

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Adjustable speed electrical power drive systems –
Part 5-1: Safety requirements – Electrical, thermal and energy**

**Entraînements électriques de puissance à vitesse variable –
Partie 5-1: Exigences de sécurité – Électrique, thermique et énergétique**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –**Part 5-1: Safety requirements – Electrical, thermal and energy**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 61800-5-1 has been prepared by subcommittee 22G: Adjustable speed electric power drive systems (PDS), of IEC technical committee 22: Power electronic systems and equipment. It is an International Standard.

This third edition cancels and replaces the second edition published in 2007 and Amendment 1:2016. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) harmonization with IEC 62477-1:2022;
- b) harmonization with UL 61800-5-1 and CSA C22.2 No. 274, including an annex with a list of national deviation which was considered not possible to harmonize within a reasonable timeframe;
- c) more detailed information about the evaluation of components according to this document and relevant safety component standards;
- d) updated requirement for mechanical hazards including multiple IP ratings.

The text of this International Standard is based on the following documents:

Draft	Report on voting
22G/455/FDIS	22G/457/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

In this document, terms in *italic* are defined in Clause 3.

The reader's attention is drawn to the fact that

- Annex S and Annex T list all of the "in-some-country" clauses on differing practices of a less permanent nature relating to the subject of this document.
- Due to the rules of ISO/IEC Directives, Part 2, the term "must" instead of the term "shall" is used in Annex S and Annex T.

A list of all parts of the IEC 61800 series, published under the general title *Adjustable speed electrical power drive systems*, is available on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

0.1 General

This document contains the revision of IEC 61800-5-1:2007 and IEC 61800-5-1:2007/AMD1:2016.

Several important issues have influenced the scope and the chosen approach of the maintenance of IEC 61800-5-1:2007 in the development of this document.

The most significant changes compared to IEC 61800-5-1:2007 are the following.

a) Structure and content is based on IEC 62477-1 considering modifications and new topics such as the following

- Clause 1: Scope updated to include radio emitting/transmitting *BDM/CDM/PDS*.
- 4.1, 5.1, 6.1: "Intended use" included.
- 4.2: Single fault/abnormal operation analysis (significantly reworked).
- 4.3: Short-circuit and overload protection included as new subclause.
- 4.4 and Annex A: Protection against electric shock updated according to IEC 61140:2016 and IEC 60364-4-41, including insulation coordination according to IEC 60664 (all parts) considering the following:
 - 4.4.2 – Decisive voltage classification (especially DVC As for dry, wet and salt-water wet); Table 2 and Table 3 reworked;
 - 4.4.3 – Basic protection (reworked);
 - 4.4.4 – Fault protection (reworked);
 - 4.4.5 – Enhanced protection (reworked);
 - 4.4.7 – Insulation (reworked):
 - 4.4.7.1.2 – Working voltage (new);
 - 4.4.7.1.8 – Components bridging insulation (new);
 - 4.4.7.7 – *clearance* and *creepage distances* for functional insulation on PWB and component assemblies (reworked);
 - 4.4.7.8 – Solid insulation (new/reworked);
 - 4.4.7.9 – Connection of parts of solid insulation (cemented joints) (new);
 - 4.4.8/Annex H – Compatibility with RCD (reworked);
 - 4.4.10 – Access conditions for *high-voltage PDS* (new).
- 4.5: Protection against energy hazards (new).
- 4.6: Protection against fire and thermal hazards (new).
- 4.7: Protection against mechanical hazards (new).
- 4.8: *BDM/CDM/PDS* with multiple sources of supply (new).
- 4.9: Protection against environmental stresses (new) (in alignment with IEC 61800-2).
- 4.11: Wiring and connections updated (significantly reworked).
- 4.12: Enclosure updated (significantly reworked).
- 4.13 Bibliography: Evaluation of components (new).
- 4.14 Annex P: Protection against electromagnetic fields (new).
- Clause 5: Updated with some additional/modified test requirement:
 - 5.2.2.2 – Non-accessibility test (significantly reworked);
 - 5.2.2.3 – Ingress protection test (IP rating) (significantly reworked);

- 5.2.2.4 – Enclosure integrity tests (new);
- 5.2.2.5 – Wall or ceiling mounted *BDM/CDM/PDS* test (new);
- 5.2.2.6 – Handles and manual control securement test (new);
- 5.2.2.7 – Strain relief test (new);
- 5.2.3.7 – Touch current measurement test (reworked);
- 5.2.3.9 – Limited power source (new);
- 5.2.3.11 – Protective equipotential bonding test (new);
- 5.2.3.12 – Input test (new);
- 5.2.3.13 – Thin sheet material test (new);
- 5.2.3.14 – Test procedure for determination of working voltage (new);
- 5.2.3.16 – Preconditioning of material (reworked);
- 5.2.4.4 – Protective equipotential bonding short-circuit test (new);
- 5.2.4.9 – Output overload test (new);
- 5.2.4.13.5 – Covering of openings for cooling air test (type test) (new);
- 5.2.5.6 – Cemented joints test (new);
- 5.2.7 – Hydrostatic pressure test (new);
- 5.2.8 – Electromagnetic fields (EMF) test (new).
- Clause 6: – Update with more specific marking.
 - Structure aligned with IEC 62477-1 as close as possible;
 - Table 48 simplified.
- Annex A – Additional information for protection against electric shock (reworked).
- Annex C – Symbols referred (reworked).
- Annex E – Altitude correction for *clearances* (reworked).
- Annex F – *Clearance* and *creepage distance* determination for frequencies greater than 30 kHz (reworked).
- Annex H – Guidelines for RCD compatibility (reworked).
- Annex M – Test probes for determining access (new).
- Annex O – Guidance for determination of *clearance* and *creepage distance* (new).
- Annex P – Protection of persons against electromagnetic fields for frequencies from 0 Hz up to 300 GHz (new).
- Annex Q – Automatic disconnection of supply (new).
- Annex R – Guide 116 risk evaluation included (new).
- Bibliography – Relevant component safety standards (new).

b) Harmonization with UL 61800-5-1

Complete document is modified taken into consideration UL 61800-5-1 US National deviations. US National deviations from UL 61800-5-1 not possible to harmonize have been placed in Annex S.

c) Harmonization with CSA C22.2 No. 274

- Due to a short time frame, only some few topics have been harmonized.
- Canadian National deviations from CSA C22.2 No. 274 not possible to harmonize have been placed in Annex T.

d) Harmonization with UL 347A

- Some few relevant topics have been harmonized considering safety aspects related to *high-voltage BDM/CDM/PDS*.

Further harmonization is expected to be adopted in IEC 61800-5-1 considering the content of UL 61800-5-1, CSA C22.2 No 274 and UL 347A in future editions of IEC 61800-5-1.

0.2 Feedback from industry and national committees

The use of IEC 61800-5-1:2007 by manufacturers and test institutes since its release has identified several topics which are considered useful to implement, or topics which need further information for a better understanding of the intent of the specific requirement. These topics are also implemented in this document.

0.3 Requirement covered by other relevant parts of the IEC 61800 series

- general requirements for DC *power drive systems* are covered in IEC 61800-1;
- general requirements for AC *power drive systems* are covered in IEC 61800-2;
- EMC aspects are covered in IEC 61800-3;
- functional safety aspects are covered in IEC 61800-5-2;
- functional safety aspects for encoders are covered in IEC 61800-5-3;
- type of load duty aspects are covered in IEC TR 61800-6;
- communication profiles aspects are covered in IEC 61800-7 (all parts);
- *power interface* voltage aspects are covered in IEC TS 61800-8;
- ecodesign aspects are covered in IEC 61800-9 (all parts);

The following document is not part of the IEC 61800 series, but is used often as part of the BDM:

- active infeed converters in IEC TS 62578.

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 5-1: Safety requirements – Electrical, thermal and energy

1 Scope

This part of IEC 61800 specifies requirements for adjustable speed electrical *power drive systems (PDS)* or their elements, with respect to electrical, thermal, fire, mechanical, energy and other relevant hazards. It does not cover the driven equipment except for interface requirements. It applies to adjustable speed electrical *PDS* which include the power conversion, *basic drive module (BDM)/complete drive module (CDM)* control, and a motor or motors.

Excluded are traction and electric vehicle *BDM/CDM*.

