Choose certainty.
Add value.

Technical report

of the

Type testing

of the

K*-SH Switch Amplifier**
KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1

Applicant
Pepperl + Fuchs GmbH
Lilienthalstrasse 200
68307 Mannheim
Germany

Report no. PM85769T
Revision: 1.3, Date 2020-05-27

Test body

TÜV SÜD Rail GmbH
Generic Safety Systems
D-80339 Munich

Revision history

Revision	Date	Author	Status	Modifications
1.0	2014-05-08	T. Paradzik	initial	
1.1	2017-04-27	Franz Seika	Replaced	Update of Standards, Minor Modification of Schematics
1.2	2020-02-04	T. Paradzik	Replaced	HW changes Add chapter 3.7 and chapter 6 Update with new documents Table 10 and 11
1.3	2020-05-27	T. Paradzik	active	Added schematic, layout and test documents to [D24], [D26], [D27] and [D33]

Table 1: Revision history

Content

List of Tables

List of Figures

1 Target of Evaluation (ToE)

On April 11th, 2012 Pepperl + Fuchs GmbH requested TÜV SÜD Rail GmbH to test and certify the K***-SH Switch Amplifier KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 from Pepperl + Fuchs GmbH. The Project No. related to this Technical Report was as follows: 717506303.

The ToE is a devices that transfers signals from a hazardous area to a safe area. This device is a SIL 3 amplifier according to IEC 61508, CAT 3, PL d according to ISO 13849-1 based on electronic technology.

The safety function of the KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 series is to shut off the output I and output II on demand.

With the letter of 24.03.2017 Pepperl + Fuchs GmbH requested TÜF SÜD Rail GmbH to update to the actual EN ISO 13849-1 and EN 62061. Also some small modifications in HW were announced. The Project number related to this Technical Report was as follows: 717514564

In June 2019 Pepperl + Fuchs GmbH requested TÜV SÜD Rail GmbH to test and certify the HW change of the KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 series. The Project No. related to this change request was as follows: 717519391.

2 Scope of Testing

2.1 Test specimen

The KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 consist of an input circuit to evaluate the signal from the sensor, a processing circuit to convert the input signal and the output circuit. The overview of the KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 series is depicted in Figure 1.

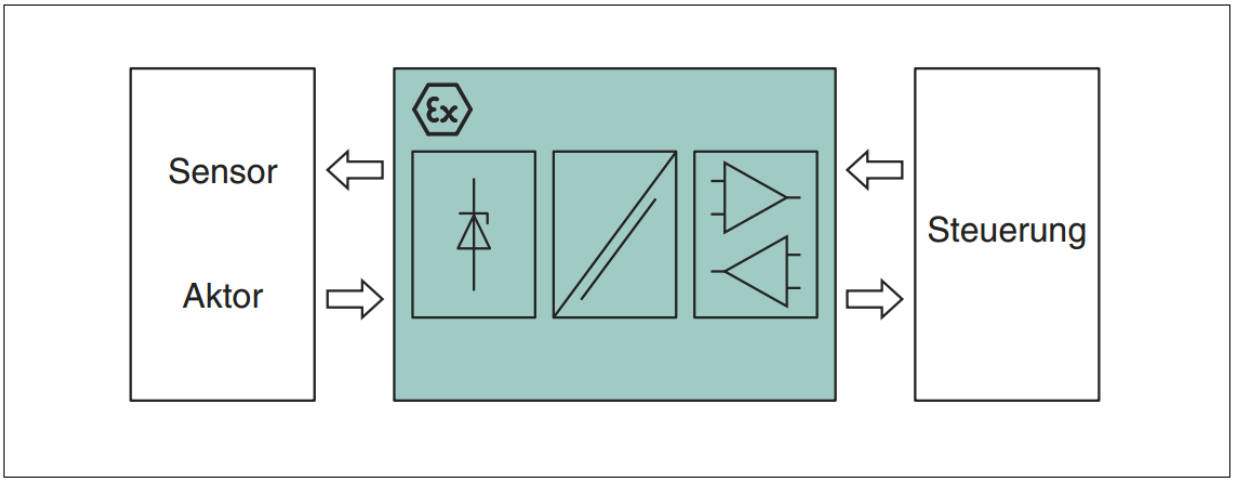

Figure 1: Block diagram of the unit KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1

In Figure 2, Figure 3 and Figure 4, it can be seen that the system consists of input, processing unit and output .

