BS EN 61800-5-1:2007+A11:2021

BSI Standards Publication

Adjustable speed electrical power drive systems

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

bsi.

Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

National foreword

This British Standard is the UK implementation of EN 61800-5-1:2007+A11:2021. It is derived from IEC 61800-5-1:2007, incorporating amendment 1:2016. It supersedes BS EN 61800-5-1:2007+A1:2017, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by A1 A1.

The UK participation in its preparation was entrusted to Technical Committee PEL/22, Power electronics.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

This publication has been prepared under a mandate given to the European Standards Organizations by the European Commission and the European Free Trade Association and is intended to support essential requirements of the EU legislation detailed in the European foreword. Annex ZA/ZZ describes how the publication relates to the legislation.

For the Great Britain market (England, Scotland and Wales), if the UK Government has designated this publication for conformity with UKCA marking legislation and has not amended the essential requirements of that legislation, Annex ZA/ZZ and any references to EU law in the publication should be read in accordance with the designation as applying to UK legislation in the same way as to EU law. Further information on designated standards can be found at www.bsigroup.com/standardsandregulation.

For the Northern Ireland market, UK law will continue to implement relevant EU law subject to periodic confirmation. References to EU legislation are therefore still valid.

More information on legislation can be found at www.gov.uk.

© The British Standards Institution 2021
Published by BSI Standards Limited 2021

ISBN 978 0 539 16989 8

ICS 29.130.01; 29.200

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 October 2007.

Amendments/corrigenda issued since publication

Date	Text affected
31 May 2018	Implementation of IEC amendment 1:2016 with CENELEC endorsement A1:2017

AVA Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

Date	Text affected
28 February 2021	Implementation of CENELEC amendment A11:2021: addition of Annex ZZ

Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61800-5-1:2007 +A11

February 2021

ICS 29.130

English Version

Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy (IEC 61800-5-1:2007)

Entraînements électriques de puissance à vitesse variable — Partie 5-1: Exigences de sécurité — Electrique, thermique et énergétique (IEC 61800-5-1:2007)

Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl — Teil 5-1: Anforderungen an die Sicherheit — Elektrische, thermische und energetische Anforderungen (IEC 61800-5-1:2007)

This European Standard was approved by CENELEC on 2007-08-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

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

© 2007 CENELEC All rights of exploitation in any form and by any means reserved worldwide for CENELEC Members.

Ref. No. EN 61800-5-1:2007+A1:2017: E

Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

European foreword

The text of document 22G/178/FDIS, future edition 2 of IEC IEC 61800-5-1, prepared by SC 22G "Adjustable speed electric drive systems incorporating semiconductor power converters" of IEC/TC 22 "Power electronic systems and equipment" was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61800-5-1 on 2007-08-01.

This European Standard supersedes EN 61800-5-1:2003.

The major areas of change in EN 61800-5-1:2007 are the following:

— addition of alphabetical Table 1 in Clause 3;

— addition of Table 2 in 4.1 for relevance to PDS/CDM/BDM;

— addition of Table 4 summary of decisive voltage class requirements;

— expansion of subclause on protective bonding (4.3.5.3);

— clarification of distinction between touch current and protective conductor current;

— revision of section on insulation (now 4.3.6) to include solid insulation;

— addition of overvoltage categories I and II to HV insulation voltage;

— revision of section on Solid insulation (now 4.3.6.8);

— addition of high-frequency insulation requirements (4.3.6.9, Annex E);

— addition of requirements for liquid-cooled PDS (4.4.5);

— addition of climatic and vibration tests (5.2.6);

— clarification of voltage test procedure to avoid over-stress of basic insulation (5.2.3.2.3);

— revision of short-circuit test requirement for large, high-voltage and one-off PDS (now 5.2.3.6);

— addition of informative Annex B for overvoltage category reduction.

The following dates are fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2008-05-01
- latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2010-08-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61800-5-1:2007 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 60034-9	NOTE	Harmonized as EN 60034-9:2005 (modified).
IEC 60071	NOTE	Harmonized as EN 60071 series (not modified).
IEC 60071-1	NOTE	Harmonized as EN 60071-1:2006 (not modified).

Documents
Document Sharing Hub

IEC 60071-2	NOTE	Harmonized as EN 60071-2-1997 (not modified).
IEC 60146-1-1	NOTE	Harmonized as EN 60146-1-1:1993 (not modified).
IEC 60309-1	NOTE	Harmonized as EN 60309-1:1999 (not modified).
IEC 60364-4-44	NOTE	Amendment 1:2003 to IEC 60364-4-44:2001 is harmonized as HD 60364-4-443:2006 (modified).
IEC 60664	NOTE	Harmonized as EN 60664 series (not modified).
IEC 60695-2-11	NOTE	Harmonized as EN 60695-2-11:2001 (not modified).
IEC 60695-2-12	NOTE	Harmonized as EN 60695-2-12:2001 (not modified).
IEC 60721	NOTE	Harmonized as EN 60721 series (not modified).
IEC 61082	NOTE	Harmonized as EN 61082 series (not modified).
IEC 61140	NOTE	Harmonized as EN 61140 2002 (not modified).
IEC 61180-1	NOTE	Harmonized as EN 61180-1:1994 (not modified).
IEC 61189-2	NOTE	Harmonized as EN EN 61189-2:2006 (not modified).
IEC 61643-12	NOTE	Harmonized as EN CLC/TS 61643-12:2006 (modified).
IEC 61800-3	NOTE	Harmonized as EN 61800-3:2004 (not modified).
IEC 62079	NOTE	Harmonized as EN 62079:2001 (not modified).

AVA Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

Foreword to amendment A1

The text of document 22G/338/FDIS, future IEC 61800-5-1:2007/A1, prepared by SC 22G “Adjustable speed electric drive systems incorporating semiconductor power converters” of IEC/TC 22 “Power electronic systems and equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61800-5-1:2007/A1:2017.

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) 2017-10-28
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2020-04-28

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.

Endorsement notice

The text of the International Standard IEC 61800-5-1:2007/A1:2016 was approved by CENELEC as a European Standard without any modification.

In the bibliography of EN 61800-5-1:2007, the following notes have to be **added** for the standards indicated:

IEC 60664-1:2007	NOTE	Harmonized as EN 60664-1:2007 (not modified).
IEC 62477-1:2012	NOTE	Harmonized as EN 62477-1:2012 (not modified).

Foreword to amendment A11

This document (EN 61800-5-1:2007/A11:2021) has been prepared by CLC/TC 22X "Power electronics".

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2021-08-05
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2023-11-17

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC 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.

AVA Documents
Document Sharing Hub

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application 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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60034	Series	Rotating electrical machines	EN 60034	Series
IEC 60034-1	-[1)]	Rotating electrical machines - Part 1: Rating and performance	EN 60034-1	2004[2)]
IEC 60034-5	-[1)]	Rotating electrical machines - Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) - Classification	EN 60034-5	2001[2)]
IEC 60050-111	-[1)]	International Electrotechnical Vocabulary (IEV) - Chapter 111: Physics and chemistry	-	-
IEC 60050-151	-[1)]	International Electrotechnical Vocabulary (IEV) - Part 151: Electrical and magnetic devices	-	-
IEC 60050-161	-[1)]	International Electrotechnical Vocabulary (IEV) - Chapter 161: Electromagnetic compatibility	-	-
IEC 60050-191	-[1)]	International Electrotechnical Vocabulary (IEV) - Chapter 191: Dependability and quality of service	-	-
IEC 60050-441	-[1)]	International Electrotechnical Vocabulary (IEV) - Chapter 441: Switchgear, controlgear and fuses	-	-
IEC 60050-442	-[1)]	International Electrotechnical Vocabulary (IEV) - Part 442: Electrical accessories	-	-
IEC 60050-551	-[1)]	International Electrotechnical Vocabulary (IEV) - Part 551: Power electronics	-	-
IEC 60050-601	-[1)]	International Electrotechnical Vocabulary (IEV) - Chapter 601: Generation, transmission and distribution of electricity - General	-	-
IEC 60060-1	1989	High-voltage test techniques - Part 1: General definitions and test requirements	HD 588.1 S1	1991

1) Undated reference.

2) Valid edition at date of issue.

3) EN 60068-2-2 includes supplement A:1976 to IEC 60068-2-2.

4) IEC 60364-1:2005 (modified) will be submitted to formal vote for acceptance as HD 60364-1.

5) EN 60664-1 is superseded by EN 60664-1:2007, which is based on IEC 60664-1:2007

6) At draft stage.

AVA Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

Publication	Year	Title	EN/HD	Year
IEC 60068-2-2	1974	Environmental testing - Part 2: Tests - Tests B: Dry heat	EN 60068-2-2[3)]	1993
IEC 60068-2-6	-[1)]	Environmental testing - Part 2: Tests - Test Fc: Vibration (sinusoidal)	EN 60068-2-6	1995[2)]
IEC 60068-2-78	-[1)]	Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state	EN 60068-2-78	2001[2)]
IEC 60112	2003	Method for the determination of the proof and the comparative tracking indices of solid insulating materials	EN 60112	2003
IEC 60204-11	-[1)]	Safety of machinery - Electrical equipment of machines - Part 11: Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV	EN 60204-11	2000
IEC 60309 (mod)	Series	Plugs, socket-outlets and couplers for industrial purposes	EN 60309	Series
IEC 60364-1 (mod)	-[1)]	Low-voltage electrical installations - Part 1: Fundamental principles, assessment of general characteristics, definitions	-[4)]	-
IEC 60364-4-41 (mod)	2005	Low-voltage electical installations - Part 4-41: Protection for safety - Protection against electric shock	HD 60364-4-41 + corr. July	2007 2007
+A1	2016		+A1	201X[6)]
IEC 60364-5-54 (mod)	2002	Electrical installations of buildings - Part 5-54: Selection and erection of electrical equipment - Earthing arrangements, protective conductors and protective bonding conductors	HD 60364-5-54	2007
IEC 60417	Database	Graphical symbols for use on equipment	-	-
IEC 60529	1989	Degrees of protection provided by enclosures (IP Code)	EN 60529 + corr. May	1991 1993
IEC 60617	Database	Graphical symbols for diagrams	-	-
IEC 60664-1 +A1 +A2	1992 2000 2002	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests	EN 60664-1[5)]	2003
IEC 60664-3	2003	Insulation coordination for equipment within low-voltage systems - Part 3: Use of coating, potting or moulding for protection against pollution	EN 60664-3	2003
IEC 60664-4	2005	Insulation coordination for equipment within low-voltage systems - Part 4: Consideration of high-frequency voltage stress	EN 60664-4 + corr. October	2006 2006
IEC 60695-2-10	-[1)]	Fire hazard testing - Part 2-10: Glowing/hot-wire based test methods - Glow-wire apparatus and common test procedure	EN 60695-2-10	2001[2)]
IEC 60695-2-13	-[1)]	Fire hazard testing - Part 2-13: Glowing/hot-wire based test methods - Glow-wire ignitability test method for materials	EN 60695-2-13	2001[2)]

1) Undated reference.

