# SIL Manufacturer's Declaration

Functional safety of inductive proximity sensors acc. to IEC 61508:2001; PF18CERT4807

## 1. Safety Evaluation

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declares as manufacturer, that for the inductive proximity sensors, types mentioned below, the calculated $PFD_{avg}$ values for low demand mode of operation are within the allowed range for SIL 2 according to IEC 61508-1:2001 table 2 and do fulfil the requirement to not claim more than 25% of this range, i.e. to be better than or equal to $2.5 \cdot 10^{-3}$.

For high demand mode of operation, the PFH is within the allowed range for SIL 2 according to IEC 61508-1:2001 table 3 and fulfils the requirement to not claim more than 25% of this range, i.e. to be better than or equal to $2.5 \cdot 10^{-7}$ 1/h.

## 2. Products

Inductive proximity sensors with NAMUR interface in accordance with IEC 60947-5-6:1999 or EN 60947-5-6:2000, see product list.

**Product List, Nominal Sensing Distance ($s_n$), Assured Release Distance ($s_{ar}$) and Targets**

| Part No. | Product Name | $s_n$ | $s_{ar}$ | Reference Target |
|---|---|---|---|---|
| 306125 | NJ2-11-N | 2.0 mm | 1.40 mm | 11 x 11 x 1 $mm^3$, Fe 360 |
| 306126 | NJ2-11-N-G | 2.0 mm | 1.40 mm | 11 x 11 x 1 $mm^3$, Fe 360 |
| 306128 | NJ2-11-N-G-15M | 2.0 mm | 1.40 mm | 11 x 11 x 1 $mm^3$, Fe 360 |
| 306129 | NJ2-11-N-G-5M | 2.0 mm | 1.40 mm | 11 x 11 x 1 $mm^3$, Fe 360 |
| 306130 | NJ5-11-N-G | 5.0 mm | 3.50 mm | 15 x 15 x 1 $mm^3$, Fe 360 |
| 306131 | NJ5-11-N-G-10M | 5.0 mm | 3.50 mm | 15 x 15 x 1 $mm^3$, Fe 360 |
| 306132 | NJ5-11-N-G-5M | 5.0 mm | 3.50 mm | 15 x 15 x 1 $mm^3$, Fe 360 |
| 306133 | NJ5-11-N-G-6M | 5.0 mm | 3.50 mm | 15 x 15 x 1 $mm^3$, Fe 360 |

## 3. Safety Function

The safe state (high impedance state) is reached when the active face is covered with a target within the assured release distance $S_{ar}$. In this case the sensor is in the high impedance state ('off state'). It is important that the gap size between the target (damping material) and the active face of the sensor is narrower than $S_{ar}$.

This evaluation is not valid for using amplifiers/safety functions that rely on the 'on state' as safe state.

| Sensor respective amplifier output | Sensor condition (see Conditions and Assumptions) |
|---|---|
| On state (low impedance) | active face uncovered and sensor functioning |
| Off state (high impedance) | active face covered or sensor defective |

The nominal sensing distance $s_n$ and therefore the assured release distance $S_{ar}$ depends on the dimensions and the material of the target.

When using a custom target that is deviating from the given reference target, check the switching distance in your application under realistic operating conditions. If the measured value

is not different from the nominal switching distance by more than 10%, your target is considered acceptable. The assured operating distance in your application is then assumed as 0.7 times the measured switching distance.

## 4. Safety Characteristic Values

| Parameter | Symbol | Condition [2)] | Value | Unit |
|---|---|---|---|---|
| Type | | | A | |
| Hardware Fault Tolerance | *HFT* | | 0 | |
| Total Failure Rate | $\lambda_{total}$ | | 2.90E-08 | 1 / h |
| Total Safe Failure Rate | $\lambda_{safe}$ | | 2.21E-08 | 1 / h |
| Total Dangerous Failure Rate | $\lambda_{dangerous}$ | | 6.91E-09 | 1 / h |
| Safe Failure Fraction | *SFF* | | 76.19 | % |
| Mean Time to Failure | *MTTF* | | 3.45+07 | h |
| Average Probability of Failure on Demand | *PFDavg* [1)] | $T_{proof}$ = 1 year | 3.02E-05 | |
| Average Probability of Failure on Demand | *PFDavg* [1)] | $T_{proof}$ = 2 years | 6.05E-05 | |
| Average Probability of Failure on Demand | *PFDavg* [1)] | $T_{proof}$ = 5 years | 1.51E-04 | |
| Probability of Dangerous Failure per Hour | *PFH* [1)] | | 6.91E-09 | 1 / h |
| Safety Integrity Level | *SIL* | | 2 | |
| Useful lifetime | $T_M$ | | 20 | a |
| Diagnostic Coverage | *DC* | | 0 | % |

