FMEDA – Report
Failure Modes, Effects and Diagnostic Analysis

Device Model Number:

KFD2-ELD-Ex16
KFD2-ELD-16

Project:
x7300

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1. Report Summary

This report summarizes the results of the FMEDA carried out on the Ground Fault Detection Isolated Barrier with circuit diagram 01-9070A from 2011-Nov-09.

Ground Fault detection 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 functions needs to be considered.
The failure rates used in this analysis are the basic failure rates from the Siemens standard SN 29500. This failure rate database is specified in the safety requirements specification from Pepperl+Fuchs GmbH for the Ground Fault Detection Barriers KFD2-ELD-Ex16 and KFD2-ELD-16.
The listed SN29500 failure rates are valid for operating stress conditions typical of an industrial field environment with an average temperature over a long period of time of 40ºC. For a higher average temperature of 60°C, the failure rates should be multiplied with an experience based factor of 2.5. A similar multiplier should be used if frequent temperature fluctuation (daily fluctuation of > 15°C) must be assumed.

The FMEDA proves that the KFD2-ELD-(Ex)16 devices only have very limited influence on safety functions designed according to EN/IEC 61508:2000 or EN/IEC 61508:2010.

The following result shows how the above stated requirements are fulfilled under worst-case assumptions.

2. Result of the assessment

The ELD is attached in parallel to an existing safety loop, therefore only the influence of the galvanically isolated input of the ELD to this existing safety loop is evaluated within the assessment. Configurations of the ELD do not have any effect on this evaluation.

The $\boldsymbol{\lambda_{du}}$ to add for a loop that uses the ELD devices KFD2-ELD-Ex16, KFD2-ELD-16 is:
$\boldsymbol{\lambda_{du}}$ **= 0.002 FIT**.

There are no further values as there are no further failures that would have any negative effect on an attached safety loop.

Table of content

Reviewers

Role	
Project Leader (PL)	
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History of this document

Revision of this document	Reviewed by / [Reviewer abbreviation within the detailed comment list]	Date of Review	Changes since last version
V 0 Rev. 1	Fiebig (DP.DFI), Kindermann (DP.MKI)	2015-Jul-24	Newly created
V 1 Rev. 0	Trautmann (DP.MTR) Kindermann (DP.MKI)	2015-Oct-19	Version for EDM
V 1 Rev. 1	Fiebig (DP.DFI)	2016-Mar-09	Change values to Ed. 2 of the IEC 61508
V 2 Rev. 0	Fiebig (DP.DFI), Kindermann (DP.MKI)	2016-Mar-09	Completed for EDM

3. Functional description of the Module KFD2-ELD-Ex16 and KFD2-ELD-16

The device is a Ground Fault Detection module (ELD for Earth Loop Detection). It is used as 16-channel isolated detection device for intrinsic safety applications.

The device detects ground faults on field lines. To do this, the ELD is attached in parallel to an existing safety loop.

The 16 channels of the device continuously monitor galvanically isolated circuits and warns if their resistance to ground falls below 10 kΩ.

During an alarm condition, the appropriate channel LED is illuminated and the change-over contact is initiated (S1 = position I). The function of this relay can be reversed with switch S1 (S1 = position II).

A self-test can be activated via the test input of the device. The device reacts by switching the relay. The self-test can be triggered manually by the user or remotely by the control system.

The KFD2-ELD-* device provides 16-channel, with the terminals shown in Figure 1.

