BS EN 60947-5-3:2013

BSI Standards Publication

Low-voltage switchgear and controlgear

Part 5-3: Control circuit devices and switching elements — Requirements for proximity devices with defined behaviour under fault conditions (PDDB)

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National foreword

This British Standard is the UK implementation of EN 60947-5-3:2013. It is identical to IEC 60947-5-3:2013. It supersedes BS EN 60947-5-3:1999, which will be withdrawn on 10 September 2016.

The UK participation in its preparation was entrusted by Technical Committee PEL/17, Switchgear, controlgear, and HV-LV coordination, to Subcommittee PEL/17/2, Low voltage switchgear and controlgear.

A list of organizations represented on this committee can be obtained on request to its secretary.

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(IEC 60947-5-3:2013)

Appareillage à basse tension -
Partie 5-3: Appareils et éléments de commutation pour circuits de commande - Exigences pour dispositifs de détection de proximité à comportement défini dans des conditions de défaut (PDDB)
(CEI 60947-5-3:2013)

Niederspannungsschaltgeräte -
Teil 5-3: Steuergeräte und Schaltelemente -
Anforderungen für Näherungsschalter mit definiertem Verhalten unter Fehlerbedingungen (PDDB)
(IEC 60947-5-3:2013)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B - 1000 Brussels

Foreword

The text of document 17B/1821/FDIS, future edition 2 of IEC 60947-5-3, prepared by SC 17B "Low-voltage switchgear and controlgear" of IEC/TC 17 "Switchgear and controlgear" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60947-5-3:2013.

The following dates are fixed:

– latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2014-06-10

– latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2016-09-10

This document supersedes EN 60947-5-3:1999.

EN 60947-5-3:2013 includes the following significant technical changes with respect to EN 60947-5-3:1999:

a) general principles of EN 61508 series;

b) classification according to the requirements of EN 62061;

c) classification according to EN ISO 13849-1.

This European Standard is to be read in conjunction with EN 60947-1, *Low-voltage switchgear and controlgear – Part 1: General rules* and EN 60947-5-2, *Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements - Proximity switches*. The provisions of Part 1 and Part 5-2 are only applicable to this European Standard where specifically called for. The numbering of the subclauses of this European Standard is sometimes not continuous because it is based on the numbering of the subclauses of EN 60947-1 or EN 60947-5-2.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For the relationship with EU Directive(s), see informative Annex ZZ, which is an integral part of this document.

This European Standard does not deal with any specific requirements on noise as the noise emission of control circuit devices and switching elements is not considered to be a relevant hazard.

Endorsement notice

The text of the International Standard IEC 60947-5-3:2013 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60068-2-6:2007	NOTE	Harmonized as EN 60068-2-6:2008 (not modified).
IEC 60068-2-14:2009	NOTE	Harmonized as EN 60068-2-14:2009 (not modified).
IEC 60068-2-27:2008	NOTE	Harmonized as EN 60068-2-27:2009 (not modified).
IEC 60204-1:2005 A1:2008	NOTE	Harmonized as EN 60204-1:2006 (modified) and EN 60204-1:2006/A1:2009 (not modified).
IEC 60364	NOTE	Harmonized in HD 384 / HD 60364 series (partially modified).
IEC 60445:2010	NOTE	Harmonized as EN 60445:2010 (not modified).
IEC 60947-5-6:1999	NOTE	Harmonized as EN 60947-5-6:2000 (not modified).
IEC 61000-3-2:2005 A1:2008 A2:2009	NOTE	Harmonized as EN 61000-3-2:2006 (not modified), EN 61000-3-2:2006/A1:2009 (not modified) and EN 61000-3-2:2006/A2:2009 (not modified).
IEC 61000-3-3:2008	NOTE	Harmonized as EN 61000-3-3:2008 (not modified).
IEC 61000-4-13:2002 A1:2009	NOTE	Harmonized as EN 61000-4-13:2002 (not modified) and EN 61000-4-13:2002/A1:2009 (not modified).
IEC 61140:2001 A1:2004	NOTE	Harmonized as EN 61140:2002 (not modified) and EN 61140:2002/A1:2006 (modified).
IEC 61165:2006	NOTE	Harmonized as EN 61165:2006 (not modified).
IEC 61326-3-1:2008	NOTE	Harmonized as EN 61326-3-1:2008 (not modified).
IEC 61496-1:2012	NOTE	Harmonized as EN 61496-1:201X [1)].
IEC 61496-2:2013	NOTE	Harmonized as EN 61496-2:201X [2)] (not modified).
IEC 61496-3:2008	NOTE	Harmonized as CLC/TS 61496-3:2008 (not modified).
IEC 61508-4:2010	NOTE	Harmonized as EN 61508-4:2010 (not modified).
IEC 61508-5:2010	NOTE	Harmonized as EN 61508-5:2010 (not modified).
IEC 61508-6:2010	NOTE	Harmonized as EN 61508-6:2010 (not modified).
IEC 61508-7:2010	NOTE	Harmonized as EN 61508-7:2010 (not modified).

1) At draft stage.

2) To be published.

