SIL Manufacturer's Declaration

Functional safety of dual inductive proximity sensors acc. to IEC 61508:2000; PF20CERT2382F

1 Safety Evaluation

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declares as manufacturer that for the inductive dual 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 61508-1:2000 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 61508-1:2000 table 3. It 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.

The sensors are considered to be Type A components. Therefore, the SFF has to be 60 % to 90 % according to EN/IEC 61508-2 table 2 for SIL 2 (sub-) systems with a hardware fault tolerance of 0.

2 Products

Dual inductive proximity sensors with NAMUR interface in accordance with IEC 60947-5-6:1999 or EN 60947-5-6:2000, see product list. See the data sheet for the special pin assignment of these sensors.

The nominal sensing distance s_n and therefore the assured release distances S_{ar} depend on the dimensions and the material of the target. The distance is the air gap between the target surface and the sensing face while the reference target is in parallel with the sensing face, is centered to the reference axis and is moving along the reference axis.

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

Part No.	Product Name	*Function*[1)]	s_n	S_{ar}	Reference Target
222679	NCN3-F31K-N4	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
222680	NCN3-F31K-N4-K	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
222681	NCN3-F31K-N4-K-S	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
222682	NCN3-F31K-N4-V1-V1	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
223953	NCN3-F31K-N4-S	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
252896	NCN3-F31K-N4-K-Y244381	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
281187	NCN3-F31K-N4-B13-S	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
223954	NCN3-F31-N4-K	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
223955	NCN3-F31-N4-K-10M	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
223956	NCN3-F31-N4-K-K	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
223957	NCN3-F31-N4-V1	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
223959	NCN3-F31-N4-V16-K	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
223960	NCN3-F31-N4-V16-V1-Y223960	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
223961	NCN3-F31-N4-V16-V16	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
223962	NCN3-F31-N4-V18	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
7011 0340	NCN3-F31K-N4-B13	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305

The sensor can simulate a wrong state if a pin assignment according to IEC 60947-5-6:1999 or EN 60947-5-6:2000 is assumed. See data sheet for correct application.

Part No.	Product Name	*Function*[1)]	s_n	S_{ar}	Reference Target
223958	NCN3-F31-N4-V1-Y223958	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305
223963	NCN3-F31-N4-V18-Y223963	NC	3.0 mm	2.1 mm	8.5 x 8.5 x 0.5 mm³, 1.4305

[1)] NC = normally closed (break)

3 Safety Function

The safe state is reached when the active face is covered with a target (actuator element, damping material) within the assured release distance S_{ar}. In this case the sensor is in the high impedance state ('off state', I < 1.2 mA). It is important that the gap size between the target and the active face of the sensor is smaller than S_{ar}.

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

If customized targets are used it must be ensured that the distance between the damping material and the active face of the sensor is closer than 0.7 times the individual measured real sensing distance.

This evaluation is only valid for using amplifiers/safety functions that rely on the 'off state' as safe state.

Sensor respective amplifier output	Sensor condition
On state (low impedance)	active face uncovered (target not present) and sensor functioning
Off state (high impedance, safe state)	active face covered (target present) or sensor defective

4 Safety Characteristic Values

Parameter	Symbol	Condition	Value	Unit
Type			A	
Hardware Fault Tolerance	*HFT*		0	
Safe Failure Rate	λ_{safe}		77	FIT
No Effect Failure Rate	$\lambda_{no\ effect}$		29	FIT
Dangerous Failure Rate	$\lambda_{dangerous}$		69	FIT
Total Failure Rate	λ_{total}		175	FIT
Total Safe Failure Rate	λ_S		106	FIT
Total Dangerous Failure Rate	λ_D		69	FIT
Safe Failure Fraction	*SFF*		60.59	%
Mean Time to Failure	*MTTF*		5.71E+06	h
Average Probability of Failure on Demand	PFD_{avg} [1)]	T_1 = 1 year	3.02E-04	
Average Probability of Failure on Demand	PFD_{avg} [1)]	T_1 = 2 years	6.04E-04	
Average Probability of Failure on Demand	PFD_{avg} [1)]	T_1 = 5 years	1.51E-03	
Probability of Dangerous Failure per Hour	*PFH* [1)]		6.9E-08	1/h
Safety Integrity Level	*SIL*		2	
Useful lifetime (Mission Time T_M)			20	years
Diagnostic Coverage	*DC*		0	%

[1)] 1oo1 structure

5 Conditions and Assumptions

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

- Failure rates are based on the Siemens standard SN 29500.
- Failure rates are constant, wear is not included.
- Propagation of failures is not relevant.
- All component failure modes are known (Type A).
- PFD and PFH values are calculated for use in a 1oo1 structure.
- 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 60645-1, Class C (sheltered location) with an average temperature over a long period of time of 40 ºC.

- For the high impedance state the object is within the assured release distance ($s < S_{ar}$).
- 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, as stated in IEC 60947-5-6:1999 and EN 60947-5-6:2000 (NAMUR). The wires must be isolated from any other circuit.
- The products are designed for a useful lifetime of 20 years regarding constant failure rates of its components. 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.
- The sensor is operated within the limits given in its datasheet.
- The sensor is connected to a NAMUR interface in accordance with EN 60947-5-6:2000 or IEC 60947-5-6:1999 that relies on the high impedance state ("off state") of the sensor as safe state and is qualified for SIL 2 applications.
- The valve connection circuit is not part of this functional safety declaration.

6 Definitions

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

Application according to EN 60947-5-6:2000 or IEC 60947-5-6:1999 (DC interface for proximity sensors and switching amplifiers (NAMUR)):

Safe State	The safe state is defined as the output being below 1.2 mA (high impedance).
Safe Failure	Failure that causes the sensor current consumption to go to the defined safe state without a demand from the process.
Dangerous Failure	Failure leading to an output current above 1.2 mA when the target is within the assured release distance (i.e. being unable to go to the defined safe state).
"No Effect" Failure	Failure of a component that is part of the safety function but 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:

$$\lambda_{total} = \lambda_{safe} + \lambda_{dangerous} + \lambda_{no\ effect}$$

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

The failure categories listed above expand on the categories listed in IEC 61508:2000 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 61508:2000.

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

Although the safety characteristic values of the sensor are within the allowed range for SIL 2 according to IEC 61508:2000 it depends on the failure rates of the other devices in the safety loop whether a SIL 2 safety function can be implemented.

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