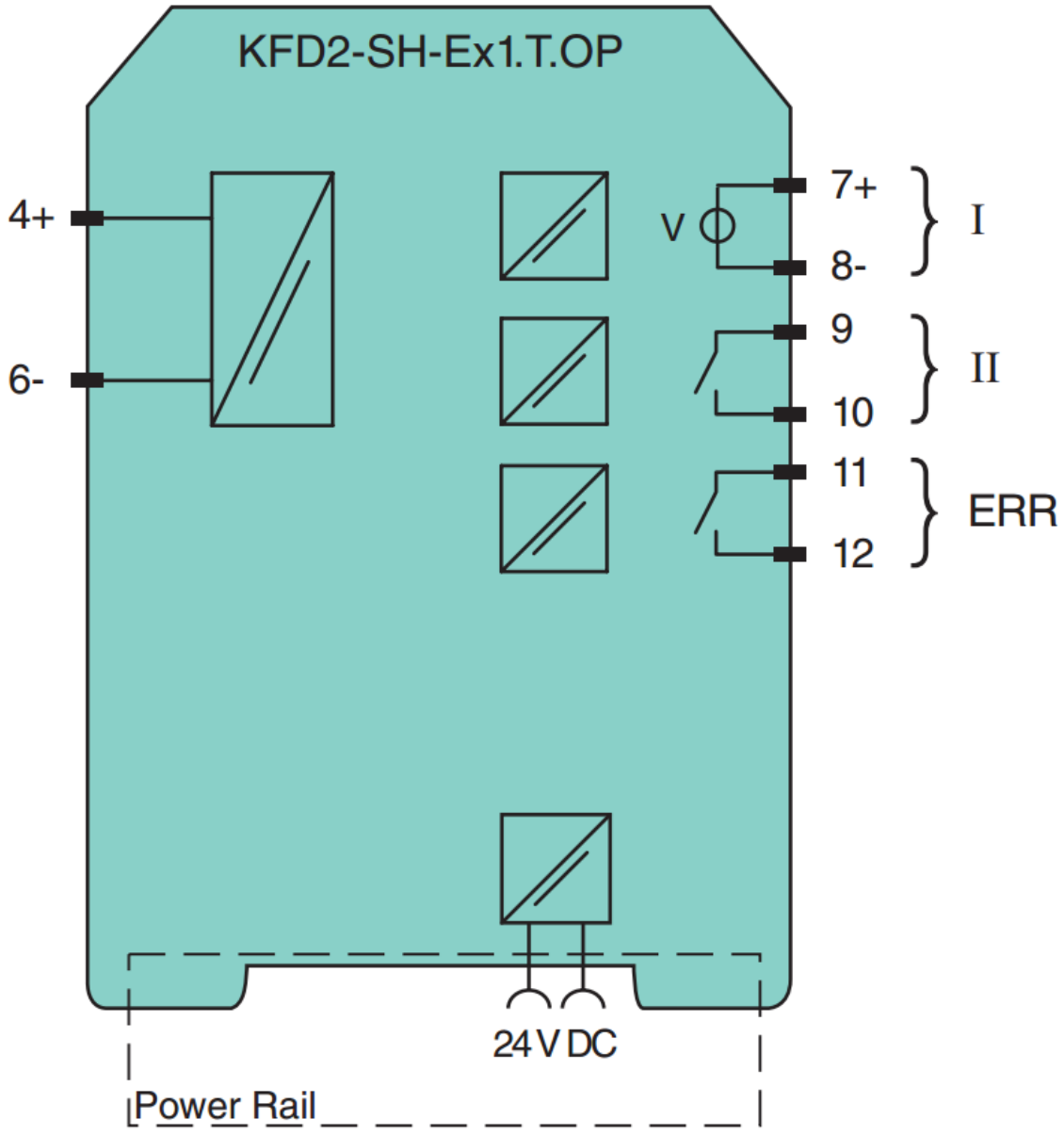

Figure 2: Block diagram of the unit KFD2-SH-Ex1.T.(OP)[1]