IEC 61511	NOTE	Harmonized in EN 61511 series (not modified).
IEC 61511-1:2003	NOTE	Harmonized as EN 61511-1:2004 (not modified).
IEC 61511-2:2003	NOTE	Harmonized as EN 61511-2:2004 (not modified).
IEC 61511-3:2003	NOTE	Harmonized as EN 61511-3:2004 (not modified).
CISPR 11:2009 A1:2010	NOTE	Harmonized as EN 55011:2009 (modified) and EN 55011:2009/A1:2010 (not modified).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60068-2-1	2007	Environmental testing - Part 2-1: Tests - Test A: Cold	EN 60068-2-1	2007
IEC 60068-2-30	2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)	EN 60068-2-30	2005
IEC 60529 - + A1	1989 - 1999	Degrees of protection provided by enclosures (IP Code)	EN 60529 + corr. May + A1	1991 1993 2000
IEC 60947-1 + A1	2007 2010	Low-voltage switchgear and controlgear - Part 1: General rules	EN 60947-1 + A1	2007 2011
IEC 60947-5-1 - + A1	2003 - 2009	Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices	EN 60947-5-1 + corr. July + A1	2004 2005 2009
IEC 60947-5-2 + A1	2007 2012	Low-voltage switchgear and controlgear - Part 5-2: Control circuit devices and switching elements - Proximity switches	EN 60947-5-2 + A1	2007 2012
IEC 61000-4-2	2008	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	EN 61000-4-2	2009
IEC 61000-4-3 + A1 + A2	2006 2007 2010	Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	EN 61000-4-3 + A1 + A2	2006 2008 2010
IEC 61000-4-4	2012	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	EN 61000-4-4	2012
IEC 61000-4-5 + corr. October	2005 2009	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test	EN 61000-4-5	2006
IEC 61000-4-6	2008	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	EN 61000-4-6	2009

Publication	Year	Title	EN/HD	Year
IEC 61000-4-8	2009	Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test	EN 61000-4-8	2010
IEC 61000-4-11	2004	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests	EN 61000-4-11	2004
IEC 61131-2	2007	Programmable controllers - Part 2: Equipment requirements and tests	EN 61131-2 [3)]	2007
IEC 61508-1	2010	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirements	EN 61508-1	2010
IEC 61508-2	2010	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems	EN 61508-2	2010
IEC 61508-3	2010	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 3: Software requirements	EN 61508-3	2010
IEC 62061 + corr. July + corr. April + A1	2005 2005 2008 2012	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems	EN 62061 + corr. February - + A1	2005 2010 - 2013
ISO 13849-1	2006	Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design	-	-

3) EN 61131-2 is superseded by EN 61010-2-201:2013, which is based on IEC 61010-2-201:2013.

Annex ZZ
(informative)

Coverage of Essential Requirements of EC Directives

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association to provide one means of conforming to Essential Requirements of the New Approach Directive for machinery 2006/42/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity with essential requirements as given in Annex I, 1.2.1 of that Directive and associated EFTA regulations.

WARNING: Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

CONTENTS

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 5-3: Control circuit devices and switching elements – Requirements for proximity devices with defined behaviour under fault conditions (PDDB)

1 General

1.1 Scope

This part of IEC 60947 series provides additional requirements to those given in IEC 60947-5-2. It addresses the fault performance aspects of proximity devices with a defined behaviour under fault conditions (PDDB). It does not address any other characteristics that can be required for specific applications.

This standard does not cover proximity devices with analogue output.

This Standard does not deal with any specific requirements on acoustic noise as the noise emission of control circuit devices and switching elements is not considered to be a relevant hazard.

For a PDDB used in applications where additional characteristics, dealt with in other standards, are required, the requirements of all relevant standards apply.

The use of this standard alone does not demonstrate suitability for the implementation of any specific safety related functionality. In particular, this standard does not provide requirements for the actuation characteristics of a PDDB, or for means to reduce the effects of mutual interference between devices, e.g. coded targets. Therefore these and any other application-specific requirements will need to be considered in addition to the requirements of this standard.

NOTE 1 Due to their behaviour under fault conditions, PDDBs can, for example, be used as interlocking devices (see ISO 14119).

NOTE 2 The requirements for electro-sensitive protective equipment for the detection of persons are given in the IEC 61496 series.

1.2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 + 12 h cycle)*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
Amendment 1:1999

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*
Amendment 1:2010

IEC 60947-5-1:2003, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*
Amendment 1:2009

IEC 60947-5-2:2007, *Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches*
Amendment 1:2012

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*
Amendment 1:2007
Amendment 2:2010

IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2008, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61131-2:2007, *Programmable controllers – Part 2: Equipment requirements and tests*

IEC 61508-1:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements*

IEC 61508-2:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems*

IEC 61508-3:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 3: Software requirements*

IEC 62061:2005, *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*
Amendment 1:2012

ISO 13849-1:2006, *Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*

2 Terms, definitions and abbreviations

2.1 General

For the purposes of this document, the terms and definitions given in IEC 60947-1 and IEC 60947-5-2, as well as the following terms, definitions and abbreviations apply.

2.2 Alphabetic index of terms

S

2.3 Basic terms and definitions

2.3.1
Performance Level
PL
discrete level (from a to e) used to specify the ability of safety-related parts of control systems to perform a safety function under foreseeable conditions

[SOURCE: ISO 13849-1:2006, 3.1.23, modified – update of the definition]

2.3.2
Safety Integrity Level
SIL
discrete level (one out of a possible three) for specifying the safety integrity requirements of the safety-related control functions to be allocated to the safety related parts of the control system, where safety integrity level three has the highest level of safety integrity and safety integrity level one has the lowest

Note 1 to entry: SIL 4 is not considered in this standard. For requirements applicable to SIL 4, see IEC 61508 series.

[SOURCE: IEC 62061:2005, 3.2.23, modified – update of the note]

2.3.3
low complexity component
component in which:

– the failure modes are well-defined; and
– the behaviour under fault conditions can be completely defined

Note 1 to entry: Behaviour of the low complexity component under fault conditions may be determined by analytical and/or test methods.