It applies to low-voltage adjustable speed electrical *PDS* intended to feed a motor or motors from a *BDM/CDM* connected to phase-to-phase voltages of up to and including 1,0 kV AC (50 Hz or 60 Hz) and up to and including 1,5 kV DC.

It also applies to high-voltage adjustable speed electrical *PDS* intended to feed a motor or motors from a *BDM/CDM* connected to phase-to-phase voltages of up to and including 35 kV AC (50 Hz or 60 Hz) and up to and including 52 kV DC.

NOTE 1 At the time of publication of this document, the technical upper voltage limit for DC motors is 2,25 kV DC.

NOTE 2 Above voltage and frequency limits reflect the scope of IEC 61800-1 and IEC 61800-2.

NOTE 3 For adjustable speed electrical *PDS* not covered by the scope of this document, applicable requirements of other standards, for example IEC 62477-1 and IEC 62477-2, can be used.

This document also applies to *PDS* which intentionally emit or receive radio waves for the purpose of radio communication.

Motors for driven equipment (see Figure 1) are covered by IEC 60034 (all parts).

NOTE 4 In some cases, safety requirements of the *PDS* (for example, protection against access to hazardous parts) can necessitate the use of special components and/or additional measures.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034 (all parts), *Rotating electrical machines*

IEC 60034-1:2022, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-5:2020, *Rotating electrical machines – Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification*

IEC 60050-112, *International Electrotechnical Vocabulary (IEV) – Part 112: Quantities and units* (available at www.electropedia.org)

IEC 60050-113, *International Electrotechnical Vocabulary (IEV) – Part 113: Physics for electrotechnology* (available at www.electropedia.org)

IEC 60050-114, *International Electrotechnical Vocabulary (IEV) – Part 114: Electrochemistry* (available at www.electropedia.org)

IEC 60050-131, *International Electrotechnical Vocabulary (IEV) – Part 131: Circuit theory* (available at www.electropedia.org)

IEC 60050-151, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices* (available at www.electropedia.org)

IEC 60050-161, *International Electrotechnical Vocabulary (IEV) – Part 161: Electromagnetic compatibility* (available at www.electropedia.org)

IEC 60050-192, *International Electrotechnical Vocabulary (IEV) – Part 192: Dependability* (available at www.electropedia.org)

IEC 60050-426, *International Electrotechnical Vocabulary (IEV) – Part 426: Explosive atmospheres* (available at www.electropedia.org)

IEC 60050-441, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses* (available at www.electropedia.org)

IEC 60050-442, *International Electrotechnical Vocabulary (IEV) – Part 442: Electrical accessories* (available at www.electropedia.org)

IEC 60050-551, *International Electrotechnical Vocabulary (IEV) – Part 551: Power electronics* (available at www.electropedia.org)

IEC 60050-601, *International Electrotechnical Vocabulary (IEV) – Part 601: Generation, transmission and distribution of electricity – General* (available at www.electropedia.org)

IEC 60050-826, *International Electrotechnical Vocabulary (IEV) – Part 826: Electrical installations* (available at www.electropedia.org)

IEC 60050-903, *International Electrotechnical Vocabulary (IEV) – Part 903: Risk assessment* (available at www.electropedia.org)

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

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6:2007, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

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

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IEC 60068-2-68:1994, *Environmental testing – Part 2-68: Tests – Test L: Dust and sand*

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IEC 60364-4-41:2005/AMD1:2017

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IEC 60364-5-54:2011/AMD1:2021

IEC 60417, *Graphical symbols for use on equipment* (available at <https://www.graphical-symbols.info/equipment>)

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IEC 60947-4-1:2018, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

IEC 60990:2016, *Methods of measurement of touch current and protective conductor current*

IEC 61032:1997, *Protection of persons and equipment by enclosures – Probes for verification*

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IEC 61180:2016, *High-voltage test techniques for low-voltage equipment – Definitions, test and procedure requirements, test equipment*

IEC 61189-3:2007, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 3: Test methods for interconnection structures (printed boards)*

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IEC 62109-1:2010, *Safety of power converters for use in photovoltaic power systems – Part 1: General requirements*

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¹ This publication has been withdrawn.

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ISO 7000, *Graphical symbols for use on equipment* (available at <http://www.graphical-symbols.info/equipment>)

ISO 7010, *Graphical symbols – Safety colours and safety signs – Registered safety signs* (available at <https://www.iso.org/obp>)

ISO 9614-1:1993, *Acoustics – Determination of sound power levels of noise sources using sound intensity – Part 1: Measurement at discrete points*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-112:2010, IEC 60050-113:2011, IEC 60050-114:2014, IEC 60050-131:2002, IEC 60050-426:2020, IEC 60050-151:2001, IEC 60050-161:1990, IEC 60050-192:2015, IEC 60050-441:1984, IEC 60050-442:1998, IEC 60050-551:1998, IEC 60050-601:1985, IEC 60050-826, IEC 60050-903:2013 and IEC 60664-1:2020, and the following apply.

Table 1 provides an alphabetical cross-reference listing of terms.

Table 1 – Alphabetical list of terms

Term	Term no.	Term	Term no.	Term	Term no.
abnormal operating condition (abnormal operation)	3.1	fault protection	3.33	protective class II	3.65
accessible part	3.2	field wiring terminal	3.34	protective class III	3.66
accessory	3.3	fire enclosure	3.35	protective earthing (PE)	3.67
adjacent circuit	3.4	functional insulation	3.36	PE conductor	3.68
ambient temperature	3.5	hand-held BDM/CDM/PDS	3.37	protective impedance	3.69
basic drive module (BDM)	3.6	general-access area	3.38	reinforced insulation	3.70
basic insulation	3.7	hazardous live part	3.39	restricted-access area	3.71
basic protection	3.8	high-voltage BDM/CDM/PDS	3.40	routine test	3.72
bypass	3.9	hinged panel	3.41	sample test	3.73
BDM/CDM rated output current	3.10	installation	3.42	SELV circuit	3.74
clearance	3.11	integrated PDS	3.43	service-access area	3.75
control circuit	3.12	interlock	3.44	short-circuit backup protection	3.76
commissioning test	3.13	live part	3.45	short-circuit protective device (SCPD)	3.77
complete drive module (CDM)	3.14	low-voltage (LV)	3.46	short time withstand current (I_{CW})	3.78
component	3.15	low-voltage BDM/CDM/PDS	3.47	skilled person	3.79
conditional short-circuit current (I_{CC})	3.16	mains supply	3.48	single-fault condition	3.80
cover	3.17	minimum required prospective short-circuit current ($I_{cp,mr}$)	3.49	solid insulation	3.81
creepage distance	3.18	movable	3.50	surrounding air temperature	3.82
decisive voltage class (DVC)	3.19	non-mains supply	3.51	surroundings	3.83
door	3.20	open type	3.52	supplementary insulation	3.84
double insulation	3.21	ordinary person	3.53	surge protective device (SPD)	3.85
direct plug-in BDM/CDM/PDS	3.22	output short-circuit current	3.54	system	3.86
DVC As	3.23	overcurrent	3.55	system voltage	3.87
electrical breakdown	3.24	PELV circuit	3.56	temporary overvoltage	3.88
electrical insulation (insulation)	3.25	permanently connected equipment	3.57	thermal memory	3.89
electrically protective screening (protective screening)	3.26	pluggable equipment type A	3.58	thermal memory retention	3.90
electronic motor overload protection	3.27	pluggable equipment type B	3.59	touch current	3.91
electronic power output short-circuit protection (circuitry)	3.28	port	3.60	trip	3.92
enclosure	3.29	power drive system (PDS)	3.61	type test	3.93
enhanced protection	3.30	prospective short-circuit current (I_{cp})	3.62	visual inspection	3.94
expected lifetime	3.31	protective equipotential bonding	3.63	working voltage	3.95
extra-low voltage (ELV)	3.32	protective class I	3.64	zone of equipotential bonding	3.96

3.1

abnormal operating condition

abnormal operation

temporary operating condition that is not a normal operating condition and is not a *single-fault condition* of the equipment itself

Note 1 to entry: An *abnormal operating condition* may be introduced by the equipment or by a person and may result in a failure of a *component*, a device or *insulation*.

[SOURCE: IEC 62368-1:2018, 3.3.7.1, modified – Note 1 to entry deleted, and Notes 2 and 3 to entry merged.]

3.2

accessible part

part or surface that can be touched by means of test probe B of IEC 61032, and if the part or surface is metal, any conductive part connected to it

Note 1 to entry: Test probe B is found in IEC 61032:1997, Figure 2. See also Figure M.2.