[1] The hardware revision is part of the unit number

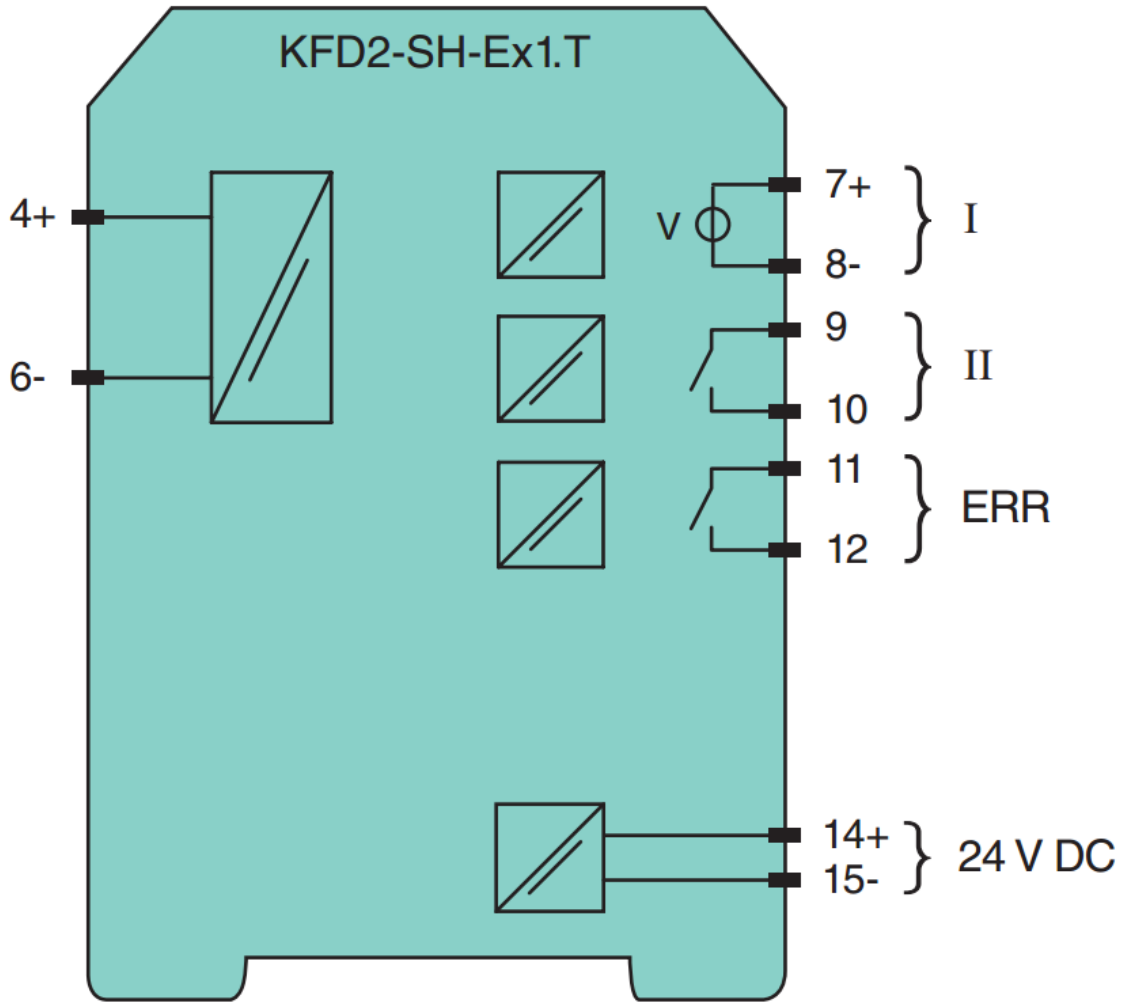

Figure 3: Block diagram for the unit KFD2-SH-Ex1[2]

