

MANUAL

**Functional Safety**  
**Inductive Dual Sensor**  
**NCN3-F31K2(M)-N\*-B\*3-S**



**SIL 2**



With regard to the supply of products, the current issue of the following document is applicable:  
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in its most recent version as well as the supplementary clause: "Expanded reservation of proprietorship"



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# 1 Introduction

## 1.1 Content of this Document

This document contains safety-relevant information for usage of the device. You need this information to use your product throughout the applicable stages of the product life cycle. These can include the following:

- Product identification
- Delivery, transport, and storage
- Mounting and installation
- Commissioning and operation
- Maintenance and repair
- Troubleshooting
- Dismounting
- Disposal



### **Note!**

For full information on the product, refer to the further documentation on the Internet at [www.pepperl-fuchs.com](http://www.pepperl-fuchs.com).

The documentation consists of the following parts:

- Present document
- Instruction manual
- Manual
- Datasheet

Additionally, the following parts may belong to the documentation, if applicable:

- EU-type examination certificate
- EU declaration of conformity
- Attestation of conformity
- Certificates
- Control drawings
- FMEDA report
- Assessment report
- Additional documents

For more information about Pepperl+Fuchs products with functional safety, see [www.pepperl-fuchs.com/sil](http://www.pepperl-fuchs.com/sil).

## 1.2 Safety Information

### Target Group, Personnel

Responsibility for planning, assembly, commissioning, operation, maintenance, and dismantling lies with the plant operator.

Only appropriately trained and qualified personnel may carry out mounting, installation, commissioning, operation, maintenance, and dismantling of the product. The personnel must have read and understood the instruction manual and the further documentation.

### Intended Use

The device is only approved for appropriate and intended use. Ignoring these instructions will void any warranty and absolve the manufacturer from any liability.

The device is developed, manufactured and tested according to the relevant safety standards.

Use the device only

- for the application described
- with specified environmental conditions
- with devices that are suitable for this safety application

### Improper Use

Protection of the personnel and the plant is not ensured if the device is not used according to its intended use.

## 1.3 Symbols Used

This document contains symbols for the identification of warning messages and of informative messages.

### Warning Messages

You will find warning messages, whenever dangers may arise from your actions. It is mandatory that you observe these warning messages for your personal safety and in order to avoid property damage.

Depending on the risk level, the warning messages are displayed in descending order as follows:



#### ***Danger!***

This symbol indicates an imminent danger.

Non-observance will result in personal injury or death.



#### ***Warning!***

This symbol indicates a possible fault or danger.

Non-observance may cause personal injury or serious property damage.



#### ***Caution!***

This symbol indicates a possible fault.

Non-observance could interrupt the device and any connected systems and plants, or result in their complete failure.

### Informative Symbols



#### ***Note!***

This symbol brings important information to your attention.



#### **Action**

This symbol indicates a paragraph with instructions. You are prompted to perform an action or a sequence of actions.

## 2 Product Description

### 2.1 Function

#### General

The device is an inductive dual sensor. Dual sensors are used, for example, to detect the final positions of valve positions in valve actuators.

Inductive dual sensors consist of 2 sensor circuits arranged one above the other. Each sensor has its own coil. If a measuring plate is inside the sensing range of one of the coils, the magnetic field of the coil is influenced and an electrical switching signal is generated.

The device is a NAMUR sensor with 2 independent sensor circuits in 2-wire configuration. The device transmits the binary signal according to NAMUR to a connected control unit. A control unit can, e. g., be a switch amplifier or an I/O card in a PLC.

#### NCN3-F31K2(M)-N4-B\*3-S

The sensor has two separate sensor circuits with NC function (normally-closed). The device is in high impedance state when a measuring plate is located within the sensing range of the respective sensor circuit.

The sensor has a rated operating distance  $s_n$  of 3 mm.

#### NCN3-F31K2-N5-B\*3-S

The sensor has two sensor circuits. One sensor circuit of these sensor circuits is activated depending on the polarity of the supply voltage. The active sensor circuit is in high impedance state when a measuring plate is located within the sensing range of this sensor circuit.