Note 2 to entry: Accessible non-metallic parts with conductive coatings are considered to be accessible metal parts.

[SOURCE: IEC 60335-1:2020, 3.6.3, modified – Note 1 to entry added.]

3.3

accessory

additional part, component or equipment intended to expand capabilities of the BDM/CDM/PDS, but not required for the general function of the BDM/CDM/PDS

Note 1 to entry: Typical examples are:

- external mains coils or RFI filters,
- external motor output filters,
- communication, control or input/output interface kits,
- external SPD for reduction of transient,
- additional *enclosure* parts or kits,
- additional ventilation kits,
- mechanical bonding or cable support kits, or
- additional measuring device, instrument etc.

Note 2 to entry: Expanded capabilities are considered to be electrical, mechanical, thermal or acoustic noise characteristics of the *BDM/CDM/PDS* when installed and operating as intended.

Note 3 to entry: *Accessories* and *accessory* kits might be factory or field installed.

3.4

adjacent circuit

circuit next to the circuit under consideration having a requirement for *functional insulation*, *basic insulation*, *double insulation* or *reinforced insulation* between them for protection

3.5

ambient temperature

average temperature of air or another medium in the vicinity of the equipment

Note 1 to entry: During the measurement of the *ambient temperature* the measuring instrument/probe should be shielded from draughts and radiant heating.

Note 2 to entry: "Equipment" includes *BDM/CDM/PDS* as well a *components*, depending on the application of the term *ambient temperature*.

Note 3 to entry: In general, the *ambient temperature* is measured in vicinity to the equipment (approx. 50 mm to 100 mm distance), shielded from heat radiation and measured at a height of approximately 50 % height of the equipment in case of passively cooled equipment, or air inlet of actively cooled equipment.

[SOURCE: IEC 60050-826:2004, 826-10-03, modified – Notes 2 and 3 to entry added.]

3.6

basic drive module

BDM

electronic power converter and related control, connected between an electric supply and a motor

Note 1 to entry: The *BDM* is capable of transmitting power from the electric supply to the motor and may be capable of transmitting power from the motor to the electric supply.

Note 2 to entry: The *BDM* controls some or all of the following aspects of power transmitted to the motor and motor output: current, frequency, voltage, speed, torque, force.

[SOURCE: IEC 61800-2:2021, 3.4]

3.7

basic insulation

insulation of hazardous live parts which provides *basic protection*

Note 1 to entry: This concept does not apply to *insulation* used exclusively for functional purposes.

[SOURCE: IEC 60050-195:2021, 195-06-06, modified – Words "hazardous live parts" added.]

3.8

basic protection

protection against electric shock under fault-free conditions through the use of *insulation* or distance or a combination of both

[SOURCE: IEC 60050-195:2021, 195-06-01, modified – Word "normal" replaced with "fault-free" and words "through the use of *insulation* or distance or a combination of both" added.]

3.9

bypass

circuit which, when closed, creates an alternative path for current flow in parallel with the circuit being bypassed

Note 1 to entry: The *bypass* circuit typically consists of a switch or contactor.

Note 2 to entry: The *bypass* circuit allows the original circuit to be turned off while maintaining current flow to the load.

3.10

BDM/CDM rated output current

current at the motor side of the *BDM/CDM* which can be supplied continuously without exceeding established limitations, under rated operating conditions

Note 1 to entry: For AC *BDM/CDM*, this value is expressed in RMS. For DC *BDM/CDM*, this value is expressed in average.

Note 2 to entry: This term is taken from IEC 61800-1:2021, and modified and complies with IEC 61800-2:2021.

3.11

clearance

shortest distance in air between two conductive parts

Note 1 to entry: This distance can be measured along a string stretched the shortest way between these conductive parts.

[SOURCE: IEC 60050-581:2008, 581-27-76, modified – Note to entry added.]

3.12

control circuit

circuit that carries signals directing the performance of a *BDM/CDM/PDS*, and that is not the main power circuit

3.13

commissioning test

test on a device or equipment performed on site, to prove the correctness of *installation* and operation

[SOURCE: IEC 60050-411:1996, 411-53-06, modified – Word "machine" replaced with "device".]

3.14

complete drive module

CDM

drive module consisting of, but not limited to, the *BDM* and extensions such as protection devices, transformers and auxiliaries, but excluding the motor and the sensors which are mechanically coupled to the motor shaft

[SOURCE: IEC 61800-2:2021, 3.6]

3.15

component

part of *BDM/CDM/PDS*, which cannot be physically divided into smaller parts without losing its particular function

Note 1 to entry: The term "*component*" as well as the term "sub-assembly" in this document shall be read in their context. A *component* therefore could be a single capacitor, a power supply unit, which is made of several electronic *components* as well as complete drive module inside a cabinet.

Note 2 to entry: An inverter stage (module) can also be seen as sub-assembly of a drive module.

[SOURCE: IEC 60050-151:2001, 151-11-21, modified – Words "constituent part of a device" replaced with "part of *BDM/CDM/PDS*", and notes to entry added.]

3.16 conditional short-circuit current

I_{cc}

RMS value of a *prospective short-circuit current* available from a supply source, declared by the *BDM/CDM/PDS* manufacturer under specified conditions, using a specific type of *short-circuit protective device* (SCPD) protecting the *BDM/CDM/PDS*

Note 1 to entry: The *short-circuit protective device* may form an integral part of the *BDM/CDM/PDS* or may be a separate unit.

3.17 cover

unhinged portion of an *enclosure* that closes an opening

3.18 creepage distance

shortest distance along the surface of a solid insulating material between two conductive parts

[SOURCE: IEC 60050-151:2001, 151-15-50]

3.19 decisive voltage class DVC

classification of voltage range used to determine the protective measures against electric shock and the requirements of *insulation* between circuits

3.20 door

hinged portion of an *enclosure* that covers an opening, which is intended to be opened during routine maintenance, operations and adjustments

3.21 double insulation

insulation comprising both *basic insulation* and *supplementary insulation*

[SOURCE: IEC 60050-195:2021, 195-06-08]

3.22 direct plug-in *BDM/CDM/PDS*

BDM/CDM/PDS in which the mains plug forms an integral part of the equipment *enclosure* so that the equipment is supported by the mains socket-outlet

[SOURCE: IEC 60050-903:2014, 903-04-07, modified – Word "equipment" replaced with "*BDM/CDM/PDS*".]

3.23 DVC As

voltage classification of a circuit providing only safe to touch voltage, under normal operating conditions and *single-fault conditions* and limited overvoltages

Note 1 to entry: For limits refer to Table 2.

[SOURCE: IEC 61204-7:2016, modified – Definition reformulated.]

3.24**electrical breakdown**

failure of *insulation* under electric stress when the discharge completely bridges the *insulation*, thus reducing the voltage across the *insulation* almost to zero

[SOURCE: IEC 60664-1:2020, 3.1.44, modified – Words "between the electrodes" replaced with "across the *insulation*".]

3.25**electrical insulation****insulation**

electrical separation between circuits or conductive parts provided by *clearance* or *creepage distance* or *solid insulation* or combinations of them

Note 1 to entry: The meaning of *clearance* in this document is distance through air.

3.26**electrically protective screening****protective screening**

separation of circuits from *hazardous live parts* by means of an interposed conductive screen, connected to the *PE conductor*, either directly or via *protective equipotential bonding*

Note 1 to entry: If the protective screening is used as a measure for enhanced protection, see 4.4.5.

3.27**electronic motor overload protection**

BDM/CDM circuitry which protects a motor during overload conditions by reducing current to the motor

Note 1 to entry: The protection circuitry is usually a combination of hardware and software.

Note 2 to entry: This protection is typically achieved through an algorithm based on the I^2t of the current to the motor.

3.28**electronic power output short-circuit protection****circuitry**

circuitry integral to *BDM/CDM* that acts to significantly reduce current flow to the power output upon sensing a short-circuit condition

Note 1 to entry: The protection circuitry is usually a combination of hardware and software.

3.29**enclosure**

housing affording the type and degree of protection suitable for the intended application

Note 1 to entry: This document provides requirements for the *enclosure* according to IEC 60529 as well as additional requirements for mechanical and environmental impact. The purpose of the additional requirements is to ensure the *enclosure's* ability to provide *basic protection* under the environmental conditions specified by the manufacturer.