Note 2 to entry: A subsystem or subsystem element comprising one or more limit switches, operating, possibly via interposing electro-mechanical relays, one or more contactors to de-energise an electric motor is an example of a low complexity component.

[SOURCE: IEC 62061:2005, 3.2.7]

2.3.4
complex component
component in which:

– the failure modes are not well-defined; or
– the behaviour under fault conditions cannot be completely defined

[SOURCE: IEC 62061:2005, 3.2.8]

2.3.5
failure
the termination of the ability of an item to perform a required function

Note 1 to entry: After failure the system has a fault.

Note 2 to entry: “Failure” is an event, as distinguished from “fault”, which is a state.

Note 3 to entry: The concept of failure as defined does not apply to items consisting of software only.

[SOURCE: IEC 60050-191:1990, 191-04-01]

2.3.6
dangerous failure
failure of a PDDB that has the potential to cause a hazard or non-functional state

[SOURCE: IEC 62061:2005, 3.2.40, modified – deletion of the notes]

2.3.7
safe failure
failure of a PDDB that does not have the potential to cause a hazard

[SOURCE: IEC 62061:2005, 3.2.41 modified – update of the definition]

2.3.8
fault
state of an item characterized by inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources

Note 1 to entry: A fault is often the result of the item itself but can exist without prior failure.

Note 2 to entry: In English the term “fault” and its definition are identical to those given in IEC 60050-191:1990, 191-05-01. In the field of machinery, the French term “défaut” and the German term “Fehler” are used rather than the term “panne” and “Fehlzustand” that appear with this definition.

[SOURCE: IEC 62061:2005, 3.2.30, modified – new definition and new notes]

2.3.9
Safety-Related Control Function
SRCF
control function with a specified integrity level, partly or completely implemented by a PDDB, that is intended to maintain the safe condition of the equipment under control or prevent an immediate increase of the risk(s)

Note 1 to entry: ISO 13849-1 uses the term SRF (safety related function), IEC 61508 series uses SF (safety function), Terms and definitions concerning the integrity.

[SOURCE: IEC 62061:2005, 3.2.16 modified – new definition and new note]

2.3.10
safety integrity
probability of a safety related control system or its PDDB satisfactorily performing the required safety-related control functions under all stated conditions

[SOURCE: IEC 62061:2005, 3.2.19, modified – update of the definition and deletion of the notes]

2.3.11
hardware safety integrity
part of the safety integrity of a safety related control system or its PDDB comprising requirements for both the probability of dangerous random hardware failures and architectural constraints

[SOURCE: IEC 62061:2005, 3.2.20, modified – update of the definition]

2.3.12
software safety integrity
part of the safety integrity of a PDDB relating to systematic failures in a dangerous mode of failure that are attributable to software

Note 1 to entry: Software safety integrity cannot usually be quantified precisely.

[SOURCE: IEC 61508-4:2010, 3.5.5, modified – update of the definition and addition of a note]

2.3.13
systematic safety integrity
part of the safety integrity of a PDDB relating to systematic failures in a dangerous mode of failure

Note 1 to entry: Systematic safety integrity cannot usually be quantified (as distinct from hardware safety integrity which usually can).

Note 2 to entry: Requirements for systematic safety integrity apply to both hardware and software aspects of a PDDB.

[SOURCE: IEC 61508-4:2010, 3.5.6 modified – update of the definition and addition of a note]

2.3.14
mode of operation
way in which a safety function operates, which may be either:

– **low demand mode**: where the safety function is only performed on demand, in order to transfer the EUC into a specified safe state, and where the frequency of demands is no greater than one per year; or

Note 1 to entry: The E/E/PE safety-related system that performs the safety function normally has no influence on the EUC or EUC control system until a demand arises. However, if the E/E/PE safety-related system fails in such a way that it is unable to carry out the safety function then it may cause the EUC to move to a safe state.

– **high demand mode:** where the safety function is only performed on demand, in order to transfer the EUC into a specified safe state, and where the frequency of demands is greater than one per year; or
– **continuous mode:** where the safety function retains the EUC in a safe state as part of normal operation

[SOURCE: IEC 61508-4:2010, 3.5.16, modified – update of the note]

2.3.15
target failure measure
intended probability of dangerous mode failures to be achieved in respect of the safety integrity requirements, specified in terms of either:

– the average probability of dangerous failure to perform the design function on demand PFD_{avg} (for a low demand mode of operation);
– the average frequency of a dangerous failure over a given period of time PFH_D (for a high demand or continuous mode of operation)

Note 1 to entry: The term “probability of dangerous failure per hour” is not used in the standard but the abbreviation PFH has been retained but when it is used it means “average frequency of dangerous failure”.

Note 2 to entry: The numerical values for the target failure measures are given in Table 2 and Table 3 of IEC 61508-1:2010. These limit values are valid for the whole safety related function.

[Adapted from IEC 61508-4:2010, 3.5.17]

2.3.16
SIL Claim Limit
SILCL
maximum SIL that can be claimed for a PDDB in relation to architectural constraints and systematic safety integrity

[SOURCE: IEC 62061:2005, 3.2.24 modified – update of the definition]

2.3.17
mean time to dangerous failure
$MTTF_d$
expectation of the mean time to dangerous failure

Note 1 to entry: Adapted from IEC 62061:2005, definition 3.2.34.