The sensor has a rated operating distance  $s_n$  of 3 mm.



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**Note**

See corresponding datasheets for further information.

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### 2.2

#### Interfaces

The device has the following interfaces.

- Safety relevant interface: device output
- Non-safety relevant interface: none



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**Note**

For corresponding connections see datasheet.

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## 2.3 Marking

Pepperl+Fuchs Group Lilienthalstraße 200, 68307 Mannheim, Germany	
Internet: <a href="http://www.pepperl-fuchs.com">www.pepperl-fuchs.com</a>	
NCN3-F31K2-N4-B13-S NCN3-F31K2-N4-B33-S NCN3-F31K2M-N4-B13-S NCN3-F31K2M-N4-B23-S NCN3-F31K2-N5-B13-S NCN3-F31K2-N5-B33-S	Up to SIL 2

## 2.4 Standards and Directives for Functional Safe

### Device-specific standards and directives

Functional safety	IEC/EN 61508, part 1 – 2, edition 2010: Functional safety of electrical/electronic/programmable electronic safety-related systems (manufacturer)
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## 3 Planning

### 3.1 System Structure

#### 3.1.1 Low Demand Mode of Operation

If there are two control loops, one for the standard operation and another one for the functional safety, then usually the demand rate for the safety loop is assumed to be less than once per year.

The relevant safety parameters to be verified are:

- the  $PFD_{avg}$  value (average **P**robability of dangerous **F**ailure on **D**emand) and the  $T_1$  value (proof test interval that has a direct impact on the  $PFD_{avg}$  value)
- the SFF value (**S**afe **F**ailure **F**raction)
- the HFT architecture (**H**ardware **F**ault **T**olerance)

#### 3.1.2 High Demand or Continuous Mode of Operation

If there is only one safety loop, which combines the standard operation and safety-related operation, then usually the demand rate for this safety loop is assumed to be higher than once per year.

The relevant safety parameters to be verified are:

- the PFH value (**P**robability of dangerous **F**ailure per **H**our)
- Fault reaction time of the safety system
- the SFF value (**S**afe **F**ailure **F**raction)
- the HFT architecture (**H**ardware **F**ault **T**olerance)

#### 3.1.3 Safe Failure Fraction

The safe failure fraction describes the ratio of all safe failures and dangerous detected failures to the total failure rate.

$$SFF = (\lambda_s + \lambda_{dd}) / (\lambda_s + \lambda_{dd} + \lambda_{du})$$

A safe failure fraction as defined in IEC/EN 61508 is only relevant for elements or (sub)systems in a complete safety loop. The device under consideration is always part of a safety loop but is not regarded as a complete element or subsystem.

For calculating the SIL of a safety loop it is necessary to evaluate the safe failure fraction of elements, subsystems and the complete system, but not of a single device.

## 3.2 Assumptions

The following assumptions have been made during the FMEDA:

- Failure rate based on the Siemens standard SN 29500.
- Failure rates are constant, wear is not considered.
- External power supply failure rates are not included.
- The safety-related device is considered to be of type **A** device with a hardware fault tolerance of **0**.
- The device will be used under average industrial ambient conditions comparable to the classification "stationary mounted" according to MIL-HDBK-217F.  
Alternatively, operating stress conditions typical of an industrial field environment similar to IEC/EN 60654-1 Class C with an average temperature over a long period of time of 40 °C may be assumed. For a higher average temperature of 60 °C, the failure rates must be multiplied by a factor of 2.5 based on experience. A similar factor must be used if frequent temperature fluctuations are expected.

### SIL 2 Application

Only use the device in SIL 2 applications in combination with a control unit according to EN 60947-5-6 (NAMUR).

- The device claims less than 25 % of the total failure budget for a SIL 2 safety loop.
- For a SIL 2 application operating in low demand mode the total  $PFD_{avg}$  value of the SIF (**S**afety **I**nstrumented **F**unction) should be smaller than  $1 \times 10^{-2}$ , hence the maximum allowable  $PFD_{avg}$  value would then be  $2.5 \times 10^{-3}$ .
- For a SIL 2 application operating in high demand mode the total PFH value of the SIF should be smaller than  $1 \times 10^{-6}$  per hour, hence the maximum allowable PFH value would then be  $2.5 \times 10^{-7}$  per hour.
- Since the safety loop has a hardware fault tolerance of **0** and it is a type **A** device, the SFF must be  $> 60$  % according to table 2 of IEC/EN 61508-2 for a SIL 2 (sub) system.

