BS EN 61800-2:2015

BSI Standards Publication

Adjustable speed electrical power drive systems

Part 2: General requirements — Rating specifications for low voltage adjustable speed a.c. power drive systems

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National foreword

This British Standard is the UK implementation of EN 61800-2:2015. It is identical to IEC 61800-2:2015. It supersedes BS EN 61800-2:1998 which will be withdrawn on 26 August 2018.

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 secretary.

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Published by BSI Standards Limited 2015

ISBN 978 0 580 75848 5
ICS 29.160.30; 29.200

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 October 2015.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61800-2

September 2015

ICS 29.160.30; 29.200

Supersedes EN 61800-2:1998

English Version

Adjustable speed electrical power drive systems - Part 2: General requirements - Rating specifications for low voltage adjustable speed a.c. power drive systems (IEC 61800-2:2015)

Entraînements électriques de puissance à vitesse variable - Partie 2: Exigences générales - Spécifications de dimensionnement pour systèmes d'entraînement de puissance à vitesse variable en courant alternatif et basse tension (IEC 61800-2:2015)

Drehzahlveränderbare elektrische Antriebe - Teil 2: Allgemeine Anforderungen - Festlegungen für die Bemessung von Niederspannungs-Wechselstrom-Antriebssystemen mit einstellbarer Frequenz (IEC 61800-2:2015)

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Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Ref. No. EN 61800-2:2015 E

European foreword

The text of document 22G/303/FDIS, future edition 2 of IEC 61800-2, 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 61800-2:2015.

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)	2016-05-26
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2018-08-26

This document supersedes EN 61800-2:1998.

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.

Endorsement notice

The text of the International Standard IEC 61800-2:2015 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 60027-3	NOTE	Harmonized as EN 60027-3.
IEC 60034-1	NOTE	Harmonized as EN 60034-1.
IEC 60204-1	NOTE	Harmonized as EN 60204-1.
IEC 60364 Series	NOTE	Harmonized as HD 60364 Series.
IEC 61131-2	NOTE	Harmonized as EN 61131-2.
IEC 61158 Series	NOTE	Harmonized as EN 61158 Series.
IEC 61158-1	NOTE	Harmonized as EN 61158-1.
IEC 61158-2	NOTE	Harmonized as EN 61158-2.
IEC 61378-1	NOTE	Harmonized as EN 61378-1.
IEC 61439-1	NOTE	Harmonized as EN 61439-1.
IEC 61800-1	NOTE	Harmonized as EN 61800-1.
IEC 61800-4	NOTE	Harmonized as EN 61800-4.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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

NOTE 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 60034-9	-	Rotating electrical machines - Part 9: Noise limits	EN 60034-9	-
IEC 60038	-	IEC standard voltages	EN 60038	-
IEC 60050	Series	International Electrotechnical Vocabulary	-	-
IEC 60068	series	Environmental testing	EN 60068	Series
IEC 60068-2-2	2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat	EN 60068-2-2	2007
IEC 60068-2-6	2007	Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)	EN 60068-2-6	2008
IEC 60068-2-27	2008	Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock	EN 60068-2-27	2009
IEC 60068-2-52	1996	Environmental testing - Part 2-52: Tests - Test Kb: Salt mist, cyclic (sodium chloride solution)	EN 60068-2-52	1996
IEC 60068-2-68	1994	Environmental testing - Part 2-68: Tests - Test L: Dust and sand	EN 60068-2-68	1996
IEC 60068-2-78	2012	Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state	EN 60068-2-78	2013
IEC 60079	Series	Explosive atmospheres	EN 60079	Series
IEC 60146-1-1	-	Semiconductor converters - General requirements and line commutated converters - Part 1-1: Specification of basic requirements	EN 60146-1-1	-
IEC/TR 60146-1-2	-	Semiconductor converters - General requirements and line commutated converters - Part 1-2: Application guide	-	-
IEC 60529	-	Degrees of protection provided by enclosures (IP Code)	EN 60529	-

Publication	Year	Title	EN/HD	Year
IEC 60664-1	-	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests	EN 60664-1	-
IEC 60721-3-1	1997	Classification of environmental conditions - - Part 3: Classification of groups of environmental parameters and their severities - Section 1: Storage	EN 60721-3-1	1997
IEC 60721-3-2	1997	Classification of environmental conditions - - Part 3: Classification of groups of environmental parameters and their severities -- Section 2: Transportation	EN 60721-3-2	1997
IEC 60721-3-3 +A1 +A2	1994 1995 1996	Classification of environmental conditions - - Part 3: Classification of groups of environmental parameters and their severities - Section 3: Stationary use at weatherprotected locations	EN 60721-3-3 +A2	1995 1997
IEC 60721-3-4 +A1	1995 1996	Classification of environmental conditions - - Part 3: Classification of groups of environmental parameters and their severities - Section 4: Stationary use at non-weatherprotected locations	EN 60721-3-4 +A1	1995 1997
IEC 61800-3	-	Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods	EN 61800-3	-
IEC 61800-5-1	2007	Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy	EN 61800-5-1	2007
IEC 61800-5-2	2007	Adjustable speed electrical power drive systems - Part 5-2: Safety requirements - Functional	EN 61800-5-2	2007
IEC/TR 61800-6	-	Adjustable speed electrical power drive systems - Part 6: Guide for determination of types of load duty and corresponding current ratings	CLC/TR 61800-6	-
IEC 61800-7	Series	Adjustable speed electrical power drive systems - Part 7: Generic interface and use of profiles for power drive systems	EN 61800-7	Series
IEC 61800-7-1	-	Adjustable speed electrical power drive systems - Part 7-1: Generic interface and use of profiles for power drive systems - Interface definition	EN 61800-7-1	-

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 2: General requirements – Rating specifications for low voltage adjustable speed a.c. power drive systems

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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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 61800-2 has been prepared by subcommittee 22G: Adjustable speed electric drive systems incorporating semiconductor power converters, of IEC technical committee 22: Power electronic systems and equipment.

This second edition cancels and replaces the first edition published in 1998. This edition constitutes a technical revision.

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

a) Clause 1 (Scope) has been updated
b) Clause 2 (Normative references) has been updated

c) Clause 3 (Definitions) has been updated including fundamental definitions to be used across the IEC 61800 series of standards.

d) Clause 4 has been updated with respect to:

   1) description of the basic topology for *BDM/CDM/PDS* (4.2);

   2) ratings and performance (4.3 and 4.4);

   3) reference to applicable standards within the IEC 61800 series with respect to EMC (IEC 61800-3), Electrical safety (IEC 61800-5-1), Functional safety (IEC 61800-5-2), Load duty aspects (IEC TR 61800-6), Communication profiles (IEC 61800-7 series) and *Power interface* voltage (IEC TS 61800-8) to avoid conflicting requirements. (4.5, 4.6, 4.7, 4.10, 4.11, 4.12,);

   4) update of requirement for ECO design (4.8);

   5) update of requirement for environmental evaluation. (4.9);

   6) implementation of requirement for explosive atmosphere (4.13).

e) Clause 5 has been updated with test requirement in order to provide a clear link between design requirement and test requirement.

f) Clause 6 has been updated to harmonize the marking and documentation requirement within the IEC 61800 series.

g) Existing Annexes A to G have been deleted and replaced with new Annexes A to C.

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

FDIS	Report on voting
22G/303/FDIS	22G/305/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 in the IEC 61800 series, published under the general title *Adjustable speed electrical power drive systems*, can be found on the IEC website.

In this standard, the terms in *italics* are defined in Clause 3.

The committee has decided that the contents of this publication will remain unchanged until the stability 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.

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 document using a colour printer.

INTRODUCTION

0.1 General

This document is part of the IEC 61800 series specifying requirements for adjustable speed electric drive systems (*PDS*). Since the publication of the first edition of IEC 61800-2 several documents of the IEC 61800 have been developed and maintained, which has resulted in outdated references and conflicting requirements across the IEC 61800 series.

This document contains general requirements for *PDS*s intended to feed a.c. *motors* and with rated *converter* input voltages (line-to-line voltage) up to 1 000 V a.c.

*PDS*s intended to feed a.c. *motors* with rated *converter input* voltages above 1 000 V a.c. are covered by IEC 61800-4.

*PDS*s intended to feed d.c. *motors* are covered by IEC 61800-1.

0.2 Consistency of requirement

This document specifies requirements for *PDS*s under its scope for the identified topics not covered by any other of the standards in the IEC 61800 series.

The following requirements are covered by other standards in the IEC 61800 series:

- EMC requirements are covered in IEC 61800-3;
- electrical safety requirements are covered in IEC 61800-5-1;
- functional safety requirements are covered in IEC 61800-5-2;
- type of load duty requirements are covered by IEC TR 61800-6;
- communication profiles aspects which are covered by IEC 61800-7 series;
- *power interface* voltage specification is specified in IEC TS 61800-8.

Generally this document provides a basic description of topics and refers to the relevant standard for specific requirement. This is done in order to ensure consistency and avoid conflicting requirement within the IEC 61800 series as well as minimize future maintenance of the documents.

As part of the work inside SC22G MT9 this edition of IEC61800-2 defines basic definition as used across the IEC 61800 series of standards.

For issues related to *active infeed converters,* IEC TS 62578 has been considered.

At the time of writing IEC SC 22G is developing a standard to provide requirement for energy *efficiency* for *BDM*/*CDM*/*PDS*. The next edition of IEC 61800-2 will reference this standard similar to the approach taken with the other IEC 61800 series standards.

As a result of the development of the IEC 61800 series of standards the need to reference documents outside the series has decreased and especially the need to reference the IEC 60146 series of standards has decreased dramatically.

0.3 Tool for agreement between *customer* and *manufacturer*

This document is intended to be used to create a comprehensive list of requirements to be used as a specification between *customer* and *manufacturer*. The requirement in this document is in itself not applicable for the *BDM/CDM/PDS*. Instead each topic should be specified by the *customer* as a compliance requirement.

The document may be useful as a specification tool, when *BDM/CDM/PDS*s are built into a final *installation* or application applied as a component. The following applications are considered relevant: lift and hoist, machinery, conveyor, switchgears, heating and ventilation, pump, wind, tidal and marine propulsion applications.

In every application, an identification of the environmental conditions under which the product is stored, transported and operated is essential for the proper specification of the *BDM/CDM/PDS*s. The environmental conditions considered should include electrical, mechanical, thermal, pollution and humidity environmental condition.

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 2: General requirements – Rating specifications for low voltage adjustable speed a.c. power drive systems

1 Scope

This part of IEC 61800 applies to adjustable speed electric a.c. power drive systems, which include semiconductor power conversion and the means for their control, protection, monitoring, measurement and the a.c. *motor*s.

It applies to adjustable speed electric power drive systems intended to feed a.c. *motors* from a *BDM* connected to line-to-line voltages up to and including 1 kV a.c. 50 Hz or 60 Hz and/or voltages up to and including 1,5 kV d.c. input side.

NOTE 1 Adjustable speed electric a.c. power drive systems intended to feed a.c. motors, and with rated *converter* input voltages above 1 000 V a.c. are covered by IEC 61800-4.

NOTE 2 Adjustable speed electric d.c. power drive systems intended to feed d.c. *motors* are covered by IEC 61800-1.

NOTE 3 For adjustable speed electric a.c. power drive systems having series-connected electronic power *converter* sections, the line-to-line voltage is the sum of the series connected input voltages.

Traction applications and electric vehicles are excluded from the scope of this standard.

This part of IEC 61800 is intended to define the following aspects of an a.c. power drive system (*PDS*):

- principal parts of the *PDS*;
- ratings and performance;
- specifications for the environment in which the *PDS* is intended to be installed and operated;
- other specifications which might be applicable when specifying a complete *PDS*.

This standard provides minimum requirements, which may be used for the development of a specification between *customer* and *manufacturer*.

Compliance with this standard is possible only when each topic of this standard is individually specified by the *customer* developing specifications or by product standard committees developing product standards.

For some aspects which are covered by specific *PDS* product standards in the IEC 61800 series, this document provides a short introduction and reference to detailed requirements in these product standards.

This applies to the following aspects:

- EMC which is covered in IEC 61800-3;
- electrical safety which is covered in IEC 61800-5-1;
- functional safety which is covered in IEC 61800-5-2;
- type of load duty which are covered by IEC TR 61800-6;
- communication profiles which are covered by IEC 61800-7 series;
- *power interface* voltage specification which is covered by IEC TS 61800-8.

2 Normative references

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

IEC 60034-9, *Rotating electrical machines – Part 9: Noise l*imits

IEC 60038, *IEC standard voltages*

IEC 60068 (all parts), *Environmental testing*

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 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-52:1996, *Environmental testing – Part 2: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

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

IEC 60068-2-78:2012, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60050 (all parts): *International Electrotechnical Vocabulary (available at <http://www.electropedia.org>)*

IEC 60079 (all parts), *Explosive atmospheres*

IEC 60146-1-1, *Semiconductor convertors – General requirement and line commutated convertors – Part 1-1: Specification of basic requirements*

IEC TR 60146-1-2, *Semiconductor convertors – General requirement and line commutated convertors – Part 1-2: Application guide*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60664-1, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60721-3-1:1997, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 1: Storage*

IEC 60721-3-2:1997, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 2: Transportation*

IEC 60721-3-3:1994, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 3: Stationary use at weatherprotected locations*
IEC 60721-3-3:1994/AMD1:1995
IEC 60721-3-3:1994/AMD2:1996

IEC 60721-3-4:1995, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 4: Stationary use at non-weatherprotected locations*
IEC 60721-3-4:1995/AMD1:1996

IEC 61800-3, *Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods*

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

IEC 61800-5-2:2007, *Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional*

IEC TR 61800-6, *Adjustable speed electrical power drive systems – Part 6: Guide for determination of types of load duty and corresponding current ratings*

IEC 61800-7 (all parts), *Adjustable speed electrical power drive systems – Part 7: Generic interface and use of profiles for power drive systems*

IEC 61800-7-1, *Adjustable speed electrical power drive systems – Part 7-1: Generic interface and use of profiles for power drive systems – Interface definition*

3 Terms and definitions

For the purposes of this document, 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 60146-1-1, IEC TR 60146-1-2, and the following apply

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Table 1 – List of terms

3.1	acceptance test [a]	3.17	four quadrant operation [b]	3.80	power factor [a] (λ)
3.2	a.c. mains power port [a]	3.18	total harmonic distortion (THD) [a]	3.81	product packaging
3.3	active infeed converter [a]	3.19	high voltage PDS <for a.c motor> [b]	3.84	rectifier [a]
3.4	basic drive module <BDM> [b]	3.40	installation [a]	3.85	*regeneration* [b]
3.5	(BDM/CDM/PDS) customer [a]	3.41	integrated PDS [b]	3.86	routine test [a]
3.6	(BDM/CDM/PDS) manufacturer [a]	3.42	inverter [b]	3.87	sample test [a]
3.7	commissioning test [a]	3.43	low voltage PDS <for a.c motor> [b]	3.88	shipping packaging
3.8	complete drive module (CDM) [b]	3.50	electric motor [a]	3.89	short circuit ratio (R_{SC})
3.9	converter <of the BDM> [b]	3.51	Original Equipment Manufacturer (OEM)	3.90	signal interface [a]
3.10	d.c. braking	3.74	output overload capability [a]	3.91	special test [a]
3.11	d.c. link [b]	3.75	port [a]	3.92	stimulus
3.12	dynamic braking [a]	3.76	port for process measurement and control [a]	3.93	system integrator [a]
3.13	efficiency <of the CDM> [b]	3.77	power port [a]	3.94	two quadrant operation [b]
3.14	efficiency <of the PDS> [b]	3.78	power interface a	3.95	type test [a]
3.15	end user <non-professional> [a]	3.79	power drive system (PDS) [b]	3.96	witness test [a]
3.16	end user <professional> [a]				

[a] Definitions used in several standards of the IEC 61800 series.

[b] Fundamental definition across IEC 61800 series.

NOTE This document contains the fundamental definitions used across the IEC 61800 series in a way that they can be used in future revisions of all IEC 61800 standards.

Table 2 – List of input ratings of *BDM/CDM/PDS*

3.20	input active power <BDM> (P_V)	3.28	input current <BDM> (I_V)	3.36	input voltage <BDM> (U_V)
3.21	rated input active power <BDM> (P_{VN})	3.29	rated input current <BDM> (I_{VN})	3.37	rated input voltage <BDM> (U_{VN})
3.22	input active power <CDM/PDS> (P_L)	3.30	input current <CDM/PDS> (I_L)	3.38	input voltage <CDM/PDS> (U_L)
3.23	rated input active power <CDM/PDS> (P_{LN})	3.31	rated input current <CDM/PDS> (I_{LN})	3.39	rated input voltage <CDM/PDS> (U_{LN})
3.24	input apparent power <BDM> (S_V)	3.32	input frequency <BDM> (f_V)		
3.25	rated input apparent power <BDM> (S_{VN})	3.33	rated input frequency <BDM> (f_{VN})		
3.26	input apparent power <CDM/PDS> (S_L)	3.34	input frequency <CDM/PDS> (f_L)		
3.27	rated input apparent power <CDM/PDS> (S_{LN})	3.35	rated input frequency <CDM/PDS> (f_{LN})		

NOTE Subscriptions follow the concept of IEC 60146-1-1.