[SOURCE: ISO 13849-1:2006, 3.1.25]

2.3.18
failure in time
FIT
the number of failures in 10^9 device-hours of operation

2.4 Terms and definitions concerning the architectural constraints

2.4.1
safe failure fraction
SFF
ratio of the average failure rates of safe failures plus dangerous detected failures of the PDDB to the total average failure rate (sum of safe failure rate and all dangerous failure rate) of the PDDB

[Adapted from IEC 61508-4:2010, 3.6.15]

2.4.2
diagnostic coverage
DC
measure of the effectiveness of diagnostics, which may be determined as the ratio between the failure rate of detected dangerous failures and the failure rate of total dangerous failures

[SOURCE: ISO 13849-1:2006, 3.1.26, modified – deletion of the notes]

fraction of dangerous failures detected by automatic on-line diagnostic tests

Note 1 to entry: The fraction of detected dangerous failures is computed to be the rate of dangerous failures that are detected by automatic on-line diagnostic tests divided by the rate of total dangerous failures.

Note 2 to entry: There is a different approach between the IEC 62061/IEC 61508 and ISO 13849-1 failure concepts. Prescriptions for architectural constraints on subsystems according to IEC 62061:2005 (Table 5) are given as a function of the hardware fault tolerance and the safe failure fraction. ISO 13849-1 does not consider any safe failure/safe failure fraction. Performance levels are based on well-defined architectures. The achieved PL is then a function of the architecture, the $MTTF_d$, the diagnostic coverage and the common cause failures.

[SOURCE: IEC 62061:2005, 3.2.38, modified – update of the notes]

2.4.3
hardware fault tolerance
HFT
ability of a system to perform its safety function in the presence of faults

Note 1 to entry: Hardware fault tolerance of N means that N+1 faults could cause a loss of the safety function. In determining the hardware fault tolerance no consideration is given to other faults, for example in diagnostics.

[Adapted from IEC 61508-2:2010, 7.4.4.1.1]

2.4.4
diagnostic test interval
interval between on-line tests to detect faults in a safety-related system that has a specified diagnostic coverage

[SOURCE: IEC 61508-4:2010, 3.8.7]

2.4.5
proof test
periodic test performed to detect failures in a safety-related system so that, if necessary, the system can be restored to an “as new” condition or as close as practical to this condition

[SOURCE: IEC 61508-4:2010, 3.8.5, modified – update of the definition and deletion of the notes]

2.4.6
safety-related system
designated system that both

– implements the required safety functions necessary to achieve or maintain a safe state for the Equipment Under Control; and
– is intended to achieve, on its own or with other E/E/PE safety-related systems, other technology safety-related systems or external risk reduction facilities, the necessary safety integrity for the required safety functions

[SOURCE: IEC 61508-4:2010, 3.4.1, modified – deletion of the notes]

2.4.7
equipment under control
EUC
equipment, machinery, apparatus or plant used for manufacturing, process, transportation, medical or other activities

Note 1 to entry: The EUC control system is separate and distinct from the EUC.

[SOURCE: IEC 61508-4:2010, 3.2.1]

2.5 Terms and definitions concerning the parts of a PDDB

2.5.1
sensing means
part of the PDDB which detects the presence or absence of a defined target

2.5.2
output signal switching device
OSSD
component of the PDDB which goes to the OFF-state according to the defined behaviour

2.5.3
control and monitoring device
device which receives and processes signals from the sensing means, provides signals to the OSSD(s) and monitors correct operation

2.6 Terms and definitions concerning the operation of a PDDB

2.6.1
defined behaviour
changing of the OSSD(s) to the off-state in the defined position of the specified target and in accordance with the requirements of this standard

2.6.2
OFF-state
state in which the output circuits interrupts the flow of current other than residual current (I_r)

2.6.3
ON-state
state in which the output circuits permits the flow of current

2.6.4
assured operating distance of a PDDB
S_{ao}
distance from the sensing face within which the presence of the specified target is correctly detected under all specified environmental conditions and manufacturing tolerances

2.6.5
assured release distance of a PDDB
S_{ar}
distance from the sensing face beyond which the absence of the specified target is correctly detected under all specified environmental conditions and manufacturing tolerances

2.6.6
risk time
maximum period of time during which OSSD(s) can deviate from the defined behaviour

2.6.7
mission time
T_M
period of time covering the intended use of a PDDB

2.6.8
lock-out state
state in which at least one OSSD is OFF and remains in OFF-state until the fault is corrected. The device enters the lock-out state whenever a fault is detected

2.7 Symbols and abbreviations

Symbol or abbreviation	Description	Definition
DC	diagnostic coverage	2.4.2
EUC	equipment under control	2.4.7
FIT	failures in time	2.3.19
HFT	hardware fault tolerance	2.4.3
$MTTF_d$	mean time to dangerous failure	2.3.17
OSSD	output signal switching device	2.5.2
PFH_D	average frequency of a dangerous failure over a given period of time	2.3.15
PFD	probability of dangerous failure on demand	2.3.15
PL	performance level	2.3.1
S_{ao}	assured operating distance of a PDDB	2.6.4
S_{ar}	assured release distance of a PDDB	2.6.5
SRF	safety related function	2.3.9
SFF	safe failure fraction	2.4.1
SIL	safety integrity level	2.3.2
SILCL	SIL claim limit	2.3.16
SRCF	safety-related control function	2.3.9
T_M	mission time	2.6.7

3 Classification

Clause 3 of IEC 60947-5-2:2007 applies.

4 Characteristics

4.1 General

Clause 4 of IEC 60947-5-2:2007 applies, with the following additions.

4.2 Constructional characteristics

4.2.1 Proximity device with defined behaviour

A PDDB is composed of the following elements:

a) sensing means;
b) OSSD(s);
c) control and monitoring device (when required).

These elements may be integrated into a single device or may be separate devices.

4.2.2 Specified target

The manufacturer shall specify the necessary target to achieve the distances S_{ao} and S_{ar}.