[2] The hardware revision is part of the unit number

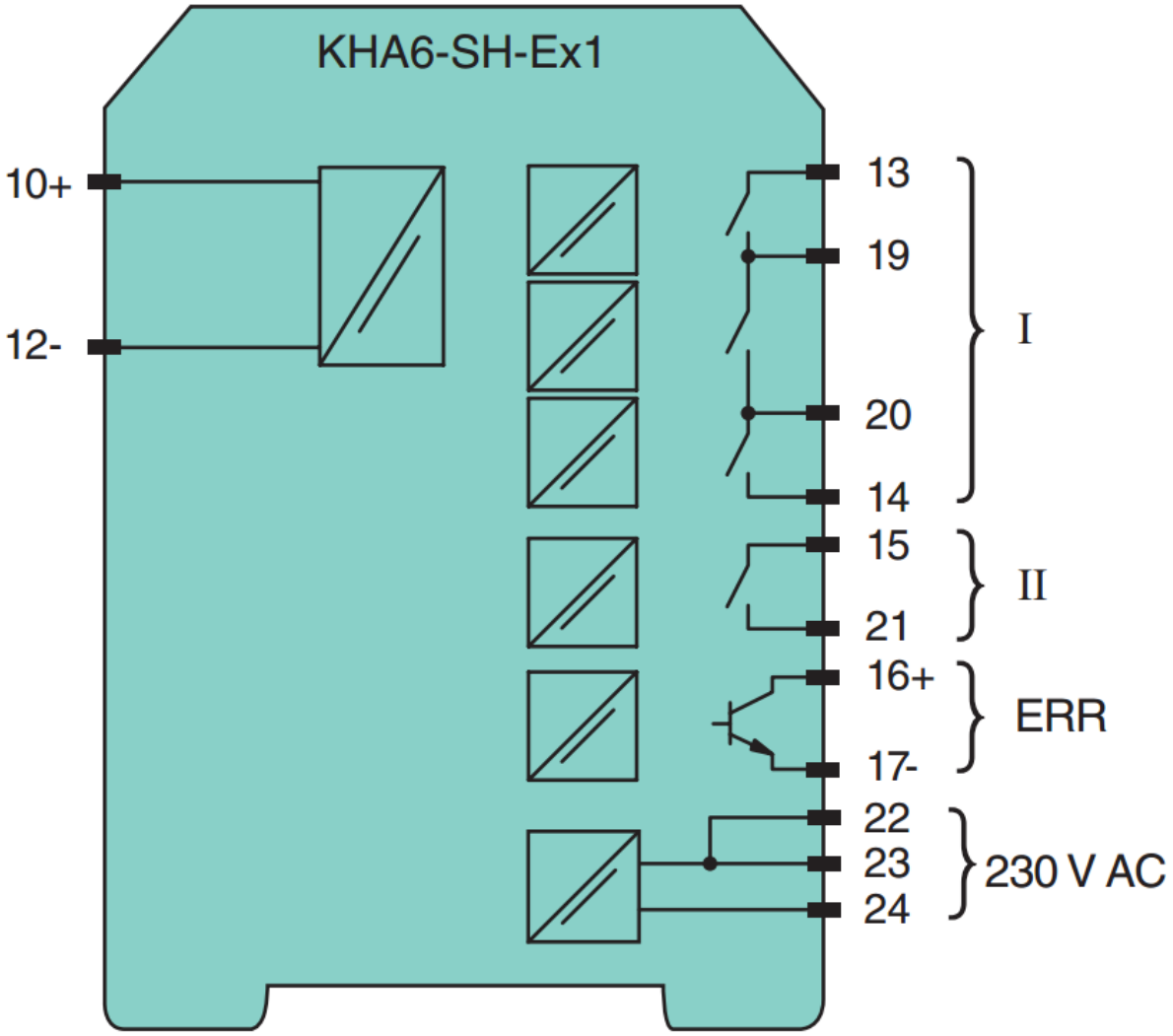

Figure 4: Block diagram of the unit KHA6-SH-Ex1[3]

[3] The hardware revision is part of the unit number

2.2 Tests

The KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 were examined with regard to the following testing operations:

I. Functional safety including
- Functional safety management (FSM) und safety lifecycle
- Analysis of the hardware (FMEDA[4] on component or block level)
- Error simulations
- Test of the error prevention measures
- Functional tests

II. Electrical safety

III. Susceptibility to environmental errors including
- Climate and temperature
- IP degree of protection
- Mechanical effects

IV. Electromagnetic compatibility
- Immunity

V. Safety information in the product documentation (safety manual, operating instructions)

[4] Failure Mode, Effects and Diagnosis Analysis

3 Basis of Testing

The regulations and guidelines which form the basis of the type testing are listed below.

3.1 European directives

No.	Standard	Title
[L1]	2006/42/EC	DIRECTIVE 2006/42/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)

Table 2: European directives

3.2 Functional safety

No.	Standard	Title
[N1]	EN 61508-1: 2010 (SIL 3)	Functional safety of electrical/electronic/programmable electronic safety-related systems Part 1: General requirements
[N2]	EN 61508-2: 2010 (SIL 3)	Functional safety of electrical/electronic/programmable electronic safety-related systems Part 2: Requirements for electrical/electronic/ programmable electronic safety-related systems
[N3]	EN 61508-4: 2010 (SIL 3)	Functional safety of electrical/electronic/programmable electronic safety-related systems Part 4: Definitions and abbreviations
[N4]	EN ISO 13849-1: 2015 (PL d, Cat. 3)	Safety of machinery - Safety-related parts of control systems Part 1: General principles for design
[N5]	EN 62061/A2:2015	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
[N6]	EN 60947-5-3/A1: 2005	Low-voltage switchgear and controlgear – Part 5-3: Control circuit devices and switching elements – Requirements for proximity devices with defined behaviour under fault conditions (PDF)

Table 3: Functional safety

3.3 Electrical safety

No.	Standard	Title
[N7]	EN 61010-1: 2010	Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements

Table 4: Electrical safety

3.4 Susceptibility to environmental errors

3.4.1 IP Code testing

No.	Standard	Title
[N8]	EN 60529/A1: 2000	Degrees of protection provided by enclosures (IP Code)

Table 5: IP Code testing

3.5 Electromagnetic immunity

No.	Standard	Title
[N9]	EN 61326-3-1:2008	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications

Table 6: Electromagnetic immunity

3.5.1 Environmental testing

No.	Standard	Title
[N10]	EN 60068-1:1995	Environmental testing Part 1: General and guidance

Table 7: Environmental testing

3.6 Safety information in the product documentation (safety manual, operating instructions)

No.	Standard	Title
[N11]	EN 61508-2: 2010 (SIL 3)	Functional safety of electrical/electronic/programmable electronic safety-related systems Part 2: Requirements for electrical/electronic/ programmable electronic safety-related systems
[N12]	EN ISO 13849-1: 2008 (PL d, Cat. 3)	Safety of machinery – Safety-related parts of control systems Part 1: General principles for design

Table 8: Safety information

3.7 Quality Management System

No.	Reference	Description
[M1]	QMS	Quality Management System TÜV SÜD Rail GmbH
	TR_RA_P_04.50	Test Program Functional Safety TR_RA_P_04.51Definition Scope of testing TR_RA_P_04.07Product modification TR_RA_P_04.52Concept Phase & Safety Lifecycle TR_RA_P_04.53Detail Phase Hardware (HW) TR_RA_P_04.56Result of Testing (R)

No.	Reference	Description
[M2]	D-IS-11190-01-00	DAkkS accreditation according to DIN EN ISO/IEC 17020:2012; inspection body type A

Table 9: Quality Management System

4 Documents provided for testing of KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1

Following documents were provided by Pepperl + Fuchs GmbH to be checked and evaluated by the test house.