[SOURCE: IEC 60050-151:2001, 151-13-08, modified – Note 1 to entry added.]

3.30**enhanced protection**

protective provision having a reliability of protection not less than that provided by two independent protective provisions through the use of *insulation* or distance or a combination of both

[SOURCE: IEC 61140:2016, 3.19, modified – Word "protective provision" replaced with "protection" in the term, and words "through the use of *insulation* or distance or a combination of both" added to the definition.]

3.31**expected lifetime**

design duration for which the performance characteristics are valid as specified by the manufacturer

3.32**extra-low voltage****ELV**

voltage not exceeding the relevant voltage limit specified in IEC 61140:2016, Table 1

Note 1 to entry: In IEC 61140, *ELV* is defined as not exceeding 50 V AC RMS and 120 V DC. Other product committees may have defined *ELV* with different voltage levels.

Note 2 to entry: In this document, protection against electric shock is dependent on the *decisive voltage class*.

3.33**fault protection**

protection against electric shock under *single-fault conditions*

Note 1 to entry: For *low-voltage installations, systems* and equipment, *fault protection* in IEC 60364-4-41 generally corresponds to the formerly used "protection against indirect contact", mainly with regard to failure of *basic insulation*.

[SOURCE: IEC 60050-195:2021, 195-06-02, modified – Note to entry added.]

3.34**field wiring terminal**

terminal provided for connection of external conductors to the *BDM/CDM/PDS*

Note 1 to entry: See Figure 7 and Figure 8 for examples of connection of internal and external conductors.

3.35**fire enclosure**

part of the equipment intended to minimize the spread of fire or flames from within the *enclosure* to outside the *enclosure*

3.36**functional insulation**

insulation between conductive parts within a circuit that is necessary for the proper function of the circuit, but which does not provide protection against electric shock

Note 1 to entry: *Functional insulation* may, however, reduce the likelihood of ignition and fire.

3.37**hand-held BDM/CDM/PDS**

BDM/CDM/PDS intended to be held in the hand during normal use

[SOURCE: IEC 60050-826:2004, 826-16-05, modified – Word "equipment" replaced with "*BDM/CDM/PDS*" in the term.]

3.38**general-access area**

area of the *BDM/CDM/PDS* to which both *ordinary persons* and *skilled persons* are permitted to access

Note 1 to entry: *General-access areas* do not require the use of a tool or key.

3.39

hazardous live part

live part which, under certain conditions, can give a harmful electric shock

Note 1 to entry: In this document, a hazardous live part does not meet the requirement of *DVC* As in 4.4.2.2.

[SOURCE: IEC 60050-195:2021, 195-06-05, modified – Hyphens removed from the term and note to entry replaced.]

3.40

high-voltage BDM/CDM/PDS

BDM/CDM/PDS having a *port* voltage above 1 kV AC 50 Hz or 60 Hz or above 1,5 kV DC

Note 1 to entry: "*Port*" generically applies to both input and output, and the scope of this document addresses only the range of voltages at the input power *port*.

Note 2 to entry: See IEC 61800-2:2021, Table 5.

Note 3 to entry: For *PDS* having series-connected converter sections, a sum of the series-connected phase to phase input voltages is used as the equivalent input voltage of the converter sections (see IEC 61800-2:2021, Annex A).

Note 4 to entry: In the United States of America (USA), the voltage range of this definition is considered medium voltage.

[SOURCE: IEC 61800-2:2021, 3.16, modified – Words "phase to phase" added in Note 3 to entry, "the scope of this document" replaced with "this definition" in Note 4 to entry, and Note 5 to entry deleted.]

3.41

hinged panel

portion of an *enclosure* that has hinges, but no hand-operable latching *system*, secured in the closed position by multiple bolts or other hardware requiring a tool other than a key to operate

Note 1 to entry: *Hinged panels* are not intended to be opened during normal operating conditions, routine adjustment or simple maintenance operations such as replacement of fuses.

3.42

installation

apparatus or set of devices and/or apparatuses associated in a given location to fulfil specified purposes, including all means for their satisfactory operation

Note 1 to entry: The word *installation* is also used in this document to denote the process of installing a *PDS*. In these cases, the word does not appear in italics.

[SOURCE: IEC 60050-151:2001, 151-11-26, modified – Note to entry added.]

3.43

integrated PDS

PDS where motor and *BDM/CDM* are mechanically integrated into a single unit

[SOURCE: IEC 61800-2:2021, 3.28, modified – Word "combined" replaced with "mechanically integrated".]

3.44

interlock

device(s) that prevent operation of some other device with which it is directly associated under specific conditions

Note 1 to entry: *Interlocks* may be electrical, mechanical, or a combination of both.

3.45**live part**

conductive part intended to be energized under normal operating conditions, including the neutral conductor and mid-point conductor, but excluding the PEN conductor, PEM conductor and PEL conductor

Note 1 to entry: This concept does not necessarily imply a risk of electric shock.

Note 2 to entry: By convention, the PE conductor is not a live part.

[SOURCE: IEC 60050-195:2021, 195-02-19, modified – Notes to entry added.]

3.46**low-voltage****LV**

set of voltage levels used for the distribution of electricity and whose upper limit is generally accepted to be 1 000 V AC or 1 500 V DC

[SOURCE: IEC 60050-601:1985, 601-01-26, modified – Words "or 1 500 V DC" added.]

3.47**low-voltage BDM/CDM/PDS**

BDM/CDM/PDS having a *port* voltage less than or equal to 1 kV AC (50 Hz or 60 Hz) or 1,5 kV DC

Note 1 to entry: For *PDS* having series-connected converter sections, a sum of the series-connected input voltages is used as the equivalent input voltage of the converter sections (see IEC 61800-2:2021, Annex A).

[SOURCE: IEC 61800-2:2021, 3.30, modified – Note 2 to entry deleted.]

3.48**mains supply**

low-voltage or high-voltage power distribution system for supplying power to a *BDM/CDM/PDS*

3.49**minimum required prospective short-circuit current**

$I_{cp,mr}$

RMS value of a minimum *prospective short-circuit current*, which shall be available from the source to ensure operation of the specific type of *short-circuit protective device*

[SOURCE: IEC 62477-1:2022, 3.38]

3.50**movable**

<*BDM/CDM/PDS*> equipment that is either:

- 18 kg or less in mass and not fixed in place, or
- provided with wheels, casters, or other means to facilitate movement by an *ordinary person* as required to perform its intended use

[SOURCE: IEC 60050-903:2014, 903-04-06, modified – Word "limited" replaced with "18 kg or less", and Note to entry deleted.]

3.51**non-mains supply**

electrical source that is not connected directly to the *mains supply*

EXAMPLE Source isolated by a transformer providing *basic insulation* from a *mains supply*, AC generator, fuel cell, photovoltaic array or similar AC or DC sources.

3.52

open type

<BDM/CDM> intended to be incorporated within an *enclosure* or *restricted-access area* that will provide protection against hazards

Note 1 to entry: Hazards are defined in 4.2.

3.53

ordinary person

person who is not a *skilled person*

EXAMPLE An operator, any person who may have access to the equipment or any person who may be in the vicinity of the equipment, when such equipment is not installed in a *restricted-access area*.

[SOURCE: IEC 60050-826:2004, 826-18-03, modified – Words "nor an instructed person" deleted, and example added.]

3.54

output short-circuit current

available current that flows at the output power *port* of the *BDM/CDM* when a short-circuit is applied by a conductor of negligible impedance

3.55

overcurrent

current in excess of the rated current

Note 1 to entry: In this document, the term *overcurrent* covers both short-circuit and overload.

3.56

PELV circuit

electric *system* in which the voltage cannot exceed the value of *extra-low voltage*:

- under normal operating conditions; and
- under *single-fault conditions*, except earth faults in other electric circuits

Note 1 to entry: *PELV* is the abbreviation for protective *extra-low voltage*.

[SOURCE: IEC 60050-826:2004, 826-12-32, modified – Word "system" replaced with "circuit" in the term, and word "operating" added to the first dash.]

3.57

permanently connected equipment

equipment that can only be connected to or disconnected from the electric power *system* by the use of a tool

[SOURCE: IEC 60050-151:2014, 151-11-29]

3.58

pluggable equipment type A

equipment that is intended for connection to the *mains supply* or *non-mains supply* via a non-industrial plug and socket-outlet or via a non-industrial appliance coupler, or both

Note 1 to entry: For non-industrial plug and socket-outlets, see IEC TR 60083 or a national equivalent. For non-industrial appliance couplers, see IEC 60320-1.