5 Product information

5.1 Nature of information

The following information shall be given by the manufacturer.

5.2 Identification

Subclause 5.1 of IEC 60947-5-2:2007 applies with the following additions:

aa) assured operating distance;

ab) assured release distance;

ac) specified target;

ad) risk time;

ae) defined safe state of the OSSD(s);

af) mission time;

and either:

ag) SFF/DC (if any) and HFT (in accordance with IEC 61508 series and derivatives), and reliability data (e.g. λ, PFH_D , PFD_{avg}, B_{10d}, as appropriate);

or

ah) designated architecture (if any) and B_{10d}, λ, $MTTF_d$ and DC (in accordance with ISO 13849-1), as appropriate.

5.3 Marking

5.3.1 General

Subclause 5.2.1 of IEC 60947-5-2:2007 applies, with the following additions.

In the case of a PDDB comprising separate devices, the marking of data under items a) and b) of 5.1 of IEC 60947-5-2:2007 on every device is mandatory.

Data under items c) to ah), when not included on the proximity device or on any separate devices, shall be included in the manufacturer's literature.

5.3.2 Connection identification and marking

Subclause 7.1.7.4 of IEC 60947-5-2:2007, Amendment 1 (2012) applies. When the terminals cannot be marked in accordance with 7.1.7.4 of IEC 60947-5-2:2007, Amendment 1 (2012), for example when located within a separate enclosure, the manufacturer shall provide appropriate terminal identification.

5.4 Instructions for installation, operation and maintenance

Subclause 5.3 of IEC 60947-5-2:2007, Amendment 1 (2012) applies, with the following additions.

Details of known and reasonably foreseeable external influences that can affect the S_{ao} and/or the S_{ar} shall be stated and their effects explained.

For a PDDB with test input the manufacturer shall define:

a) the behaviour of the OSSD(s) during test;

b) input(s) and/or output(s) for external test.

6 Normal service, mounting and transport conditions

6.1 Normal service conditions

Subclause 6.1 of IEC 60947-5-2:2007 applies.

6.2 Conditions during transport and storage

Subclause 6.2 of IEC 60947-5-2:2007 applies.

6.3 Mounting

Mounting dimensions and conditions shall be specified by the manufacturer.

7 Constructional and performance requirements

7.1 Constructional requirements

7.1.1 Materials

Subclause 7.1.1 of IEC 60947-5-2:2007 applies.

7.1.2 Current-carrying parts and their connections

Subclause 7.1.2 of IEC 60947-5-2:2007 applies.

7.1.3 Clearance and creepage distances

Subclause 7.1.3 of IEC 60947-5-2:2007 applies.

7.1.4 Vacant

7.1.5 Vacant

7.1.6 Vacant

7.1.7 Terminals

7.1.7.1 Constructional requirements

Subclause 7.1.7.1 of IEC 60947-5-2:2007 applies.

7.1.7.2 Connecting capacity

Subclause 7.1.7.2 of IEC 60947-5-2:2007 applies.

7.1.7.3 Connection means

Subclause 7.1.7.3 of IEC 60947-5-2:2007, Amendment 1 (2012) applies.

7.1.7.4 Connection identification and marking

Subclause 7.1.7.4 of IEC 60947-5-2:2007, Amendment 1 (2012) applies, with the following additions.

PDDBs with integrally connected cables shall have wires identified with colours in accordance with 7.1.7.4 of IEC 60947-5-2:2007, Amendment 1 (2012).

7.1.8 Provision for protective earthing

Subclause 7.1.9 of IEC 60947-5-2:2007 applies, with the following additions.

PDDB parts having Class II or Class III protection shall have no connection for protective earthing.

7.1.9 IP degree of protection (in accordance with IEC 60529)

The sensing means of a PDDB shall have minimum IP65 protection.

Control and monitoring devices shall have minimum IP54 protection.

Control and monitoring devices which are designed to be mounted in a housing with a minimum degree of protection of IP54 may have a lower protection degree.

7.2 Functional safety management

Functional safety management shall be implemented as appropriate for the PDDB lifecycle. This may be achieved for example by the use of Clause 6 of IEC 61508-1:2010 or appropriate sector standards.

7.3 Functional requirements specification for SRCFs

7.3.1 General

The functional requirements specification for PDDB shall describe details of each SRCF to be performed including, as applicable:

a) a description of the SRCF;

b) the frequency of operation;

c) the required risk time;

d) the interface(s) of the PDDB;

e) a description of fault reaction function(s);

f) a description of the required operating environment for the PDDB (e.g. temperature, humidity, dust, chemical substances, mechanical vibration and shock);

g) tests and any associated facilities (e.g. test equipment, test access ports);

h) rate of operating cycles, duty cycle, and/or utilisation category, for PDDBs that incorporate electromechanical devices.

7.3.2 Safety integrity requirements specification for SRCFs

The safety integrity requirements for a PDDB with a given architecture shall include:

a) SIL claim limit or PL (category);

b) reliability data.

7.3.3 Electromagnetic compatibility

7.3.3.1 General

In addition to the EMC requirements of IEC 60947-5-2, this part specifies additional requirements for devices intended to perform safety functions as defined in IEC 61508 series and derived standards. These additional requirements apply only to the safety related function of the device. These devices, if d.c. powered, shall not be connected to a d.c. distribution network. EMC performance requirements for PDDBs are listed in Table 1.

7.3.3.2 Performance Criteria FS (fail safe)

The functions of the PDDB intended for safety applications are not affected outside their specification or may be disturbed temporarily or permanently if the PDDB reacts on this disturbance in such a way that an OFF-state of the output is maintained or achieved within a stated time and maintained. Destruction of components is allowed if a defined state of the EUT (equipment under test) is achieved within a stated time and maintained.