No.	Title	Document-No./ File identifier	Revision	Date
	System Level			
[D1]	SYSTEMBESCHREIBUNG K-System Trennbarrieren	TDOCT-0187PGER	-	07/2012
[D2]	Technischer Bericht zur Produktklassifizierung nach EN 954-1 TÜV Produkt Service	990187427	1.0	24.01.2000
[D3]	Technischer Bericht Änderungsprüfung TÜV Produkt Service	200188825	1.0	05.07.2000
[D4]	Technischer Bericht Änderungsprüfung TÜV Produkt Service	7B70711	1.0	11.03.1998
[D5]	Circuit diagram K.D2-SH-Ex1	T01-4382BEN	B	12.09.2011
[D6]	Circuit diagram KHA6-SH-Ex1	1-4383	C	12.09.2011
[D7]	Circuit diagram KFD2-SH-Ex1.T.OP	T01-3832EEN	E	23.09.2004
[D8]	Schnittstelle für SN-Sensoren und SH-Schaltverstärker Definition der Schaltschwellen	14-0876 B	-	23.11.2012
[D9]	Schnittstelle für SN-Sensoren und SH-Schaltverstärker - elektrische Daten für funktionale Sicherhei	14-0876B2	-	14.08.2013
[D10]	FMEDA KFD2-SH-EX1	FS-0026TV-26	1.0	30.01.2014
[D11]	FMEDA KFD2-SH-EX1	FS-0026TV-26_2	1.0	30.01.2014
[D12]	FMEDA KFD2-SH-EX1.T(.OP)	FS-0026TV-26_3	1.0	30.01.2014
[D13]	FMEDA KFD2-SH-EX1.T(.OP)	FS-0026TV-26_4	1.0	30.01.2014

No.	Title	Document-No./ File identifier	Revision	Date
[D14]	FMEDA KHA6-SH-EX1	FS-0026TV-26_5	1.0	30.01.2014
[D15]	FMEDA KHA6-SH-EX1	FS-0026TV-26_6	1.0	30.01.2014
[D16]	FMEDA KFD2-SH-EX1	FS-0026TV-26_7	1.0	30.01.2014
[D17]	FMEDA and Proven-in-use Assessment Isolated Switch Amplifier K***-SH-EX1.*	P+F 04/11-22 R022	V2, R0	May 2009
[D18]	SAFETY MANUAL Switch Amplifier KFD2-SH-Ex1(.T)(.OP), KHA6-SH-Ex1	DOCT-2992	-	05/2014
[D19]	EMV Prüfprotokoll KFD2-SH-Ex1.T.OP	130429 KFD2-SH-Ex1 EMV Prüfprotokoll.docx	-	17.04.2013
[D20]	Prüfbericht Elektromagnetische Verträglichkeit (EMV) KHA6-SH-Ex1	40069/607-1 PRDE-AU49	-	09.05.1996
[D21]	Test and Assessment report KHA6-SH-Ex1	PRDE-B3G3	-	21.01.2014
[D22]	Test and Assessment report KFD2-SH-Ex1	PRDE-AYL9	-	21.01.2014
[D23]	Impact Analysis for changes on SIL devices/ For Switch Amplifier Kxxx-SH-Ex1(.T(.OP))	FS-0026PF-25D	V1 Rev1	05.04.2017
[D24]	Impact Analysis for changes on SIL devices/ for EX-Redesign Kxxx-SH-Ex1 - Circuit diagram - Layout - EMC-Report	FS-0026PF-25F - 01-4383D - 05-7539A - PRDE-8753D/ PRDE-AYF6B	V0 Rev4	13.02.2017
[D25]	ORIGINAL INSTRUCTIONS Functional Safety Switch Amplifier KFD2-SH-Ex1(.T)(.OP), KHA6-SH-Ex1	DOCT-2992B		04/2017
	Change request HW (06/19)			
[D26]	Impact Analysis for changes on SIL Devices - Layout	FS-0132TV-25 - 05-7843C	V1 Rev2	2019-10-11
[D27]	Impact Analysis for changes in devices with functional safety according to IEC61508 Change of Relay K3 in Kxxx-SH-Ex1 Relay PCB - Circuit diagram - Layout	FS-0026PF-25H - 01-A0K2 - 05-1822E	-	2019-02-20