Table 3 – List of output ratings of *BDM/CDM/PDS*

3.52	output current <BDM> (I_a)	3.60	output voltage <BDM> (U_{a1})	3.68	output apparent power <BDM> (S_a)
3.53	rated output current <BDM> (I_{aN})	3.61	rated output voltage <BDM> (U_{aN1})	3.69	rated output apparent power <BDM> (S_{aN})
3.54	output current <CDM> (I_A)	3.62	output voltage <CDM> (U_{A1})	3.70	output apparent power <CDM> (S_A)
3.55	rated output current <CDM> (I_{AN})	3.63	rated output voltage <CDM> (U_{AN1})	3.71	rated output apparent power <CDM> (S_{AN})
3.56	output frequency <BDM> (f_a)	3.64	Output active power <BDM> (P_a)	3.72	output power <PDS> (P_s)
3.57	rated output frequency <BDM> (f_{aN})	3.65	rated output active power <BDM> (P_{aN})	3.73	rated output power <PDS> (P_{SN})
3.58	output frequency <CDM> (f_A)	3.66	output active power <CDM> (P_A)		
3.59	rated output frequency <CDM> (f_{AN})	3.67	rated output active power <CDM> (P_{AN})		

NOTE Subscriptions follows the concept of IEC 60146-1-1

Table 4 – List of motor speed and torque ratings

3.44	speed <of a motor> (N)	3.47	minimum speed <of a motor> (N_{Min})	3.82	torque <of a motor> (M)
3.45	maximum rated safe speed <of a motor> (N_{sNMax})	3.48	minimum rated speed <of a motor> (N_{NMin})	3.83	rated torque <of a motor> (M_N)
3.46	maximum rated speed <of a motor> (N_{NMax})	3.49	rated speed <of a motor> (N_N)		

NOTE 1 Subscriptions follows the concept of IEC 60146-1-1.

NOTE 2 See also Figure 8, 4.3.3.2.

3.1
acceptance test
contractual test to prove to the *customer* that the device meets certain conditions of its specification

[SOURCE: IEC 60050-151:2001, 151.16.23, modified — The word "item" is replaced by the word "device"]

3.2
a.c. mains power port
power port which feeds the *PDS* for only the power which, after electrical power conversion, is converted by the *motor* into mechanical power

3.3
active infeed converter
AIC
self-commutated electronic power *converter*s of all technologies, topologies, voltages and sizes which are connected between the a.c. power supply system (lines) and a stiff d.c.-side (current source or voltage source) and which can convert electric power in both directions (generative or regenerative) and which can control the reactive power or the *power factor*

Note 1 to entry: Some of them can additionally control the harmonics to reduce the distortion of an applied voltage or current.

Note 2 to entry: Basic topologies may be realized as a Voltage Source *Converter* (VSC) or a Current Source *Converter* (CSC).

Note 3 to entry: In IEC 60050, these terms (VSC and CSC) are defined as voltage stiff a.c./d.c. *converter* [551-12-03] and current stiff a.c./d.c. *converter* [551-12-04]. Most of the AICs are bi-directional *converter*s and have sources on the d.c. side

Note 4 to entry: In some literature *active infeed converters* are also known as active front end (AFE).

Note 5 to entry: This note applies to the French language only.

[SOURCE: IEC TS 62578:2009, 3.1 modified]

3.4
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

Note 3 to entry: This note applies to the French language only.

3.5
(BDM/CDM/PDS) customer
OEM, system integrator or *end use*r (*professional*/*non-professional*) specifying and purchasing a *BDM/CDM/PDS* from the *BDM/CDM/PDS manufacturer*

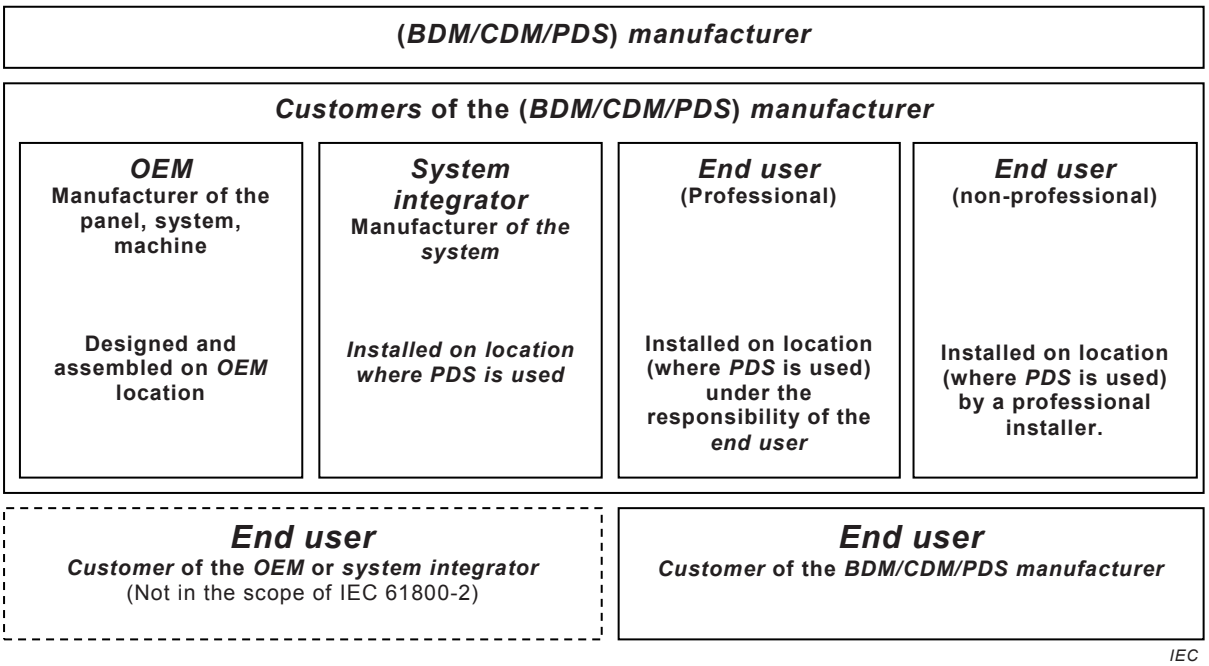


Figure 1 – (*BDM/CDM/PDS*) m*anufacturer/customer* relationship

3.6
(BDM/CDM/PDS) manufacturer
entity which designs and *manufactures* all or part of a *BDM/CDM/PDS*

SEE: Figure 1.

3.7
commissioning test
test on a device or equipment carried out on site, to prove the correctness of *installation* and operation

[SOURCE: IEC 60050-151:2001, 151.16.24 and IEC 60050-411:1984, 411.53.06 modified — Both the definitions have been combined here.]

3.8
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

Note 1 to entry: This note applies to the French language only.

3.9
converter, <of the *BDM*>
unit which changes the form of electrical power supplied by the main to the form fed to the *motor*(s) by changing one or more of the voltage, current and/or frequency

SEE: Figure 1.

Note 1 to entry: The *converter* comprises electronic commutating devices and their associated commutation circuits. It is controlled by transistors or thyristors or any other power switching semiconductor devices.

Note 2 to entry: The *converter* can be line-commutated or self-commutated and can consist for example of one or more *rectifiers*.

3.10
d.c. braking
process of converting the rotational energy of the rotor and connected inertial load to electrical energy dissipated in the rotor by injection of d.c. current into the stator

3.11
d.c. link
power d.c. circuit linking the input *converter* and the output *converter* of an indirect *converter*, consisting of capacitors and/or reactors to reduce d.c. voltage ripple or d.c. current ripple

3.12
dynamic braking
process of converting the rotational energy of the rotor and connected inertial load to electrical energy dissipated in a resistance

3.13
efficiency <of the *CDM*>
ratio of the total electrical power at the *CDM power interface* at the *motor* terminals to the total power at the *a.c. mains power port*

Note 1 to entry: See feeding line in Figure 2

Note 2 to entry: *Efficiency* is usually expressed as a percentage.

3.14
efficiency <of the *PDS*>
the ratio of the mechanical power at the *motor* shaft to the total electrical power at the *a.c. mains power port*

Note 1 to entry: See feeding line in Figure 2.

Note 2 to entry: *Efficiency* is usually expressed as a percentage.

3.15
end user <non-professional>
entity who does not have technical knowledge about operating a *PDS* in the performance of his profession and has little or no relevant formal instruction

3.16
end user <professional>
entity who is skilled or instructed for machines or systems provided by an *OEM*, *system integrator* or the *PDS manufacturer* for the application operation

3.17
four quadrant operation
converter operation of a machine as a *motor* or a generator in either direction of machine rotation

Note 1 to entry: Four quadrant operation involves operation in quadrants I, II, III and IV as shown in Figure 3.

3.18
total harmonic distortion
THD
ratio of the r.m.s. value of the harmonic content of an alternating quantity to the r.m.s. value of the fundamental component of the quantity

Note 1 to entry: This note applies to the French language only.

[SOURCE: IEC 60050-551:1998, 555.17.06]

3.19
high-voltage PDS <for a.c. *motor*>
power drive system with a *BDM converter* section of which the rated *input voltage* is above 1 kV a.c. and not exceeding 35 kV a.c. 50 Hz or 60 Hz or above 1,5 kV d.c.

Note 1 to entry: This *PDS* is covered by the scope of IEC 61800-4.

Note 2 to entry: For *PDS* having series-connected *converter* sections, a sum of the series-connected *input voltage*s is used as the equivalent *input voltage* of the *converter* sections (see Annex B).

3.20
input active power <BDM>
P_{v}
power determined by the fundamental components of voltage and current at the supply terminals of the *BDM* (valve side)

3.21
rated input active power <BDM>
P_{vN}
rated power determined by the fundamental components of voltage and current at the supply terminals of the *BDM* (valve side)

3.22
input active power <CDM/PDS>
P_{L}
power determined by the fundamental components of voltage and current at the supply terminals of the *CDM/PDS* (*installation* side)

3.23
rated input active power <*CDM/PDS*>
P_{LN}
rated power determined by the fundamental components of voltage and current at the supply terminals of the *CDM/PDS* (*installation* side)

3.24
input apparent power <*BDM*>
S_v
power determined by the r.m.s values of voltage and current at the supply terminals of the *BDM* (valve side)

3.25
rated input apparent power <*BDM*>
S_{vN}
rated power determined by the r.m.s values of voltage and current at the supply terminals of the *BDM (*valve side*)*

3.26
input apparent power <*CDM/PDS*>
S_L
power determined by the r.m.s values of voltage and current at the supply terminals of *CDM/PDS* (*installation* side)

3.27
rated input apparent power <*CDM/PDS*>
S_{LN}
rated power determined by the r.m.s values of voltage and current at the supply terminals of the *CDM/PDS* (*installation* side)

3.28
input current <*BDM*>
I_v
r.m.s. value of current at the supply terminals of the *BDM* (valve side)

3.29
rated input current <*BDM*>
I_{vN}
maximum r.m.s. value of current at the supply terminals of the *BDM* (valve side) under rated conditions

Note 1 to entry: It takes into account rated load and the most onerous combination of all other conditions within their specified ranges, e.g. line voltage and frequency deviations.

3.30
input current <*CDM/PDS*>
I_L
r.m.s. value of current at the supply terminals of the *CDM*/*PDS* (*installation* side)

3.31
rated input current <*CDM/PDS*>
I_{LN}
maximum r.m.s. value of current at the supply terminals of the *CDM*/*PDS* (*installation* side) under rated conditions

Note 1 to entry: It takes into account rated load and the most onerous combination of all other conditions within their specified ranges, e.g. line voltage and frequency deviations.

3.32
input frequency <*BDM*>
f_v
frequency of the power input system at the supply terminals of the *BDM* (valve side)

3.33
rated input frequency <*BDM*>
f_{vN}
rated value of the frequency at the supply terminals of the *BDM* (valve side*)*

3.34
input frequency <*CDM/PDS*>
f_L
frequency of the supply terminals of the *CDM/PDS* (*installation* side)

3.35
rated input frequency <*CDM/PDS*>
f_{LN}
rated value of the frequency at the supply terminals of the *CDM*/*PDS* (*installation* side)

3.36
input voltage <*BDM*>
U_v
r.m.s. input line-to-line voltage at the supply terminals of the *BDM* (valve side)

3.37
rated input voltage <*BDM*>
U_{vN}
r.m.s. value of the rated input line-to-line voltage at the supply terminals of the *BDM* (valve side)

3.38
input voltage <*CDM/PDS*>
U_L
r.m.s. input line-to-line voltage at the supply terminals of the *CDM*/*PDS* (*installation* side)

3.39
rated input voltage <*CDM/PDS*>
U_{LN}
r.m.s. value of the rated input line-to-line voltage at the supply terminals of the *CDM*/*PDS* (*installation* side)

3.40
installation
equipment or equipments which include at least both the *PDS* and the driven equipment

Note 1 to entry: The words “act of installing” are used in this international standard to denote the process of installing a *PDS*.

3.41
integrated PDS
PDS where *motor* and *BDM/CDM* are mechanically integrated into a single unit

3.42
inverter
electric energy *converter* that changes direct electric current to single-phase or polyphase alternating current

[SOURCE: IEC 60050-151:2001, 151.13.46]

3.43
low-voltage PDS <for a.c. *motor*>
power drive system with a *BDM converter* section of which the rated *input voltage* is below or equal to 1 kV a.c. 50 Hz or 60 Hz or 1,5 kV d.c.

Note 1 to entry: This *PDS* is covered by the scope of IEC 61800-2.

Note 2 to entry: For *PDS* having series-connected *converter* sections, a sum of the series-connected *input voltage*s is used as the equivalent *input voltage* of the *converter* sections (see Annex B).

3.44
speed <of a *motor*>
N
rotational velocity of the *motor*

[SOURCE: IEC 60050-811:1991, 811.13.03, modified]

3.45
maximum rated safe speed <of a *motor*>
N_{SNMax}
maximum speed, at which the *motor* may be operated continuously

Note 1 to entry: Operation above the maximum rated safe speed could lead to a hazard.

Note 2 to entry: See also Figure 8 and 4.3.3.2

3.46
maximum rated speed <of a *motor*>
N_{NMax}
maximum speed specified by the *PDS manufacturer*

Note 1 to entry: This might include operation in the field weakening mode, at a speed higher than the *rated speed*, but with torque lower than *rated torque* (constant power region).

Note 2 to entry: When operating a *motor* at speeds above *rated speed*, the mechanical stress increases and the expected lifetime of the bearings may be reduced. Fine balance of the *motor* as well as service of the *motor* should be considered. See also IEC 60034-1.

Note 3 to entry: See also Figure 8 and 4.3.3.2

3.47
minimum speed <of a *motor*>
N_{Min}
minimum allowed speed of the *motor*, at which the *motor* is able to continuously deliver torque, without overheating the *motor*

Note 1 to entry: See also Figure 8 and 4.3.3.2.

Note 2 to entry: Operating at minimum speed may also include operation with reduced torque.

3.48
minimum rated speed <of a *motor*>
N_{NMin}
minimum allowed speed, at which the *motor* is able to continuously deliver *rated torque*, without overheating the *motor*

Note 1 to entry: See also Figure 8 and 4.3.3.2.

3.49
rated speed <of a *motor*>
N_N
maximum speed, at which the *motor* is able to continuously deliver *rated torque* (M_N), at *rated* output *voltage* (U_{aN1}/U_{AN1}), *current* (I_{aN}/I_{AN}) and *frequency* (f_{aN}/f_{AN}) conditions

Note 1 to entry: See also Figure 8 and 4.3.3.2.

3.50
electric motor
electric machine intended to transform electric energy into mechanical energy

Note 1 to entry: For the purposes of this standard, the *motor* includes all sensors which are mounted on it and which are relevant for supporting the operating mode and interacting with a *CDM*.

3.51
Original Equipment Manufacturer
OEM
entity which designs and manufactures series of machines, panels or systems incorporating one or more *PDS*s

Note 1 to entry: This note applies to the French language only.

3.52
output current <*BDM*>
I_a
r.m.s. value of the current at the *motor* side of the *BDM*

3.53
rated output current <*BDM*>
I_{aN}
maximum r.m.s. value of the current at the *motor* side of the *BDM* which can be supplied continuously without exceeding established limitations, under rated operating conditions

3.54
output current <*CDM*>
I_A
r.m.s. value of the current at the *motor* side of the *CDM*

3.55
rated output current <*CDM*>
I_{AN}
maximum r.m.s. value of the current at the *motor* side of the *CDM* which can be supplied continuously without exceeding established limitations, under rated operating conditions

3.56
output frequency <*BDM*>
f_a
fundamental frequency at the *motor* side of the *BDM*

Note 1 to entry: The frequency is usually specified as the operating range by the *manufacturer*.

3.57
rated output frequency <*BDM*>
f_{aN}
range of fundamental frequency at the *motor* side of the *BDM*

3.58
output frequency <*CDM*>
f_A
fundamental frequency at the *motor* side of the *CDM*

Note 1 to entry: The frequency is usually specified as the operating range by the *manufacturer*.

3.59
rated output frequency <*CDM*>
f_{AN}
range of fundamental frequency at the *motor* side of the *CDM*

3.60
output voltage <*BDM*>
U_{a1}
r.m.s. value of the rated fundamental voltage at the *motor* side of the *BDM*

3.61
rated output voltage <*BDM*>
U_{aN1}
r.m.s. value of the rated fundamental voltage at the *motor* side of the *BDM*

3.62
output voltage <*CDM*>
U_{A1}
r.m.s. value of the rated fundamental voltage at the *motor* side of the *CDM*

3.63
rated output voltage <*CDM*>
U_{AN1}
r.m.s. value of the rated fundamental voltage at the *motor* side of the *CDM*

3.64
output active power <*BDM*>
P_a
power determined by the fundamental components of voltage and current at the *motor* side of the *BDM*

3.65
rated output active power <*BDM*>
P_{aN}
rated power determined by the fundamental components of voltage and current at the *motor* side of the *BDM*

3.66
output active power <*CDM*>
P_A
power determined by the fundamental components of voltage and current at the *motor* side of the *CDM*

3.67
rated output active power <*CDM*>
P_{AN}
rated power determined by the fundamental components of voltage and current at the *motor* side of the *CDM*

3.68
output apparent power <*BDM*>
S_a
power determined by the r.m.s values of voltage and current at the *motor* side of the *BDM*

3.69
rated output apparent power <*BDM*>
S_{aN}
rated power determined by the r.m.s values of voltage and current at the *motor* side of the *BDM*

3.70
output apparent power <*CDM*>
S_A
power determined by the r.m.s values of voltage and current at the *motor* side of the *CDM*

3.71
rated output apparent power <*CDM*>
S_{AN}
rated power determined by the r.m.s values of voltage and current at the *motor* side of the *CDM*

3.72
output power <*PDS*>
P_s
(mechnical) power of the *PDS* determined by the torque and speed at the *motor* shaft

3.73
rated output power <*PDS*>
P_{sN}
rated (mechnical) power of the *PDS* determined by the torque and speed at the *motor* shaft

3.74
output overload capability
maximum *output current* which can be supplied, for a specified period of time, without exceeding established limitations under prescribed operating conditions

3.75
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

3.76
port for process measurement and control
input/output (I/O) *port* for conductor or cable which connects the process to the *PDS*

3.77
power port
port which connects the *PDS* to the power supply which also feeds other equipment

3.78
power interface
connections needed for the distribution of electrical power within the *PDS*

3.79
power drive system
PDS
system consisting of one or more *complete drive module*(s) (*CDM*) and a *motor* or *motor*s; any sensors which are mechanically coupled to the *motor* shaft are also part of the *PDS*, however the driven equipment is not included

SEE: Figure 2.

