Failure Modes, Effects and Diagnostic Analysis

Project:
Surge Protective Devices DEHNconnect DCO SD2

Customer:
DEHN + SÖHNE GmbH + Co. KG.
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Management summary

This report summarizes the results of the hardware assessment carried out on the Surge Protective Devices DEHNconnect DCO SD2 in the versions listed in the drawings referenced in section 2.4.1. Table 1 gives an overview of the different configurations that belong to the considered Surge Protective Devices DEHNconnect DCO SD2.

The hardware assessment consists of a Failure Modes, Effects and Diagnostics Analysis (FMEDA). A FMEDA is one of the steps taken to achieve functional safety assessment of a device per IEC 61508. From the FMEDA, failure rates are determined and consequently the Safe Failure Fraction (SFF) is calculated for the device. For full assessment purposes all requirements of IEC 61508 must be considered.

Table 1: Configuration overview DEHNconnect DCO SD2

DCO SD2 ME 12 DCO SD2 ME 24 DCO SD2 ME 48	Energy-coordinated two-stage arrester with disconnection function for protecting two single lines sharing a common reference potential as well as unbalanced interfaces.
DCO SD2 MD 12 DCO SD2 MD 24 DCO SD2 MD 48	Energy-coordinated two-stage arrester with disconnection function that has no leakage current to earth. Protects one unearthed pair as well as balanced interfaces.
DCO SD2 MD EX 24	Surge arrester with energy-coordinated low-capacitance protective circuit and disconnection module for disconnecting signal circuits. For protecting one pair in intrinsically safe measuring circuits and bus systems, meets FISCO requirements. Self-capacitance and self-inductance negligibly small. Insulation strength > 500 V to earth.
DCO SD2 MD HF 5	Energy-coordinated two-stage surge arrester with disconnection function for protecting balanced interfaces with extra-low voltages. Also suitable for high transmission rates due to a diode matrix with minimized capacitance. It is advisable to use SAK shield connection systems for shielded bus lines.
DCO SD2 E 12 DCO SD2 E 24 DCO SD2 E 48	Finely-limiting surge protective device with disconnection function and powerful diodes to earth for two single lines sharing a common reference potential and unbalanced interfaces.

For safety applications only the described configurations were considered. All other possible variants or electronics are not covered by this report.

Surge Protective Devices are not considered to be elements according to IEC 61508-4 section 3.4.5 as they are not performing one or more element safety functions. Therefore there is no need to calculate a SFF (Safe Failure Fraction). Only the interference on a safety function needs to be considered. This interference is expressed in a contribution to the overall PFD_{AVG} / PFH.

The failure rates used in this analysis are from the *exida* Electrical & Mechanical Component Reliability Handbook for Profile 1.

The following tables show how the above stated requirements are fulfilled under worst-case assumptions.

Table 2: DCO SD2 ME 12, DCO SD2 ME 24 and DCO SD2 ME 48 – Failure rates

	exida Profile 1	
	Analysis 1 [1]	**Analysis 2** [2]
Failure category	**Failure rates (in FIT)**	**Failure rates (in FIT)**
Fail Safe Detected (λ_{SD})	**0**	**0**
Fail Safe Undetected (λ_{SU})	**3.5**	**3.5**
Fail Dangerous Detected (λ_{DD})	**0**	**7.4**
Fail Dangerous Undetected (λ_{DU})	**10.5**	**3.1**
No effect	37	37
No part	1	1
Total failure rate (safety function)	**14 FIT**	**14 FIT**
MTBF	**2225 years**	**2225 years**

[1] Analysis 1 represents a worst-case analysis.

[2] Analysis 2 represents an analysis with the assumption that line short circuits and short circuits to GND are detectable or do not have an effect.

Table 3: DCO SD2 MD 12, DCO SD2 MD 24 and DCO SD2 MD 48 – Failure rates

	exida Profile 1	
	Analysis 1 [3]	**Analysis 2** [4]
Failure category	**Failure rates (in FIT)**	**Failure rates (in FIT)**
Fail Safe Detected (λ_{SD})	**0**	**0**
Fail Safe Undetected (λ_{SU})	**3.5**	**3.5**
Fail Dangerous Detected (λ_{DD})	**0**	**4.9**
Fail Dangerous Undetected (λ_{DU})	**7.8**	**2.9**
No effect	37	37
No part	1	1
Total failure rate (safety function)	**11.3 FIT**	**11.3 FIT**
MTBF	**2363 years**	**2363 years**

[3] Analysis 1 represents a worst-case analysis.

[4] Analysis 2 represents an analysis with the assumption that line short circuits and short circuits to GND are detectable or do not have an effect.

Table 4: DCO SD2 MD EX 24 – Failure rates

	exida Profile 1	
	Analysis 1 [5]	**Analysis 2** [6]
Failure category	**Failure rates (in FIT)**	**Failure rates (in FIT)**
Fail Safe Detected (λ_{SD})	**0**	**0**
Fail Safe Undetected (λ_{SU})	**3.5**	**3.5**
Fail Dangerous Detected (λ_{DD})	**0**	**5.9**
Fail Dangerous Undetected (λ_{DU})	**9.8**	**3.9**
No effect	55	55
No part	1	1
Total failure rate (safety function)	**13.3 FIT**	**13.3 FIT**
MTBF	**1671 years**	**1671 years**

[5] Analysis 1 represents a worst-case analysis.

[6] Analysis 2 represents an analysis with the assumption that line short circuits and short circuits to GND are detectable or do not have an effect.

Table 5: DCO SD2 MD HF 5 – Failure rates

	exida Profile 1	
	Analysis 1 [7]	**Analysis 2** [8]
Failure category	**Failure rates (in FIT)**	**Failure rates (in FIT)**
Fail Safe Detected (λ_{SD})	**0**	**0**
Fail Safe Undetected (λ_{SU})	**3.5**	**3.5**
Fail Dangerous Detected (λ_{DD})	**0**	**4.9**
Fail Dangerous Undetected (λ_{DU})	**10.2**	**5.3**
No effect	39	39
No part	1	1
Total failure rate (safety function)	**13.7 FIT**	**13.7 FIT**
MTBF	**2150 years**	**2150 years**

[7] Analysis 1 represents a worst-case analysis.

[8] Analysis 2 represents an analysis with the assumption that line short circuits and short circuits to GND are detectable or do not have an effect.

Table 6: DCO SD2 E 12, DCO SD2 E 24 and DCO SD2 E 48 – Failure rates

	exida Profile 1	
	Analysis 1 [9]	**Analysis 2** [10]
Failure category	**Failure rates (in FIT)**	**Failure rates (in FIT)**
Fail Safe Detected (λ_{SD})	**0**	**0**
Fail Safe Undetected (λ_{SU})	**2.4**	**2.4**
Fail Dangerous Detected (λ_{DD})	**0**	**5.4**
Fail Dangerous Undetected (λ_{DU})	**5.8**	**0.4**
No effect	1	1
No part	1	1
Total failure rate (safety function)	**8.2 FIT**	**8.2 FIT**
MTBF	**12016 years**	**12016 years**

The failure rates are valid for the useful life of the Surge Protective Devices DEHNconnect DCO SD2 (see Appendix 2).

[9] Analysis 1 represents a worst-case analysis.

[10] Analysis 2 represents an analysis with the assumption that line short circuits and short circuits to GND are detectable or do not have an effect.