2) Valid edition at date of issue.

3) EN 60068-2-2 includes supplement A:1976 to IEC 60068-2-2.

4) IEC 60364-1:2005 (modified) will be submitted to formal vote for acceptance as HD 60364-1.

5) EN 60664-1 is superseded by EN 60664-1:2007, which is based on IEC 60664-1:2007

6) At draft stage.

AVA Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

Publication	Year	Title	EN/HD	Year
IEC 60695-11-10	-[1)]	Fire hazard testing - Part 11-10: Test flames - 50 W horizontal and vertical flame test methods	EN 60695-11-10	1999[2)]
IEC 60695-11-20	-[1)]	Fire hazard testing - Part 11-20: Test flames - 500 W flame test methods	EN 60695-11-20	1999[2)]
IEC/TR 60755	-[1)]	General requirements for residual current operated protective devices	-	-
IEC 60947-4-1	2009	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters	EN 60947-4-1	2010
+A1	2012		+A1	2012
IEC 60947-7-1	2002	Low-voltage switchgear and controlgear - Part 7-1: Ancillary equipment - Terminal blocks for copper conductors	EN 60947-7-1	2002
IEC 60947-7-2	2002	Low-voltage switchgear and controlgear - Part 7-2: Ancillary equipment - Terminal blocks for copper conductors	EN 60947-7-2	2002
IEC 60990	1999	Methods of measurement of touch current and protective conductor current	EN 60990	1999
IEC 61230 (mod)	-[1)]	Live working - Portable equipment for earthing or earthing and short-circuiting	EN 61230 +A11	1995[2)] 1999
IEC 61800-1	-[1)]	Adjustable speed electrical power drive systems - Part 1: General requirements - Rating specifications for low voltage adjustable speed d.c. power drive systems	EN 61800-1	1998[2)]
IEC 61800-2	-[1)]	Adjustable speed electrical power drive systems - Part 2: General requirements - Rating specifications for low voltage adjustable frequency a.c. power drive systems	EN 61800-2	1998[2)]
IEC 61800-4	-[1)]	Adjustable speed electrical power drive systems - Part 4: General requirements - Rating specifications for a.c. power drive systems above 1 000 V a.c. and not exceeding 35 kV	EN 61800-4	2003[2)]
IEC 62020	-[1)]	Electrical accessories - Residual current monitors for household and similar uses (RCMs)	-	-
IEC 62271-102	-[1)]	High-voltage switchgear and controlgear - Part 102: Alternating current disconnectors and earthing switches	EN 62271-102 + corr. March	2002[2)] 2005
ISO 3864	Series	Graphical symbols - Safety colours and safety signs	-	-
ISO 7000	2004	Graphical symbols for use on equipment - Index and synopsis	-	-

1) Undated reference.

2) Valid edition at date of issue.

3) EN 60068-2-2 includes supplement A:1976 to IEC 60068-2-2.

4) IEC 60364-1:2005 (modified) will be submitted to formal vote for acceptance as HD 60364-1.

5) EN 60664-1 is superseded by EN 60664-1:2007, which is based on IEC 60664-1:2007

6) At draft stage.

AVA Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

Annex ZZ
(informative)

Relationship between this European standard and the safety objectives of Directive 2014/35/EU [2014 OJ L96] aimed to be covered

This European standard has been prepared under a Commission's standardisation request relating to harmonised standards in the field of the Low Voltage Directive, M/511, to provide one voluntary means of conforming to safety objectives of Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits [2014 OJ L96].

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard given in Table ZZ.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding safety objectives of that Directive, and associated EFTA regulations.

Table ZZ.1 — Correspondence between this European standard and Annex I of Directive 2014/35/EU [2014 OJ L96]

Safety objectives of Directive 2014/35/EU (Annex I)	Clause(s) / sub-clause(s) of this EN	Remarks / Notes
1. General:	Ref. of all Clauses from the CLC/TC 22X Committee standard, that are linked to the Safety Objectives	Remarks & Notes from CLC/TC 22X Secretariat
1 a) the essential characteristics, the recognition and observance of which will ensure that electrical equipment will be used safely and in applications for which it was made, shall be marked on the electrical equipment, or, if this is not possible, on an accompanying document	6	
1 b) the electrical equipment, together with its component parts, shall be made in such a way as to ensure that it can be safely and properly assembled and connected;	4.3.8 6.1, 6.2, 6.3, 6.4, 6.5	
1 c) the electrical equipment shall be so designed and manufactured as to ensure that protection against the hazards set out in points 2 and 3 is assured, providing that the equipment is used in applications for which it was made and is adequately maintained.	1, 2, 3 6.2, 6.3, 6.4, 6.5	

Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

Safety objectives of Directive 2014/35/EU (Annex I)	Clause(s) / sub-clause(s) of this EN	Remarks / Notes
2. Protection against hazards arising from the electrical equipment		
2 a) persons and domestic animals are adequately protected against the danger of physical injury or other harm which might be caused by direct or indirect contact;	4.1, 4.2, 4.3, 4.4, 4.5 Annex C 5.1, 5.2.1, 5.2.2, 5.2.3, 5.2.4	
2 b) temperatures, arcs or radiation which would cause a danger, are not produced;	4.1, 4.2, 4.3, 4.4 5.1, 5.2.3, 5.2.4, 5.2.5, 5.2.8	Hazards arising from electric, magnetic and electromagnetic fields, other ionizing and non-ionizing radiation are covered by separate standards.
2 c) persons, domestic animals and property are adequately protected against non-electrical dangers caused by the electrical equipment which are revealed by experience;	4.1, 4.2, 4.5 5.1, 5.2.1, 5.2.2, 5.2.4	
2 d) the insulation is suitable for foreseeable conditions.	4.1, 4.2, 4.3.6, 4.4. 5.1, 5.2.1, 5.2.3, 5.2.4, 5.2.5	
3. Protection against hazards which may be caused by external influences on the electrical equipment		
3 a) meets the expected mechanical requirements in such a way that persons, domestic animals and property are not endangered;	4.1, 4.2, 4.3, 4.3.7, 4.5, 4.6 5.1, 5.2.1, 5.2.2, 5.2.6.	
3 b) is resistant to non-mechanical influences in expected environmental conditions, in such a way that persons, domestic animals and property are not endangered;	4.1, 4.5.3, 4.6 5.1, 5.2.1, 5.2.6, 5.2.7	
3 c) does not endanger persons, domestic animals and property in foreseeable conditions of overload.	4.1, 4.2, 4.4.6 5.1, 5.2.1, 5.2.4, 5.2.8 6	

WARNING 1: Presumption of conformity stays valid only as long as a reference to this European standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2: Other Union legislation may be applicable to the product(s) falling within the scope of this standard.

AVA Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

Contents

Page

FOREWORD ..... **xii**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **3**

4 Protection against electric shock, thermal, and energy hazards **10**
4.1 General 10
4.2 Fault conditions 11
4.3 Protection against electric shock 12
4.3.1 *Decisive voltage classification* 12
4.3.2 *Protective separation* 14
4.3.3 Protection against direct contact 15
4.3.4 Protection in case of direct contact 17
4.3.5 Protection against indirect contact 18
4.3.6 Insulation 24
4.3.7 Enclosures 36
4.3.8 Wiring and connections 39
4.3.9 Output short-circuit requirements 42
4.3.10 Residual current-operated protective (RCD) or monitoring (RCM) device compatibility 43
4.3.11 Capacitor discharge 43
4.3.12 Access conditions for *high-voltage PDS* 44
4.4 Protection against thermal hazards 44
4.4.1 Minimizing the risk of ignition 44
4.4.2 Insulating materials 44
4.4.3 Flammability of enclosure materials 45
4.4.4 Temperature limits 46
4.4.5 Specific requirements for liquid cooled *PDS* 47
〖A1〗 4.4.6 Motor overload and overtemperature protection 〈A1〉 48
4.5 Protection against energy hazards 49
4.5.1 Electrical energy hazards 49
4.5.2 Mechanical energy hazards 49
4.5.3 Acoustic noise emission 50
4.6 Protection against environmental stresses 50

5 Test requirements **50**
5.1 General 50
5.1.1 Test objectives and classification 50
5.1.2 Selection of test samples 51
5.1.3 Sequence of tests 51
5.1.4 Earthing conditions 51
5.1.5 Compliance 51
5.1.6 Test overview 51
5.2 Test specifications 53
5.2.1 Visual inspections (*type test, sample test* and *routine test*) 53
5.2.2 Mechanical tests 53
5.2.3 Electrical tests 55
5.2.4 Abnormal operation tests 69
5.2.5 Material tests 70
5.2.6 Environmental tests (*type tests*) 73
5.2.7 Hydrostatic pressure (*type test* and *routine test*) 75
〖A1〗 5.2.8 *Electronic motor overload protection* test (*type test*) 〈A1〉 75
〖A1〗 5.2.9 Circuit functionality evaluation (*routine* and/or *sample test*) 〈A1〉 78