Note 1 to entry: This note applies to the French language only.

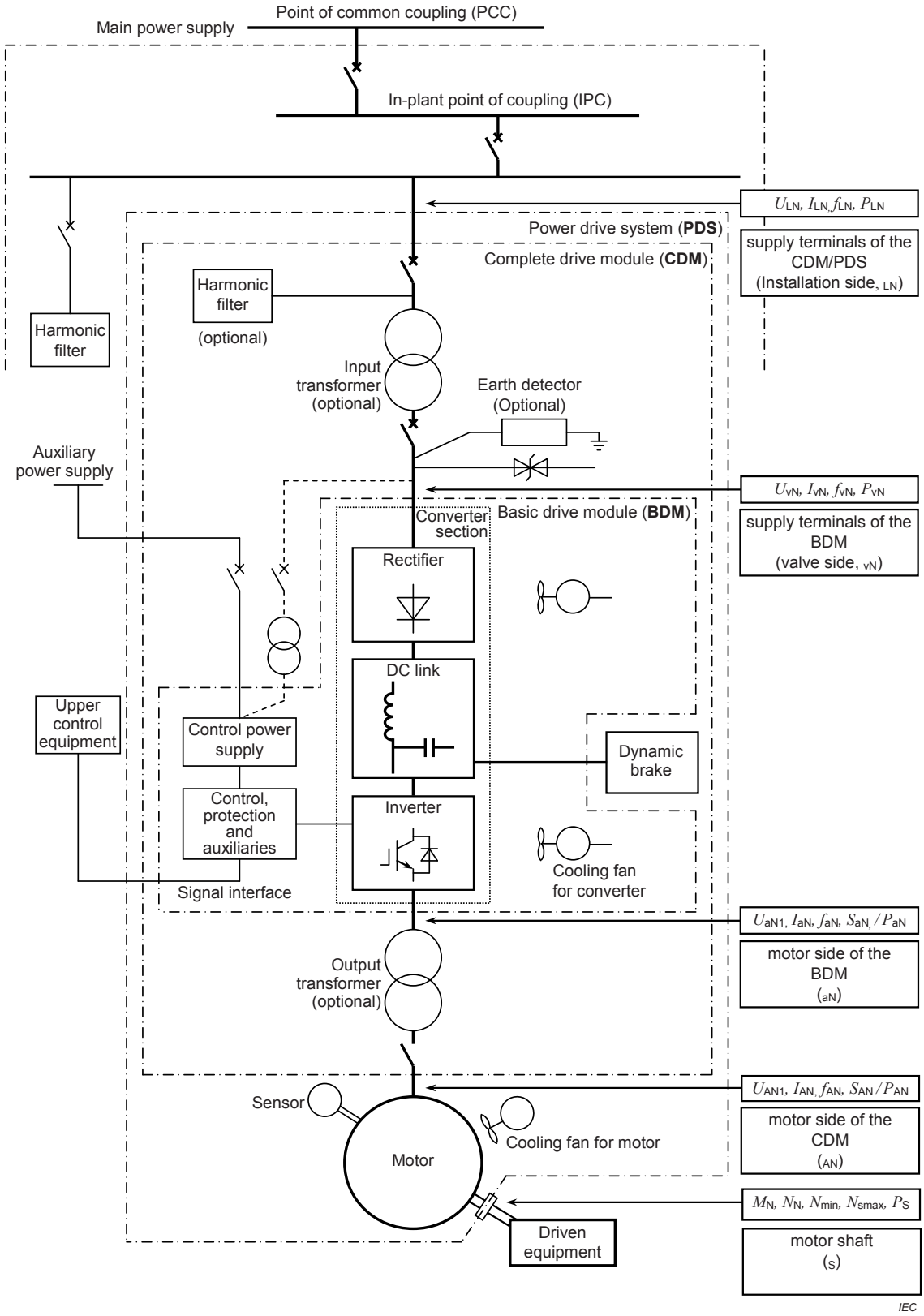


Figure 2 – Example of a *power drive system*

3.80
power factor
λ
under periodic conditions, ratio of the absolute value of the active power P to the apparent power S

$$\lambda = \frac{|P|}{S}$$

[SOURCE: IEC 60050-131:2002, 131.11.46, modified — Note is deleted.]

3.81
product packaging
temporary protection of the *BDM/CDM/PDS* or part of it during storage and known in-house transport routes

3.82
torque <of a *motor*>
M
twisting moment of force with respect to the longitudinal axis of the *motor* shaft

[SOURCE: IEC 60050-113:2011, 113.03.26, modified — Note is adopted as this definition.]

3.83
rated torque <of a *motor*>
M_N
torque the *motor* develops at its shaft end at *rated output power* and *speed*

[SOURCE: IEC 60050-411:1984, 411.48.05]

3.84
rectifier
electric energy *converter* that changes single-phase or polyphase alternating electric currents to unidirectional current

[SOURCE: IEC 60050-151:2001, 151.13.45]

3.85
regeneration
temporary process of converting the mechanical energy at the *motor* shaft of the *PDS* to electrical energy

3.86
routine test
test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

[SOURCE: IEC 60050-811:1991, 811.10.05]

3.87
sample test
test on a number of devices taken at random from a batch

[SOURCE: IEC 60050-811:1991, 811.10.06 modified — Sampling test changed to *sample test*

3.88
shipping packaging
temporary protection to prevent damage during worldwide air, sea and land transportation

Note 1 to entry: *Shipping packaging* can be realized as product specific transport packaging or as a *product packaging* with additional transport packaging.

3.89
short circuit ratio
R_{SC}
ratio of the short-circuit power of the source at the point of common coupling (PCC) to the *rated apparent power* of the *BDM/CDM/PDS*

3.90
signal interface
input/output (I/O) connection for a line connecting the *basic drive module* or *complete drive module* (*BDM/CDM*) to another part of the *PDS*

3.91
special test
test in addition to *type* test and *routine tests*, made either at the discretion of the *manufacturer* or according to an agreement between the *manufacturer* and the *customer* or his representative

3.92
stimulus
change, variation or fluctuation of parameter which may cause deviation of performance or behavior of the *PDS*

Note 1 to entry: Examples of *stimulus*: change of speed reference, load of *PDS*, *input voltage* or temperature.

3.93
system integrator
entity with responsibility to design the complete system of the application incorporating one or more *PDS*s

3.94
two quadrant operation
c*onverter* operation of a machine as a *motor* in two directions of machine rotation; it involves operation in quadrants I and III

SEE: Figure 3

3.95
type test
test of one or more devices made to a certain design to show that the design meets certain specifications

[SOURCE: IEC 60050-811:1991, 811.10.04]

3.96
witness test
tests performed in the presence of the *customer* or the representative of the *customer*

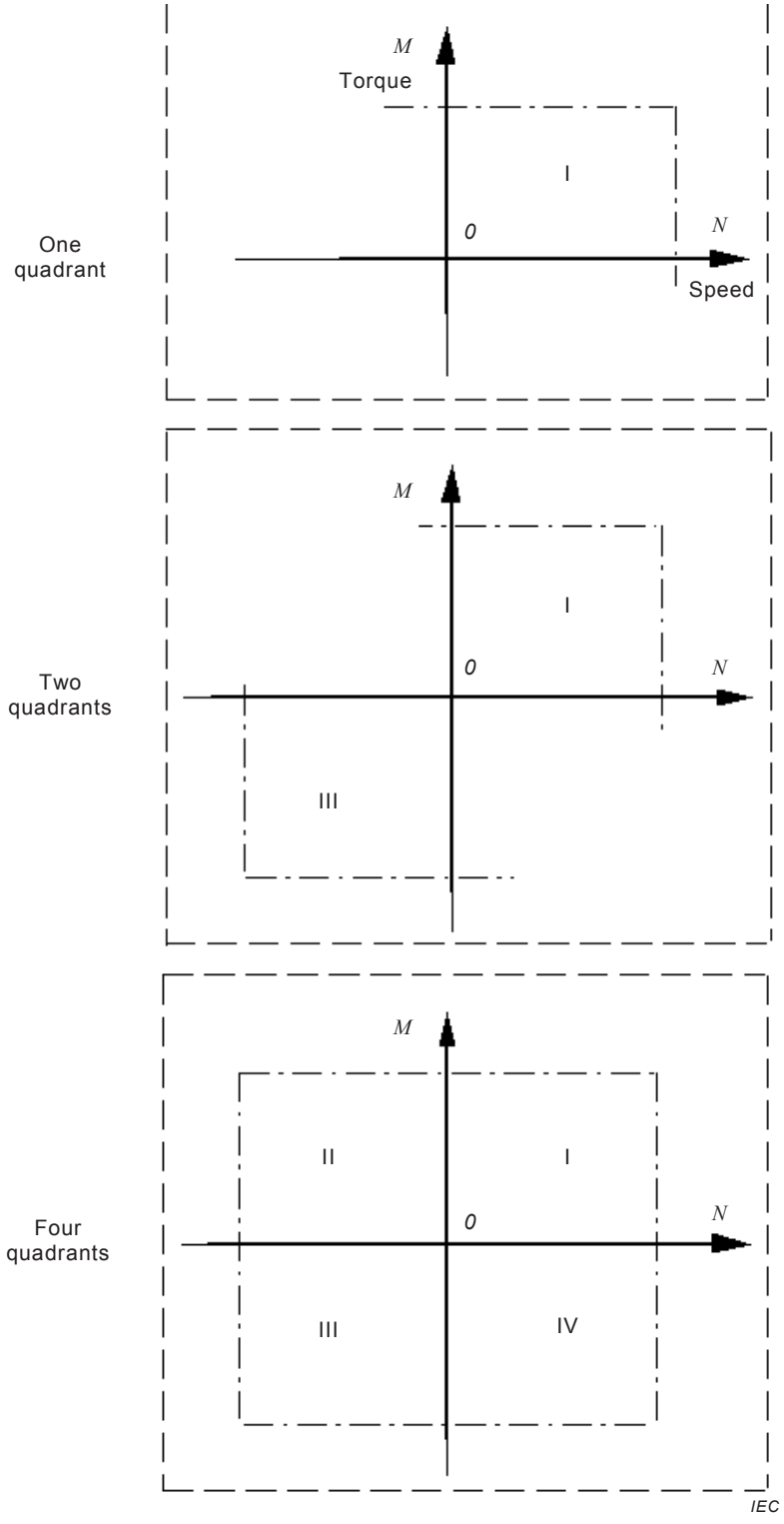


Figure 3 – Operating *quadrants*

4 Ratings and specifications for the act of installing, commissioning and operation

4.1 General

The requirements in 4.3 to 4.13 provide a list of requirements relevant for the specification of a *BDM/CDM/PDS*. More severe requirements might be specified if considered relevant for the considered application.

A *BDM/CDM/PDS* is typically used for a specific application in a specific environment under specific conditions, in which the product has to operate, be transported or stored. These conditions include, but are not limited to the electrical, electro-magnetic, mechanical, thermal, and chemical environment as well as requirements on the functionality, safety and functional safety. These conditions are known by the *customer* or product standard committees using this document as a reference document and will need to be specified.

The *manufacturer* of the *BDM/CDM/PDS* shall specify which requirements of IEC 61800-2 apply to his equipment.

In order to ensure consistency and avoid conflicting requirements across the IEC 61800 series, some of the subclauses in 4.3 to 4.13 refer directly to other parts of the IEC 61800 series.

4.2 *BDM*/*CDM*/*PDS* characteristics and topology

4.2.1 General

Subclauses 4.2.2 and 4.2.3 are intended to be informative regarding common characteristics and topology for *PDS*'s. The information in these clauses shall not be construed as requirements.

4.2.2 *BDM/CDM/PDS* characteristics

A.C. *PDS*'s are a type of electronic power conversion equipment, which provide speed, current or torque control for a.c. electric *motor*s. Because a.c. induction *motor*s dominate industrial applications, a.c. *PDS*'s designed to operate a.c. induction *motor*s are the most numerous. However, many high *efficiency motor* technologies require a *CDM* for operation. Therefore the use of a.c. *PDS*'s with other types of a.c. *motor*s will increase. The use of *CDM* with permanent magnet (PM) *motor*s has already reached a significant level.

Some significant characteristics of low voltage *BDM*/*CDM*/*PDS*'s include the following.

- *BDM*/*CDM*/*PDS*'s are commonly available with *output power* ranging from 0,2 kW to several thousand kW.
- Most industrial *BDM*/*CDM*/*PDS*'s are designed to be powered from a 3 phase a.c. supply.
- Some low power *BDM*/*CDM*/*PDS*'s are designed to be powered from single phase a.c.
- Many *BDM*/*CDM*/*PDS*'s are designed to receive d.c. power from a *port* connecting d.c. links of more than one *PDS*. Many *PDS*'s may receive power from both an a.c. supply and from a *port* connecting d.c. links
- *BDM*/*CDM*/*PDS*'s vary the speed of an a.c. *motor* by controlling the frequency and voltage of the power provided to the *motor*.
- The most common *BDM*/*CDM*/*PDS*'s are designed to control 3 phase induction *motor*s with voltage ratings such as 240 V, 400 V, 480 V, 600 V, and 690 V.
- Some *BDM*/*CDM*/*PDS*'s are designed for use with stepper, or switched reluctance *motor*s.
- Many *BDM/CDM/PDS*'s are designed for use with permanent magnet *motor*s.
- Energy *efficiency* of the typical a.c. *BDM*/*CDM* is typically very high In general it is beneficial to reduce energy lost to heating effects in order to minimize size and operating cost.
- Most a.c.. *PDS*'s return power from the *motor* to the *d.c. link* during periods when the *motor* operates as a generator (operation in II and IV *quadrants*). (see Figure 3)
- Many a.c. *PDS*'s are provided with a dynamic brake (also called "chopper brake" or "brake chopper") in order to manage power returned from the *motor* to the *d.c. link* during periods when the *motor* operates as a generator.

- Regenerative *PDS*'s are designed to return power from the *d.c. link* of the *BDM*/*CDM*/*PDS*'s to the a.c. supply. In some implementations, power conversion from the *d.c. link* to the a.c. supply may be accomplished in a subsystem separate from the *BDM*/*CDM*/*PDS*.
- *BDM*/*CDM*/*PDS*'s for use with a.c. induction *motor*s are available with different control algorithms which optimize cost, and speed/torque regulation for different applications. Examples include
  - volts/hertz control,
  - sensorless vector control,
  - flux vector control,
  - sensorless flux vector control,
  - field oriented control,
  - sensorless field oriented control.

4.2.3 Basic topology for *BDM*/*CDM*/*PDS*'s

The most commonly-used topology for low voltage *BDM*/*CDM*/*PDS*'s is that of the voltage source *converter* (VSC). In a VSC, a supply-side c*onverter* changes electricity from the a.c. supply to d.c. Capacitance is used to smooth the d.c. output of the *converter*, and provide short-term energy storage. The d.c. output of the supply-side *converter*, sometimes referred to as the *d.c. link*, supplies energy to the *motor*-side *converter*, also known as an *inverter*. The *inverter* typically uses PWM (Pulse Width Modulation) to power an a.c. *motor* and permit control of *motor* speed and torque.

Figure 4 below illustrates a common *BDM*/*CDM*/*PDS*'s topology. In the *BDM*/*CDM*/*PDS*'s of Figure 4, energy flow is unidirectional from the a.c. power source into the *converter*. Energy flow between the *inverter* and *motor* is bidirectional depending upon the dynamics of the mechanical load on the *motor*.

The d.c. link port allows exchange of energy with the *d.c. link port* of other *BDM*/*CDM*/*PDS*'s or with a dynamic brake. If the *d.c. link port* is connected to the *d.c. link* ports of other *PDS*'s, it is possible to share energy either from the c*onverter*, or energy developed by the *motor* during operation in *quadrants* II and IV, with other *PDS* operating in *quadrants* I and III. Otherwise, the *d.c. link port* may be connected to an external dynamic brake in order to dissipate excess energy when the voltage of the *d.c. link* exceeds desired limits. It is also possible to connect an external regenerative unit to the *d.c. link* and feed power back to a.c. mains.