[SOURCE: IEC 60050-903:2014, 903-04-08, modified – Word "*mains*" replaced with "*mains supply or non-mains supply*".]

3.59**pluggable equipment type B**

equipment that is intended for connection to the *mains supply* or *non-mains supply* via an industrial plug and socket-outlet or via an industrial appliance coupler, or both

Note 1 to entry: For industrial plug and socket-outlets, see IEC 60309-1 or a national equivalent. For non-industrial appliance couplers, see IEC 60320-1.

[SOURCE: IEC 60050-903:2014, 903-04-09, modified – Word "*mains*" replaced with "*mains supply or non-mains supply*".]

3.60**port**

access to a device or network where electromagnetic energy or signals may be supplied or received or where the device or network variables may be observed or measured

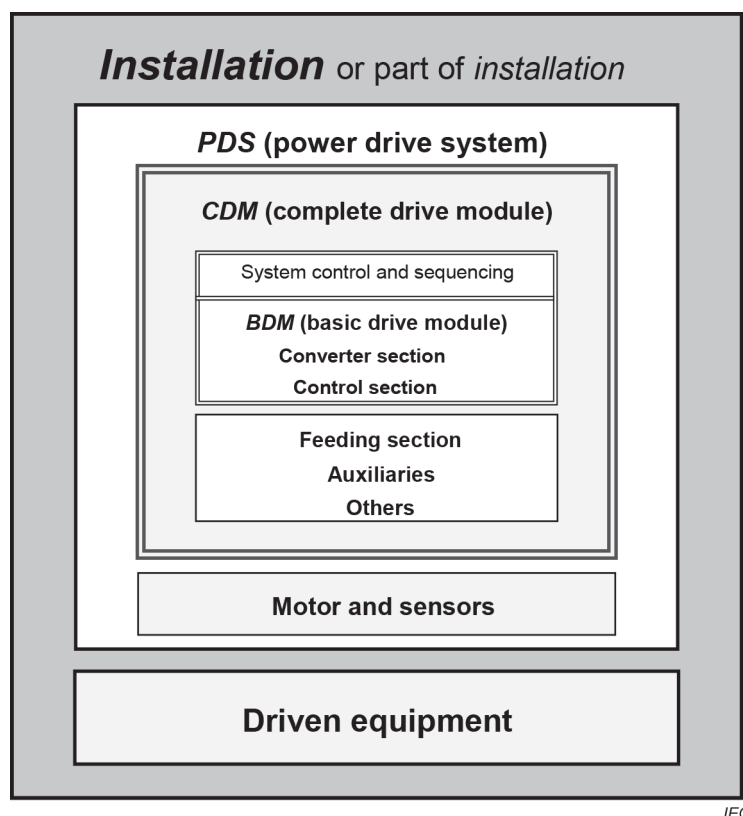
Note 1 to entry: In this document, "input", "output", "power" and "control" are indicated to define usage.

Note 2 to entry: For the evaluation of safety, ports also cover power interfaces as defined in IEC 61800-1:2021, IEC 61800-2:2021 and IEC 61800-3:2017.

[SOURCE: IEC 60050-131:2002, 131-12-60, modified – Note replaced with Note 1 to entry and Note 2 to entry.]

3.61**power drive system****PDS**

system consisting of one or more *complete drive module(s)* (CDM) and a motor or motors



IEC

Figure 1 – PDS hardware configuration within an *installation*

Note 1 to entry: See Figure 1. For more detailed information, see IEC 61800-2:2021, Figure 1.

Note 2 to entry: Any sensors which are mechanically coupled to the motor shaft are also part of the *PDS*; however, the driven equipment is not included.

[SOURCE: IEC 61800-2:2021, 3.52, modified – Note 1 to entry added.]

3.62 prospective short-circuit current

I_{cp}

RMS value of the symmetrical current which would flow if the supply conductors to the circuit are short-circuited by a conductor of negligible impedance located as near as practicable to the supply terminals of the *BDM/CDM/PDS*

[SOURCE: IEC 61439-1:2020, 3.8.7, modified – Word "current" replaced with "RMS value of the symmetrical current", and "assembly" with "*BDM/CDM/PDS*".]

3.63 protective equipotential bonding

provision of electric connections between conductive parts, intended to minimize any difference in potential between those parts, for purposes of safety

EXAMPLE Protection against electric shock.

3.64 protective class I

equipment in which protection against electric shock does not rely on *basic protection* only, but which includes an additional safety precaution in such a way that means are provided for the connection of conductive *accessible parts* to the *PE conductor* in the fixed wiring of the *installation*, in such a way that conductive *accessible parts* cannot become live in the event of a failure of the *basic insulation*

Note 1 to entry: *Protective class I* is defined in IEC 61140:2016, 7.3.

3.65 protective class II

equipment in which protection against electric shock does not rely on *basic protection* only, but in which additional safety precautions such as *supplementary insulation* or *reinforced insulation* are provided, there being no provision for *protective earthing* or reliance upon *installation* conditions

Note 1 to entry: *Protective class II* is defined in IEC 61140:2016, 7.4.

3.66 protective class III

equipment in which protection against electric shock relies on supply at *DVC As* (or *DVC B* under certain conditions) and in which voltages higher than those of *DVC As* (*DVC B*) are not generated and there is no provision for *protective earthing*

Note 1 to entry: *Protective class III* is defined in IEC 61140:2016, 7.5.

Note 2 to entry: Other standards define *protective class III* as supplied by *ELV*.

3.67 protective earthing

PE

earthing of a point in a *system*, or equipment, for protection against electric shock in case of a fault

3.68**PE conductor**

conductor in the *installation* wiring or in the power supply cord, connecting a main protective earthing terminal in the equipment to an earthing point in the *installation* for safety purposes

Note 1 to entry: In the USA and Canada, the term "ground" is used instead of "earth".

3.69**protective impedance**

impedance connected between *hazardous live parts* and conductive *accessible parts*, of such value that the current, under normal operating conditions and under *single-fault conditions*, is limited to a safe value, and which is constructed so that its ability is maintained throughout the life of the equipment

[SOURCE: IEC 60050-442:1998, 442-04-24, modified – Definition reformulated.]

3.70**reinforced insulation**

insulation of *hazardous live parts* which provides a degree of protection against electric shock equivalent to *double insulation*

[SOURCE: IEC 60050-826:2004, 826-12-17, modified – Note to entry deleted.]

3.71**restricted-access area**

enclosed electrical area not intended for service, maintenance or commissioning while the *BDM/CDM/PDS* is energized and to which only *skilled persons* are permitted to access

Note 1 to entry: *Restricted-access areas* require the use of a tool or key to get access.

3.72**routine test**

conformity test made on each individual item during or after manufacture

[SOURCE: IEC 60050-151:2001, 151-16-17]

3.73**sample test**

test on a number of devices taken at random from a batch

[SOURCE: IEC 61800-2:2021, 3.85]

3.74**SELV circuit**

electric *system* in which the voltage cannot exceed the value of *extra-low voltage*:

- under normal conditions; and
- under *single-fault conditions*, including earth faults in other electric circuits

Note 1 to entry: *SELV* is the abbreviation for safety *extra-low voltage*.

[SOURCE: IEC 60050-826:2004, 826-12-31, modified – Word "system" replaced with "circuit" in the term.]

3.75**service-access area**

enclosed electrical area intended for service, maintenance and commissioning while the *BDM/CDM/PDS* is energized and to which only *skilled persons* have permitted to access

Note 1 to entry: *Service-access areas* require the use of a tool or key to get access.

Note 2 to entry: *Service-access area* can be a place within a building or a space within an *enclosure*.

3.76**short-circuit backup protection**

protection that is intended to operate when other protective measures within a *system* or equipment fail to clear a fault

[SOURCE: IEC 62477-1:2022, 3.67]

3.77**short-circuit protective device****SCPD**

device intended to protect a circuit or parts of a circuit against short-circuit currents by interrupting them

Note 1 to entry: A *short-circuit protective device* is suitable for protection against short-circuit only, not for protection against overload. An *overcurrent* protective device may also incorporate the function of a *SCPD*.

[SOURCE: IEC 61439-1:2020, 3.1.11, modified – Note to entry added.]