No.	Title	Document-No./ File identifier	Revision	Date
[D28]	Impact Analysis for changes on SIL devices with functional safety according to IEC61508 #046903 KFD2-SH-Ex1 power supply	FS-0026PF-25G	-	2019-01-28
[D29]	V&V Development Test KFD2-SH-Ex1	136076a.pdf	V2 Rev.0	2019-11-13
[D30]	Circuit diagram K.D2-SH-Ex1	01-4382C	C	2014-08-04
[D31]	Schematic K…-SH-EX1	01a091a.pdf	-	2016-12-16
[D32]	Schematic KFD2-SH-Ex1	01-A1H5D	-	2019-06-24
[D33]	Impact Analysis for changes in devices with functional safety according to IEC61508 Obsolete Timer 555 #018162 / replacement in KFD2/KHA6-SH devices	FS-0026PF-25E - 01-3832F	-	2015-07-08

Table 10: Documentation

5 Performance and result of tests

5.1 Test reports

Following test reports were issued by TÜV SÜD Rail GmbH or other accredited test laboratories.

No.	Title	Document-No./ File identifier	Revision	Date
[R1]	IEC 61508-1 FSM 2nd Edition	P+F_61508_FSM.pdf	1.1	2014-04-15
[R2]	Checklist for Functional Safety of E/E/PE Safety-Related Systems according to IEC 61508, part 1 Lifecycle	P+F_61508_Lifecycle.pdf	1.0	2014-04-14
[R3]	Meeting Minutes	20140414_TÜV_Süd.docx	-	2014-04-14
[R4]	Review Report IEC 61508 Manual	Review_Manual_61508.pdf	1.1	2014-04-11
[R5]	Review Report ISO 13849 Manual	Review_Manual_13849.pdf	1.1	2014-04-11
[R6]	Review Report EMV Prüfungen	Review Report_EMV Pruefungen.pdf	1.0	2012-12-03
[R7]	Minutes of Meeting	MoM_P+F_120920.pdf	1.0	2014-09-20
[R8]	Review FMEDA	TR_RA_F_04.25_Review_Report.pdf	1.1	2014-03-24
[R9]	Response time measurement K***-SH-Ex…	13-4190	-	2014-05-06

No.	Title	Document-No./ File identifier	Revision	Date
[R10]	Checklist for Functional Safety of E/E/PE Safety-Related Systems according to IEC 61508 Ed. 2, part 2 Hardware	Chklst_2014_04_17_P+F_61508_2.pdf	1.0	2014-04-17
[R11]	Checklist according to EN ISO 13849-1 - Second edition: 2008	Check-liste_13849_1_HW.docx	1.0	2014-05-08
[R12]	Checklist according to EN 60947-5-3	Chklst_2014_04_17_P+F_60947_5_3.pdf	1.0	2014-04-23
[R13]	Test report Fault Insertion P+F	Test report Fault Insertion Tests P+F.pfd	1.0	2014-04-23
[R14]	Checkliste_62061_short.pdf	Checklist for safety of machinery Conformity evaluation according IEC 62061	1.0	31.03.2017
[R15]	Delta-Checklist for safety of machinery Conformity evaluation according IEC 62061:2005 + A1:2012+A2:2015	Delta Checklist 62061 Short.pdf	1.0	31.03.2017
[R16]	Delta Checklist according to ISO 13849-1:2015	Delta Checklist according to ISO 13849	1.0	31.03.2017
[R17]	Review Protocol FS-0026PF-25D	Review Report Impact Analysis FS-0026PF-25D.pdf	1.1	10.04.2017
[R18]	Review Protocol FS-0026PF-25F	Review Report Impact Analysis FS-0026PF-25F.pdf	1.0	31.03.2017
[R19]	Review Protocol Safety Manual	Review Report Manual EN 62061.pdf	1.0	27.04.2017
	Change request HW (06/19)			
[R20]	Review Protocol Analysis FS0026PF	Review_Impact_Analysis_fs0026pf	1.1	27.01.2020
[R21]	Review Protocol Analysis SH	Review_Impact_ Analysis_1_1	1.1	27.01.2020

Table 11: Test results

5.2 Functional Safety Management and Lifecycle Audit

A functional safety management and lifecycle audit was executed to evaluate the management and technical activities during the overall, E/E/PES and software safety lifecycle phases which are necessary for the achievement of the required functional safety of the E/E/PES safety-related systems.

Result:

The analysis of the organization and procedures of Pepperl + Fuchs GmbH has shown that the requirements specified in checklists [R1] and [R2] for SIL 3 according to IEC 61508 (see [N1] to [N3]) are covered.