The *d.c. link* connection should be designed and protected well. In poorly designed *d.c. link* systems it is possible for a low power *CDM* to feed a high power *CDM*. This may lead to destruction of the low power *CDM*. Also, if no suitable protection of the *d.c. link* connection has been provided, e.g. by fuses, fault conditions can lead to the destruction of one or more units connected to the common *d.c. link.*

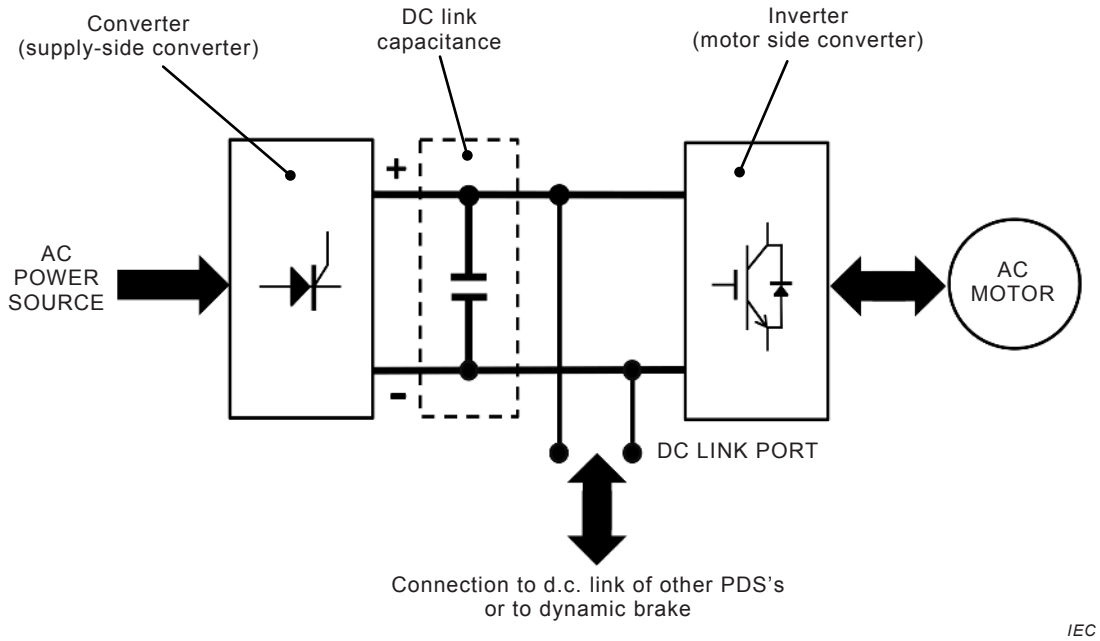


Figure 4 – Typical *BDM*/*CDM*/*PDS*

BDM/*CDM*/*PDS*'s with common d.c. link ports can be constructed without a supply-side *converter*. These *PDS*'s are intended for use together with other power conversion units. In these configurations, the *d.c. link port* becomes a means of energy exchange between the different units. Examples of these units include:

- *BDM*/*CDM*/*PDS*(s) with a d.c. link *port* (Figure 5),
- dedicated supply-side *converter*(s) (no figure),
- dedicated dynamic brake*(s)* (no figure).

A *PDS* with a d.c. link *port* is illustrated in Figure 5 below.

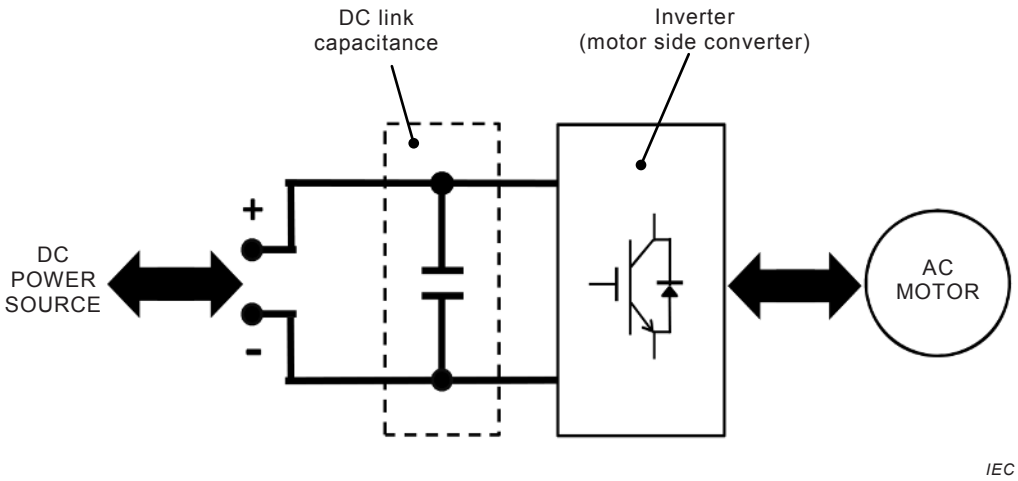


Figure 5 – Common d.c.link *BDM*/*CDM*/*PDS*

When a *BDM*/*CDM*/*PDS* operates in *quadrants* II and IV, the inertia of the *motor* and connected load, or sometimes potential energy in the connected load, results in energy being generated by the *motor* and returned through the *inverter* to the d.c. link *port*. During these periods, the energy returned to the d.c link *port* is often managed using one or more of the following options:

- *BDM*/*CDM*/*PDS*(s) with d.c. link ports which use(s) energy available from the d.c. link to power other *motor*s;
- *dynamic braking* which dissipates excess energy from the d.c. link using resistors (Figure 6);
- return of energy in the d.c. link to an a.c. power system for use by other loads.

Figure 6 illustrates a *BDM*/*CDM*/*PDS* which incorporates a dynamic brake. Dynamic brakes are also commonly available as stand-alone units for connection to a d.c. link *port*.

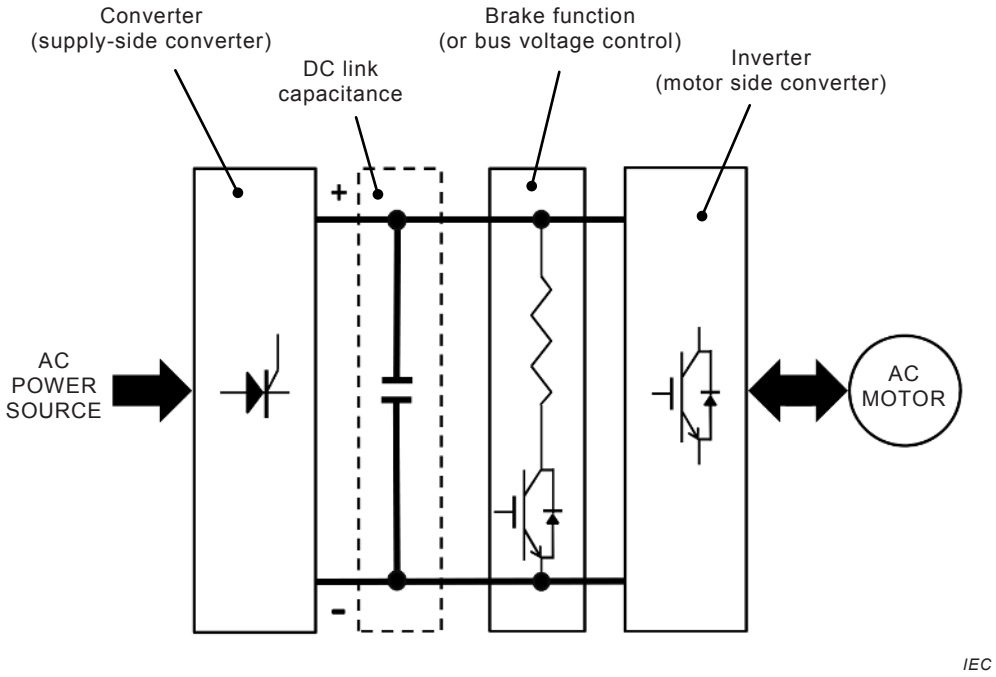


Figure 6 – *BDM*/*CDM*/*PDS* with brake

Figure 7 illustrates a regenerative *PDS* which can return energy to the a.c. supply using a supply side *converter* which also can operate as an *inverter*, also known as *active infeed converters* (AIC's).

Additional information regarding AIC is available in IEC TS 62578.

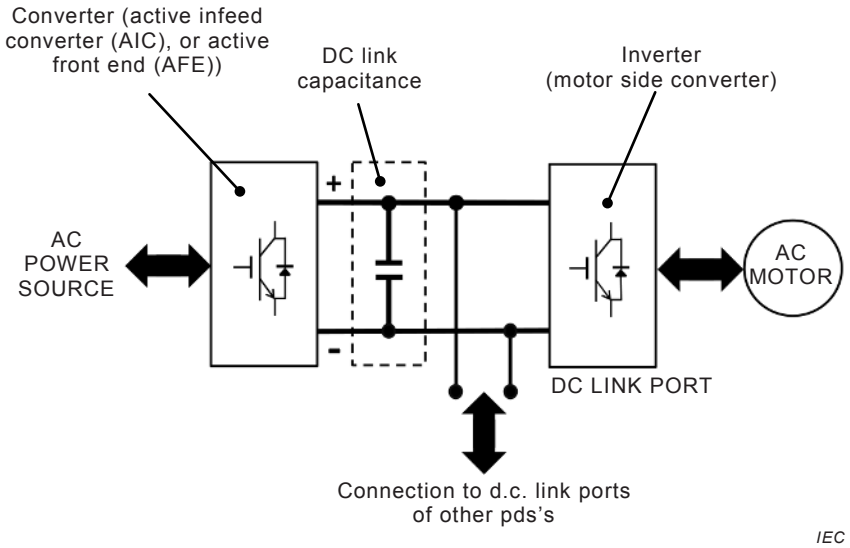


Figure 7 – *BDM*/*CDM*/*PDS* with AIC

4.3 Ratings

4.3.1 General

The input and output ratings shall be specified by the *manufacturer* according to the requirements in 4.3.2 to 4.3.6 as shown Table 5.

Table 5 – Overview of input and output ratings of the *BDM*/*CDM*/*PDS*

Input ratings			Output ratings		
BDM	***CDM***	***PDS***	***BDM***	***CDM***	***PDS***
Voltage (U_{vN}) [V]	Voltage (U_{LN}) [V]	Voltage (U_{LN}) [V]	Voltage (U_{aN1}) [V]	Voltage (U_{AN1}) [V]	-----
Current (I_{vN}) [A]	Current (I_{LN}) [A]	Current (I_{LN}) [A]	Current (I_{aN}) [A]	Current (I_{AN}) [A]	Torque (M_N) [N·m]
Power (S_{vN} or P_{vN}) [kVA] or [kW]	Power (S_{LN} or P_{LN}) [kVA] or [kW]	Power (S_{LN} or P_{LN}) [kVA] or [kW]	Power (S_{aN} or P_{aN}) [kVA] or [kW]	Power (S_{AN} or P_{AN}) [kVA] or [kW]	Power (P_{SN}) [kW]
Frequency (f_{vN}) [Hz]	Frequency (f_{LN}) [Hz]	Frequency (f_{LN}) [Hz]	Frequency (f_{aN}) [Hz]	Frequency (f_{AN}) [Hz]	Speed (N_N and N_{NMax}) [r/min]

NOTE 1 In case no transformer nor other optional device such a filter are installed between mains input (i.e. *CDM*/*PDS* input) and *BDM* input, the ratings of *CDM*/*PDS* input and those of *BDM* input are same values, i.e. $U_{vN} = U_{LN}$ and so on.

NOTE 2 In case no transformer nor other optional device such a filter are installed between *BDM* output and *motor* input (i.e. *CDM* output), the ratings of *CDM* output and those of *BDM* output are same values, i.e. $U_{aN1} = U_{AN1}$ and so on.

NOTE 3 The *BDM/CDM output power* rating can be provided in either apparent power [kVA] or active power [kW]. Apparent power can be calculated using voltage and current.

NOTE 4 The *BDM/CDM/PDS* current, voltage and frequency ratings can be provided within a range of values.

4.3.2 Input ratings

4.3.2.1 *Input voltages* and *frequencies*

The *BDM*/*CDM*/*PDS input voltage* and *frequency* ratings/range shall be specified by the *manufacturer*.

Preferred values are listed in Table 6:

Table 6 – Standard voltages as specified in IEC 60038

At 50 Hz	At 60 Hz
100	100
110	---
---	115
---	120
200	200
---	208
220	220
230	230
240	240
380	---
400	400
415	---
440	440
	460
---	480
500	---
---	575
660	---
---	600
690	---
NOTE 1 Voltage tolerances are provided in IEC 61800-3.	
NOTE 2 Standard voltages as specified in IEC 60038	

For compliance see 5.4.2.4.1

4.3.2.2 *Input current*

The *BDM*/*CDM*/*PDS input current* rating shall be specified by the *manufacturer*.

The specified *input current* includes the current required by the auxiliaries if they are supplied from the same supply of the *BDM*/*CDM*/*PDS*.

These values shall be stated by *the manufacturer*.

For compliance see 5.4.2.4.3.

4.3.3 Output ratings

4.3.3.1 *BDM*/*CDM* continuous output ratings

Continuous output ratings shall be stated by the *manufacturer* and shall be in terms of the *motor* output of the *BDM*/*CDM*:

- fundamental a.c. voltage (U_{aN1}/U_{AN1});
- *rated output current* (I_{aN}/I_{AN}); and
- *output frequency* range;
- *rated maximum apparent output power* (S_{aN}/S_{AN}) [kVA] or maximum *output active power* (P_{aN}/P_{AN}) [kW]

Rating in term of U_{aN1} U_{AN1} and I_{aN}/ I_{AN} allows use of direct measurement techniques and adequately addresses conductor current capacity.

For compliance see 5.4.2.5.2, 5.4.2.5.3, 5.4.2.5.4.

NOTE When *CDM* and *motor* are not provided by the same *manufacturer*/supplier, information can be exchanged to define proper performance and compatibility of *CDM* and *motor*.

4.3.3.2 *PDS* continuous output ratings

Continuous output ratings shall be stated by the *manufacturer* and shall be in terms of the *motor* shaft of the *PDS:*

- *rated torque* (M_N) [N·m];
- *rated speed* (N_N) [r/min];
- *maximum rated speed* (N_{NMax}) [r/min];
- *minimum rated speed* (N_{NMin}) [r/min];
- *minimum speed* (N_{Min}) [r/min];
- *maximum rated safe speed* (N_{SNMax}) [r/min];
- *rated output power* (P_{SN}) [kW].

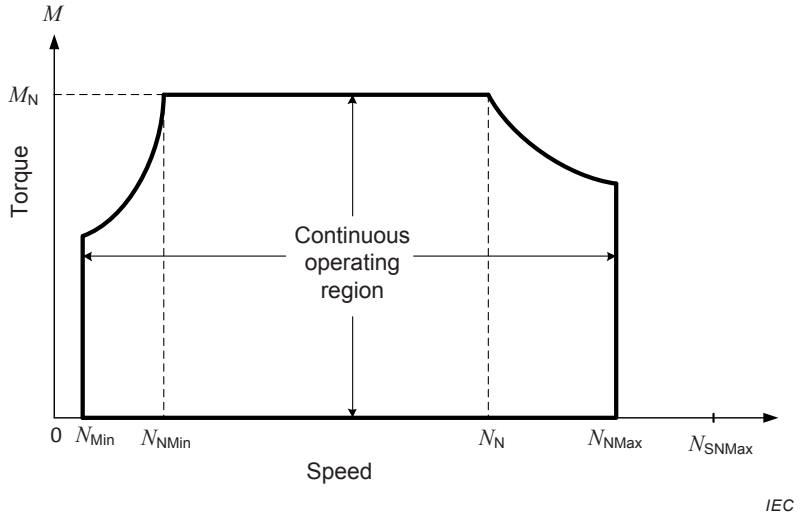


Figure 8 – Example of operating region of a *PDS*

For compliance see 5.4.2.5.2, 5.4.2.5.3, 5.4.2.5.4

4.3.3.3 Overcurrent and torque capability

Besides the rated value under continuous load conditions of *BDM*/*CDM*/*PDS*, the *manufacturer* may assign additional values of the rated current, each under specified overload conditions, i.e. a *BDM*/*CDM*/*PDS* equipment may be specified by *the manufacture*r with different overload ratings for different types of load. The *output overload capability* applies to the *rated speed* range.

The *output overload capability* of a *BDM*/*CDM*/*PDS* can be specified as an intermittent load duty, or as a repetitive load duty. A wider classification, as well as calculation methods, can be found in IEC TR 61800-6.

NOTE The relationship between the overload currents specified and the torque developed by the *motor* is not covered by the above, i.e. *PDS* overload is defined as the overload currents of the *BDM/CDM* and not as the torque of the *motor*.

Special overload conditions can be specified. E.g. overload magnitude and duration may be the subject of such a specification. Examples of typical overload magnitudes and duration are given in 4.10, IEC 60146-1-1 and IEC TR 61800-6.

For any type of duty cycle, the r.m.s value of the current over the complete cycle shall not exceed the rated current. Table 7 and Figure 9 show 6 typical examples of a 1 min overload with a 10 min and 60 min. load cycle.

Table 7 – Example of reduced maximum continuous load as a function of an overload

Overload		Reduced continuous load	
Amplitude I_{aM} [p.u. of rated]	**Duration** T_{aM} [min]	**Maximum amplitude of** I_{aR} [p.u. of rated]	**Duration** T_{aR} [min]
1,5	1	0,928	9
1,5	1	0,989	59
1,25	1	0,968	9
1,25	1	0,995	59
1,1	1	0,988	9
1,1	1	0,998	59

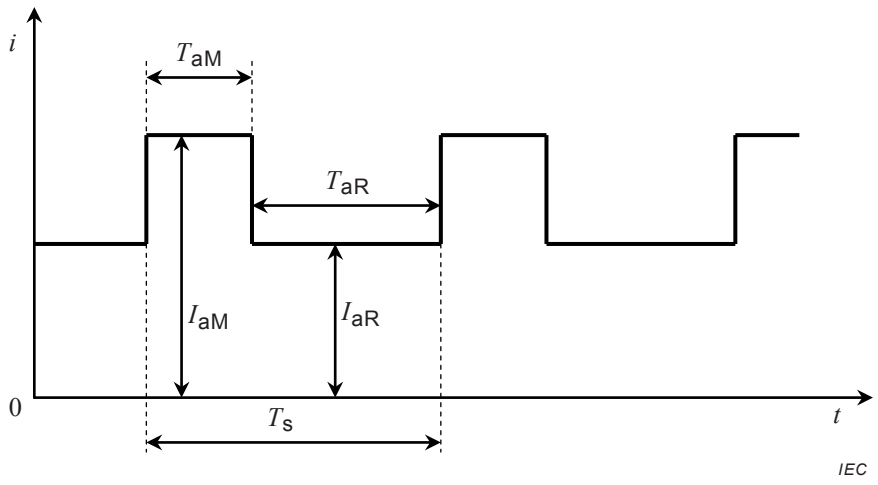


Figure 9 – Overload cycle example

For repetitive load duty, the *rated converter output current* (I_{aN1}) shall correspond, as a minimum, to the r.m.s. value of the *motor* current for a full period of the *motor* duty cycle and the *output overload capability* of the *converter* shall be adequate for the load duty cycle.