### 3.3 Safety Function and Safe State

#### Safe State

The safe state of the device is the high impedance state (low current).

Applications with control units or safety functions where the safe state is the low impedance state (high current) were not evaluated.

#### Safety Function

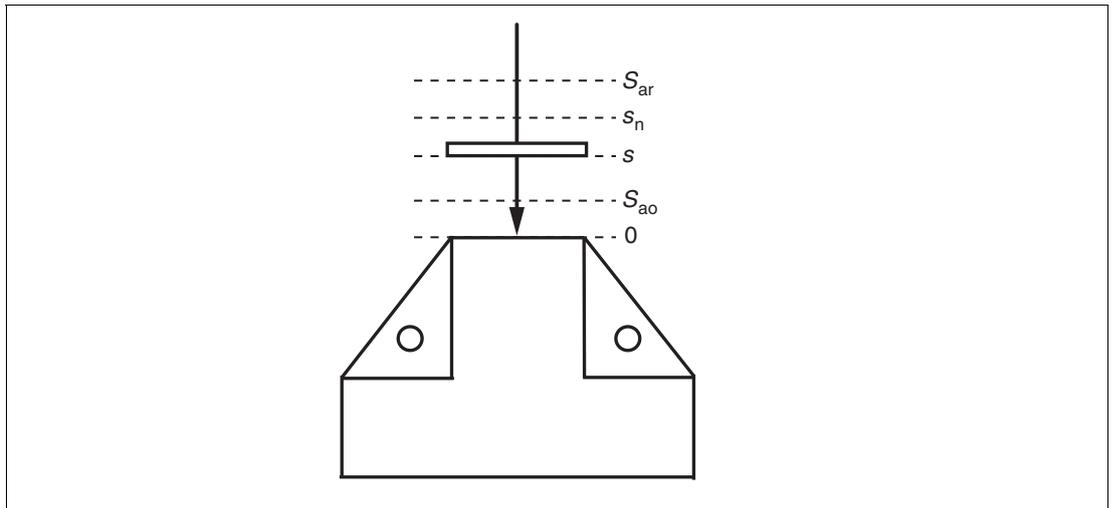


Figure 3.1 Distance values for the design of the safety function (abstract figure)

- s** Current operating distance
- s<sub>n</sub>** Rated operating distance
- S<sub>ao</sub>** Assured operating distance of a PDBB
- S<sub>ar</sub>** Assured release distance of a PDBB

The NAMUR sensor signals the safe state when the reference object is inside of the operating distance of the respective sensor ( $s < S_{ao}$ ). The assured operating distance  $S_{ao}$  is 2.1 mm.

This assured operating distance is valid when using a reference object with a size of 12 mm x 12 mm x 0.4 mm, made of stainless steel 1.4305.

To ensure the safety of the safety loop according to SIL 2, only use control units according to EN 60947-5-6 (NAMUR).

#### Reaction Time

The reaction time for all safety functions is  $< 1$  ms.



#### Note

See corresponding datasheets for further information.

### 3.4 Characteristic Safety Values

Parameter	Characteristic values
Assessment type and documentation	Full assessment
Device type	A
Mode of operation	Low Demand Mode or High Demand Mode
HFT	0
Safety function	High impedance state, depending on the position of the measuring plate
SIL	2 in combination with a control unit according to EN 60947-5-6 (NAMUR)
SC	3
$\lambda_s^{-1}$	107 FIT
$\lambda_{du}$	66 FIT
$\lambda_{total}$ (safety function)	173 FIT
SFF <sup>1</sup>	62 %
PFH	$6.55 \times 10^{-8}$ 1/h
PFD <sub>avg</sub> for T <sub>1</sub> = 1 year	$2.87 \times 10^{-4}$
PFD <sub>avg</sub> for T <sub>1</sub> = 2 years	$5.74 \times 10^{-4}$
PFD <sub>avg</sub> for T <sub>1</sub> = 5 years	$1.43 \times 10^{-3}$
MTTF <sub>d</sub>	1730 years
Useful life time	20 years
Reaction time <sup>2</sup>	< 1 ms

Table 3.1

<sup>1</sup> "No effect failures" are not influencing the safety function and are therefore not included in SFF and in the failure rates of the safety function.