7.3.3.3 Use of external devices

Where immunity to certain EM phenomena can only be achieved by the use of external devices then those devices are considered for the purposes of this International Standard to be part of the PDDB and the type and installation requirements for these devices shall be stated in the manufacturer's documentation. If particular installation requirements are necessary to achieve the required functional safety performance (for example, installation in accordance with IEC 60204-1) these requirements shall be stated in the manufacturer's documentation. The input power ports of d.c. proximity device(s) that are PELV or SELV powered are not considered as connected to a d.c. distribution network and instead are treated as I/O signal/control ports.

Table 1 – EMC requirements for PDDBs

Port	Phenomenon	Basic standard	Test value	Performance criterion
Enclosure	Electrostatic discharge (ESD)	IEC 61000-4-2	6 kV contact discharge [a] 8 kV air discharge [a]	FS FS
	EM field	IEC 61000-4-3	20 V/m (80 MHz to 1 GHz) 10 V/m (1,4 GHz to 2 GHz) 3 V/m (2,0 GHz to 2,7 GHz)	FS FS FS
	Power frequency magnetic field	IEC 61000-4-8	30 A/m (50 Hz, 60 Hz) [b]	FS
A.C. power (including protective earth)	Burst	IEC 61000-4-4	3 kV (5/50 ns, 5 kHz) [c]	FS
	Surge	IEC 61000-4-5	2 kV line to line [d] 4 kV line to earth [d]	FS FS
	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz)	FS
	Voltage dip	IEC 61000-4-11	0 % during 1 cycle 40 % during 10/12 cycles [e] 70 % during 25/30 cycles [e]	FS FS FS
	Short interruptions	IEC 61000-4-11	0 % during 250/300 cycles [e]	FS
D.C. power [f] (including protective earth)	Burst	IEC 61000-4-4	2 kV (5/50 ns, 5 kHz) [c]	FS
	Surge	IEC 61000-4-5	2 kV line to earth [d]	FS
	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz)	FS
I/O signal / control	Burst	IEC 61000-4-4	2 kV (5/50 ns, 5 kHz) [c]	FS
	Surge [g]	IEC 61000-4-5	2 kV line to earth [d]	FS
	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz)	FS
Functional earth	Burst [h]	IEC 61000-4-4	2 kV (5/50 ns, 5 kHz) [c]	FS

[a] For equipment intended to be used in SIL 3 applications the number of discharges at the highest level shall be increased by a factor of 3 compared to the number as given in the basic standard.

[b] Only to magnetically sensitive equipment. CRT display interference is allowed above 1 A/m.

[c] For equipment intended to be used in SIL 3 applications, the duration of the test at the highest level shall be increased by a factor of 5 compared to the duration as given in the basic standard.

[d] For equipment intended to be used in SIL 3 applications, the number of pulses at the highest level shall be increased by a factor of 3 compared to the number as given in the basic standard.

[e] For example “25/30 cycles" means "25 cycles for 50 Hz test" or "30 cycles for 60 Hz test".

[f] D.C. connections between parts of equipment/system which are not connected to a d.c. distribution network are treated as I/O signal/control ports.

[g] Only in the case of lines > 30 m.

[h] Only in the case of lines > 3 m.

7.3.4 Design and development of PDDB

The PDDB shall be designed and validated in accordance with its safety requirements specification and the requirements of IEC 61508 series, IEC 62061, or ISO 13849-1 as appropriate. The requirements for systematic safety integrity (systematic capability), shall be met by following compliance Route 1_H or 2_H (see 7.4.4.3 of IEC 61508-2:2010) and 1_S or 2_S (in accordance with 7.4.2.12 of IEC 61508-3:2010, as appropriate).

NOTE In IEC 62061:2005, Amendment 1(2012) (Scope, Note 2) it is considered that Route 2_H is not suitable for general machinery applications.

7.4 Information for use

7.4.1 Objective

Information shall be provided to enable the user to develop procedures to ensure that the required functional safety of the PDDB is maintained during use and maintenance of the equipment under control.

7.4.2 Documentation for installation, use and maintenance

The documentation shall provide information for installation, use and maintenance of the PDDB. This shall take the form of a safety manual in accordance with Annex D of IEC 61508-2:2010, including:

– comprehensive description of the PDDB, installation and mounting;
– statement of the intended use of the PDDB and any measures that can be necessary to prevent reasonably foreseeable misuse;
– information on the physical environment (e.g. lighting, vibration, noise levels, atmospheric contaminants) where appropriate;
– connection diagram(s);
– useful lifetime;
– proof test interval where relevant;
– parameterization information, where relevant;
– description of the maintenance requirements applicable to the PDDB if any;
– specification for periodic testing, preventive maintenance and corrective maintenance.

NOTE 1 Periodic tests are those functional tests necessary to confirm correct operation and to detect faults. They mean a comprehensive description of periodical test principles like diagnostic test and / or proof test.

NOTE 2 Preventive maintenance is the measures necessary, if any, to maintain the required performance of the PDDB.

NOTE 3 Corrective maintenance includes the measures, if any, taken after the occurrence of specific fault(s) that are necessary to bring the PDDB back into the as-designed state.

8 Tests

8.1 Kind of tests

8.1.1 General

Subclause 8.1.1 of IEC 60947-1:2007 applies.

8.1.2 Type tests

Subclause 8.1.2 of IEC 60947-5-2:2007 applies, with the following addition.

- performance under fault conditions.

8.1.3 Routine tests

Subclause 8.1.3 of IEC 60947-5-2:2007 applies.