For continuous duty, the *rated converter output current* (I_{aN1}) shall correspond, as a minimum, to the continuous *motor* current necessary to supply the specified continuous *motor* torque. In the case of intermittent load duty, the overloads shall not cause the *converter* current to exceed its overload rating.

For compliance see 5.4.2.5.5

4.3.4 Operating *quadrants*

4.3.4.1 General

The above ratings of 4.3.2 and 4.3.3 shall be given for all *operating quadrants* (I, II, III, IV).

4.3.4.2 Operation in II and IV *quadrants*

The operation in II and IV quadrant applies to applications when the *motor* is running in generative mode generating power back into the *BDM*/*CDM*/*PDS* as explained in 4.2.

The input and output ratings under the operation in II and IV quadrants shall be specified including the relevant parameters for the applicable solution.

For compliance see 5.4.2.5.6

4.3.5 Ratings and properties of the control equipment

The ratings and properties of the control equipment shall be specified by the *manufacturer*.

NOTE Examples of properties: limits for voltage, current, speed and torque, *BDM/CDM* protection against motor overload and, output short circuit.

For compliance see 5.4.2.6

4.3.6 Special ratings related to *BDM*/*CDM*/*PDS* or *motor*

4.3.6.1 General

Special ratings can be specified to provide further information for specific applications or considerations. This includes the effect on the mains supply side, inside the *BDM*/*CDM*/*PDS* as well as the effect on the *motor*.

For compliance see 5.4.2.8.2, 5.4.2.8.3, 5.4.2.8.4, 5.4.2.8.5

4.3.6.2 Transformers

Power transformers may be used on the mains as well on the *motor* side of the *BDM*/*CDM*/*PDS* as step-up or step-down transformers.

The IEC 61378 series provide specifications for the design of these transformers.

IEC 61800-4 provides further information about the use of transformers in *BDM/CDM/PDS installations*.

4.4 Performance

4.4.1 Operational

4.4.1.1 General

The ratings of included features shall be specified by the *manufacturer*. One or more of the following features can be included:

- timed acceleration/ deceleration;
- *dynamic braking*;
- reversing;
- *regeneration*;
- line filtering;
- input/output data processing (analog/digital);
- automatic restart;
- *d.c. braking.*

4.4.1.2 Steady state performance

4.4.1.2.1 General

The control system is in a steady state when the reference and operating variables have been constant for more than three times the settling time of the control system and the service variables have been constant for more than the three times the longest time constant of the equipment (E.g. the thermal time constant of the speed sensor). Steady state performance for drive variables such as torque, speed, position etc. shall be specified in accordance with 4.4.1.2.2 to 4.4.1.2.6.

For compliance see 5.4.2.9

4.4.1.2.2 Deviation band

The deviation band (see Figure 10) is the total excursion of the directly controlled variable (unless another variable is specified) under steady state conditions as a result of changes in the service or operating conditions within their specified ranges.

The deviation band is expressed:

- as a percentage of the ideal maximum value of the directly controlled (or other specified) variable, see example in 4.4.1.3.3;
- as an absolute number for variables which have no readily definable base, such as position.

The signal representing the directly controlled variable should be filtered, e.g. by a first order low-pass filter with a 100 ms time constant, in order to remove noise and ripple from the signal.

NOTE The deviation band cannot be used to specify items which are not related with the steady state control performance (e.g. torque pulsation, or the speed ripple caused by load torque or *motor* torque pulsation).

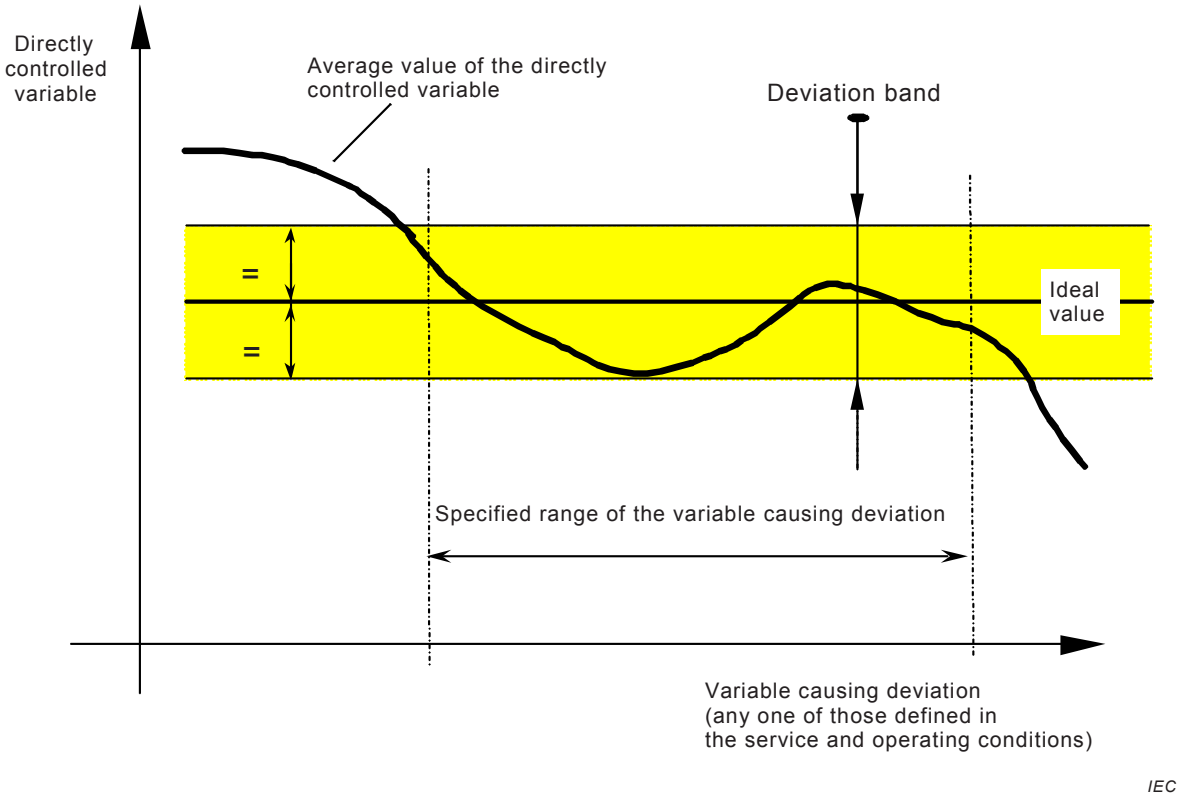


Figure 10 – Deviation band

4.4.1.2.3 Selection of deviation band

The steady state performance of a feedback control system shall be described by a number, selected from Table 8 (other levels may be defined by agreement).

The range of variables to which the deviation band applies shall be specified (see Figure 10).

Table 8 – Maximum deviation bands (percent)

±20	±10	±5	±2	±1	±0,5	±0,2	±0,1	±0,05	±0,02	±0,01

EXAMPLE: A *PDS* has a 60 Hz – 1 780 r/min *motor* that is fed by a frequency *converter*. The maximum speed of the *PDS* is 2 000 r/min and the specified deviation band for the speed control is ±0,5 %. Operating conditions are, speed range: 0 to 2 000 r/min; load torque range: zero to *rated torque*. Service conditions, ambient temperature range: 5 °C to 40 °C.

Thus the deviation of the actual speed from the ideal value (speed reference) is:

±0,5 % of 2 000 r/min = ±10 r/min

when the value of the speed reference, load torque and ambient temperature are within their specified ranges.

E.g. if the speed reference is 1 200 r/min, the actual speed of the *motor* will be 1 200 r/min ± 10 r/min, that is between 1 190 r/min and 1 210 r/min.

4.4.1.2.4 Service deviation band – limits

The specified service deviation band (selected from Table 8) shall not be exceeded under any combination of applicable service conditions at any time during any 1 h interval following a warm-up period as specified by *the manufacturer*, with the operating variables held constant during the observation.

4.4.1.2.5 Operating deviation band – limits

The operating deviation band of the directly controlled variable (selected from Table 8) shall not be exceeded for the range of the operating variable indicated. The service conditions shall be held constant during the observation.

When required by the application, the performance information should also include data on the steady state relationship of the directly controlled variable to the reference. This aspect of performance is not included in the above discussion of operating or service deviation bands.

4.4.1.2.6 Resolution

The resolution represents the minimum obtainable variation of the controlled variable. It may be represented by an absolute value or a percentage of the maximum value.

4.4.1.3 Dynamic performance

4.4.1.3.1 General

The *BDM/CDM*/*PDS* shall be provided with either a current limit or a timed acceleration.

Dynamic performance shall be specified according to 4.4.1.3.2 to 4.4.1.3.3.

For compliance see 5.4.2.10.2, 5.4.2.10.3; 5.4.2.10.4, 5.4.2.10.5, 5.4.2.11 and 5.4.2.12

4.4.1.3.2 Time responses

4.4.1.3.2.1 General

Time response represents the output versus time curve resulting from the application of a specified input, under specified operating and service conditions.

The *PDS* shall operate before the application of a specified input under the following operating and service conditions:

- *maximum rated* speed;
- no load;
- rated *input voltage* and *input frequency*;
- temperature stabilized after a 1 h warm-up of the measuring equipment and interfaces, ambient temperature being within service conditions.

The output curve may contain a significant amount of ripple, e.g. due to the operation of the power semiconductor devices in the *BDM*. The average curve shall be used in the determination of the time response, see Figure 11. Typical time responses for a *PDS* are the time responses following a step change of speed reference, current reference or torque reference, see Figure 11, and the time response following a change in the load torque, see Figure 12. For specification purposes, the load torque of the driven equipment shall be assumed to increase linearly from zero to a specified torque (or decrease from a specified torque to zero) within 100 ms, without overshoot.

4.4.1.3.2.2 Response time

The response time is the time required, following the initiation of a specified *stimulus* to a system, for an output going in the direction of the necessary corrective action to first reach a specified value.

The specified value for a time response following a step change of reference input, see Figure 11, shall be the initial average value plus 90 % of the steady state increment. The

transient overshoot shall be equal or less than 10 % of the steady state increment. For a time response following a change in an operating variable, Figure 12, the specified value shall be the final average value plus 10 % of the maximum transient deviation.

4.4.1.3.2.3 Rise time

The rise time is the time required for the output of a control system to make the change from a small specified percentage of the steady-state increment to a large specified percentage of the steady-state increment, either before overshoot or in the absence of overshoot (see Figure 12).

The small specified percentage shall be 10 %, the large specified percentage shall be 90 % and the transient overshoot shall be equal or less than 10 % of the steady state increment. If the term "rise time" is unqualified, response to a step change is understood. Otherwise the pattern and magnitude of the *stimulus* should be specified.

4.4.1.3.2.4 Settling time

The settling time is the time required, following the initiation of a specified *stimulus* to a system, for a specified variable to enter and remain within a specified narrow band centered on its final average value.

For a time response following a step change of reference input, see Figure 11, the specified band shall be ±2 % of the steady state increment. For a time response following a change in an operating variable, see Figure 12, the specified band shall be ±5 % of the maximum transient deviation.

4.4.1.3.2.5 Load impact speed deviation area

Load impact speed deviation area (corresponding to a drift of the position) provides an assessment of the response of a speed control for a sudden change in load torque (see Figure 12). The formula is

$$\text{Load impact speed deviation area} = \frac{\text{response time} \times \text{maximum transient deviation}}{2} \quad (1)$$

where the maximum transient deviation is given as a percentage of the maximum operating speed. Thus, the unit of the load impact speed deviation area is percent seconds (% s).

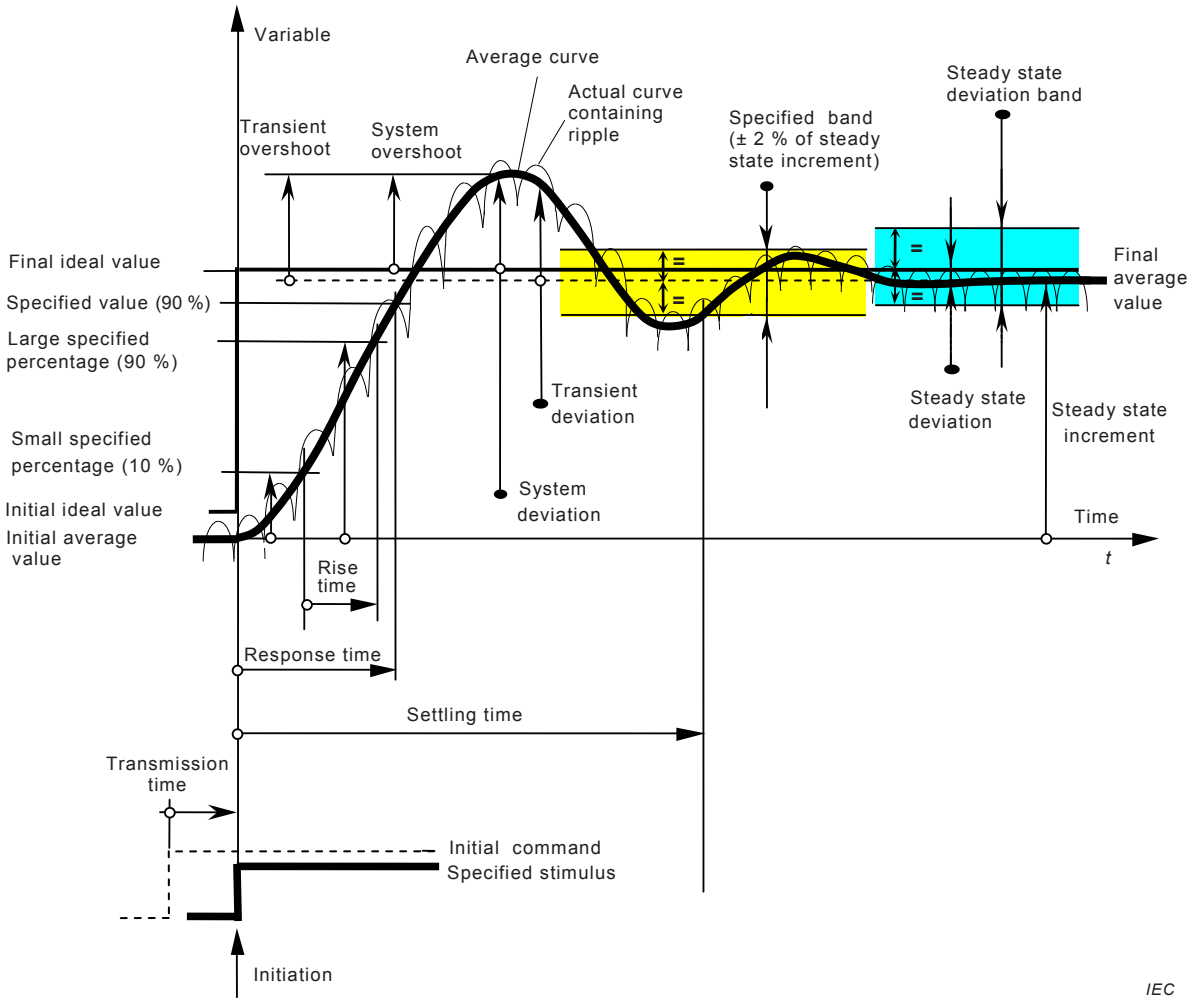


Figure 11 – Time response following a step change of reference input no change in operating variables

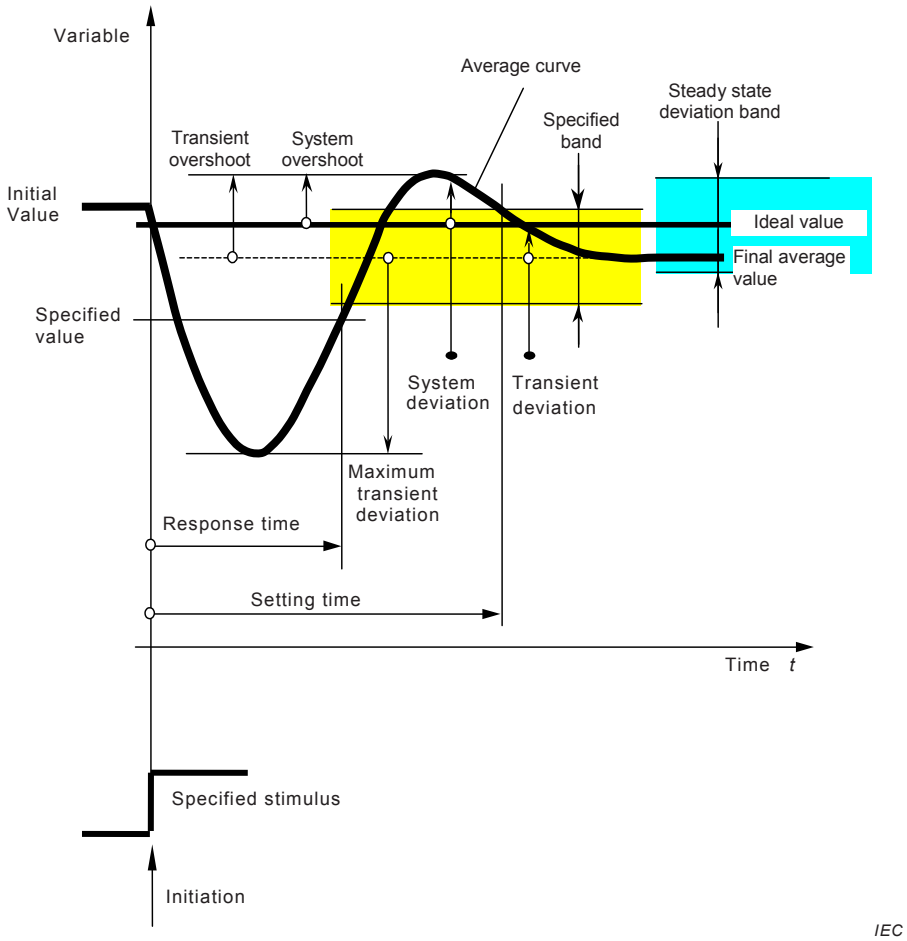


Figure 12 – Time response following a change in an operating variable – no reference change

4.4.1.3.2.6 Dynamic deviation

Dynamic deviation is the deviation between the reference (ideal value) and actual value when the reference is changed at specified rate (see Figure 13).

