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SIL Manufacturer's Declaration

Functional safety of inductive proximity sensors acc. to IEC 61508:2001; PF18CERT1606A

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. They fulfil the requirement not to claim more than 25% of this range for a low demand application, 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. 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

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
181094	NCB2-12GM35-N0	2.0 mm	1.4 mm	12 x 12 x 1 mm³, Fe 360
181099	NCB2-12GM35-N0-V1	2.0 mm	1.4 mm	12 x 12 x 1 mm³, Fe 360
181169	NCB2-12GK35-N0	2.0 mm	1.4 mm	12 x 12 x 1 mm³, Fe 360

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

Sensor respective amplifier output	Sensor condition
On state	active face uncovered and sensor functioning
Off state	active face covered or sensor defective

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4. Safety Characteristic Values

Parameter	Symbol	Condition	Value	Unit
Type			A	
Hardware Fault Tolerance	*HFT*		0	
Total Safe Failure Rate	λ_{safe}		1.28E-07	1 / h
Dangerous Failure Rate	$\lambda_{dangerous}$		7.41E-08	1 / h
No Effect Failure Rate	$\lambda_{no\ effect}$		4.02E-08	1 / h
Total Failure Rate	λ_{total}		2.02E-07	1 / h
Safe Failure Fraction	*SFF*		63	%
Mean Time to Failure	*MTTF*		4.95E+06	h
Average Probability of Failure on Demand	*PFDavg* [1)]	T_{proof} = 1 year	3.24E-04	
Average Probability of Failure on Demand	*PFDavg* [1)]	T_{proof} = 2 years	6.48E-04	
Average Probability of Failure on Demand	*PFDavg* [1)]	T_{proof} = 5 years	1.62E-03	
Probability of Dangerous Failure per Hour	*PFH* [1)]		7.41E-08	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 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 (T_M = 20a).
- Propagation of failures is not relevant.
- All component failure modes are known (Type A).
- The sensor is connected to a NAMUR interface in accordance with EN 60947-5-6:2000.
- 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.
- 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 60947-5-6:2000 (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:

$\lambda_{total} = \lambda_{safe} + \lambda_{dangerous}$

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

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 their 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/	Leiter BU Sensoren Fabrikautomation BU Sensoren	Leiter Innovation Unit Elektromagnetische Sensoren Fabrikautomation – BU Sensoren
Function of the signer:	Manager BU Sensors Factory Automation – BU Sensors	Head of Innovation Unit Electromagnetic Sensors Factory Automation – BU Sensors
Datum/Date:	Juli/ July 2018	

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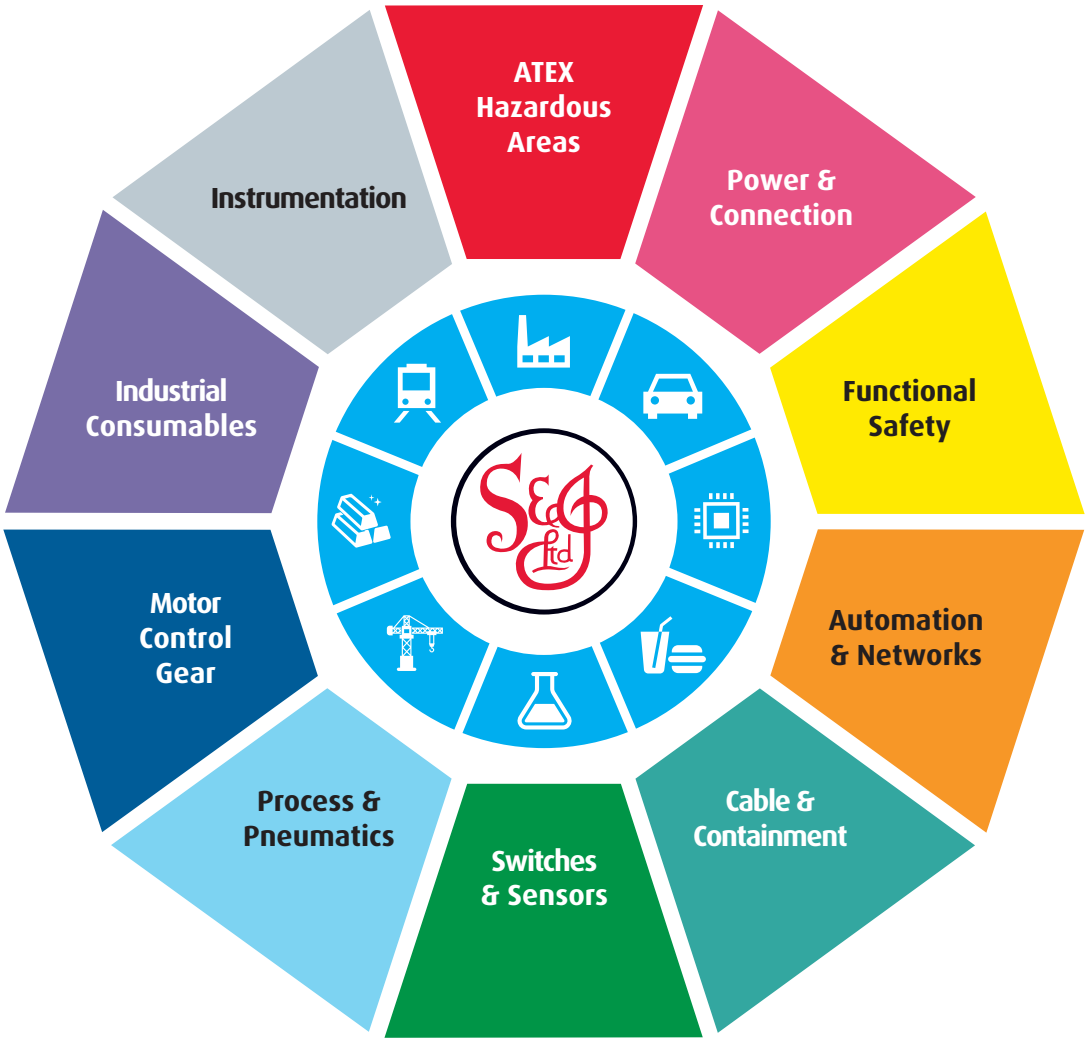

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