5.3 Failure Mode and Effect Analysis (FMEA) and Hardware Fault Simulations (FIT)

Failure mode and effect analysis was carried out on the KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 series at the component level for the two safety relevant outputs I and II. All component failures and function-related faults in components or component groups were examined to assess their effects on the safe functioning of control unit. These examinations were limited to faults in the part of the hardware which is relevant with regard to functional safety. Component faults in the part of the hardware which is not relevant to functional safety were observed to assess their effect on non-interaction characteristics.

Practical fault simulations were carried out to provide subsequent evaluation of the knowledge obtained from the theoretical failure mode and effect analysis. The performances of these fault simulations provide information on the fail-safe characteristics of the system.

The hardware fault simulation was carried out on-site by TÜV Product Service in the year 2000. For the fault simulation, a number of representative fault simulations were defined by TÜV Product Service based on the fault models. These faults represent a series of faults according the new FMEDAs [D10] to [D16] which have an identical effect on the functions of the system.

Result:

All fault models according to [N1] to [N3] and [N5] were covered.

The FMEDA4 on component or block level and the FIT demonstrated that the system structure of the K***-SH Switch Amplifier meets the requirements of the regulations and standards listed in clause 3 of this Technical Report.

The results of the fault insertion tests are given in the technical reviews [D2], [D3] and [D4] and the test report [R13].

5.4 Testing of fault avoidance measures

Testing of the individual fault avoidance measures in the individual design phases is supposed to demonstrate that the implemented hardware and software are sufficiently fault-free. The following techniques and measures were used:

- Project management
- Documentation
- Structured specification
- Inspection of the specification or walk-through of the specification
- Observance of relevant guidelines and standards
- Structured design
- Modularization
- Use of well tried components
- Inspection of the hardware
- Functional testing (also under environmental conditions)
- Operational and maintenance instructions
- User- and maintenance friendliness

Result:

The individual measures for the avoidance of failures which provide the required degree of effectiveness are evaluated. The results of the evaluation are documented in the checklists [R10] and [R10]. They meet the requirements according to [N1] to [N6].

5.5 Quantitative analysis of output I and output II

For the quantitative analysis of the output I of the KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 the basic failure rate λ (FIT, [10^{-9} h^{-1}]) for each component was calculated. For the failure rate calculation, the part count methodology due to SN 29500 Part 1-14 and the estimation at block level have been used ([D10], [D12] and [D14]).

The proof test interval is specified in accordanc to the safety standards mentioned in chapter 3.2, within which the assemblies have been completely tested in order to detect an initial fault before combination with a possible second fault becomes harmful. The result of the maintenance has been calculated as proof test interval. The table 12 depicts the values from the quantitative analysis for output I.

Value	KFD2-SH-EX1	KFD2-SH-EX1.T(.OP)	KHA6-SH-EX1
$MTTF_d$ [a]	2240	2500 (2860)	1477
PFD_{avg} [10 a]	2,83E-05	6,04E-05	2,83E-05
PFH [h^{-1}]	6.47E-10	1,38E-09	6,47E-10
SFF [%]	99,8	99,4	99,8
DC [%]	98,7	96,5	99,2

Table 12: Quantitative analysis for the output I of KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 series

For the quantitative analysis of the output II of the KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 the basic failure rate λ (FIT, [10^{-9} h^{-1}]) for each component was also calculated but only related to the standard [N1]. For the failure rate calculation, the part count methodology due to SN 29500 Part 1-14 and the estimation at block level have been used ([D11], [D13] and [D15]).

Value	KFD2-SH-EX1	KFD2-SH-EX1.T(.OP)	KHA6-SH-EX1
PFD_{avg} [10 a]	2,27E-03	2,26E-03	2,27E-03
PFH [h^{-1}]	5,19E-08	5,16E-08	5,19E-08
SFF [%]	82,3	81,8	81,5

Table 13: Quantitative analysis for the output II of KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 series

The power supply for the KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 was analysed in a separate document according the basic failure rate λ (FIT, [10^{-9} h^{-1}]) for each component. For the failure rate calculation, the part count methodology due to SN 29500 Part 1-14 and the estimation at block level have been used ([D16]).

Result for output I of the KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1:

The total probability of failure on demand (PFD) for the output I of the devices KFD2-SH-EX1, KFD2-SH-EX1.T(.OP) and KHA6-SH-EX1 calculated is within the admissible value of IEC 61508-1 for SIL 3 ≥10^{-4} to <10^{-3}.

The probability of dangerous failure per hour (PFH) for the output I of the devices KFD2-SH-EX1, KFD2-SH-EX1.T(.OP) and KHA6-SH-EX1 calculated is within than the admissible value of IEC 61508-1 for SIL 3 ≥10^{-8} to <10^{-7}.

The mean time to dangerous failure ($MTTF_d$) for the output I of the devices KFD2-SH-EX1, KFD2-SH-EX1.T(.OP) and KHA6-SH-EX1 resulting from the calculation is “High” according to EN ISO 13849-1 (see [N4]) (30 years ≤ $MTTF_d$ 100 years). The maximum value of 100 years has been taken into account.