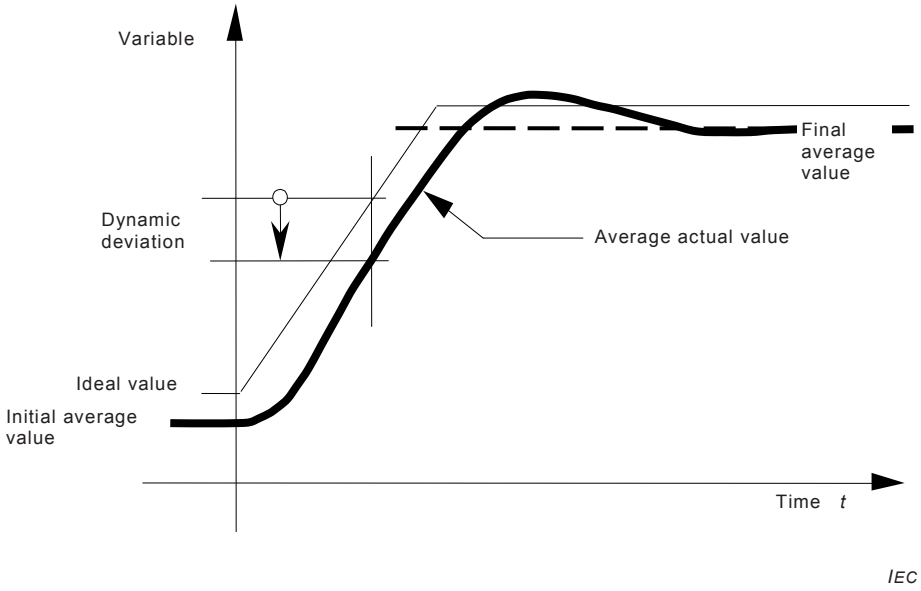


Figure 13 – Time response following a reference change at specified rate

4.4.1.3.3 Frequency response of the control

4.4.1.3.3.1 Frequency analysis

Frequency response represents the amplitude ratio (amplification) and phase difference between the controlled variable and the sinusoidal *stimulus* as a function of the *stimulus* frequency when the feedback loop (if it exists) is closed.

NOTE 1 It is possible to use multi-frequency *stimulus* (noise) instead of the sinusoidal variable frequency *stimulus* when the frequency response is measured using a frequency analyzer.

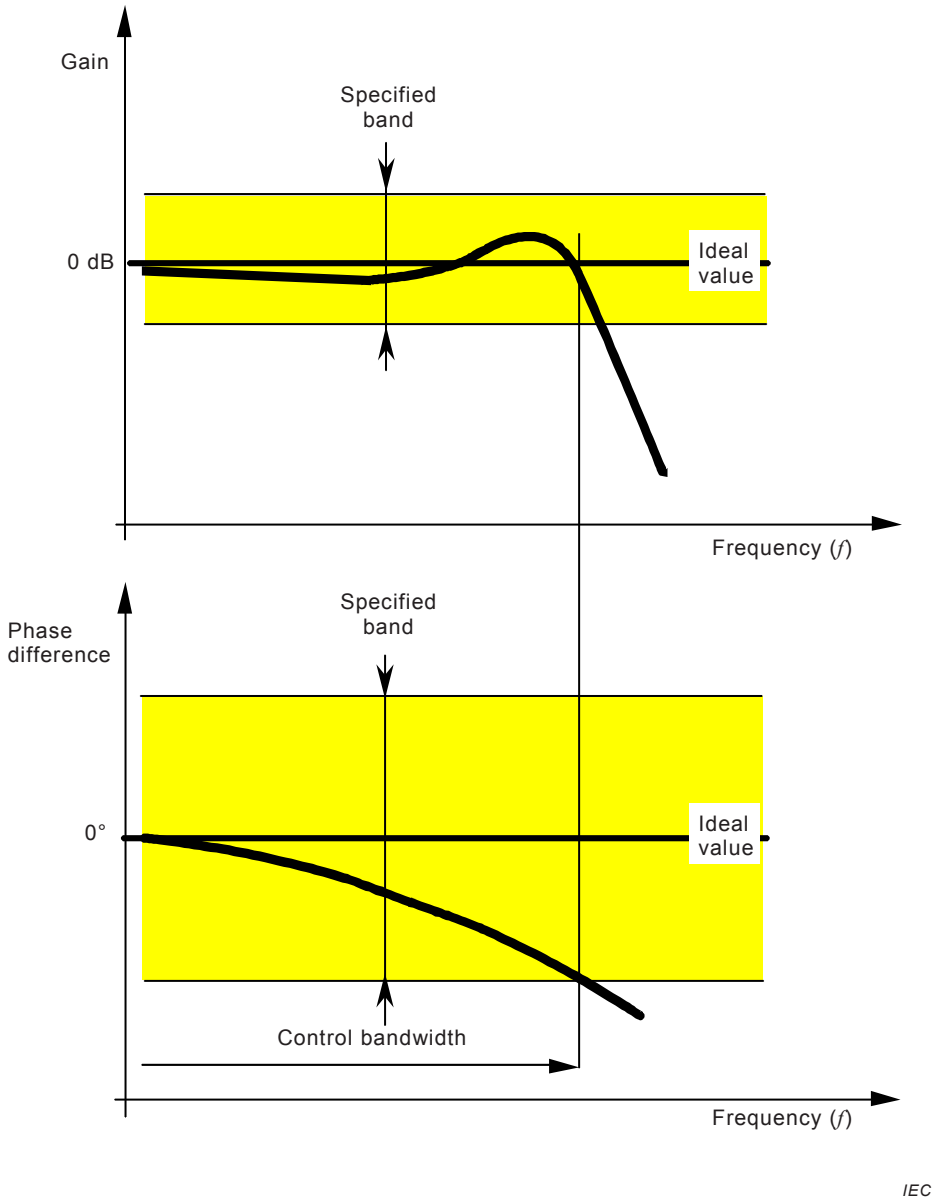
NOTE 2 It is common to use decibels (dB) with the amplification, see IEC 60027-3. The formula is:

$$G = 20 \log_{10} \left(\frac{F_2}{F_1} \right) \text{dB} \tag{2}$$

where F_2/F_1 is the amplitude ratio and G is the gain. E.g. if the amplitude ratio is 0,708, the gain is approximately –3 dB.

4.4.1.3.3.2 Control bandwidth

The control bandwidth is the frequency interval where both the amplification (gain) and phase difference of the frequency response with the reference variable as a *stimulus* remain within specified bands centered on 0 dB and 0° values, respectively, see Figure 14. The specified bands shall be ±3 dB and ±90°.



NOTE The control bandwidth of the case shown in the figure is limited by the specified phase band.

Figure 14 – Frequency response of the control – Reference value as *stimulus*

4.4.1.3.3.3 Disturbance sensitivity

The disturbance sensitivity is the frequency response amplification when the *stimulus* is a specified operating variable. Typical example is the sensitivity of the *motor* speed for pulsating load torque.

NOTE The sensitivity can be expressed in dB only when both the controlled variable amplitude and the *stimulus* amplitude are expressed in per unit (p.u.).

4.4.1.4 *Dynamic braking*

4.4.1.4.1 General

Dynamic braking refers to the addition of dissipative elements (resistors) to allow faster electrical braking of the machine. *Dynamic braking* here is considered to apply only to the use of a resistor across the d.c. link of *BDM/CDM/PDS*. This requires maintained control of the *inverter*. It is not necessarily the only or best method of emergency stopping.

4.4.1.4.2 *Dynamic braking* (stop)

When *dynamic braking* (stop) is provided:

a) the *converter* shall be capable of braking a load at a current depending on *converter* rating;

b) *PDS's* with large variable inertia of the driven equipment (such as winders) shall be capable of braking the maximum stored energy. With the *dynamic braking* resistor initially at ambient temperature, the energy rating shall be adequate to allow stopping the drive system once from any operating speed. In this case, the inertia of the driven equipment shall be provided by the *customer*.

4.4.1.4.3 *Dynamic braking* (slowdown)

When *dynamic braking* (slowdown) is provided:

a) the resistor shall be capable of absorbing the total stored rotational energy of the *motor* and the driven equipment under specified braking sequences between specified speeds with the resistor initially at ambient temperature;

b) the *converter* shall be capable of handling the a.c. current during the above sequence(s).

c) the inertia shall be provided by the *customer.*

4.4.1.4.4 *D.C. braking*

D.C. braking can also be available.

NOTE The available braking torque can decrease at low speed.

4.4.1.5 Other performance requirements

4.4.1.5.1 General

Other performance requirements are to be quantified by the *customer* or by the *manufacturer* together with the *customer*, e.g. considering 4.4.1.5.2 to 4.4.1.5.4.

4.4.1.5.2 Application requirements

Application requirements include:

- audible noise;
- operating quadrants: the usual combination are quadrants I, I and III, or all quadrants;
- torque as a function of speed;
- special mechanical conditions.

4.4.1.5.3 Supply connection requirements

Supply connection requirements include:

- earthing;
- displacement factor at rated condition;
- line side harmonic content;
- maximum symmetrical fault current, short circuit.

NOTE For details, see IEC 61800-3 and IEC 61800-5-1.

4.4.1.5.4 Rating requirements

Rating requirements include:

- *rated output current* (I_{aN}/I_{AN}) (See 4.3.3.1);
- *rated output voltage* (U_{aN1}/U_{AN1}) (See 4.3.3.1);

4.4.2 Fault supervision

The *BDM*/*CDM* shall provide specified fault indication and response. This may consist of a common alarm and/or trip signal provided via dry relay contact(s) or static relay(s). The fault indication is normally activated by one or more of the *BDM*/*CDM* faults, which may include but are not limited to the following:

- external faults;
- *output power* stage fault;
- instantaneous overcurrent;
- overtemperature (*converter*);
- loss of cooling air;
- *motor* overload;
- auxiliary power supply fault;
- supply overvoltage/undervoltage;
- loss of supply phase;
- internal control system fault;
- regulator/power circuit diagnostics;
- current limit or timed acceleration;
- overspeed and loss of speed feedback;
- cooling fan failure

4.4.3 Minimum status indication required

The *BDM*/*CDM*/*PDS* should be equipped with a status indication signal for "drive on" (whether *motor* rotating or at standstill). The *BDM*/*CDM*/*PDS* may also be equipped with a status indication signal "drive ready for operation".

4.4.4 I/O devices

4.4.4.1 General

Number and nature of I/O shall be stated by the *manufacturer*.

Inputs and outputs are needed for both variables and parameters. They are provided through analog or digital inputs/outputs using voltage or current. They are also communicated through serial or parallel links according to various communications standards. Both analog and digital variables can be manually set by the use of a control panel and can be read on displays. Variables and parameters are treated in the same manner.

4.4.4.2 Process control interface/*port*

4.4.4.2.1 General

The process control interface/*port* and its performance shall be defined. The following list can be used for the definitions.

4.4.4.2.2 Analog input

The items specified may include, but are not limited to, the following:

– number of analog inputs;

– type of analog input:
  - single-ended voltage input,
  - differential voltage input,
  - current loop input;
– isolation voltage level of the input;
– input voltage or current range depending on the input type;
– input impedance;
– time constant or bandwidth of the hardware low-pass filter;
– gain and offset errors;
– resolution of the A/D converter;
– sampling interval of the A/D converter.

4.4.4.2.3 Analog output

The items specified may include, but are not limited to, the following:

– number of analog outputs;
– type of analog output:
  - single-ended voltage output,
  - differential voltage output,
  - current loop output;
– isolation voltage level of the output;
– output voltage or current range depending on the output type;
– maximum load;
– time constant or bandwidth of the hardware low-pass filter;
– gain and offset errors;
– resolution of the D/A converter, if it exists;
– conversion interval of the D/A converter, if it exists.

4.4.4.2.4 Digital input

The items specified may include, but are not limited to, the following:

– number of digital inputs;
– type of digital input:
  - relay input,
  - opto-coupler input;
– isolation voltage level of the input;
– rated control voltage and type (a.c. or d.c.);
– input resistance;
– propagation delay of the input.

4.4.4.2.5 Digital output

The items specified may include, but are not limited to, the following:

– number of digital outputs;
– type of digital output:
  - relay output of normally open contact,

- relay output of normally closed contact,
- transistor output of normally open contact;

– isolation voltage level of the output;
– maximum voltage and type (a.c. or d.c.);
– maximum current and type (a.c. or d.c.);
– operation delay of the output;
– propagation delay from input to output.

4.4.4.2.6 Communication interface/ports

The items specified may include, but are not limited to, the following:

– number of communication interfaces/ports;
– type of communication interface/*port*:
  - commissioning and maintenance interface/*port*,
  - automatic system interface;
– type of the physical interface/*port* (connector and cable type);
– protocol used;
– maximum data transfer rate in bits per second;
– maximum length of the cable that can be connected to the interface/*port*;
– maximum number of interfaces/ports that can be connected to the same communication cable or communication bus system.

See 4.11 for further information about generic communication interface and profiles.

4.5 Electrical safety

Protection against thermal and electric hazards in *BDM*/*CDM*/*PDS* during the act of installing, normal operation and maintenance for the expected lifetime of the *BDM/CDM/PDS*, needs to be addressed during the design and construction of the *BDM*/*CDM*/*PDS*. Hazards resulting from reasonably foreseeable misuse should also be included.

Protection against thermal hazards and electric shock is to be maintained in single fault conditions as well as under normal environmental and operating conditions specified by the *manufacturer*.

This standard does not give any requirements for the safety evaluation of the *BDM*/*CDM*/*PDS* as this is covered by the products safety standards IEC 61800-5-1.

Compliance according to IEC 61800-5-1 shall be shown with respect to protection against thermal and electrical hazards.

4.6 Functional safety

The product safety standard IEC 61800-5-2 provides requirements and guidance to prevent dangerous situations caused by failure in the *BDM*/*CDM*/*PDS* affecting motion.

Functional safety is also applicable when the *BDM*/*CDM*/*PDS* is used for applications in explosive atmosphere. See 4.13.

Examples of safety functions are:

- unexpected start-up,
- speed, torque or temperature exceeding the maximum permitted value.

This standard does not give any requirements for the functional safety evaluation of the *BDM*/*CDM*/*PDS* as this is covered by the functional safety standard IEC 61800-5-2.

4.7 EMC

BDM/*CDM*/*PDS* are often installed in industrial environments which include both high power equipment and low-power electronic controls. EM (electro-magnetic) disturbances are prevalent in these environments on the a.c. main, on conductors used for communications and I/O between equipment, and also radiated through the air.

In other applications in commercial and residential environments, such as lifts, pumps, and HVAC (heating, ventilation, and air-conditioning), *BDM*/*CDM*/*PDS*'s may operate in proximity to computers and consumer electronics. It is important that a *PDS* provide sufficient immunity to EM disturbances present in the application environment in order to operate properly and reliably. It is also important that a *BDM*/*CDM*/*PDS* does not generate EM disturbances which interfere with the proper operation of other equipment.

Requirements to insure EM compatibility of *BDM*/*CDM*/*PDS* with different application environments are provided in IEC 61800-3. IEC 61800-3 differentiates between application environments in which the *BDM*/*CDM*/*PDS* is powered from:

- the public low-voltage main (1st environment) and
- application environments in which the *BDM*/*CDM*/*PDS* is powered from private power networks (2nd environment).

IEC 61800-3 provides requirements for immunity to both low frequency disturbances as well as high frequency disturbances, and requirements for both low frequency and high frequency emissions.

IEC 61800-3 does not define EM immunity requirements for functional safety in *BDM*/*CDM*/*PDS*. Guidance for EM immunity in *BDM*/*CDM*/*PDS* associated with functional safety is provided in IEC 61800-5-2.

4.8 Eco design

4.8.1 General

The use of energy during the complete lifetime of the *BDM/CDM/PDS* including manufacturing, transportations, operation and disposal, as well as consideration about the selection, use and recycling of raw materials and substances may be taken into consideration.

4.8.2 Energy *efficiency* and losses

Energy *efficiency* and/or power losses may be determined for the *BDM/CDM/PDS* itself.

NOTE No IEC standard is available at the time of development of this standard. CSA C838-13 or ANSI/AHRI 1211 or EN 50598-2 are available as reference documents. Future IEC 61800-9 series will provide requirements for the evaluation and determination of energy *efficiency*.

4.8.3 Environmental impact

The *manufacturer* may provide Environmental Product Declaration (EPD) information about the environmental impact, including the energy consumption during manufacturing, transportation and disposal of the *BDM*/*CDM*/*PDS*. The information concerning energy consumption shall be based on a calculation including energy consumption used for manufacturing and transportation of individual components used in the *BDM*/*CDM*/*PDS*.