3.78**short time withstand current**

I_{cw}

RMS value of short time current, declared by the *BDM/CDM/PDS* manufacturer, which can be withstood under specified conditions, defined in terms of current and time

3.79**skilled person**

person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which the equipment can create

[SOURCE: IEC 60050-826:2004, 826-18-01, modified – Word "(electrically)" deleted from the term, and "electricity" replaced with "the equipment" in the text.]

3.80**single-fault condition**

condition in which one failure is present which could cause a hazard covered by this document

Note 1 to entry: If a *single-fault condition* results in other subsequent failures, the set of failures is considered as one *single-fault condition*.

Note 2 to entry: Examples of hazards include, but are not limited to, electric shock, fire, energy, mechanical, acoustic noise etc.

Note 3 to entry: IEC Guide 116 provides examples of hazards.

3.81**solid insulation**

solid insulating material, or a combination of solid insulating materials, placed between two conductive parts or between a conductive part and a body part

Note 1 to entry: In this document, *solid insulation* does not cover liquid *insulation*.

[SOURCE: IEC 60050-903:2015, 903-04-14, modified – Example replaced with note to entry 1]

3.82**surrounding air temperature**

<open type> maximum *ambient temperature* of air immediately surrounding *open type* equipment inside of the ultimate *enclosure*

3.83**surroundings**

parts of the *BDM/CDM/PDS* adjacent to the circuit or part under consideration

3.84**supplementary insulation**

independent insulation applied in addition to basic insulation for *fault protection*

Note 1 to entry: *Basic insulation* and *supplementary insulation* are separate, each designed for *basic protection* against electric shock.

[SOURCE: IEC 60664-1:2020, 3.1.31, modified – Note to entry added.]

3.85**surge protective device****SPD**

device that contains at least one non-linear *component* that is intended to limit surge voltages and divert surge currents

Note 1 to entry: An SPD is a complete assembly, having appropriate connecting means.

[SOURCE: IEC 61643-11:2011, 3.1.1]

3.86**system**

set of interrelated and/or interconnected independent elements

Note 1 to entry: A *system* is generally defined with the view of achieving a given objective, for example by performing a definite function, such as grounding *systems*, wiring *systems*, power *systems*, *insulation systems*.

3.87**system voltage**

voltage used to determine *insulation* requirements

Note 1 to entry: See 4.4.7.1.7 for further consideration of *system voltage*.

3.88**temporary overvoltage**

overvoltage at power frequency of relatively long duration

[SOURCE: IEC 60664-1:2020, 3.1.12]

3.89**thermal memory**

ability of an overload protective *system* to approximate the heating and cooling of a protected motor during operation

3.90**thermal memory retention**

ability to retain a representation of the thermal state of a motor prior to tripping or loss of power

Note 1 to entry: Typically, the thermal memory retention will be used by the overload protective *system* to approximate the thermal state of the motor upon restart.

Note 2 to entry: The thermal memory retention may include an ongoing reduction of the thermal representation to reflect cooling of the motor during tripping or loss of power.

3.91

touch current

electric current passing through a human body or through an animal body when it touches one or more conductive *accessible parts* of an electrical *installation* or electrical equipment

[SOURCE: IEC 60050-826:2004, 826-11-12, modified – Word "conductive" added.]

3.92

trip

initiate a controlled rapid reduction or elimination of the transfer of energy to any device or process initiated by a detected fault or an *abnormal operating condition*

3.93

type test

conformity test made on one or more *BDM/CDM/PDS* representative of the production

[SOURCE: IEC 60050-151:2001, 151-16-16, modified – Word "items" replaced with "*BDM/CDM/PDS*".]

3.94

visual inspection

scrutiny by eye of an item carried out either without dismantling, or with the addition of partial dismantling as required in order to arrive at a reliable conclusion as to the condition of an item

[SOURCE: IEC 60050-426:2020, 426-14-02, modified – Definition reformulated.]

3.95

working voltage

voltage, at rated supply conditions (without tolerances) and worst case operating conditions, which occurs by design in a circuit or across *insulation*

Note 1 to entry: The *working voltage* can be DC or AC. Both the RMS and recurring peak values are used.

3.96

zone of equipotential bonding

zone where all simultaneously conductive *accessible parts* are electrically connected to prevent hazardous voltages appearing between them

4 Protection against hazards

4.1 General

Clause 4 defines the minimum requirements for the design and construction of a *BDM/CDM/PDS* and *accessories* for the intended use, to ensure its safety during installation, normal operating conditions and maintenance for the *expected lifetime* of the *BDM/CDM/PDS*. Consideration is also given to minimize hazards resulting from reasonably foreseeable misuse.

Protection against hazards shall be maintained under normal *operating conditions*, *abnormal operating conditions* and *single-fault conditions*, as specified in this document.

Where the *PDS* is intended to be used together with specific equipment or *accessories*, the safety evaluation and testing shall include this, unless it can be shown that it does not affect the safety of either the *PDS* or the specific equipment.

Guidance for risk assessment for electrical equipment and systems is provided in IEC Guide 116 which is transformed for *BDM/CDM/PDS* in Annex R.

4.2 *Single-fault conditions and abnormal operating conditions*

BDM/CDM/PDS and *accessories* shall be designed to avoid operating modes or sequences that can cause a *single-fault condition* or *component* failure leading to a hazard, unless other measures to prevent the hazard are provided by the *installation* and are described in the installation information provided with the *BDM/CDM/PDS*, see Clause 6. The requirements in 4.2 also apply to *abnormal operating conditions* as applicable.

Circuit analysis shall be performed to identify potential hazards.

This circuit analysis shall include situations where a failure of any component, *insulation* system or *port* would result in

- a risk of electromagnetic force and thermal hazards according to 4.3,
- an impact on the decisive voltage determination according to 4.4.2,
- a risk of electric shock due to
 - degradation of the *basic protection* according to 4.4.3, or
 - degradation of the *fault protection* according to 4.4.4,
- a risk of energy hazard according to 4.5,
- a risk of degradation due to emission of flame, burning particles or molten metal of the fire according to 4.6,
- a risk of thermal hazard due to high temperature according to 4.6, and
- a risk of mechanical hazard according to 4.7.

NOTE This document does not provide any requirement to protect against chemical hazard.

The circuit analysis shall include the effect of short-circuit and open-circuit conditions. Testing is necessary unless the circuit analysis conclusively shows that no hazard will result from failure. If testing is required, compliance shall be checked by test of 5.2.4.10.

In addition to this analysis, *components* shall meet the requirements of 4.13.

Clearance, creepage distances and *solid insulation* materials designed for *enhanced protection* (see 4.4.5) according to 4.4.7.4, 4.4.7.5 and 4.4.7.8 are considered to meet these requirements and do not need any further investigation.

Functional insulation on printed wiring boards (PWB) and between legs of *components* assembled on PWBs not fulfilling the requirements for *clearance* and *creepage distance* in 4.4.7.4 and 4.4.7.5 shall meet the requirement of 4.4.7.7.

Consideration shall be given to potential safety hazards associated with major *component* parts of the *PDS*, such as motor rotating parts, flammability of transformer and capacitor fluids.

The analysis shall include limited power sourced circuits, only where a failure of the limited power source circuit *component* creates a hazard in a circuit that is not sourced from a limited power source circuit.

The analysis shall also include any other investigation, study, analysis, calculation or test required to address the non-electrical hazards. Testing is necessary unless analysis shows that no hazard will result from the failure of *components* and mechanical parts.

4.3 Short-circuit and overload protection

4.3.1 General

To comply with the requirements defined in 4.2, the *BDM/CDM/PDS* shall not present a hazard under short-circuit or overload conditions (further referred as fault) at any power *port*, including phase to phase, phase to earth and phase to neutral. Adequate information shall be provided in the documentation to allow proper selection of *installation* wiring and protective devices external of the *BDM/CDM/PDS*.

If a protective system or protective device is required for short-circuit or overload protection, it shall be provided or specified.

For marking, see 6.3.9.6.

NOTE 1 Local *installation* codes will still usually require provision of such protection for the purposes of protecting the input wiring in the *installation*. In some cases, it is possible local *installation* codes supersede requirements of this document.

Protection against *overcurrents* shall be provided for all *ports*, except

- for *ports* that comply with the requirements for limited power sources in 4.5.3, or
- if the *BDM/CDM/PDS* complies with all normal operating conditions, *abnormal operating conditions* and *single-fault conditions* in this document without such protection provided.

