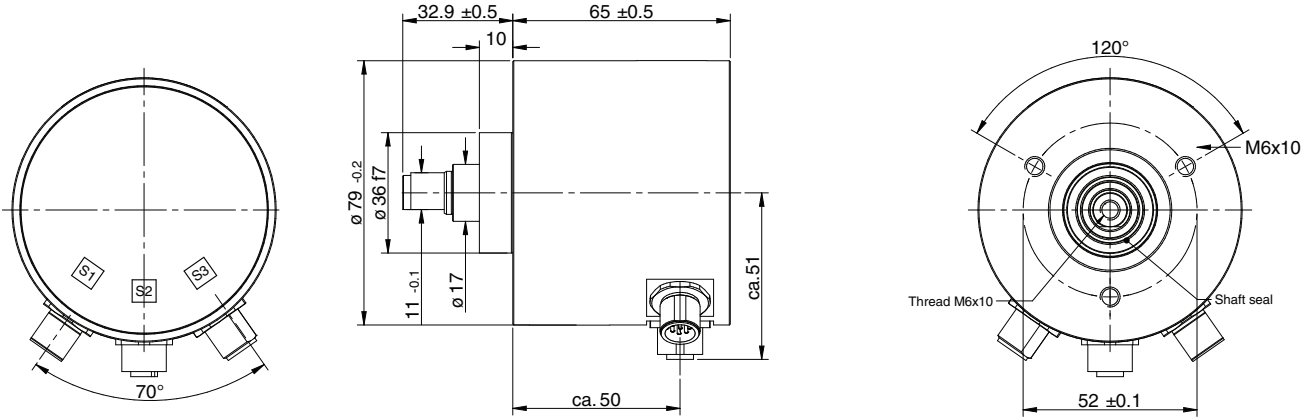
Electronic switching cam encoder - model NOCI / S3

Installation drawings

Special versions on request

Model NOCI79-KZ (3 connectors, radial) → standard version

Dimensions in mm



Connector selection exemplary

Materials used

- Aluminium housing: AIMgSi1
- Stainless steel shaft: 1.4305
- Connector: Nickel-plated Ms
- Shaft seal: NBR
- Sealing rings: NBR