6 Information and marking requirements **78**

© ISO 2021 – All rights reserved

AVA Documents Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

6.1 General ... 78
6.2 Information for selection ... 80
6.3 Information for installation and commissioning ... 81
6.3.1 General ... 81
6.3.2 Mechanical considerations ... 81
6.3.3 Environment ... 81
6.3.4 Handling and mounting ... 81
6.3.5 Motor and driven equipment ... 81
6.3.6 Connections ... 82
6.3.7 Overcurrent or short-circuit protection ... 83
A1 6.3.8 Motor overload protection and overtemperature protection A1 ... 83
6.3.9 Commissioning ... 84
6.4 Information for use ... 84
6.4.1 General ... 84
6.4.2 Adjustment ... 84
6.4.3 Labels, signs and signals ... 85
6.5 Information for maintenance ... 86
6.5.1 General ... 86
6.5.2 Capacitor discharge ... 87
6.5.3 Auto restart/bypass connection ... 87
6.5.4 PT/CT connection ... 87
6.5.5 Other hazards ... 87

Annex A (informative) **Examples of protection in case of direct contact** ... **88**

Annex B (informative) **Examples of overvoltage category reduction** ... **90**

Annex C (normative) **Measurement of clearance and creepage distances** ... **96**

Annex D (informative) **Altitude correction for clearances** ... **101**

Annex E (informative) **Clearance and creepage distance determination for frequencies greater than 30 kHz** ... **103**

Annex F (informative) **Cross-sections of round conductors** ... **106**

Annex G (informative) **Guidelines for RCD compatibility** ... **107**

Annex H (informative) **Symbols referred to in this part of IEC 61800** ... **111**

Bibliography ... **112**

© ISO 2021 – All rights reserved

AVA Documents Document Sharing Hub
Full document details: BS EN 61800-5-1:2007+A11:2021

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.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61800-5-1 has been prepared by subcommittee 22G: Semiconductor power converters for adjustable speed electric drive systems, of IEC technical committee 22: Power electronic systems and equipment.

This second edition cancels and replaces the first edition published in 2003. It constitutes a technical revision.

The major areas of change in this edition are the following:

a) addition of alphabetical Table 1 in Clause 3;

b) addition of Table 2 in 4.1 for relevance to PDS/CDM/BDM;

c) addition of Table 4 summary of decisive voltage class requirements;

d) expansion of subclause on protective bonding (4.3.5.3);

AVA Documents
Document Sharing Hub
Full document details: BS EN 61800-5-1:2007+A11:2021

e) clarification of distinction between touch current and protective conductor current;

f) revision of section on insulation (now 4.3.6) to include solid insulation;

g) addition of overvoltage categories I and II to HV insulation voltage;

h) revision of section on Solid insulation (now 4.3.6.8)

i) addition of high-frequency insulation requirements (4.3.6.9, Annex E);

j) addition of requirements for liquid-cooled PDS (4.4.5);

k) addition of climatic and vibration tests (5.2.6);

l) clarification of voltage test procedure to avoid over-stress of basic insulation (5.2.3.2.3);

m) revision of short-circuit test requirement for large, high-voltage and one-off PDS (now 5.2.3.6);

n) addition of informative Annex B for overvoltage category reduction.

The text of this standard is based on the following documents:

FDIS	Report on voting
22G/178/FDIS	22G/181/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

Terms in *italics* in the text are defined in Clause 3.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

This page deliberately left blank

Documents
Document Sharing Hub

1 Scope

This part of IEC 61800 specifies requirements for adjustable speed *power drive systems*, or their elements, with respect to electrical, thermal and energy safety considerations. It does not cover the driven equipment except for interface requirements. It applies to adjustable speed electric drive systems which include the power conversion, drive control, and motor or motors. Excluded are traction and electric vehicle drives. It applies to d.c. drive systems connected to line voltages up to 1 kV a.c., 50 Hz or 60 Hz and a.c. drive systems with converter input voltages up to 35 kV, 50 Hz or 60 Hz and output voltages up to 35 kV.

Other parts of IEC 61800 cover rating specifications, EMC, functional safety, etc.

The scope of this part of IEC 61800 does not include devices used as component parts of a *PDS* if they comply with the safety requirements of a relevant product standard for the same environment. For example, motors used in *PDS* shall comply with the relevant parts of IEC 60034.

Unless specifically stated, the requirements of this International Standard apply to all parts of the *PDS*, including the *CDM*/*BDM* (see Figure 1).

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

2 Normative references

The following referenced documents are indispensable for the application 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.

NOTE This does not mean that compliance is required with all clauses of the referenced documents, but rather that this international standard makes a reference that cannot be understood in the absence of the referenced document.

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

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

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

IEC 60050-111, *International Electrotechnical Vocabulary (IEV) — Chapter 111: Physics and chemistry*

IEC 60050-151, *International Electrotechnical Vocabulary (IEV) — Part 151: Electrical and magnetic devices*

IEC 60050-161, *International Electrotechnical Vocabulary (IEV) — Chapter 161: Electromagnetic compatibility*

IEC 60050-191, *International Electrotechnical Vocabulary (IEV) — Chapter 191: Dependability and quality of service*

IEC 60050-441, *International Electrotechnical Vocabulary (IEV) — Chapter 441: Switchgear, controlgear and fuses*

IEC 60050-442, *International Electrotechnical Vocabulary (IEV) — Part 442: Electrical accessories*

IEC 60050-551, *International Electrotechnical Vocabulary (IEV) — Part 551: Power electronics*

IEC 60050-601, *International Electrotechnical Vocabulary (IEV) — Chapter 601: Generation, transmission and distribution of electricity — General*

IEC 60060-1:1989, *High-voltage test techniques — Part 1: General definitions and test requirements*

IEC 60068-2-2:1974, *Environmental testing — Part 2: Tests. Tests B: Dry heat*

AVA Documents Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

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

IEC 60068-2-78, *Environmental testing — Part 78: Tests — Test Cab: Damp heat, steady state*

IEC 60112:2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60204-11, *Safety of machinery — Electrical equipment of machines — Part 11: Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV*

IEC 60309, *Plugs, socket-outlets and couplers for industrial purposes*

IEC 60364-1, *Low-voltage electrical installations — Part 1: Fundamental principles, assessment of general characteristics, definitions*

〈A1〉IEC 60364-4-41:2005, *Low-voltage electrical installations — Part 4-41: Protection for safety — Protection against electric shock*

IEC 60364-4-41:2005/AMD1:-[1)] 〈A1〉

IEC 60364-5-54:2002, *Electrical installations of buildings — Part 5-54: Selection and erection of electrical equipment — Earthing arrangements, protective conductors and protective bonding conductors*

IEC 60417, *Graphical symbols for use on equipment*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP code)*

IEC 60617, *Graphical symbols for diagrams*

IEC 60664-1:1992, *Insulation coordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests*[2)] Amendment 1 (2000) Amendment 2 (2002)

IEC 60664-3:2003, *Insulation coordination for equipment within low-voltage systems — Part 3: Use of coating, potting or moulding for protection against pollution*

IEC 60664-4:2005, *Insulation coordination for equipment within low-voltage systems — Part 4: Consideration of high-frequency voltage stress*

IEC 60695-2-10, *Fire hazard testing — Part 2-10: Glowing/hot-wire based test methods — Glow-wire apparatus and common test procedure*

IEC 60695-2-13, *Fire hazard testing — Part 2-13: Glowing/hot-wire based test methods — Glow-wire ignitability test method for materials*

IEC 60695-11-10, *Fire hazard testing — Part 11-10: Test flames — 50 W horizontal and vertical flame test methods*

IEC 60695-11-20, *Fire hazard testing — Part 11-20: Test flames — 500 W flame test methods*

IEC 60755, *General requirements for residual current operated protective devices*

〈A1〉IEC 60947-4-1:2009, *Low-voltage switchgear and controlgear — Part 4-1: Contactors and motor-starters — Electromechanical contactors and motor-starters*

IEC 60947-4-1:2009/AMD1:2012 〈A1〉

IEC 60947-7-1:2002, *Low-voltage switchgear and control gear — Part 7-1: Ancillary equipment — Terminal blocks for copper conductors*

---

1) 〈A1〉 Under preparation. Stage at the time of publication: IEC DEC 60364-4-41:2016. 〈A1〉

2) There exists a consolidated edition 1.2 (2002) including IEC 60664-1:1992 and its Amendments 1 and 2.

Documents
Document Sharing Hub
Full document details: BS EN 61800-5-1:2007+A11:2021

IEC 60947-7-2:2002, *Low-voltage switchgear and controlgear — Part 7-2: Ancillary equipment — Protective conductor terminal blocks for copper conductors*

IEC 60990:1999, *Methods of measurement of touch current and protective conductor current*

IEC 61230, *Live working — Portable equipment for earthing or earthing and short-circuiting*

IEC 61800-1, *Adjustable speed electrical power drive systems — Part 1: General requirements — Rating specifications for low voltage adjustable speed d.c. power drive systems*

IEC 61800-2, *Adjustable speed electrical power drive systems — Part 2: General requirements — Rating specifications for low voltage adjustable frequency a.c. power drive systems*

IEC 61800-4, *Adjustable speed electrical power drive systems — Part 4: General requirements — Rating specifications for a.c. power drive systems above 1 000 V a.c. and not exceeding 35 kV*

IEC 62020, *Electrical accessories — Residual current monitors for household and similar uses (RCMs)*

IEC 62271-102, *High-voltage switchgear and controlgear — Part 102: Alternating current disconnectors and earthing switches*

ISO 3864 (all parts), *Graphical symbols — Safety colours and safety signs*

ISO 7000:2004, *Graphical symbols for use on equipment — Index and synopsis*

3 Terms and definitions

For the purposes of this international standard, the terms and definitions given in IEC 60050-111, IEC 60050-151, IEC 60050-161, IEC 60050-191, IEC 60050-441, IEC 60050-442, IEC 60050-551, IEC 60050-601, IEC 60664-1, IEC 61800-1, IEC 61800-2, IEC 61800-3 and IEC 61800-4 (some of which are repeated below for convenience), and the following definitions apply.