NOTE 2 In this document, the term *overcurrent* covers both short-circuit and overload.

When protection against *overcurrents* is required, this may be integral to the *BDM/CDM/PDS* or it may be provided in the *installation*, and details of the required *overcurrent* protective device shall be provided in the *BDM/CDM/PDS* installation instructions in accordance with 6.3.9.6.

No protection is required against *overcurrent* to earth on *ports* that have either

- no connection to earth, or
- *enhanced protection* between *live parts* and all conductive parts connected to earth.

NOTE 3 Where *enhanced protection* is provided, a short-circuit to earth would be considered to be two faults.

Testing is not required under a *single-fault condition* to earth in *BDM/CDM/PDS* installed on an IT-system.

NOTE 4 Under a *single-fault condition* in an IT-system, no short-circuit current or a limited short-circuit current will flow. A short-circuit current would flow in an IT-system, when a second fault occurs. Typically, only detection is done after the first fault in an IT-system.

For *pluggable equipment type A*, the protective device is provided in the *installation* and shall not require any specific characteristics other than that required in IEC 60364 (all parts) or other local *installation* codes.

For *pluggable equipment type B* or *permanently connected BDM/CDM/PDS*, this protection may be provided by devices external to the *BDM/CDM/PDS*, in which case the installation instructions shall state the need for the protection to be provided in the *installation* and shall include the specifications for the required short-circuit and/or overload protection (see 6.3.9.6).

NOTE 5 IEC 60364 (all parts) provides requirements for short-circuit and overload protection of the input wiring in the installation. The above requirement ensures that the user is informed about any special characteristics of the protective devices for the protection of the PDS, in addition to the requirements in IEC 60364 (all parts) or other local installation codes.

If a protective device interrupts the neutral conductor, it shall also simultaneously interrupt all other supply conductors of the same circuit. It is permissible for the protective device to interrupt the neutral conductor after the other supply conductors of the same circuit.

Consideration shall be given to compliance with

- different type of earthing system (e.g. TN, TT, IT, star or corner-earthed in 4.4.7.1.5) as the short-circuit current to protective earth depends on the type of earthing system,
- automatic disconnection of supply in 4.4.4.4.1,
- disconnection time in 4.4.4.4.2 as required in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2, (see Annex Q), and
- alternative to automatic disconnection of supply in 4.4.4.4.3.

NOTE 6 IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2, provides more information about protection against indirect contact in case of a short-circuit between *hazardous live parts* and protective earth.

NOTE 7 The short-circuit fault current to earth is expected to be up to the rated short-circuit current of the output power *port* depending on earthing system.

4.3.2 Input short-circuit rating and available *output short-circuit current*

4.3.2.1 General

The interrupting capability of the *overcurrent* protective device shall be equal to or greater than the *prospective short-circuit current* of the *mains supply* or *non-mains supply*.

For *pluggable equipment type A*, either the *PDS* shall be designed such that the *installation* provides *short-circuit backup protection*, or additional *short-circuit backup protection* shall be provided as part of the *BDM/CDM/PDS*.

For *pluggable equipment type B* or *permanently connected BDM/CDM/PDS*, it is permitted for *short-circuit backup protection* to be in the *installation*.

4.3.2.2 Rated *conditional short-circuit current* (I_{cc}) on input power ports

The input *prospective short-circuit current* ratings apply to *ports* intended to be connected to *mains supply* or *non-mains supply* AC or DC sources, and to other *ports* for which *overcurrent* protection is necessary.

The *BDM/CDM/PDS* manufacturer shall specify a *conditional short-circuit current* (I_{cc}) rating for compliance to 4.3.2.2, and in addition the information in either a) or b):

a) information pertaining to the *short-circuit protective device*:

- minimum required prospective short-circuit current ($I_{cp, mr}$); and
- the protective device rated voltage, current, interrupt rating, I_p and I^2t at I_{cc} ; or
- the protective device manufacturer and part number;

NOTE Where a standard establishes the values as required by the second bullet for a specific class of fuse, the class of fuse can be specified in lieu of those values.

b) information pertaining to the *short-circuit protective device*:

- the associated duration, and
- if a specific protective device is used to meet this requirement, the manufacturer shall specify the protective device manufacturer and part number.

The associated duration in b) is the time the maximum symmetrical *prospective short-circuit current* was applied during the test of 5.2.4.4, 5.2.4.5 and 5.2.4.10.

Compliance is shown through evaluation according to 4.2 to determine the appropriate combination of testing according to 5.2.4.4, 5.2.4.5 and 5.2.4.10 and in order to evaluate *abnormal operating conditions* and *single-fault condition*, including *insulation faults*.

For topologies where the *BDM/CDM* includes an input transformer, special attention should be made to the fact that the fault current is significantly higher at the primary side of the transformer. This especially applies to HV topologies. See IEC 61800-2:2021, Annex A.

If it is shown by analysis that the result of one test is representative of the worst case, less severe combinations need not be tested.

For marking, see 6.2.1.4 g).

4.3.2.3 Available output short-circuit current

The available *output short-circuit current* ratings apply to each output *port* where overcurrent protection is required to be selected between the output of a *BDM/CDM* and the input of another *BDM/CDM*.

For each output *port*, the short-circuit evaluation to determine the maximum available *output short-circuit current* shall be performed according to 5.2.4.5.

For marking, see 6.2.1.4 g).

4.3.2.4 Combined input and output ports

For *ports* which are both input and output *ports*, the applicable requirements of both 4.3.2.2 and 4.3.2.3 apply.

4.3.3 Short-circuit coordination (upstream protection)

Protective devices provided or specified shall have adequate capability to interrupt the *prospective short-circuit current* specified for the *port* to which they are connected.

If internal protection of the *PDS* is not rated for the *prospective short-circuit current*, the installation instructions shall specify the upstream protective device, rated for the *prospective short-circuit current* of that *port*, which shall be used to provide protection, see 6.3.9.6. The combination of these two *overcurrent* protective devices shall be specified by the manufacturer of the protective devices as suitable for use in combination for protection of a circuit having a *prospective short-circuit current* not exceeding the rating of the upstream protective device.

NOTE IEC 60364 (all parts) provides requirements for upstream protective devices in the *installation*. The above requirement ensures that the user is informed about any special characteristics of the upstream protective devices for the protection of the *PDS*, in addition to the requirements in IEC 60364 (all parts) or other local *installation* codes.

Compliance shall be checked by *visual inspection* in 5.2.1 and by the tests of 5.2.4.5.

4.3.4 Protection by several devices

Where protective devices that require manual replacement or resetting are used in more than one pole of a supply to a given load, those devices shall be located together unless this conflicts with another safety based design consideration.

NOTE Phase segregation to prevent or reduce arc fault is a possible reason why the protective devices might not be located together.

It is permitted to combine two or more protective devices in one *component*.

Location of the protective devices shall be defined in the documentation, see 6.2.

Compliance shall be checked by *visual inspection* in 5.2.1.

4.3.5 Motor overload and overtemperature protection

4.3.5.1 Means of protection

A motor of a *PDS* shall be protected against overtemperature. Depending on the application of the motor, one or more of the following means of protection a), b), c), d) or e) for each motor driven shall be selected by the *PDS* manufacturer:

- a) a thermal or electronic overload relay that complies with the applicable requirements in IEC 60947-4-1:2018;
- b) a *BDM/CDM* with *electronic motor overload protection* according to 4.3.5.2, which might include
 - 1) *thermal memory retention* according to 4.3.5.3, and/or
 - 2) speed sensitivity according to 4.3.5.4;
- c) a *BDM/CDM* with monitoring and trip based upon a signal from a thermal sensor mounted in or on the motor according to 4.3.5.5;
- d) an embedded motor thermal protection which disconnects the motor;
- e) information in accordance with 6.3.9.7.1.

NOTE 1 Selection a) and d) are the only possible motor overload protections in the case that several motors in parallel are supplied from the same *BDM/CDM* motor power port.

For information requirements, see 6.3.9.7.

NOTE 2 In the USA, compliance with US National Electrical Code ANSI/NFPA 70 for:

- overload protection according to 430.32 is achieved by a), b), c) or d); and
- overtemperature protection according to 430.126 is achieved by b) 1) and b) 2), c) or d).

4.3.5.2 *BDM/CDM with electronic motor overload protection*

Electronic motor overload protection shall comply with 5.2.4.6.1 to 5.2.4.6.4 and is subjected to the test requirements in 5.2.4.7.