<sup>2</sup> Step response time, also valid under fault conditions (including fault detection and fault reaction)

The characteristic safety values like PFD, SFF, HFT and T<sub>1</sub> are taken from the SIL report/FMEDA report. Observe that PFD and T<sub>1</sub> are related to each other.

The function of the devices has to be checked within the proof test interval (T<sub>1</sub>).

### 3.5 Useful Lifetime

Although a constant failure rate is assumed by the probabilistic estimation this only applies provided that the useful lifetime of components is not exceeded. Beyond this useful lifetime, the result of the probabilistic estimation is meaningless as the probability of failure significantly increases with time. The useful lifetime is highly dependent on the component itself and its operating conditions – temperature in particular. For example, the electrolytic capacitors can be very sensitive to the operating temperature.

This assumption of a constant failure rate is based on the bathtub curve, which shows the typical behavior for electronic components.

Therefore it is obvious that failure calculation is only valid for components that have this constant domain and that the validity of the calculation is limited to the useful lifetime of each component.

It is assumed that early failures are detected to a huge percentage during the installation and therefore the assumption of a constant failure rate during the useful lifetime is valid.

The standard EN/ISO 13849-1:2015 proposes a useful lifetime  $T_M$  of 20 years for devices used within industrial environments. This device is designed for this lifetime.

Observe that the useful lifetime can be reduced if the device is exposed to the following conditions:

- highly stressful environmental conditions such as constantly high temperatures
- temperature cycles with high temperature differences
- permanent repeated mechanical stress (vibration)

Please note that the useful lifetime refers to the (constant) failure rate of the device. The effective lifetime can be higher.

## 4 Mounting and Installation



### Mounting and Installing the Device

1. Observe the safety instructions in the instruction manual.
2. Observe the information in the manual.
3. Observe the requirements for the safety loop.
4. Connect the device only to devices that are suitable for this safety application.
5. Check the safety function to ensure the expected output behavior.

### 4.1 Mounting



#### **Danger!**

Danger to life from missing safety function

An incorrectly mounted, incorrectly positioned or missing measuring plate can lead to failure of the safety loop.

- Fasten the measuring plate in a suitable manner.
- For SN sensors: Do not remove the measuring plate.



### Mounting the Measuring Plate

1. If you are using a custom-specific measuring plate, check the operating distance in your application under realistic environmental conditions.  
↳ The measuring plate is suitable if the measured value does not differ by more than 10 % from the rated operating distance.
2. Fasten the measuring plate so that the measuring plate does not come loose or get lost.

### 4.2 Installation



### Connecting the Sensor

1. Connect the device in safety applications up to SIL 2 to a control unit according to EN 60947-5-6 (NAMUR).  
Observe the limitations, see chapter 1.2.
2. Observe that the insulation resistance must be greater than 1 MΩ.  
Insulate the single wires from any other electrical connections.
3. Observe that the loop resistance must be less than 50 Ω.

### 4.3 Configuration

A configuration of the device is not necessary and not possible.

## 5 Operation



### **Danger!**

Danger to life from missing safety function

If the safety loop is put out of service, the safety function is no longer guaranteed.

- Do not deactivate the device.
- Do not bypass the safety function.
- Do not repair, modify, or manipulate the device.



### Operating the device

1. Observe the safety instructions in the instruction manual.
2. Observe the information in the manual.
3. Use the device only with devices that are suitable for this safety application.
4. Correct any occurring safe failures within 8 hours. Take measures to maintain the safety function while the device is being repaired.