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

Table 1 — Alphabetical list of terms

Term	Term number	Term	Term number	Term	Term number
adjacent circuit	3.1	(earth) leakage current	3.16	protective screening	3.31
basic drive module (BDM)	3.2	live part	3.17	protective separation	3.32
basic insulation	3.3	low-voltage *PDS*	3.18	reinforced insulation	3.33
CDM (complete drive module)	3.4	open-type (product)	3.19	routine test	3.34
closed electrical operating area	3.5	power drive system (PDS)	3.20	safety *ELV* (SELV) circuit	3.35
commissioning test	3.6	protective *ELV* (PELV) circuit	3.21	sample test	3.36
decisive voltage class (DVC)	3.7	prospective short-circuit current	3.22	supplementary insulation	3.37
double insulation	3.8	protective bonding	3.23	system voltage	3.38
extra low voltage (ELV)	3.9	protective class 0	3.24	temporary overvoltage	3.39
electrical breakdown	3.10	protective class I	3.25	touch current	3.40
expected lifetime	3.11	protective class II	3.26	type test	3.41
functional insulation	3.12	protective class III	3.27	user terminal	3.42
high-voltage *PDS*	3.13	protective earthing (PE)	3.28	working voltage	3.43

AVA Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

Table 1 *(continued)*

Term	Term number	Term	Term number	Term	Term number
installation	3.14	protective earthing conductor	3.29	zone of equipotential bonding	3.44
integrated *PDS*	3.15	protective impedance	3.30		

3.1
adjacent circuit
circuit having no galvanic connection to the circuit under consideration

NOTE A protective impedance is not considered to be a galvanic connection.

3.2
basic drive module (BDM)
drive module, consisting of a converter section and a control section for speed, torque, current or voltage, etc. (see Figure 1)

3.3
basic insulation
insulation applied to *live parts* to provide basic protection against electrical shock

[SOURCE: IEV 826-12-14, modified]

3.4
complete drive module
CDM
drive system, without the motor and the sensors which are mechanically coupled to the motor shaft, consisting of, but not limited to, the *BDM*, and extensions such as feeding section and auxiliaries (see Figure 1)

3.5
closed electrical operating area
room or location for electrical equipment to which access is restricted to skilled or instructed persons by the opening of a door or the removal of a barrier by the use of a key or tool and which is clearly marked by appropriate warning signs

3.6
commissioning test
test on a device or equipment performed on site, to prove the correctness of installation and operation

[SOURCE: IEV 151-16-24, modified]

3.7
decisive voltage class
DVC
classification of voltage range used to determine the protective measures against electric shock

3.8
double insulation
insulation comprising both *basic insulation* and *supplementary insulation*

[SOURCE: IEV 826-12-16]

NOTE *Basic* and *supplementary insulation* are separate, each designed for basic protection against electric shock.

Documents
Document Sharing Hub
Full document details: BS EN 61800-5-1:2007+A11:2021

3.9
extra low voltage
ELV
any voltage not exceeding 50 V a.c. r.m.s. and 120 V d.c.

NOTE 1 R.M.S. ripple voltage of not more than 10 % of the d.c. component.

NOTE 2 In this international standard, protection against electric shock is dependent on the *decisive voltage classification. DVC* A and B are contained in the voltage range of *ELV*.

3.10
electrical breakdown
failure of insulation under electric stress when the discharge completely bridges the insulation, thus reducing the voltage between the electrodes almost to zero

[SOURCE: IEC 60664-1:1992, definition 1.3.20]

3.11
expected lifetime
minimum duration for which the safety performance characteristics are valid at rated conditions of operation

3.12
functional insulation
insulation between conductive parts within a circuit, which is necessary for the proper functioning of the circuit, but which does not provide protection against electric shock

3.13
high-voltage *PDS*
product with rated supply voltage between 1 kV and 35 kV a.c., 50 Hz or 60 Hz

NOTE These products fall into the scope of IEC 61800-4

3.14
installation
equipment or equipments including at least the *PDS* and the driven equipment (see Figure 1)

NOTE The word "installation" is also used in this international standard to denote the process of installing a *PDS*/*CDM*/*BDM*. In these cases, the word does not appear in italics.

3.15
integrated *PDS*
PDS where motor and *CDM*/*BDM* are mechanically integrated into a single unit

3.16
(earth) leakage current
current flowing from the *live parts* of the *installation* to earth, in the absence of an insulation fault

[SOURCE: IEV 442-01-24]

3.17
live part
conductor or conductive part intended to be energized in normal use, including a neutral conductor but not a protective earth neutral

3.18
low-voltage *PDS*
product with rated supply voltage up to 1 000 V a.c., 50 Hz or 60 Hz

NOTE These products fall into the scope of IEC 61800-1 or IEC 61800-2.

AVA Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

3.19
open type (product)
(product) intended for incorporation within enclosure or assembly which will provide access protection

3.20
power drive system
PDS
system for the speed control of an electric motor, including the *CDM* and motor but not the driven equipment (see Figure 1)

3.21
protective *ELV* (PELV) circuit
electrical circuit with the following characteristics:

- the voltage does not continuously exceed *ELV* under single fault as well as normal conditions;
- *protective separation* from circuits other than *PELV* or *SELV*;
- provisions for earthing of the *PELV circuit*, or its accessible conductive parts, or both

3.22
prospective short-circuit current
current which flows when the supply conductors to the circuit are short-circuited by a conductor of negligible impedance located as near as possible to the supply terminals of the *PDS*/*CDM*/*BDM*

3.23
protective bonding
electrical connection of conductive parts for safety purposes

3.24
protective class 0
equipment in which protection against electric shock relies only upon *basic insulation*

NOTE Equipment of this class becomes hazardous in the event of a failure of the *basic insulation*.

3.25
protective class I
equipment in which protection against electric shock does not rely on *basic insulation* only, but which includes an additional safety precaution in such a way that means are provided for the connection of accessible conductive parts to the *protective (earthing) conductor* in the fixed wiring of the *installation*, so that accessible conductive parts cannot become live in the event of a failure of the *basic insulation*

3.26
protective class II
equipment in which protection against electric shock does not rely on *basic insulation* 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

3.27
protective class III
equipment in which protection against electric shock relies on supply at *ELV* and in which voltages higher than those of *ELV* are not generated and there is no provision for *protective earthing*

[SOURCE: see IEC 61140, subclause 7.4]

3.28
protective earthing (PE)
earthing of a point in a system, or equipment, for protection against electric shock in case of a fault

AVA Documents Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

3.29
protective earthing conductor
protective conductor provided for *protective earthing*

[SOURCE: IEV 195-02-11]

3.30
protective impedance
impedance connected between *live parts* and accessible conductive parts, of such value that the current, in normal use and under likely fault conditions, is limited to a safe value, and which is so constructed that its reliability is maintained throughout the life of the equipment

[SOURCE: IEV 442-04-24, modified]

3.31
protective screening
separation of circuits from hazardous live-parts by means of an interposed conductive screen, connected to the means of connection for a *protective earthing conductor*

3.32
protective separation
separation between circuits by means of basic and supplementary protection (*basic insulation* plus *supplementary insulation* or *protective screening*) or by an equivalent protective provision (for example, *reinforced insulation*)

3.33
reinforced insulation
single insulation system, applied to *live parts*, which provides a degree of protection against electric shock equivalent to *double insulation* under the conditions specified in the relevant IEC standard

[SOURCE: IEC 60664-1: 1992, definition 1.3.17.5]

3.34
routine test
test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

[SOURCE: IEV 151-16-17]

3.35
Safety *ELV* (SELV) circuit
electrical circuit with the following characteristics:

- the voltage does not exceed *ELV*;
- *protective separation* from circuits other than *SELV* or *PELV*;
- no provisions for earthing of the *SELV circuit*, or its accessible conductive parts;
- *basic insulation* of the *SELV circuit* from earth and from *PELV circuits*

3.36
sample test
test on a number of devices taken at random from a batch

[SOURCE: IEV 151-16-20, modified]

AVA Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

3.37
supplementary insulation
independent insulation applied in addition to *basic insulation* in order to provide protection against electric shock in the event of a failure of *basic insulation*

[SOURCE: IEC 60664-1: 1992, definition 1.3.17.3]

NOTE *Basic* and *supplementary insulation* are separate, each designed for basic protection against electric shock.

3.38
system voltage
voltage used to determine insulation requirements

NOTE See 4.3.6.2.1 for further consideration of *system voltage*.

3.39
temporary overvoltage
overvoltage at the supply frequency of relatively long duration

[SOURCE: IEC 60664-1:1992, definition 1.3.7.1, modified]

3.40
touch current
electric current passing through a human body or through an animal body when it touches one or more accessible parts of an electrical installation or electrical equipment

[SOURCE: IEV 826-11-12]

3.41
type test
test of one or more devices made to a certain design to show that the design meets certain specifications

[SOURCE: IEV 151-16-16, modified]

3.42
user terminal
terminal provided for external connection to the *PDS*/*CDM*/*BDM*

3.43
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 The *working voltage* can be d.c. or a.c. Both the r.m.s. and recurring peak values are used.

3.44
zone of equipotential bonding
zone where all simultaneously accessible conductive parts are electrically connected to prevent hazardous voltages appearing between them

NOTE For equipotential bonding, it is not necessary for the parts to be earthed.