Adjustable *electronic motor overload protection* shall not be adjustable in such a way that the limits of Table 37 are exceeded.

- a) For *PDS* where motor and *BDM/CDM* are known, limits other than those in Table 37 can be specified and tested in accordance with 5.2.4.6.1 to 5.2.4.6.4.
- b) For information requirements, see 6.3.9.7.2.

4.3.5.3 *BDM/CDM with electronic motor overload protection with thermal memory retention*

Electronic motor overload protection with thermal memory retention shall comply with 5.2.4.6.1 to 5.2.4.6.6 and is subjected to the requirements in 5.2.4.7.

4.3.5.4 *BDM/CDM with electronic motor overload protection which is speed sensitive*

Electronic motor overload protection that is speed sensitive shall comply with 5.2.4.6.1 to 5.2.4.6.7 and is subjected to the requirements in 5.2.4.7.

EXAMPLE Induction motor with fan mounted on the shaft.

4.3.5.5 *BDM/CDM providing monitoring and trip by means of thermal sensors*

BDM/CDM intended to be used with motors that have thermal protection or thermal sensor in or on the motors requiring signal *interface* shall be provided with means to connect to that protection.

Insulation requirements for the connection of the thermal protector or thermal sensor shall be taken into account. See Table 3.

For marking, see 6.3.10.2.

4.3.6 BDM/CDM providing current limiting control

BDM/CDM incorporating a current limiting control, i.e. a circuit that limits the output current to a set value regardless of the load on the motor, shall be tested according to 5.2.4.8.

NOTE Current limiting control can be a fixed or operator-adjustable value.

4.4 Protection against electric shock

4.4.1 General

Protection against electric shock depends on the *decisive voltage class (DVC)* from 4.4.2 and protection requirements from Table 3 and shall be provided by at least one of the following measures a) or b):

- a) *basic protection* from 4.4.3 and *fault protection* from 4.4.4; or
- b) *enhanced protection* from 4.4.5.

Protection under normal operating conditions is provided by *basic protection* 4.4.3, and protection under *single-fault conditions* is provided by *fault protection* 4.4.4.

Enhanced protection (see 4.4.5) provides protection under both normal operating conditions and *single-fault conditions*.

Basic protection, *fault protection* and *enhanced protection* may be achieved by means of *clearance* and *creepage distances* (see 4.4.7.4 and 4.4.7.5), *solid insulation* (see 4.4.7.8) or protection by means of *enclosure* and barriers (see 4.4.3.3) or a combination of those.

Clause A.6 provides an overview about the fundamental concept for protection against electric shock within this document.

NOTE In this document, 4.4.1 to 4.4.6 have been harmonized with the concepts of the horizontal standard IEC 61140 for protection against electric shock. *Basic protection*, *fault protection*, *enhanced protection* and the combination of those measures have been implemented.

Additional protection can be provided by residual current-operated protective devices (RCD). For further information, see 4.4.8.

4.4.2 Decisive voltage class (DVC)

4.4.2.1 General

This document defines four voltage levels with different requirements for the protection against electric shock: *DVC As*, *DVC B*, *DVC C* and *DVC D*.

The determination of a *decisive voltage class* includes the following considerations:

- a) environmental indoor unconditioned or outdoor unconditioned in Table 20;
- b) normal operating conditions, *abnormal operating conditions* and *single-fault conditions*;
- c) maximum *working voltage* V_{ac} RMS, V_{ac} peak and V_{dc} in Table 2, Figure 2, Figure 3 and Figure 4;
- d) protection requirement between circuits and between circuits and surroundings in 4.4.2.7 or Table 3;

e) *impulse withstand voltage* in Table 2, Table 6 or Table 7 for all *DVC*.

More information for evaluation of the *working voltage* is provided in Clause A.5.

4.4.2.2 *DVC As*

A *DVC As* circuit is defined as to be safe to touch under normal operating conditions, *abnormal operating conditions* and *single-fault conditions* (see Table 2).

DVC As shall meet all of the minimum requirements a), b) and c) of 4.4.2.2:

- a) voltage not exceeding the maximum steady state *working voltage* according to Table 2;
- b) separation from other circuits according to 4.4.2.7 or Table 3;
- c) maximum short time voltage during *abnormal operating conditions* and *single-fault conditions* according to Table 2, Figure 2, Figure 3 and Figure 4.

A circuit which does not meet all of the minimum requirements a), b) and c) of 4.4.2.2 shall be considered as either a *DVC B*, *DVC C* or *DVC D* circuit and shall be next evaluated to determine if it meets the *DVC B* requirement according to 4.4.2.3.

Circuits intended to be connected to devices external to the *BDM/CDM/PDS*, having a voltage level within *DVC As*, shall comply with the minimum requirements a), b) and c) of 4.4.2.2.

See also 4.4.6.5.3.

For marking, see 6.2.1.

4.4.2.3 *DVC B*

A *DVC B* circuit is needed if the circuit is an *interface* to *SELV* circuits or *PELV* circuits, when the nominal voltage or maximum short time voltage during *abnormal operating conditions* and *single-fault conditions* exceeds the *DVC As* voltage limits.

NOTE The maximum *DVC B* voltage is limited to the ELV limits as defined in IEC 61140 (same as *SELV* and *PELV*) under normal and *single-fault condition* (see Table 2).

DVC B shall meet all of the requirements a), b) and c) of 4.4.2.3:

- a) voltage not exceeding the maximum steady state *working voltage* according to Table 2;
- b) separation from other circuits according to 4.4.2.7 or Table 3;
- c) maximum short time voltage during *abnormal operating conditions* and *single-fault conditions* according to Table 2, Figure 2, Figure 3 and Figure 4.

A circuit which does not meet all of the minimum requirements a), b) and c) of 4.4.2.3 shall be considered as either a *DVC C* or *DVC D* circuit and shall be next evaluated to determine if it meets the requirements for *DVC C* according to 4.4.2.4.

4.4.2.4 *DVC C*

DVC C circuits have hazardous voltages and require *basic protection* and *fault protection* or *enhanced protection* in dry, wet and salt water wet areas for the protection against electric shock.

DVC C shall meet all of the requirements a), b) and c) of 4.4.2.4:

- a) voltage not exceeding the maximum steady state *working voltage* according to Table 2;
- b) separation from other circuits according to 4.4.2.7 or Table 3;

- c) a maximum impulse withstand voltage and temporary overvoltage if applicable according to 4.4.7.1 to 4.4.7.4.

Separation requirements to other *DVC C* circuits shall be based on the consequence of a *single-fault condition* (see 4.2) in the *insulation* and they can be either *enhanced protection*, *basic protection* or *functional insulation* and shall be based on the highest *working voltage* and *impulse withstand voltage*.

A circuit which does not meet all of the minimum requirements a), b) and c) of 4.4.2.4 shall be considered as a *DVC D* circuit and shall be next evaluated to determine if it meets the requirements for *DVC D* according to 4.4.2.5.

4.4.2.5 *DVC D*

DVC D circuits have hazardous voltages for *high-voltage BDM/CDM/PDS* and require *basic protection* and *fault protection* or *enhanced protection* in dry, wet and salt water wet areas for the protection against electric shock.

DVC D are all circuits which are not classified as *DVC As*, *DVC B* or *DVC C* and shall meet all of the requirements a) and b) of 4.4.2.5:

- a) separation from other circuits according to 4.4.2.7 or Table 3;
- b) a maximum impulse withstand voltage and temporary overvoltage according to 4.4.7.1 to 4.4.7.4, if applicable.

Separation requirements to other *DVC D* circuits shall be based on the consequence of a *single-fault condition* (see 4.2) in the *insulation* and they can be either *enhanced protection*, *basic protection* or *functional insulation* and shall be based on the highest *working voltage* and *impulse withstand voltage*.

For marking, see 6.5.7.

4.4.2.6 Determination of *decisive voltage class (DVC)*

4.4.2.6.1 General

Protective measures against electric shock depend on the *DVC* of circuits according to 4.4.2.2 to 4.4.2.5. The *DVC* in turn determines the minimum required level of protection for the circuit.

4.4.2.6.2 Limits of the *working voltage* for the *DVC*

Limits for the *working voltage* depending on the *DVC* for normal operating conditions, *abnormal operating conditions* and *single-fault conditions* are given in Table 2.