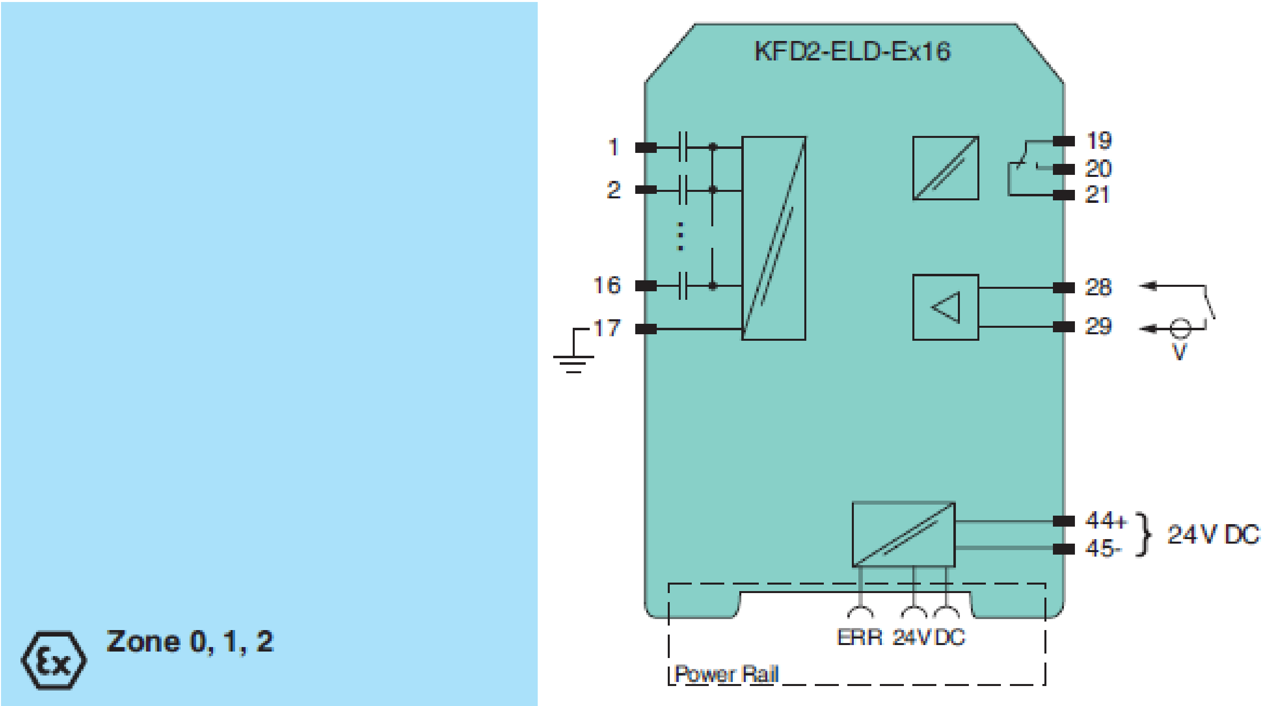

Fig. 1: Connection of the KFD2-ELD-Ex16

Supply (via Power Rail):

Rated voltage 20…30 VDC

4. Results of the assessment

The ELD is attached in parallel to an existing safety loop, therefore only the influence of the galvanically isolated input of the ELD to this existing safety loop is evaluated within the assessment. Configurations of the ELD do not have any effect on this evaluation.

The $\boldsymbol{\lambda_{du}}$ to add for a loop that uses the ELD devices KFD2-ELD-Ex16, KFD2-ELD-16 is:
$\boldsymbol{\lambda_{du}}$ **= 0.002 FIT**.

From that, a PFH and a PFD_{avg} value can be calculated.
PFH = $2 * 10^{-12}$ 1/h
PFD_{avg} (T_1 = 1 year) = $8,76 * 10^{-9}$

There are no further values as there are no further failures that would have any detrimental effect on an attached safety loop. The rest of the failures in the input circuit of these devices are not affecting functional safety.

5. Useful life time

Although a constant failure rate is assumed by the probabilistic estimation this only applies provided that the useful life time of components is not exceeded. Beyond this useful life time, the result of the probabilistic calculation is meaningless as the probability of failure significantly increases with time. The useful life time 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 working 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 life time of each component.

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

However, according to IEC 61508-2, a useful life time, based on experience, should be assumed. Experience has shown that the useful life time often lies within a range period of about 8 ... 12 years.

As noted in DIN EN 61508-2:2011 note NA4, appropriate measures taken by the manufacturer and operator can extend the useful lifetime. Our experience has shown that the useful life time of a Pepperl+Fuchs product can be higher

- if there are no components with reduced life time in the safety path (like electrolytic capacitors, relays, flash memory, opto coupler) which can produce dangerous undetected failures and
- if the ambient temperature is significantly below 60 °C.

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

6. Abbreviations

FMEDA	Failure Modes, Effects and Diagnostic Analysis
PFD	Probability of dangerous failure on demand
PFH	Probability of dangerous failure per hour
SIL	Safety Integrity Level
T_1	Time for Proof Test Interval
AVG	Average
λ_{du}	Probability of dangerous undetected failure

7. Literature

Manufacturer Documentation

(KFD2-ELD-Ex16 - P2 – Part No. 811040)
01-9070A from 2011-Nov-09, Circuit diagram for KFD2-ELD-Ex16
53-1227A from 2011-Jun-15, Layout for P2, KFD2-ELD-Ex16
Bill of material for KFD2-ELD-Ex16, drawing 53-1228 dated 2013-Jun-03
Datasheet Part No. 233849 dated 2015-Mar-11
FS-0016PF-27 V1R2 from 2016-Mar-09, Calculations File

Standards

IEC 61508-1:1998 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems – General Part
IEC 61508-2:2000 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems – Requirements
IEC 61508-1:2010 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems – General Part
IEC 61508-2:2010 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems – Requirements
SN 29500 parts 1 – 13, Failure rates of components
FMD-91, RAC 1991 Failure Mode / Mechanism Distributions
FMD-97, RAC 1997 Failure Mode / Mechanism Distributions