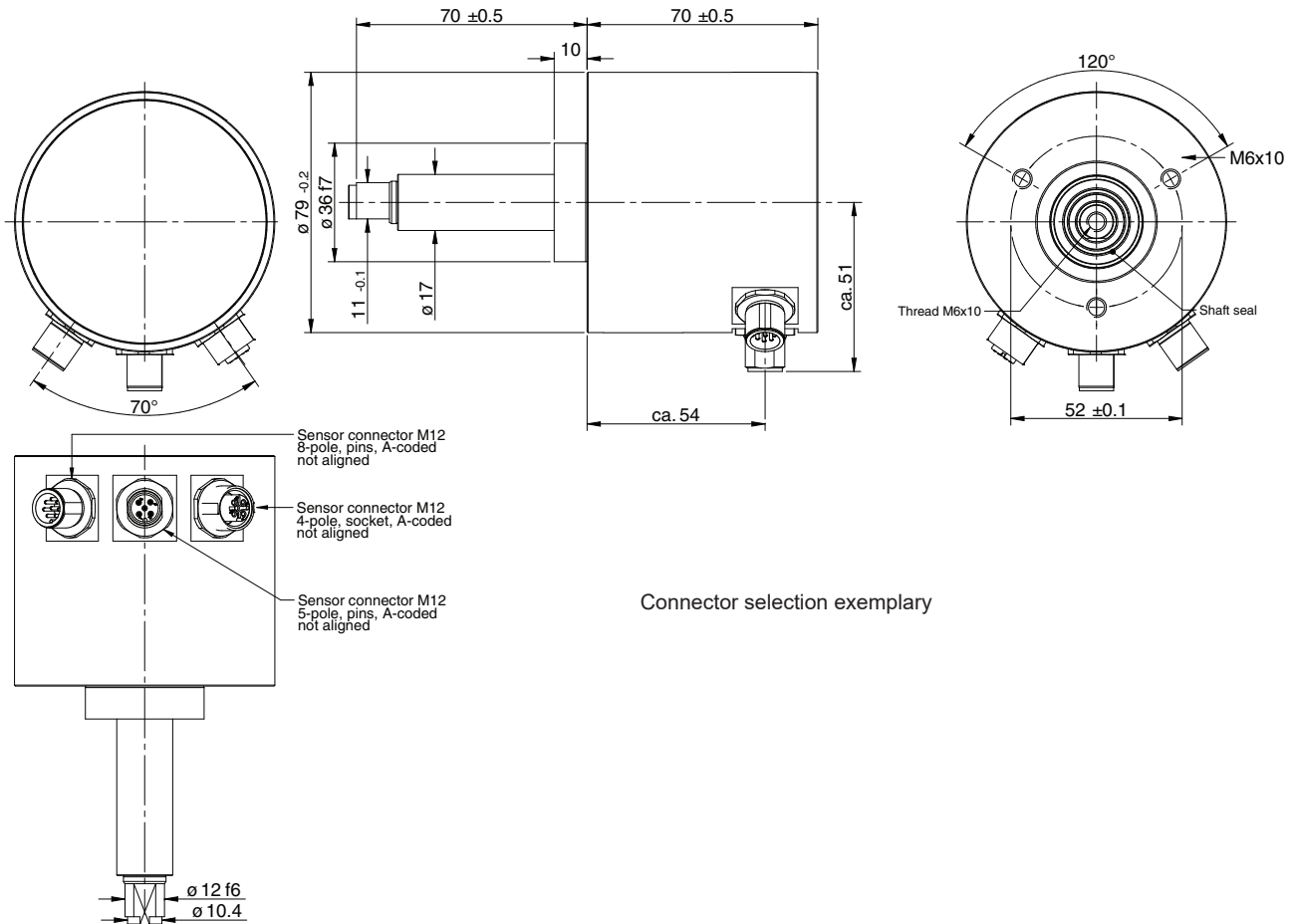
Electronic switching cam encoder - model NOCI / S3

Installation drawings

Special versions on request

Model NOCI79-KZ (3 connectors, radial) → version with extended shaft

Dimensions in mm



Materials used

Aluminium housing:	AlMgSi1
Stainless steel shaft:	1.4305
Connector:	Nickel-plated Ms
Shaft seal:	NBR
Sealing rings:	NBR

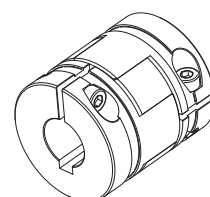
Accessories

Play-free clamp coupling KK14N / x - y (with groove)

x and y: hole diameter for shaft mounting

with groove for feather key according to DIN 6885 page 1 – JS9.

See data sheet [KK 12301](#)