The diagnostic coverage (DC) for the output I of the units KFD2-SH-EX1 and KHA6-SH-EX1 is calculated as “High” (DC < 99%)., the DC of the unit KFD2-SH-EX1.T(.OP) is calculated as “Medium” according to EN ISO 13849-1 (90% ≤ DC < 99%).

The quantitative requirements of SIL 3 are satisfied in case of:

- Proof test interval, T1 = 10 years
- Mean time to restoration, MTTR = 8 h

It is necessary to perform this periodic test to detect dangerous failures.

With the values of $MTTF_d$ and DC, KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 the output I meets the quantitative requirements of Category 3 and PL d according to EN ISO 13849-1.

The Markov modeling and calculations are recorded in the document [D17].

Result for output II of the KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1:

The total probability of failure on demand (PFD) for the output II of the devices KFD2-SH-EX1, KFD2-SH-EX1.T(.OP) and KHA6-SH-EX1 calculated is within the admissible value of IEC 61508-1 for SIL 2 ≥10^{-3} to <10^{-2}.

The probability of dangerous failure per hour (PFH) for the output II of the devices KFD2-SH-EX1, KFD2-SH-EX1.T(.OP) and KHA6-SH-EX1 calculated is within than the admissible value of IEC 61508-1 for SIL 3 ≥10^{-7} to <10^{-8}.

The quantitative requirements of SIL 2 are satisfied in case of:

- Proof test interval, T1 = 10 years
- Mean time to restoration, MTTR = 8 h

It is necessary to perform this periodic test to detect dangerous failures.

The Markov modeling and calculations are recorded in the document [D17].

Result for the power supply of the KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1:

The FMEDA of the power supply shows no dangerous undetected failure. The power supply does not increase the failure rate or the values for $MTTF_d$,PFD, PFH or DC of the KFD2-SH-Ex1, KFD2-SH-Ex1.T(.OP), KHA6-SH-Ex1 units.

5.6 Electrical Safety

The electrical safety was tested in accordance with [N7] and the regulations related to these standards.

Result:

The results about the electrical safety are documented in report [D21] and [D22]. The tests demonstrated that the devices KFD2-SH-EX1, KFD2-SH-EX1.T(.OP) and KHA6-SH-EX1 fulfils the requirements referring to the electrical safety in accordance to [N7].

5.7 Climatic stress tests

The strength of the design versus climatic stress was tested in accordance with [N1] to [N4] and [N10] and the related standards.

Result:

The individual tests are documented in report [D21] and [D22].

The test sample worked properly during and after the test.

5.8 Mechanical stress tests

The strength of the design versus mechanical stress was tested in accordance with [N1] to [N5] and [N10] and the related standards.

Result:

The individual tests are documented in report [D21] and [D22].

The test sample worked properly during and after the test.

5.9 Testing of the noise immunity

The strength of the design versus electromagnetic immunity was tested in accordance with [N9].

Result:

The individual tests are documented in report [D19] and [D20].

The test sample worked properly during and after the test.

5.10 Verification of the degree of protection

The degree of protection was tested according to [N8].

Result:

The tests for the devices KFD2-SH-EX1, KFD2-SH-EX1.T(.OP) and KHA6-SH-EX1 are recorded in report [D21] and [D22]. The requirements in accordance with [N8] are fulfilled.

5.11 Inspection of the technical documentation

The safety manual [D18] and [D25] (for Modification) was examined to verify the completeness of the technical documentation.

Result:

The results are documented in reports [R4] and [R6].

The technical documentation fulfils the requirements in accordance with [L1] and [N2] to [N5].

5.12 Modification

For the update to EN ISO 13849-1 and EN 62061 no modifications in HW were necessary. The modifications acc. to [D23] and [D24] were reviewed by TÜV SÜD Rail GmbH.

Result:

The results are documented in reports [R17] and [R18].

The requirements in accordance with [L1] and [N2] to [N5] are still fulfilled.

6 Testing Body

This report is based on the accreditation of the testing laboratory for safety components; see table “Quality Management System”.

The following test reports were issued from other accredited laboratories as integrated part of the test result:

No.	Issued by and Title	Document number / ID	Rev.	Date
[R1]	See [D19] to [D22]	-	-	-

Table 14: Test Reports issued from other laboratories

7 Summary

The test results of clause 5 showed that the ToE, as specified in clause 2.1, fulfils the requirements of clause 3 and the related standards and guidelines.

Digital unterschrieben von Guido Neumann
Datum: 2020.05.27 09:13:56 +02'00'

Guido Neumann

Reviewer

Digital unterschrieben von Paradzik-2019
Datum: 2020.05.27 07:47:20 +02'00'

Tomislav Paradzik

Project Manager