[1)] 1oo1 structure

## 5. Conditions and Assumptions

The sensor is connected to a NAMUR interface in accordance with EN 60947 5 6:2000. The failure rates are based on the Siemens standard SN 29500. According to IEC 61508-1:2001 table 2, the average *PFD* for systems operating in low demand mode of operation has to be lower than $10^{-2}$ for SIL 2 safety functions. However, as the sensor under consideration is only one part of an entire safety function it should not claim more than 25 % of this range, i.e. it should be better than or equal to $2.5 \cdot 10^{-3}$.

For high demand mode of operation, the PFH has to be lower than $10^{-6}$ for SIL 2 safety functions. However, as the sensor under consideration is only one part of an entire safety function it should not claim more than 25 % of this range, i.e. it should be better than or equal to $2.5 \cdot 10^{-7}$ 1/h.

The sensor is considered to be Type A component. Therefore the *SFF* has to be > 60 % according to IEC 61508-2:2001 table 2 for SIL 2 (sub-) systems with a hardware fault tolerance of 0.

The following assumptions have been made during the Failure Mode Effect and Diagnostic Analysis:

- Failure rates are constant, wear out mechanisms are not included ($T_M$ = 20a)
- Propagation of failures is not relevant.
- All component failure modes are known (Type A).
- The repair time after a safe failure is 8 hours.
- The average temperature over a long period of time is 40 °C.
- The stress levels are average for an industrial environment and can be compared to the Ground Fixed classification of MIL-HDBK-217F. Alternatively, the assumed environment is similar to IEC 60654-1, Class C (sheltered location) with an average temperature over a long period of time of 40 ºC.

- When using a custom target that is deviating from the given reference target, check the switching distance in your application under realistic operating conditions. If the measured value is not different from the nominal switching distance by more than 10%, your target is considered acceptable. The assured operating distance in your application is then assumed as 0.7 times the measured switching distance.
- The 2-wire connection cable between the sensor and the switching amplifier must meet the qualities as follows: Line resistance $R_{series}$ < 50 Ω (both leads in series); Insulation resistance $R_{insulation}$ > 1 MΩ.
- PFD and PFH values are calculated for use in a 1oo1 structure.
- The products are designed for a useful lifetime of 20 years regarding constant failure rates of its components. This is ensured by excluding the use of more rapidly aging components like wet electrolytic capacitors or optical isolators in the safety path. Nonetheless this can be reduced if the device is driven under harsh working conditions with either excessive mechanical stress (vibration), higher average ambient temperature than assumed or prevalent substantial temperature cycles.

## 6. Definitions

The following definitions for the failure of the product were considered.

Application according to EN 60947-5-6 (DC interface for proximity sensors and switching amplifiers (NAMUR)):

| | |
|---|---|
| Fail-Safe State | The fail-safe state is defined as the output being below 1.2 mA (high impedance). |
| Fail Safe | Failure that causes the module / (sub)system to go to the defined fail-safe state without a demand from the process. |
| Fail Dangerous | Failure leading to an output current above 1.2 mA (i.e. being unable to go to the defined fail-safe state). |
| Fail No Effect | Failure of a component that is part of the safety function but that has no effect on the safety function. For the calculation of the *SFF* it is treated like a safe undetected failure. |

For the calculation of the Safe Failure Fraction (*SFF*) the following has to be noted:

$SFF = 1 - \lambda_D / \lambda_{total}$

The failure categories listed above expand on the categories listed in IEC 61508:2001 which are only safe and dangerous. It is important to realize that the „no effect“ failures are included in the „safe“ failure category according to IEC 61508:2001.

Note that these failures on its own will not affect system reliability or safety, and should not be included in spurious trip calculations.

| | | |
|---|---|---|
| Hersteller-Unterschrift / Signature of manufacturer | ppa. Wolfgang Helm | i.V. Ulrich Ehrenfried |
| Funktion des Unterzeichners / Function of the signer: | Leiter GF Sensoren Fabrikautomation<br>Manager BU Sensors Factory Automation | Leiter Entwicklung GF Sensoren Fabrikautomation<br>Manager R&D BU Sensors Factory Automation |
| Datum / Date: | August 2018 | |

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