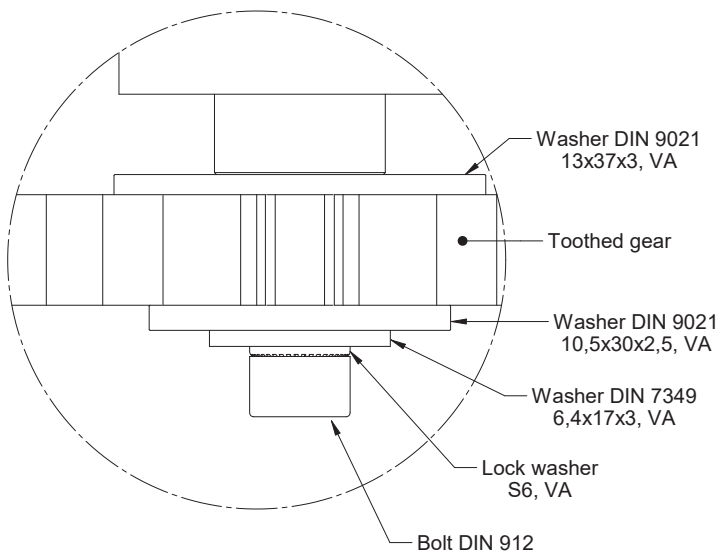
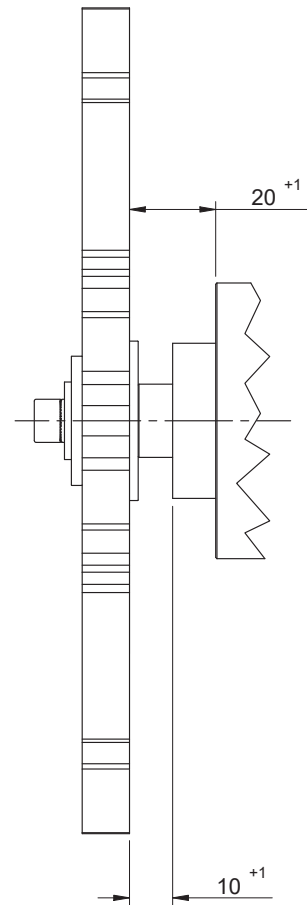
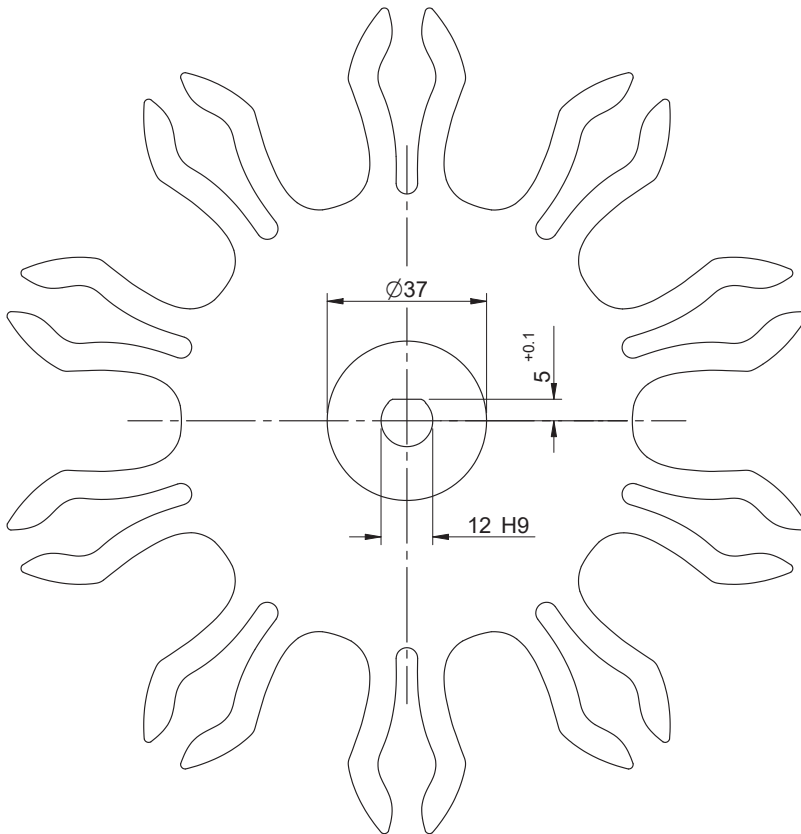


Electronic switching cam encoder - model NOCI / S3

Play-compensating measurement gear ZRS

To mechanically drive the switching cam encoder shaft without play on a ring gear (slewing ring) or a toothed rack, we offer a 'play-compensating measurement gear' ZRS. Different modules and numbers of teeth are available. ZRS material: polyamide. See also data sheet [ZRS 11877](#). Mechanical connection necessitates a specific shaft design.

Installation recommendation: tighten 6 mm bolt to a torque of 6 Nm and secure with Loctite (medium adhesive strength).



Order number

ZRS - 12 - 10 - A 01

variants **:

A 01 Standard

Number of teeth :

10 Teeth *

Module:

12 5 to 24 *

Model:

ZRS Play-compensating measurement gear

*: Further values on request

**: Please contact our technical staff to adapt the measurement gear to your requirements. ZRS11877 data sheet.