NOTE No IEC standard for *PDS* is available at the time of development of this standard. EN 50598-3 is available as a reference document.

4.9 Environmental condition for service, transport and storage

4.9.1 General

The product standard committee for the relevant part of the IEC 61800 series or the *manufacturer* shall select the service conditions for operation according to Table 4 and Table 5 and for storage and transportation according to 4.9.3.

The environmental conditions in 4.9.1 to 4.9.4 are minimum requirements. More severe conditions might be specified.

In 4.9 the values of the severity levels of IEC 60721 series with dated reference are copied and provided in the relevant clause for convenience. The levels are informative and the levels of IEC 60721 series take precedence in case of deviations.

4.9.2 Operation

4.9.2.1 Climatic conditions

4.9.2.1.1 General

The manufacturer shall state the environmental service condition for the BDM/CDM/PDS according to Table 9.

Table 9 – Environmental service conditions

Condition	Indoor conditioned IEC 60721-3-3:1994 and IEC 60721-3-3:1994, AMD1:1995, AMD2:1996	Indoor unconditioned IEC 60721-3-3:1994 and IEC 60721-3-3:1994, AMD1:1995, AMD2:1996	Outdoor unconditioned IEC 60721-3-4:1995 and IEC 60721-3-4:1995, AMD1:1996
Climatic	**Class 3K2** (Temperature: 15 °C to 30 °C) (Humidity: 10 % R.H to 75 % R.H./ non-condensing)	**Class 3K3** (Temperature: 5 °C to 40 °C) (Humidity: 5 % R.H to 85 % R.H. / non-condensing)	**Class 4K6** (Temperature: –20 °C to 55 °C) (Humidity: 4 % R.H to100 % R.H. / condensing) Rain, snow and hail are permitted.
Pollution degree according to IEC 60664-1	**2**	**3** [b]	**4** [c]
Overvoltage category according to IEC 60664-1	**See IEC 61800-5-1**		
Humidity condition of the human skin	**Dry**	**Water wet** [a]	**Salt water wet** [a]
Chemically active substances	**Class 3C1** (No salt mist)	**Class 3C1** (No salt mist)	**Class 4C2** (Salt mist) [a]
Mechanically active substances	**Class 3S1** (No requirement)	**Class 3S1** (No requirement)	**Class 4S2** (Dust and sand)
Mechanical	**Class 3M1** (Vibration: Table 12) (Shock: Table 13)	**Class 3M1** (Vibration: Table 12) (Shock: Table 13)	**Class 4M1** (Vibration: Table 12) (Shock: Table 13)
Biological	**Class 3B1** (No requirement)	**Class 3B1** (No requirement)	**Class 4B2** (Mould/fungus/ rodents/termites)
U V resistance	**(No requirement)**	**(No requirement)**	**Yes** [d]
The environmental conditions are guidelines. More severe conditions might be specified. Ultraviolet exposure (sun), food processing industry or other special applications. Marking in manual according to Clause 6.			
[a] Where it is ensured that the equipment will not be used in a salt mist atmosphere, water wet or salt water wet condition, the *manufacturer* may choose to rate the equipment for a less severe condition. For marking see 6.3 [b] Pollution degree 2 may be provided if the conditions in 4.9.2.1.2 are satisfied [c] Pollution degree 2 or 3 may be provided if the enclosure provides sufficient protection against conductive pollution and the conditions in 4.9.2.1.2 are satisfied. [d] Material evaluated to be UV-resistant shall be used for applications subjected to UV exposure			

For an *integrated PDS,* the service conditions shall comply with the most severe conditions from Table 4 or with those of the relevant standard for the *motor* from the IEC 60034 series.

For compliance see 5.4.7.3, 5.4.7.4, 5.4.7.5, 5.4.7.6, 5.4.7.7, 5.4.7.8, 5.4.7.9, 5.4.7.10, 5.4.7.11 relevant according to environmental condition specified by the *manufacturer*.

Table 10 – Limit of temperature of the cooling medium for indoor equipment

		Temperature	
Conditions	**Cooling medium**	**Minimum**	**Maximum**
Temporary extreme temperatures of the cooling medium	Air	0 °C	40 °C
	Water	5 °C	30 °C
	Oil	–5 °C	30 °C
Daily average (testing, specification, verification, to be used for expected lifetime calculation)	Air	--	30 °C
Yearly average (testing, specification, verification, to be used for expected lifetime calculation)	Air	--	25 °C

For outdoor equipment the temperature range has to be specified considering the application.

Where the *BDM*/*CDM*/*PDS* complies with the requirements of this standard only at conditions higher than the minimum values or lower than the maximum values given in Table 10, then this shall be by agreement between the *manufacturer* and the *customer*. For marking see 6.3.

4.9.2.1.2 Pollution degree

Insulation between circuits is affected by pollution, which occurs during the expected lifetime of the *BDM*/*CDM*/*PDS*. The effect on the insulation might affect the performance of the *BDM*/*CDM*/*PDS* due to malfunctions.

The micro-environmental conditions for insulation shall be applied according to Table 11.

Table 11 – Definitions of pollution degree

Pollution degree	Description
1	No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.
2	Normally, only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation is to be expected.
3	Conductive pollution or dry non-conductive pollution occurs which becomes conductive due to condensation which is to be expected.
4	The pollution generates persistent conductivity caused, for example by conductive dust or rain or snow.

The pollution degree shall be determined according to the environmental condition for which the product is specified. See Table 9 for selection of pollution degree according to environmental classification of the *installation*.

The insulation may be determined according to pollution degree 2 if one or more of the following applies:

a) instructions are provided with the *BDM*/*CDM*/*PDS* indicating that it shall be installed in a pollution degree 2 environment; or

b) the specific *installation* application of the *BDM*/*CDM*/*PDS* is known to be a pollution degree 2 environment;or

c) the *BDM*/*CDM*/*PDS* enclosure or coatings applied within the *BDM*/*CDM*/*PDS* provide adequate protection against what is expected in pollution degree 3 and 4 (conductive pollution and condensation).

The *BDM*/*CDM*/*PDS manufacturer* shall state in the documentation the pollution degree for which the *BDM*/*CDM*/*PDS* has been designed.

If operation in pollution degree 4 environment is required, protection against conductive pollution shall be provided by means of a suitable enclosure.

4.9.2.2 Mechanical *installation* service conditions and requirements

4.9.2.2.1 General

Vibration, shock and free-fall conditions vary widely depending on the *installation* and environment and are very difficult to specify. For the purpose of this standard, the service conditions are indirectly defined by the requirements in 4.9.2.2.2 and 4.9.2.2.3 for fixed installed *BDM/CDM/PDS*.

Other *installation* circumstances require special consideration and require agreement between the *manufacturer* and *customer*. For marking see 6.3

4.9.2.2.2 Fixed *installation*s

Fixed *installation*s of *BDM*/*CDM*/*PDS* shall be placed on a rigid mounting surface which does not seriously interfere with the ventilation or cooling system.

Experience shows that equipment meeting the vibration test from 5.4.7.5 or the shock test from 5.4.7.6 is suitable for industrial use in fixed *installations*.

Vibration shall remain within the limits of Table 12 which is considered normal for stationary equipment.

Table 12 – Environmental vibration limits for fixed *installation*

	IEC 60721-3-3: 1996 and IEC 60721-3-4:1995 and IEC 60721-3-4:1995/AMD1:1996 3M1 and 4M1	
Frequency Hz	**Amplitude** mm	**Acceleration** m/s^2
$9 \leq f < 200$	n.a	1
NOTE The frequency range 2 Hz to 9 Hz covers earthquake, but not covered by this standard. Earthquake can be specified. IEC 60721-2-6 provides more details.		

Compliance is checked by test of 5.4.7.5 which is an accelerating test to demonstrate the ability of the *BDM/CDM* to withstand the mechanical stress during the estimated lifetime.

If shock has to be taken into account the values shall remain within the limits of Table 13.

Table 13 – Environmental shock limits for fixed *installation*

Shock	**IEC 60721-3-3:1996 and IEC 60721-3-4:1995 and IEC 60721-3-4:1995/AMD1:1996 3M1 and 4M1**
Peak acceleration	40 m/s^2
Duration	22 ms

Compliance is checked by test with increased values of 5.4.7.6.

4.9.2.2.3 Fixed *installation*s as part of stationary machine

If the *BDM/CDM/PDS* is part of a stationary machine which create vibrations and shock during operation, the mechanical stress can be higher than shown in Table 12 and Table 13. If these values are known the *manufacturer* shall use them for testing.

The shock test is recommended if the *BDM/CDM/PDS* is part of a stationary machine

If the mechanical stress exceeds the test values in 5.4.7.5 and 5.4.7.6 the values shall be specified by the *customer* and the *manufacturer* shall use them for testing taking into account a margin.

4.9.2.3 Unusual environmental service conditions

The use of *BDM/CDM/PDS* under conditions exceeding the specified conditions listed 4.9.2.1 and 4.9.2.2 shall be considered unusual.

Unusual service conditions may require special optional construction or protective features.

Examples to consider:

a) exposure to damaging fumes;
b) exposure to excessive moisture (relative humidity greater than specified);
c) exposure to excessive dust;
d) exposure to abrasive dust;
e) exposure to steam or water condensation;
f) exposure to oil vapour;
g) exposure to abnormal vibration, shock or tilting;
h) exposure to unusual transportation or storage conditions exceeding the values from Table 14;
i) exposure to extreme or sudden changes in temperature;
j) unusual mounting space limitations;
k) cooling water containing acid or impurities which cause excessive scale, sludge, electrolysis or corrosion;
l) unusually high nuclear radiation;
m) altitude for thermal consideration, if rated for operation above 1 000 m;
n) altitude for insulation coordination if rated for operation above 2 000 m: see IEC 61800-5-1;
o) long periods not energized (days, weeks or months).
p) severe restriction on audible noise

The unusual service conditions shall be specified by the *customer* in agreement with the *manufacturer*.

4.9.2.4 The act of installing, commissioning and operation

The act of installing, commissioning, and operation have the same normal and unusual service conditions.

4.9.3 Storage and transport of equipment

4.9.3.1 Climatic conditions

The *BDM/CDM/PDS* shall be placed under adequate cover immediately upon receipt if packing coverings are not generally suitable for outdoor or unprotected storage.

Table 14 – Storage and transport limits

		Storage according to IEC 60721-3-1:1997 in product packaging up to 6 months	Transport according to IEC 60721-3-2:1997 in shipping packaging for more than 6 months
Climatic class		1K4	2K4
Ambient temperature	**Min**	−25 °C	−40 °C
	Max	55 °C	70 °C
Biological environmental conditions		1B1 [a]	2B1 [a]
Chemically active environmental conditions		1C2	2C2
Maximum permitted temperature changes		0,5 K/min as average value over 5 min; equivalent to 30 K/h	Direct change in air/air: −40 °C to 30 °C at 95 %
Relative/absolute air humidity		1K3 (5 % R.H to 95 % R.H.)	2K4 (5 % R.H to 95 % R.H.)
Rain		Not permitted	6 mm/min [b]
Water, but not rain		Not permitted	1 m/s and wet loading surfaces [b]
Air pressure	**Min**	Above 700 hPa or below 3 000 m above sea level	
	Max	Below 1 060 hPa or above sea level.	
Condensation, spray water and ice		Permitted	
Salt spray		Permitted	
Solar radiation		1 120 W/m^2	
Vibration		1M2	2M3

[a] Mould, fungus, rodents, termites and other animal vermin not permitted.

[b] In sea- and weather-resistant *shipping packaging* (container).

4.9.3.2 Unusual climatic conditions

Where transportation temperatures below −40 °C are anticipated, the use of heated transport or the removal of selected low temperature sensitive components is required.

4.9.3.3 Mechanical conditions

Equipment shall be able to be transported, in the *product packaging* and *shipping packaging*, within the limits of IEC 60721-3-2:1997 class 2M1.

This includes the following: vibration in Table 15 and free fall in Table 16

Table 15 – Transportation vibration limits

Frequency Hz	**Amplitude** mm	**Acceleration** m/s^2
$2 \leq f < 9$	3,5	n.a.
$9 \leq f < 200$	n.a	10
$200 \leq f < 500$	n.a	15

Table 16 – Transportation limits of free fall

Shipping weight with packaging kg	**Random free-fall drop height** mm		**Number of falls**
	IEC 60721-3-2:1997 (2M1)		
	With *product packaging*	**With *shipping packaging***	
w <20	250		5
20 ≤ w < 100	250		5
w >100	100		5
NOTE More severe requirement can be found in IEC 61131-2			

If a free fall and vibration environment beyond those limits is anticipated, special packaging or transport is required.

If a less damaging environment is known to exist, packaging may reflect reduced requirements.

4.9.4 Environmental service tests (*type test*)

Environmental service testing is required to demonstrate the function of the *BDM*/*CDM*/*PDS* at the extremes of the environmental classification in Table 9 to which it will be subjected.

If size or power considerations prevent the performance of these tests on the complete *BDM*/*CDM*/*PDS*, it is permitted to test individual parts that are considered to be relevant to the function of the *BDM*/*CDM*/*PDS*.

When testing components or sub-assemblies separately, the temperature during the dry-heat test shall be chosen as to simulate actual use in the end-product. The component or sub-assembly shall be energized simulating the same conditions as in the end-product.

Error! Reference source not found. shows the standard tests to be performed for the different environmental service conditions.

Product standard committees for the relevant parts of IEC 61800 or the *manufacturer* shall select the relevant tests.

Compliance is shown by conducting tests of 5.4.7.3 to 5.4.7.10 according to **Error! Reference source not found.** as applicable for the environmental service conditions specified by the *manufacturer*.

Where the *BDM*/*CDM*/*PDS* is required to operate in conditions outside the range of values given in this standard, then the test conditions shall be specified, as defined in the particular individual enquiry or purchasing specification. In any case the test requirements shall not be less demanding than the operating conditions specified.

Table 17 – Environmental service tests

Test condition	Indoor conditioned IEC 60721-3-3:1996	Indoor unconditioned IEC 60721-3-3:1996	Outdoor unconditioned IEC 60721-3-4:1995 and IEC 60721-3-4:1995/AMD1: 1996
Climatic	Temperature (see 5.4.7.3) Damp heat (see 5.4.7.4)	Temperature (see 5.4.7.3) Damp heat (see 5.4.7.4)	Temperature (see 5.4.7.3) Damp heat (see 5.4.7.4)
Chemically active substances	-	-	Salt mist [a] (see 5.4.7.7)
Water	-	Water test (see 5.4.7.10)	Water test (see 5.4.7.10)
Mechanically active substances	-	Dust (see 5.4.7.8)	Dust and sand (see 5.4.7.8, and 6.4.7.9)
Mechanical	Vibration (see 5.4.7.5) Shock (see 5.4.7.6)	Vibration (see 5.4.7.5) Shock (see 5.4.7.6)	Vibration (see 5.4.7.5) Shock (see 5.4.7.6)
Biological	-	-	-

[a] Where it is ensured that the equipment will not be used in a salt mist atmosphere, water wet or salt water wet condition, the manufacturer may choose to rate the equipment for a less severe condition. For marking see 6.3.

When special environmental conditions are specified, additional tests (e.g. for chemically active substances) shall be considered.

For *integrated PDS* the test conditions shall comply with the most severe tests from Table 14 or with those of the relevant standard for the *motor* from the IEC 60034 series.

4.10 Types of load duty profiles

The general performance features of the *CDM* are specified in 4.4, which covers the most common applications.

For special applications where other load profiles are requested the IEC TR 61800-6 provides further information about the current rating of the *CDM* for different kinds of load profiles covering equipment, assemblies and system aspects.

This included load profiles like:

- uniform load profiles,
- intermittent peak load profiles,
- intermittent load duty,
- intermittent load duty with no-load intervals,
- repetitive load duty,
- non-repetitive load duty.

IEC TR 61800-6 also specifies duty classes for non-repetitive industrial classes (IG to VG).

Compliance with special duty cycles according to IEC 60034-1 (S1 to S10) for rotating machines, might be specified by the *manufacturer* following the guidance of IEC TR 61800-6.

4.11 Generic interface and use of profiles for *PDS*

BDM/*CDM*/*PDS*'s used in industrial applications typically interface with one or more external control systems which coordinate operation of several *PDS*.

Often the control system is separate from the drive and may consist of:

- one or more PLC's (programmable logic controllers), and/or
- a DCS (distributed control system), and/or
- a MES (manufacturing execution system).

NOTE 1 The control system software can be partially or entirely embedded in the *BDM/CDM/PDS*.

The IEC 61800-7 series of standards define a means to access functions and data in a *BDM*/*CDM*/*PDS* by providing a series of well-defined communication profiles and interfaces. The objective is a common drive model with generic functions and objects suitable to be mapped into different communication interfaces/ports.

From the perspective of control software, the communication and control functions of a *BDM*/*CDM*/*PDS* may be characterized by profiles. A *BDM*/*CDM*/*PDS* device profile is a representation of the parameters and behaviour of the *BDM*/*CDM*/*PDS* which may be used to facilitate control of the *BDM*/*CDM*/*PDS*. This device profile can then be mapped onto different network technologies (e.g. "communication profiles" of the IEC 61158 fieldbus series) to facilitate control of a *BDM*/*CDM*/*PDS* over a network.

The IEC 61800-7 series of standards defines a generic interface and profiles for *BDM*/*CDM*/*PDS* to be used with a control system and consists of the following parts.

- IEC 61800-7-1 defines requirements for a generic interface with the control software.
- IEC 61800-7 Parts 2xx specify different drive profiles.
- IEC 61800-7 Parts 3xx specify mappings of the device profiles onto various network technologies.

The relationship of IEC 61800-7 series to control system software and the *BDM*/*CDM*/*PDS* is represented in Figure 15 below.