A1 3.45
electronic motor overload protection
PDS/*CDM*/*BDM* 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.

Documents
Document Sharing Hub
Full document details: BS EN 61800-5-1:2007+A11:2021

3.46
electronic power output short-circuit protection circuitry
circuitry integral to *PDS*/*CDM*/*BDM* 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.

3.47
thermal memory
ability of an overload protective system to approximate the heating and cooling of a protected motor during operation

3.48
thermal memory retention
ability to retain a representation of the thermal state of a motor prior to shutdown or loss of power

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

Note 2 to entry: This may include an ongoing reduction of the thermal representation to reflect cooling of the motor during shutdown or loss of power.

3.49
trip
controlled rapid reduction or elimination of the transfer of energy to any device or process initiated by a detected fault or abnormal operating condition

AVA Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

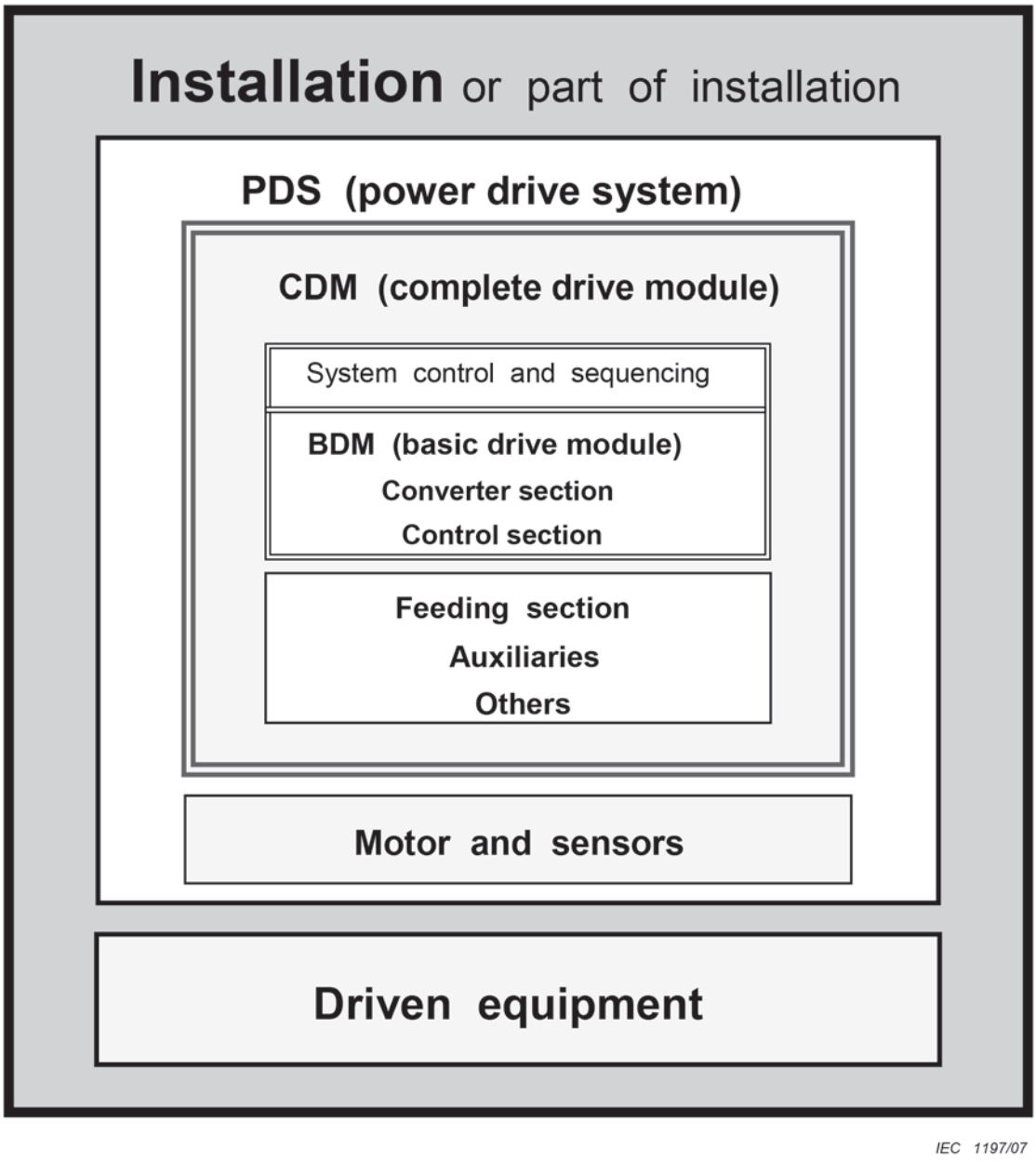


Figure 1 — *PDS* hardware configuration within an *installation*

4 Protection against electric shock, thermal, and energy hazards

4.1 General

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

Table 2 shows the application of the requirements of this Clause 4 to *PDS, CDM* or *BDM*.

Documents
Document Sharing Hub
Full document details: BS EN 61800-5-1:2007+A11:2021

Table 2 — Relevance of requirements to *PDS*/*CDM*/*BDM*

Subclause	Title	*PDS* [a]	*CDM*/ *BDM*
4.2	(Protection against electric shock, thermal, and energy hazards) - Fault conditions	A	A
4.3.1	*Decisive voltage classification*	A	A
4.3.2	*Protective separation*	A	A
4.3.3	Protection against direct contact	A	C
4.3.4	Protection in case of direct contact	A	C
4.3.5.1	(Protection against indirect contact) - General	A	A
4.3.5.2	Insulation between *live parts* and accessible conductive parts	A	C
4.3.5.3	*Protective bonding circuit*	A	C
4.3.5.4	*Protective earthing conductor*	A	A
4.3.5.5	Means of connection for the *protective earthing conductor*	A	A
4.3.5.6	Special features in equipment for *protective class II*	A	C
4.3.6	Insulation	A	A
4.3.7	Enclosures	A	C
4.3.8	Wiring and connections	A	A
4.3.9	Output short-circuit requirements	A	A
4.3.10	Residual current-operated protective (RCD) or monitoring (RCM) device compatibility	A	C
4.3.11	Capacitor discharge	A	A
4.3.12	Access conditions for *high-voltage PDS*	A	C
4.4	Protection against thermal hazards	A	A
4.4.3	Flammability of enclosure materials	A	C
4.4.5	Specific requirements for liquid cooled *PDS*	A	A
4.5	Protection against energy hazards	A	A
4.5.2	Mechanical energy hazards	A	C
4.6	Protection against environmental stresses	A	A

A Requirement always relevant.

C Requirement relevant unless *CDM* or *BDM* is incorporated into an assembly that provides the required protection.

a *Integrated PDS* shall meet the requirement for *PDS*.

4.2 Fault conditions

PDS shall be designed to avoid operating modes or sequences that can cause a fault condition or component failure leading to a hazard, unless other measures to prevent the hazard are provided by the *installation*.

Protection against thermal hazards and electric shock shall be maintained in single fault conditions as well as under normal conditions.

Circuit analysis shall be performed to identify components (including insulation systems) whose failure would result in a thermal or electric shock hazard. The analysis shall include the effect of short-circuit and open-circuit conditions of the component. The analysis need not include power semiconductor devices if equivalent testing is accomplished during short-circuit tests, or components which have been determined to have an insignificant probability of failure during the *expected lifetime* of the *PDS*. See 5.2.3.6.4 for test.

NOTE It is possible that no critical components will be revealed by the analysis. In this case, no component failure testing is required.

AVA Documents Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

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

4.3 Protection against electric shock

4.3.1 *Decisive voltage classification*

4.3.1.1 Use of *decisive voltage class (DVC)*

Protective measures against electric shock depend on the *decisive voltage classification* of the circuit according to Table 3, which correlates the limits of the *working voltage* within the circuit with the *DVC*. The *DVC* in turn determines the minimum required level of protection for the circuit.

4.3.1.2 Limits of *DVC*

Table 3 — Summary of the limits of the *decisive voltage classes*

DVC	Limits of *working voltage* (V)			Subclause
	a.c. voltage (r.m.s.) U_{ACL}	a.c. voltage (peak) U_{ACPL}	d.c. voltage (mean) U_{DCL}	
A [a]	25	35,4	60	4.3.4.2, 4.3.4.4
B	50	71	120	4.3.5.3.1 a), b)
C	1 000	4 500 [b]	1 500	
D	> 1 000	> 4 500	> 1 500	

[a] For equipment having only one *DVC* A circuit, the r.m.s. and peak voltage limits are 30 V and 42,4 V respectively.

[b] The value of 4 500 V allows all *low-voltage PDS* to be covered by Table 7 (possible reflections up to $3 \times \sqrt{2} \times 1\,000\ V = 4\,242\ V$).

4.3.1.3 Requirements for protection

Table 4 shows the requirements for the application of *basic insulation* or *protective separation*, dependent on the *DVC* of the circuit under consideration and of *adjacent circuits*.

Table 4 — Protection requirements for considered circuit

DVC of considered circuit	Protection required against direct contact	Insulation to earthed parts	Insulation to accessible conductive parts that are not earthed	Insulation to *adjacent circuit* of *DVC*:			
				A	B	C	D
A	No	a *	a	f *	b	p ‡	p
B	Yes	b	p		b	p ‡	p
C	Yes	b	p			b	p
D	Yes	b	p				b

a Insulation is not necessary for safety, but may be required for functional reasons.

* If the considered circuit is designated as a *SELV circuit*, *basic insulation* is required from earth and from *PELV circuits*.

f *Functional insulation* for circuit of higher voltage.

b *Basic insulation* for circuit of higher voltage.

p *Protective separation* for circuit of higher voltage.

‡ It is permitted to use *basic insulation* for the circuit of higher voltage if protection against direct contact is applied to the considered circuit by *basic* or *supplementary insulation* for the circuit of higher voltage.