8.1.4 Sampling tests

Subclause 8.1.4 of IEC 60947-1:2007 applies.

8.2 Compliance with constructional requirements

Subclause 8.2 of IEC 60947-1:2007, Amendment 1 (2010) applies where applicable.

8.3 Performances

8.3.1 Test sequences

Subclause 8.3.1 of IEC 60947-5-2:2007 applies.

8.3.2 General test conditions

8.3.2.1 General requirements

Subclause 8.3.2.1 of IEC 60947-5-2:2007 applies where applicable.

8.3.2.2 Test quantities

Subclause 8.3.2.2 of IEC 60947-1:2007 applies.

8.3.2.3 Test reports

Subclause 8.3.2.4 of IEC 60947-1:2007 applies.

8.3.3 Performances under no load, normal and abnormal load conditions

8.3.3.1 Operation

Subclause 8.3.3.1 of IEC 60947-1:2007 applies.

8.3.3.2 Operating limits

Subclause 8.3.3.2 of IEC 60947-5-2:2007 applies.

8.3.3.3 Temperature rise

Subclause 8.3.3.3 of IEC 60947-5-2:2007 applies.

8.3.3.4 Dielectric properties

Subclause 8.3.3.4 of IEC 60947-5-2:2007 applies.

8.3.3.5 Making and breaking capacities

8.3.3.5.1 General

Subclause 8.3.3.5 of IEC 60947-5-1:2003 and IEC 60947-5-2:2007 apply where appropriate.

8.3.3.5.2 Evaluation

During the tests no electrical or mechanical faults shall occur, no contact shall weld, no extended arcing time shall occur and no fuse shall melt. The conducted switching overvoltages shall not exceed the rated impulse withstand voltage, and the assured operating and release distances according to 2.6.4 and 2.6.5 shall remain within the stated limits.

8.3.4 Performances under short-circuit current conditions

Subclause 8.3.4 of IEC 60947-5-1:2003 and IEC 60947-5-2:2007, Amendment 1 (2012) apply where appropriate.

8.4 Verification of operating distances

The PDDB shall be tested under the rated ambient air temperature as well as maximum and minimum temperature limits stated by the manufacturer with the highest operational voltage and the rated operational current at the output switching element until the thermal equilibrium is reached.

The tests shall be in accordance with IEC 60068-2-1 and IEC 60068-2-30 test method B.

Following the temperature tests, the assured operating and release distances shall be measured in accordance with 8.4 of IEC 60947-5-2:2007 and shall be within the manufacturer's specifications.

8.5 Verification of resistance to vibration and shock

The tests shall be performed in accordance with 7.4 of IEC 60947-5-2:2007, except for separate control and monitoring devices. During each test, the state of the output(s) shall not change.

The tests shall be performed in accordance with 6.3.5 of IEC 61131-2:2007 for separate control and monitoring devices, and the following addition.

During each test, the state of the output(s) shall not change.

8.6 Verification of electromagnetic compatibility

The test shall be performed in accordance with 7.2.6 of IEC 60947-5-2:2007. In addition, the S_{ar} and S_{ao} shall be verified after test.

9 Modification

9.1 Objective

This clause specifies the modification procedure(s) to be applied when modifying the PDDB during design, integration and validation.

9.2 Modification procedure

Subclause 7.16 of IEC 61508-1:2010 shall apply.

Excerpt of 7.16.2.2 of IEC 61508-1:2010:

NOTE The reason for the request for the modification could arise from, for example:

a) functional safety below that specified;
b) systematic fault experience;
c) new or amended safety legislation;
d) modifications to the EUC (Equipment Under Control) or its use;
e) modification to the overall safety requirements;
f) analysis of operations and maintenance performance, indicating that the performance is below target;
g) routine functional safety audits.

Annex A
(informative)

Example of a simple control system in accordance with IEC 61511 series

A.1 Description

Overfill detection using a level control device and a valve (see Figure A.1). The equipment is situated in a hazardous area (flammable atmosphere) and is to be protected in accordance with the requirements of:

– level detection device: Zone 0/Division 1;
– control valve: Zone 2/Division 2.

A.2 Safety requirements specification

A.2.1 Functional requirements

In case of overfilling, the control valve is to be closed.

A.2.2 Safety integrity requirements

The risk assessment showed that a SIL 2 is appropriate for that function.

A.2.3 Conditions of use

Low demand mode (not more than one safety function demand / year).

Repair time for detected failures 8 hours.

Test interval 12 months.

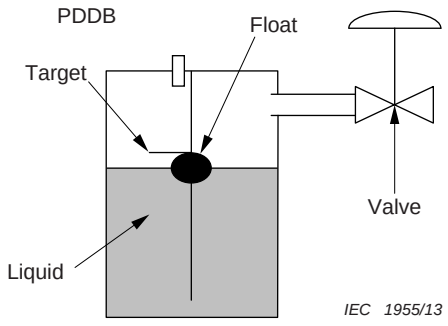

Figure A.1 – Representation of the equipment under control

NOTE There are many other requirements stated in the specification such as quality of the power supply, conditions for live maintenance etc.

A.3 Realisation

In this example the safety function will be performed by:

- a proximity switch for the float sensor (for example with an output in accordance with IEC 60947-5-6);
- an isolated switch amplifier with a relay output;
- a solenoid driver;

NOTE Since the power at the output of the intrinsically safe solenoid driver is too low to power the ball valve, in this example it is necessary to insert a control valve.

- a control valve;
- a ball valve.

A.4 Collection of data

The collection of reliability and structure data of each component to be considered in this example of control system is described in the following Table A.1.