### 5.1 Proof Test

If you perform a proof test for the safety loop, the following steps are necessary:

- Check the device for housing damages. If moisture penetrates into the device or internal components of the device are damaged, this can lead to unpredictable effects.
- Check that the device is working correctly. If the device is not working correctly or not working, replace the device.

For this proof test, no proof test coverage (PTC) can be claimed as only a full functional test with the defined reference object over the temperature range can reveal an unacceptable dislocation of the switching point (PTC = 100 %). But the safety characteristic values are considered low enough to continually manage without proof test.

## 6 Maintenance and Repair



### ***Danger!***

Danger to life from missing safety function

Changes to the device or a defect of the device can lead to device malfunction.  
The function of the device and the safety function is no longer guaranteed.

Do not repair, modify, or manipulate the device.



### **Maintaining, Repairing or Replacing the Device**

In case of maintenance, repair or replacement of the device, proceed as follows:

1. Implement appropriate maintenance procedures for regular maintenance of the safety loop.
2. While the device is maintained, repaired or replaced, the safety function does not work.  
Take appropriate measures to protect personnel and equipment while the safety function is not available.  
Secure the application against accidental restart.
3. Do not repair a defective device. A defective device must only be repaired by the manufacturer.
4. If there is a defect, always replace the device with an original device.

## 7 List of Abbreviations

<b>DC</b>	<b>D</b> iagnostic <b>C</b> overage of dangerous faults
<b>FIT</b>	<b>F</b> ailure <b>I</b> n <b>T</b> ime in $10^{-9}$ 1/h
<b>FMEDA</b>	<b>F</b> ailure <b>M</b> ode, <b>E</b> ffects, and <b>D</b> iagnostics <b>A</b> nalysis
$\lambda_s$	Probability of safe failure
$\lambda_{dd}$	Probability of dangerous detected failure
$\lambda_{du}$	Probability of dangerous undetected failure
$\lambda_{\text{no effect}}$	Probability of failures of components in the safety loop that have no effect on the safety function.
$\lambda_{\text{not part}}$	Probability of failure of components that are not in the safety loop
$\lambda_{\text{total (safety function)}}$	Probability of failure of components that are in the safety loop
<b>HFT</b>	<b>H</b> ardware <b>F</b> ault <b>T</b> olerance
<b>MTBF</b>	<b>M</b> ean <b>T</b> ime <b>B</b> etween <b>F</b> ailures
<b>MTTF<sub>D</sub></b>	<b>M</b> ean <b>T</b> ime <b>T</b> o dangerous <b>F</b> ailure
<b>MTTR</b>	<b>M</b> ean <b>T</b> ime <b>T</b> o <b>R</b> estoration
<b>OSSD</b>	<b>O</b> utput <b>S</b> ignal <b>S</b> witching <b>D</b> evice
<b>PDDB</b>	<b>P</b> roximity <b>D</b> evice with <b>D</b> efined <b>B</b> ehaviour under fault conditions
<b>PF<sub>D</sub>avg</b>	<b>A</b> verage <b>P</b> robability of dangerous <b>F</b> ailure on <b>D</b> emand
<b>PFH</b>	<b>A</b> verage frequency of dangerous failure per hour
<b>PL</b>	<b>P</b> erformance <b>L</b> evel
<b>PLC</b>	<b>P</b> rogrammable <b>L</b> ogic <b>C</b> ontroller
<b>PTC</b>	<b>P</b> roof <b>T</b> est <b>C</b> overage
<b>s</b>	Current operating distance
<b>S<sub>ao</sub></b>	Assured operating distance of a PDDB
<b>S<sub>ar</sub></b>	Assured release distance of a PDDB
<b>s<sub>n</sub></b>	Rated operating distance
<b>SC</b>	<b>S</b> ystematic <b>C</b> apability
<b>SFF</b>	<b>S</b> afe <b>F</b> ailure <b>F</b> raction
<b>SIL</b>	<b>S</b> afety <b>I</b> ntegrity <b>L</b> evel
<b>T<sub>1</sub></b>	<b>P</b> roof <b>T</b> est <b>I</b> nterval

# FACTORY AUTOMATION – SENSING YOUR NEEDS



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