AVA Documents Document Sharing Hub

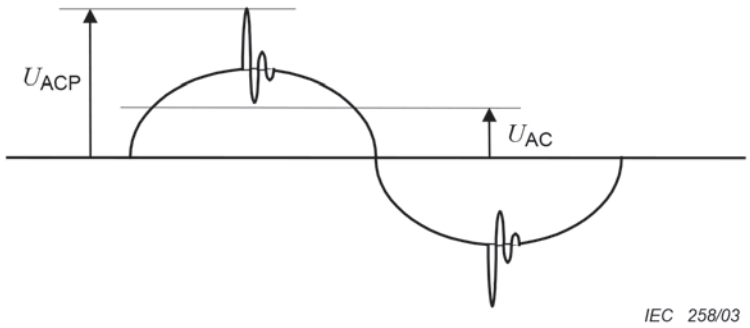
Full document details: BS EN 61800-5-1:2007+A11:2021

4.3.1.4 Circuit evaluation

4.3.1.4.1 General

The *DVC* of a given circuit is evaluated by the method set out below, three cases of waveforms being considered.

4.3.1.4.2 A.C. *working voltage* (see Figure 2)



Key

U_{AC}	r.m.s. voltage
U_{ACP}	recurring peak voltage

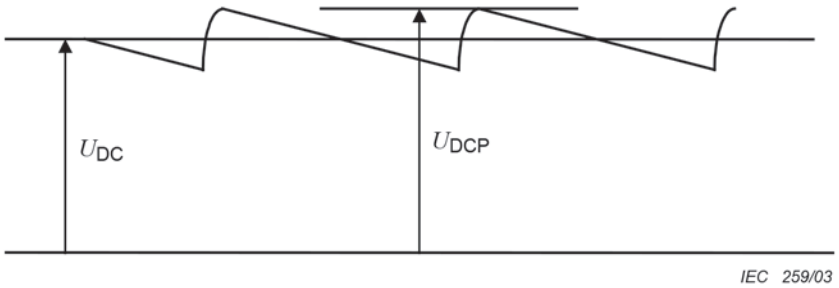
Figure 2 — Typical waveform for a.c. *working voltage*

The *working voltage* has an r.m.s. value U_{AC} and a recurring peak value U_{ACP}.

The *DVC* is that of the lowest voltage row of Table 3 for which both of the following conditions are satisfied.

- $U_{AC} \leq U_{ACL}$
- $U_{ACP} \leq U_{ACPL}$

4.3.1.4.3 D.C. *working voltage* (see Figure 3)



Key

U_{DC}	mean voltage
U_{DCP}	recurring peak voltage

Figure 3 — Typical waveform for d.c. *working voltage*

The *working voltage* has a mean value U_{DC} and a recurring peak value U_{DCP}, caused by a ripple voltage of r.m.s. value not greater than 10 % of U_{DC}.

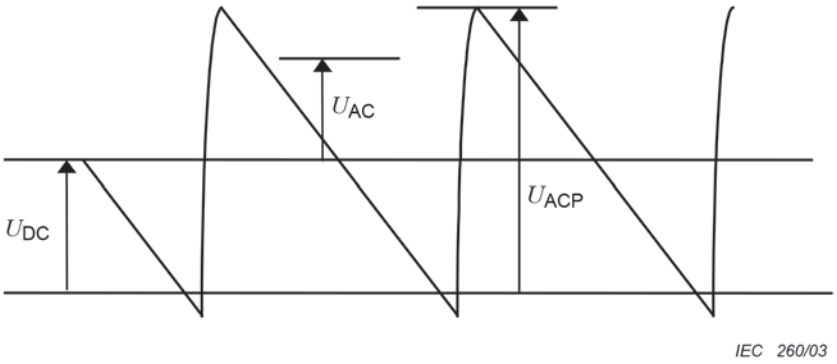
AVA Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

The *DVC* is that of the lowest voltage row of Table 3 for which both of the following conditions are satisfied.

- $U_{DC} \leq U_{DCL}$
- $U_{DCP} \leq 1{,}17 \times U_{DCL}$

4.3.1.4.4 Pulsating *working voltage* (see Figure 4)



Key

U_{DC}	mean voltage
U_{DCP}	recurring peak voltage

Figure 4 — Typical waveform for pulsating *working voltage*

The *working voltage* has a mean value U_{DC} and a recurring peak value U_{ACP}, caused by a ripple voltage of r.m.s. value U_{AC} greater than 10 % of U_{DC}.

The *DVC* is that of the lowest voltage row of Table 3 for which both of the following conditions are satisfied.

- $U_{AC}/U_{ACL} + U_{DC}/U_{DCL} \leq 1$
- $U_{ACP}/U_{ACPL} + U_{DC}/(1{,}17 \times U_{DCL}) \leq 1$

4.3.2 *Protective separation*

Protective separation shall be achieved by application of materials resistant to degradation, as well as by special constructive measures; and

- by *double* or *reinforced insulation*,

  or

- by *protective screening*, i.e. by a conductive screen connected to earth by *protective bonding* of the *PDS*, or connected to the protective earth conductor itself, whereby the screen is separated from *live parts* by at least *basic insulation*,

  or

- by *protective impedance* according to 4.3.4.3 comprising limitation of discharge energy and of current, or by limitation of voltage according to 4.3.4.4.

The *protective separation* shall be fully and effectively maintained under all conditions of intended use of the *PDS*.

Documents
Document Sharing Hub
Full document details: BS EN 61800-5-1:2007+A11:2021

4.3.3 Protection against direct contact

4.3.3.1 General

Protection against direct contact is employed to prevent persons from touching *live parts* which do not meet the requirements of 4.3.4. It shall be provided by one or more of the measures given in 4.3.3.2 and 4.3.3.3.

For *integrated PDS* the motor shall meet the requirements of IEC 60034-5. For the *BDM* the protection shall be provided by one or more of the measures given in 4.3.3.2 and 4.3.3.3.

4.3.3.2 Protection by means of insulation of *live parts*

Live parts shall be completely surrounded with insulation if their *working voltage* is greater than the maximum limit of *DVC* A or if they do not have *protective separation* from *adjacent circuits* of *DVC* C or D. The insulation shall be rated according to the impulse voltage, *temporary overvoltage* or *working voltage* (see 4.3.6.2.1), whichever gives the most severe requirement. It shall not be possible to remove the insulation without the use of a tool.

Any conductive part which is not separated from the *live parts* by at least *basic insulation* is considered to be a *live part*. A metallic accessible part is considered to be conductive if its surface is bare or is covered by an insulating layer which does not comply with the requirements of *basic insulation*.

As an alternative to solid or liquid insulation, a clearance according to 4.3.6.4, shown by L_1 and L_2 in Figure 5, may be provided.

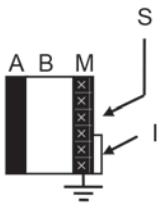
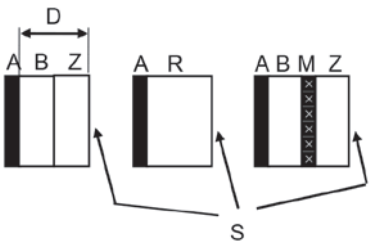
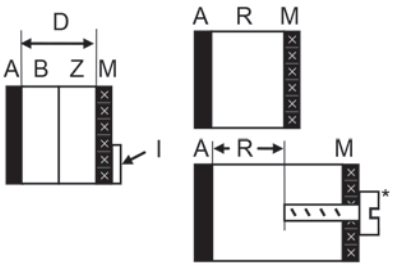
The grade of insulation - *basic*, *double* or *reinforced* - depends on:

- the *DVC* of the *live parts* or *adjacent circuits*,

  and

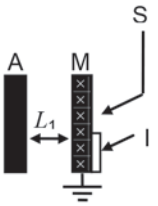
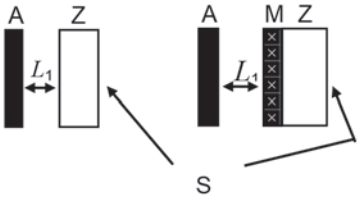
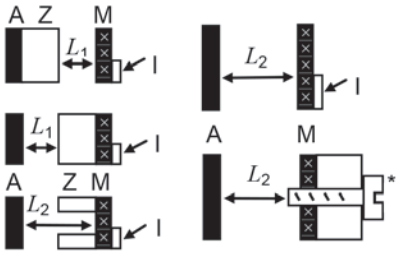
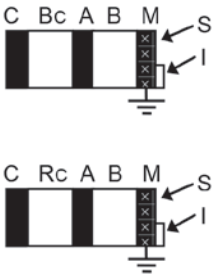
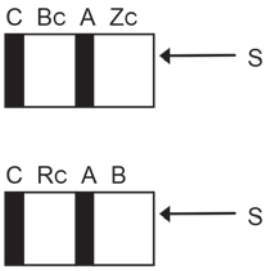
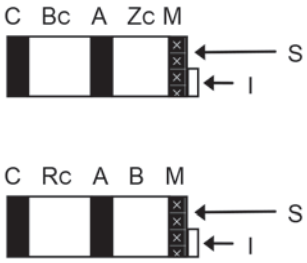
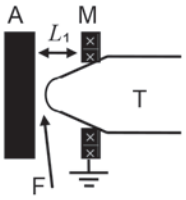
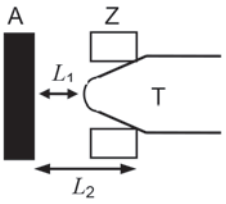
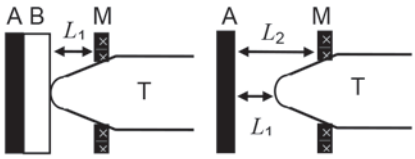
- the connection of conductive parts to earth by *protective bonding*.

Examples of insulation configurations are given in Figure 5, which also shows the requirements for apertures.