Table A.1 – Collection of reliability and structure data

Sensor: Inductive proximity device in accordance with IEC 60947-5-6	**Isolated switch amplifier: Isolated intrinsically-safe switching amplifier**	**Solenoid driver: Solenoid driver with intrinsically-safe output**	**Control valve: intrinsically-safe control valve**	**Ball valve: Generic**
SIL Claim Limit with respect to architectural constraints: 2 in a one channel configuration	SIL Claim Limit with respect to architectural constraints: 2 in a one channel configuration	SIL Claim Limit with respect to architectural constraints: 3 in a one channel configuration	SIL Claim Limit with respect to architectural constraints: 3 in a one channel configuration	SIL Claim Limit with respect to architectural constraints: 1 in a one channel configuration
SFF = 94,09 %	SFF = 91,62 %	SFF = 100 %	SFF = 99 %	SFF = 50 %
Failure rates:	Failure rates:	Failure rates:	Failure rates:	Failure rates:
λ_{DU} = 3,9 FIT	λ_{DU} = 19 FIT	λ_{DU} = 0 FIT	λ_{DU} = 0 FIT	λ_{DU} = 60 FIT
λ_{S} = 62,1 FIT	λ_{S} = 208 FIT	λ_{S} = 1,3 FIT	λ_{S} = 0 FIT	λ_{S} = 60 FIT

All the components except the ball valve (structure only up to SIL 1, SFF less than 90 %) can be used in a safety related function up to SIL 2 in accordance with Table 2 of IEC 61508-2:2010. As a consequence, the output channel (solenoid driver, control valve and ball valve) should have a redundant architecture as shown in Figure A.2.

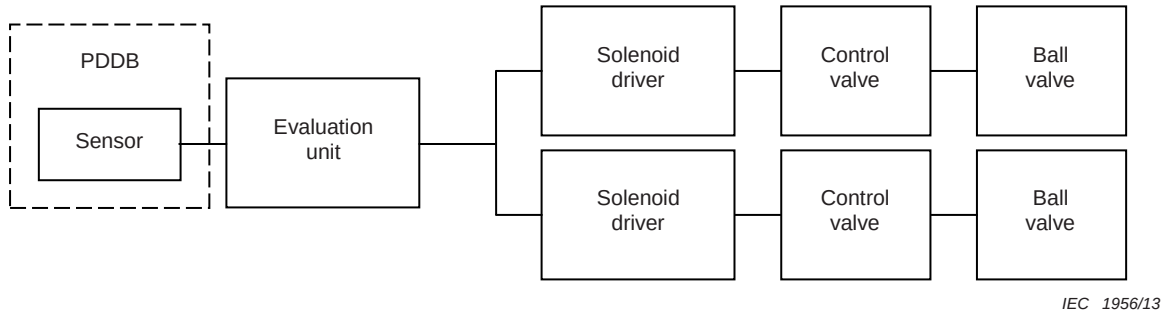

Figure A.2 – Architecture of the safety related function

Input subsystem (sensor and evaluation unit)

$\Sigma\lambda_{DU}$ = 3,9 FIT + 19 FIT = 22,9 FIT

$\Sigma\lambda_{safe}$ = 62,1 FIT + 208 FIT = 270,1 FIT

Calculation of the PFD of the input subsystem using the formulae of IEC 61508-6:2010, B.3.2.2.1:

$$t_{CE} = \frac{\lambda_{DU}}{\lambda_D}\left(\frac{T_1}{2} + \text{MRT}\right) + \frac{\lambda_{DD}}{\lambda_D}\text{MTTR}$$

$$\text{PFD}_G = (\lambda_{DU} + \lambda_{DD})t_{CE}$$

$\text{PFD}_{\text{input channel}}$ = 3,75 10^{-3}

Output subsystem (solenoid drivers and valves)

$\Sigma\lambda_{DU}$ 1 channel = 0 + 0 + 60 = 60 FIT

$\Sigma\lambda_{safe}$ 1 channel = 1,3 + 0 +60 = 61,3 FIT

MTTR = MRT = 8 h under the assumption that the time to detect a dangerous failure is far smaller than the MRT (at least one order of magnitude).

Calculations of the resulting PFD of the output subsystem using the formulae of IEC 61508-6:2010, B.3.2.2.2 and assuming a common cause failure contribution of 10 %:

$$t_{CE} = \frac{\lambda_{DU}}{\lambda_D}\left(\frac{T_1}{2} + \text{MRT}\right) + \frac{\lambda_{DD}}{\lambda_D}\text{MTTR}$$

$$t_{GE} = \frac{\lambda_{DU}}{\lambda_D}\left(\frac{T_1}{3} + \text{MRT}\right) + \frac{\lambda_{DD}}{\lambda_D}\text{MTTR}$$

$$\text{PFD}_G = 2\left((1-\beta_D)\lambda_{DD} + (1-\beta)\lambda_{DU}\right)^2 t_{CE}\, t_{GE} + \beta_D\lambda_{DD}\text{MTTR} + \beta\lambda_{DU}\left(\frac{T_1}{2} + \text{MRT}\right)$$

$\text{PFD}_{\text{output channel}}$ = 2,72 10^{-6}

$\text{PFD}_{\text{total}} = \text{PFD}_{\text{input channel}} + \text{PFD}_{\text{output channel}}$ = 3,75 10^{-3} which is within the range allowed for SIL 2 (Table 2 of IEC 61508-1:2010)

Results of the calculation:

SIL according to the PFD: SIL 2

A.5 Results

SIL according to the architecture: SIL 2

SIL according to the PFD: SIL 2

SIL of the safety function: SIL 2

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