Type of insulation	**Insulation configuration**		
	a **Accessible parts conductive and connected to earth by *protective bonding***	**b** **Accessible parts not conductive**	**c** **Accessible parts conductive, but <u>NOT</u> connected to earth by *protective bonding***
1) Solid or liquid			

Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

Type of insulation	Insulation configuration		
	a **Accessible parts conductive and connected to earth by *protective bonding***	**b** **Accessible parts not conductive**	**c** **Accessible parts conductive, but <u>NOT</u> connected to earth by *protective bonding***
2) Totally or partially by air clearance			
3) Insulation for *adjacent circuits*: Circuit A: lower voltage circuit **Circuit C: higher voltage circuit; upper row - *DVC* C only, lower row - *DVC* C or D**			
4) Requirements for apertures in enclosures			

A	*live part*	L_1	clearance for *basic insulation*	T	test finger (Clause 12 of IEC 60529)
B	*basic insulation* for circuit A	L_2	clearance for *reinforced insulation*	Z	*supplementary insulation* for circuit A
Bc	*basic insulation* for circuit C	M	conductive part	Zc	*supplementary insulation* for circuit C
C	*adjacent circuit*	R	*reinforced insulation* for circuit A	*	also applies to plastic screws
D	*double insulation* for circuit A	Rc	*reinforced insulation* for circuit C	F	*functional insulation* for circuit A
I	insulation less than B	S	surface of equipment		

NOTE 1: In column c a plastic screw is treated like a metal screw because a user could replace it with a metal screw during the life of the equipment.

NOTE 2: In row 4), the insertion of the test finger is considered to represent the first fault.

Figure 5 — Examples for protection against direct contact

Three cases are considered:

Documents
Document Sharing Hub
Full document details: BS EN 61800-5-1:2007+A11:2021

Case a): Accessible parts are conductive and are connected to earth by *protective bonding*.

- *Basic insulation* is required between accessible parts and the *live parts*. The relevant voltage is that of the *live parts* (see Figure 5, cells 1)a), 2)a), 3)a)).

Cases b) and c): Accessible parts are non-conductive (case b)) or conductive but not connected to earth by *protective bonding* (case c)). The required insulation is:

- *double* or *reinforced insulation* between accessible parts and *live parts* of *DVC* C or D. The relevant voltage is that of the *live parts* (see Figure 5, cells 1)b), 1)c), 2)b), 2)c)).
- *supplementary insulation* between accessible parts and *live parts* of circuits of *DVC* A or B which are separated by *basic insulation* from *adjacent circuits* of *DVC* C. The relevant voltage is the highest voltage of the *adjacent circuits* (see Figure 5, upper cells 3)b), 3)c)).
- *basic insulation* between accessible parts and *live parts* of circuits of *DVC* B which have *protective separation* from *adjacent circuits* of *DVC* C or D. The relevant voltage is that of the *live parts* (see Figure 5, lower cells 3)b), 3)c)).

4.3.3.3 Protection by means of enclosures and barriers

Live parts of *DVC* B, C or D shall be arranged in enclosures or located behind enclosures or barriers, which meet at least the requirements of the Protective Type IPXXB according to 15.1 of IEC 60529. The top surfaces of enclosures or barriers which are accessible when the equipment is energized shall meet at least the requirements of the Protective Type IP3X with regard to vertical access only. See 5.2.2.3 for test. It shall only be possible to open enclosures or remove barriers with the use of a tool or after de-energization of these *live parts*.

Where the enclosure is required to be opened and the *PDS* energised during installation or maintenance:

a) accessible *live parts* of *DVC* B, C or D shall be protected to at least IPXXA;

b) *live parts* of *DVC* B, C or D that are likely to be touched when making adjustments shall be protected to at least IPXXB;

c) it shall be ensured that persons are aware that *live parts* of *DVC* B, C or D are accessible.

Open type sub-assemblies and devices do not require protective measures against direct contact.

Products containing circuits of *DVC* A, B or C, intended for installation in *closed electrical operating areas*, as defined in 3.5, need not have protective measures against direct contact.

Products containing circuits of *DVC* D, intended for installation within a *closed electrical operating area*, have additional requirements (see 4.3.12).

4.3.4 Protection in case of direct contact

4.3.4.1 General

Protection in case of direct contact is required to ensure that contact with *live parts* does not produce a shock hazard.

The protection against direct contact according to 4.3.3 is not required if the circuit contacted is separated from all other circuits according to 4.3.1.3, and:

- is of *DVC* A and complies with 4.3.4.2,

  or

- is current limited via a *protective impedance* according to 4.3.4.3,

  or

AVA Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021

- is limited in voltage according to 4.3.4.4.

See Annex A for examples of these measures.

NOTE The requirements of these subclauses apply to the entire circuit including power supplies and any associated peripheral devices.

Compliance with *protective separation* requirements shall be verified according to 5.2.1, 5.2.2, and 5.2.3 as appropriate.

4.3.4.2 Protection using *DVC* A

Unearthed circuits of *DVC* A, and earthed circuits of *DVC* A used within a *zone of equipotential bonding* (see 3.44), do not require protection in case of direct contact.

Earthed circuits of *DVC* A that are not within a *zone of equipotential bonding* require additional protection in case of direct contact, by one of the measures given in 4.3.4.3 or 4.3.4.4, in order to provide protection in cases where the earth reference potentials of the *DVC* A circuits are not the same. The instruction manual shall provide information concerning the use of these circuits (see 6.3.6.5).

4.3.4.3 Protection by means of *protective impedance*

The connection of accessible *live parts* to circuits of *DVC* B, C or D, or to earthed circuits of *DVC* A not used within a *zone of equipotential bonding*, shall only be made through *protective impedances* (unless 4.3.4.4 applies).

The same constructional provisions as those for *protective separation* shall be applied for the construction and arrangement of a *protective impedance*. The current value stated below shall not be exceeded in the event of failure of a single component. The stored charge available between simultaneously accessible parts protected by the *protective impedance* shall not exceed 50 µC.

The *protective impedances* shall be designed so that the current available through them to earth at the accessible *live part* does not exceed a value of 3,5 mA a.c. or 10 mA d.c. See 5.2.3.4 for test.

The *protective impedances* shall be designed and tested to withstand the impulse voltages and *temporary overvoltages* for the circuits to which they are connected. See 5.2.3.1 and 5.2.3.2 for tests.

4.3.4.4 Protection by means of limited voltages

This type of protection implies a voltage division technique from a circuit protected against direct contact, resulting in a voltage to earth not greater than that of *DVC* A.

This circuit shall be designed so that, even in the event of failure of a single component in the voltage division circuit, the voltage across output terminals as well as the voltage to earth will not become greater than that of *DVC* A. The same constructional measures as in *protective separation* shall be employed in this case.

This type of protection shall not be used in case of *protective class II*, because it relies on protective earth being connected.

4.3.5 Protection against indirect contact

4.3.5.1 General

Protection against indirect contact is required to prevent shock currents which can result from accessible conductive parts during an insulation failure. This protection shall comply with the requirements for *protective class I*, *class II* or *class III*.

That part of a *PDS* which meets the requirements of 4.3.5.2, 4.3.5.3 and 4.3.5.3.2 is defined as *protective class I*.

Documents
Document Sharing Hub
Full document details: BS EN 61800-5-1:2007+A11:2021

That part of a *PDS* which meets the requirements of 4.3.5.6 is defined as *protective class II*.

That part of a *PDS* which meets the requirements of *SELV* is defined as *protective class III*.

Protective class 0 is only acceptable for parts of the *PDS* when instructions are provided to meet the requirements of 4.3.3.3 (*closed electrical operating areas*) (see 6.3.6.5). In the case of *high-voltage PDS*, special requirements exist (see 4.3.12).

4.3.5.2 Insulation between *live parts* and accessible conductive parts

Accessible conductive parts of equipment shall be separated from *live parts* at least by *basic insulation* or by clearances as in 4.3.6.4.

4.3.5.3 *Protective bonding* circuit

4.3.5.3.1 General

Other than in a) or b) below, *protective bonding* shall be provided between accessible conductive parts of equipment and the means of connection for the *protective earthing conductor*:

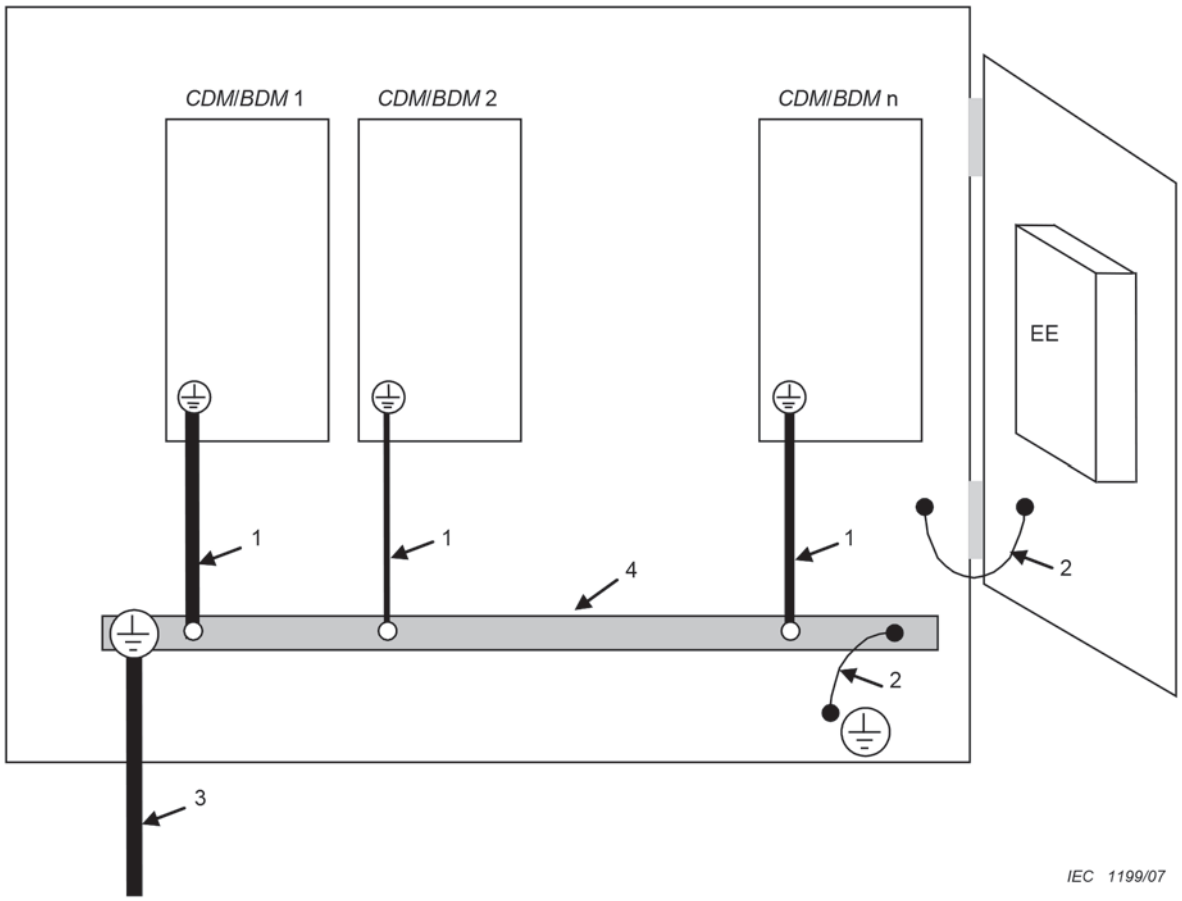
a) when accessible conductive parts are protected by one of the measures in 4.3.4.2 to 4.3.4.4;

b) when accessible conductive parts are separated from *live parts* using *double* or *reinforced insulation*.

NOTE Some examples of such parts are magnetic cores, screws, rivets, nameplates and cable clamps.

Documents
Document Sharing Hub
Full document details: BS EN 61800-5-1:2007+A11:2021

Figure 6 shows an example *CDM/BDM* assembly and its associated *protective bonding*.



1 *CDM/BDM protective earthing conductor* (dimensioned according to *CDM/BDM* requirements)

2 *Protective bonding*

3 *PDS protective earthing conductor* (dimensioned according to *PDS* requirements) to *installation* earthing point

4 *Earth* bar

EE other *electrical* equipment (bonded as relevant for that equipment)

Figure 6 — Example of *protective bonding*

Electrical contact to the means of connection of the *protective earthing conductor* shall be achieved by one or more of the following means:

- through direct metallic contact;
- through other accessible conductive parts which are not removed when the *PDS/CDM/BDM* is used as intended;
- through a dedicated *protective bonding* conductor;
- through other metallic components of the *PDS/CDM/BDM*.

NOTE When painted surfaces (in particular powder painted surfaces) are joined together, then a separate connection should be made for reliable contact.

Where electrical equipment is mounted on lids, doors, or cover plates, continuity of the *protective bonding* circuit shall be ensured and it is recommended that a dedicated conductor be used. Otherwise fastenings, hinges or sliding contacts designed and maintained to have a low resistance shall be used.

Documents
Document Sharing Hub
Full document details: BS EN 61800-5-1:2007+A11:2021

Metal ducts of flexible or rigid construction and metallic sheaths shall not be used as protective conductors.

For *high-voltage PDS*, metal ducts and metal sheathing of all connecting cables (e.g. cable armouring, lead sheath) shall be connected to earth by the *protective bonding* circuit. If only one end of such ducting or sheathing is so connected, it shall not be possible to touch the other end. This shall be connected to earth by the *protective bonding* circuit via an impedance to limit any induced voltage to a maximum of 50 V a.c.

The *protective bonding* circuit shall not incorporate a switching device, an overcurrent device (e.g. switch, fuse) or means of current detection for such devices.

4.3.5.3.2 Rating of protective bonding

Protective bonding shall withstand the highest thermal and dynamic stresses that can occur to the *PDS*/*CDM*/*BDM* item(s) concerned when they are subjected to a fault connecting to accessible conductive parts.

The *protective bonding* shall remain effective for as long as a fault to the accessible conductive parts persists or until an upstream protective device removes power from the part.

NOTE In cases where the *protective bonding* is routed through conductors of low cross-section (for example, PWB tracks), particular care should be taken to ensure that no undetected damage to the bonding circuit can occur in the event of a fault.

These conditions will be satisfied if the cross-section of the *protective bonding* conductor is the same as that for the *protective earthing conductor* according to 4.3.5.4. For testing, see 5.2.3.9.

Alternatively, *protective bonding* may be designed to meet the impedance requirements of 4.3.5.3.3.

4.3.5.3.3 *Protective bonding* impedance

The impedance of the *protective bonding* shall be sufficiently low that:

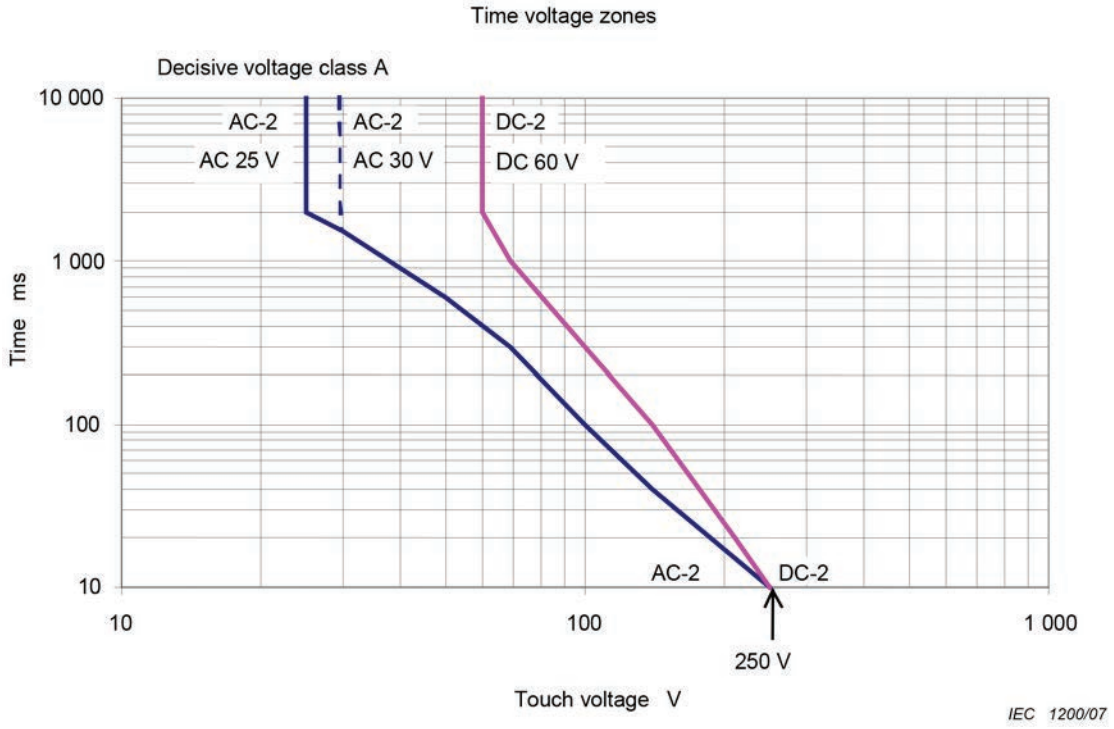
- during normal operation, no voltage exceeding continuously 5 V a.c. or 12 V d.c. can persist between the accessible conductive parts and the means of connection for the *protective earthing conductor*,

  and

- under fault conditions, no voltage exceeding AC-2 or DC-2 in Figure 7 can persist between accessible conductive parts and the means of connection for the *protective earthing conductor* until an upstream protective device removes power from the part. The upstream protective device considered for this requirement shall have the characteristics required by the installation manual according to 6.3.7.

AVA Documents
Document Sharing Hub

Full document details: BS EN 61800-5-1:2007+A11:2021



NOTE The dashed line of AC-2 applies if only a single *DVC* A circuit is present; the solid line applies if more than one *DVC* A circuit is present.

Figure 7 — Voltage limits under fault conditions

For testing, see 5.2.3.9.

4.3.5.4 *Protective earthing conductor*

A *protective earthing conductor* shall be connected at all times when power is supplied to the *PDS/CDM/BDM*, unless the *PDS/CDM/BDM* complies with the requirements of *protective class II* (see 4.3.5.6). Unless local wiring regulations state otherwise, the *protective earthing conductor* cross-sectional area shall be determined from Table 5 or by calculation according to 543.1 of IEC 60364-5-54.

If the *protective earthing conductor* is routed through a plug and socket, or similar means of disconnection, it shall not be possible to disconnect it unless power is simultaneously removed from the part to be protected.

Table 5 — *Protective earthing conductor* cross-section

Cross-sectional area of phase conductors of the *PDS/CDM/BDM S* **(mm²)**	**Minimum cross-sectional area of the corresponding *protective earthing conductor* S_p** **(mm²)**
$S \leq 16$	S
$16 < S \leq 35$	16
$35 < S$	$S/2$
The values in Table 5 are valid only if the *protective earthing conductor* is made of the same metal as the phase conductors. If this is not so, the cross-sectional area of the *protective earthing conductor* shall be determined in a manner which produces a conductance equivalent to that which results from the application of Table 5.	

The cross-sectional area of every *protective earthing conductor* which does not form part of the supply cable or cable enclosure shall, in any case, be not less than:

- 2,5 mm² if mechanical protection is provided,

Documents
Document Sharing Hub
Full document details: BS EN 61800-5-1:2007+A11:2021