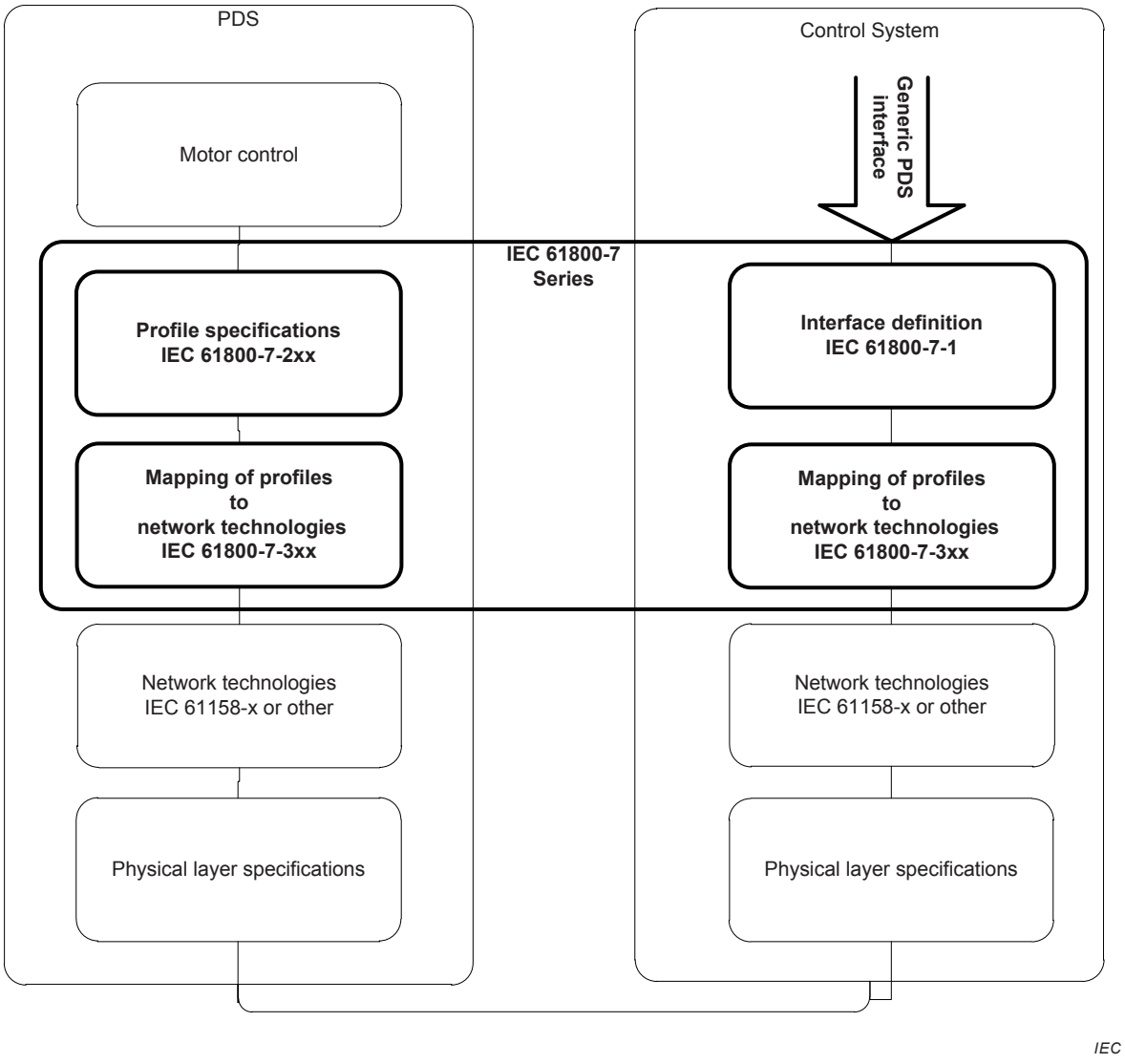


Figure 15 – Example of relationship of IEC 61800-7 series to control system software and the *BDM*/*CDM*/*PDS*

NOTE 2 Other network technologies can be applicable (e.g. EN 50325-4 or other)

For compliance see 5.4.8.

4.12 Voltage on *power interface*

The voltage interface between the *CDM* and the *motor* is a topic, which might require special consideration, to ensure compatibility between *CDM* and *motor*.

For applications where the voltage interface is of importance, the IEC TS 61800-8 can provide further information about the determination of voltages on the *power interface*.

The IEC TS 61800-8 provides information about determination of the voltage on the *power interface* for:

- indirect *converter* of the voltage source type, with single-phase *rectifier* as line side *converter*;
- indirect *converter* of the voltage source type, with three *rectifiers* as line side *converter*;

- indirect *converter* of the voltage source type, with three-phase active line side *converter.* (e.g. *active infeed converter*).

Specification of the voltage *power interface* might be specified by the *manufacturer* following the guidance of IEC TS 61800-8.

For compliance see 5.4.2.8.5.

4.13 Explosive environment

PDS's may be used in applications involving explosive atmospheres. Considerations include whether the *BDM/CDM* and/or *motor* are located in the explosive atmosphere, and whether the *BDM/CDM* provides a safety control system associated with a hazard related to the explosive atmosphere.

Requirements to achieve the necessary level of safety have been defined in the IEC 60079 series of standards.

NOTE 1 EN 50495 provides more information regarding the minimum requirements for safety devices required for the safe functioning of equipment with respect to explosion risks. EN 50495 is under consideration to be adopted as part of the IEC 60079 series standard.

NOTE 2 The 2nd edition of IEC 61800-5-2[1] will contain appropriate information about *PDS* used in safety systems related to explosive atmospheres.

5 Test

5.1 General

Sublauses 5.2 to 5.4 provide guidance for the test to show compliance with the requirement of Clause 4 as agreed between *manufacturer* and *customer* or specified by product standard committees.

5.2 Performance of tests

5.2.1 General conditions

It is advisable to restrict the performance of costly tests to those which are necessary.

This recommendation is therefore outlined so that testing can normally be limited to the tests in *manufacturer's* works on the *BDM*/*CDM*/*PDS* and separate components.

When the *customer* or his representative desires to witness factory tests, it shall be specified in the order.

Tests shall be performed by the *manufacturer* prior to shipment, unless otherwise agreed.

5.2.2 Supply system earthing conditions

Type tests shall be performed to verify complete *BDM*/*CDM* performance with the acceptable earthing systems. These may include:

- neutral to earth;
- line to earth;
- neutral to earth through high impedance;

_____

1 Under consideration.

- isolated neutral (not earthed).

For marking see 6.3.

5.3 Standard tests for *BDM/CDM/PDS*

5.3.1 General

Table 18 provides an overview over applicable test which may be chosen to show compliance with the requirement in Clause 4.

Table 18 – Test overview

Test	Type	Routine	Sample	Requirement(s)	Specification
Visual inspections	X	X	X	4	5.4.1
Ratings	X			4	5.4.2
Input ratings				4.3.2	5.4.2.4
Input voltage and frequency	X			4.3.2.1	5.4.2.4.2
Input currents	X			4.3.2.2	5.4.2.4.3
Output ratings	X			4.3.3	5.4.2.5
BDM/*CDM* continuous output ratings	X			4.3.3.1	5.4.2.5.2, 5.4.2.5.3, 5.4.2.5.4
PDS continuous output ratings	X			4.3.3.2	
Overcurrent and torque capability	X			4.3.3.3	5.4.2.5.5
Operating *quadrants*				4.3.4	
Operation in II and IV *quadrants*	X			4.3.4.2	5.4.2.5.6
Ratings and properties of the control equipment	X			4.3.5	5.4.2.6
Additional test for special ratings				4.3.6	5.4.2.7
Power factor measurement	X				5.4.2.7.2
Current sharing	X				5.4.2.7.3
Voltage division					5.4.2.7.4
Checking of auxiliary devices	X	X			5.4.2.7.5
Checking of protective measures	X				5.4.2.7.6
Properties under unusual service conditions	X				5.4.2.7.7
Additional test (effect on *motor*) for special rating				4.3.6	5.4.2.8
Motor vibration	X				5.4.2.8.2
Audible noise	X				5.4.2.8.3

Test	Type	Routine	Sample	Requirement(s)	Specification
Bearing current	X				5.4.2.8.4
Motor insulation	X				5.4.2.8.5
Steady state performance	X			4.4.1.2	5.4.2.9
Dynamic performance & ratings				4.4.1.3	5.4.2.10
Current limit and current loop	X				5.4.2.10.2
Speed loop	X				5.4.2.10.3
Torque pulsation	X				5.4.2.10.4
Automatic restart	X			4.4.1	5.4.2.10.5
Fault supervision	X			4.4.2	5.4.2.11
I/O devices	X			4.4.4	5.4.2.12
Electrical safety	X	X	X	4.5	5.4.3
Functional safety	X			4.6	5.4.4
EMC	X			4.7	5.4.5
Eco- design	X			4.8	5.4.6
Environmental conditions	X			4.9	5.4.7
Temperature test	X			4.9.1, 4.9.2, 4.9.3, 4.9.4,	5.4.7.3
Damp heat test	X				5.4.7.4
Vibration test	X				5.4.7.5
Shock test	X				5.4.7.6
Salt mist test	X				5.4.7.7
Dust test	X				5.4.7.8
Sand test	X				5.4.7.9
Water test	X				5.4.7.10
Hydrostatic pressure test	X				5.4.7.11
Communication profiles	X			4.11	5.4.8
Voltage on power interface				4.12	5.4.2.8.5
Explosive environment				4.13	5.4.9

5.3.2 Test for mass produced products

Product standard committees for other parts of IEC 61800 can select tests from Table 18 and can classify them to become *type*, *sample* or *routine test*.

5.3.3 Test for one-off products

Product standard committees for other parts of IEC 61800 can select tests from Table 18 under consideration that some tests cannot be performed.

5.4 Test specifications

5.4.1 Visual inspections (*type test*, *sample test* and *routine test*)

Visual inspections shall be made:

- as *routine tests*, to check features such as adequacy of labelling, warnings and other aspects;
- as acceptance criteria of individual *type tests*, *sample tests* or *routine tests*, to verify that the requirements of this standard have been met.

Visual inspections in *routine test* may be part of the production or assembly process.

Before *type test*, a check shall be made that the *BDM*/*CDM*/*PDS* delivered for the test is as expected with respect to supply voltage, input and output ranges, etc.

5.4.2 Static performance and rating test

5.4.2.1 General

The satisfactory operation of the equipment shall also be verified for the whole range of supply voltage for which it is designed, if this has not yet been done in another test (e.g. checking the protective devices). For the *type test,* the function of the equipment is tested at maximum and minimum values of each *input voltage* range

Under the input and output rating test in 5.4.2.4 and 5.4.2.5 the following data are measured:

- voltage range U_{L}, current range I_{L} and frequency range f_{L} at the input transformer (if any) input;
- voltage range U_{V}, current range I_{V} and frequency range f_{V} at the *converter* input;
- voltage range U_{a1}, current range I_{a}, frequency range f_{a} and power $S_{\mathrm{a}}/P_{\mathrm{a}}$ at *BDM* output;
- voltage range U_{A1}, current range I_{A}, frequency range f_{A} and power $S_{\mathrm{A}}/P_{\mathrm{A}}$ at *CDM* output;
- torque range M, power range P_{s}, and speed range N at the *motor* shaft;

NOTE 1 Voltage U_{a1} and U_{A1} is measured with an instrument of type and adequate accuracy to indicate the r.m.s. value of the fundamental component of the *converter output voltage*. Currents I_{L}, I_{v}, I_{a} and I_{A} are measured with an a.c. ammeter of adequate accuracy to indicate the r.m.s. value of the total current.

NOTE 2 The load is the driven equipment or, for test purposes, a simulation of the driven equipment.

The *BDM*/*CDM*/*PDS* shall meet the specified functionality and performance as specified by the *manufacturer*.

The load and functionality as specified in 5.4.2.3 may be used for showing compliance.

The *manufacturer* and the *customer* have to agree if this test is carried out as a *type test* as an *acceptance test* at the *manufacturer* location or as a *commissioning test* on location.

Regarding measuring circuit see Figure 16. In this figure physical variables are directly measured or calculated from indirect measurements.

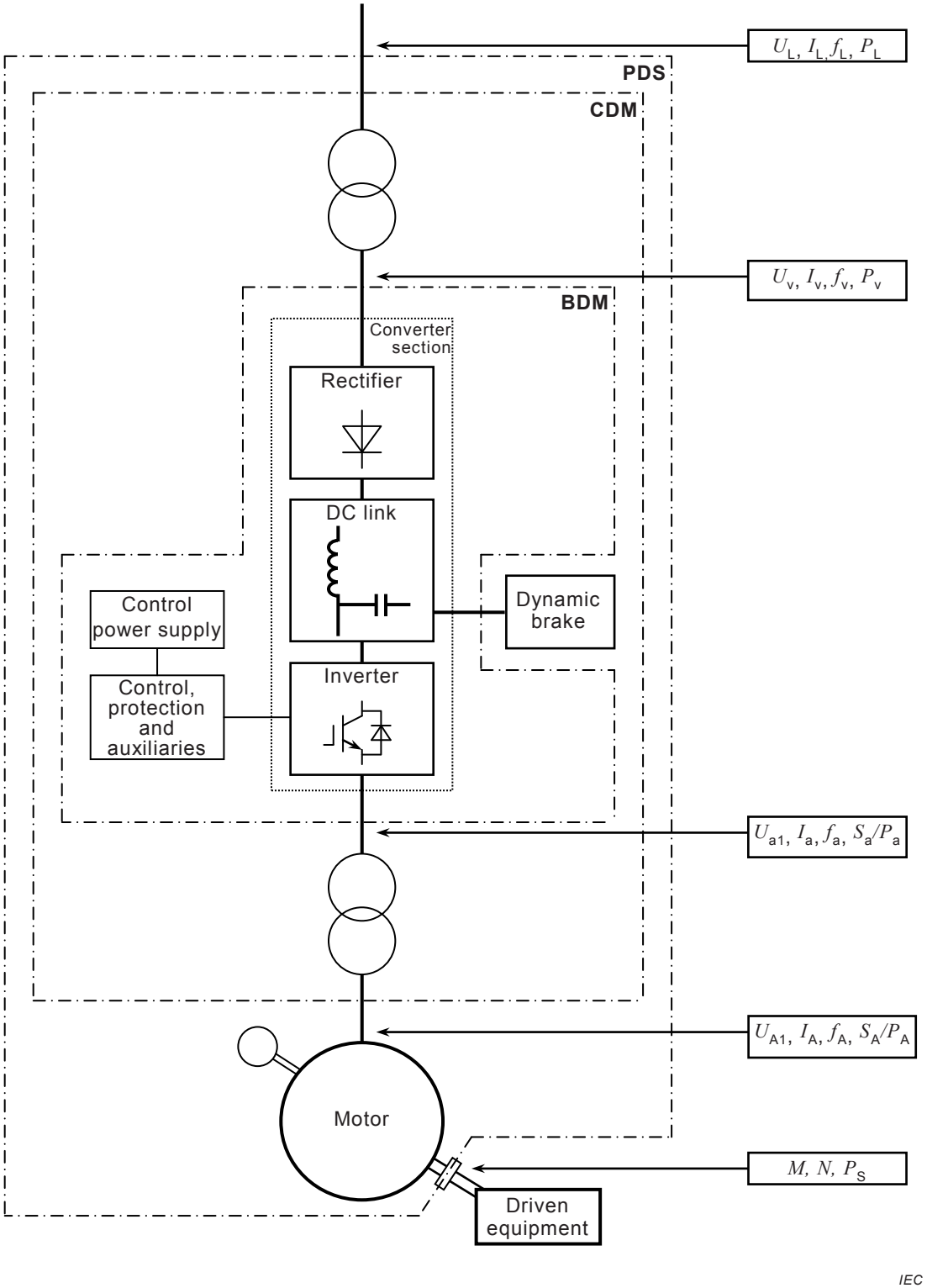


Figure 16 – Measuring circuit of *PDS*

5.4.2.2 Instrumentation for performance testing

The *output currents* and *output voltages* of the *converter*s will have varying amounts of harmonics, depending on frequency setting and type of modulation in the *inverter* stage.

5.4.2.3 Load and functionality/performance

Based on the specification of the *BDM*/*CDM*/*PDS* the *manufacturer* may choose to specify a load and functionality/performance test program, under which the specified performance and functionality can be proven under the conditions specified by the *manufacturer*.

The shaft of the *motor* is coupled to a load, which is able to provide conditions to the tested drive, such that the correct function of the control system can be proven. The *motor* should be selected to require adequate current to prove correct *BDM*/*CDM* functions.

A no load test can be used.

NOTE The load is the driven equipment, or a simulation of the driven equipment for test purposes.

5.4.2.4 Input ratings

5.4.2.4.1 General

The specified input rating according to 4.3.2 of the *BDM*/*CDM*/*PDS* shall be verified under the rated voltage, current and frequency conditions.

See also Annex B

5.4.2.4.2 *Input voltage* and input *frequency*

Under the *input voltage* and input *frequency* conditions specified by the *manufacturer* the specified functionality and performance of the *BDM*/*CDM*/*PDS* shall be verified.

5.4.2.4.3 *Input currents*

Under the test in 5.4.2.4.2 showing compliance with the *input voltage* and *input frequency* conditions specified by the *manufacturer*, the *input current* range shall be measured and specified for the *BDM*/*CDM*/*PDS*.

5.4.2.5 Output ratings

5.4.2.5.1 General

The specified output rating according to 4.3.3 of the *BDM*/*CDM*/*PDS* shall be verified under the rated conditions.

5.4.2.5.2 Voltage rating

The voltage rating of the *BDM*/*CDM*, specified by the *manufacturer* according to 4.3.3.1, shall be verified by test.

5.4.2.5.3 Torque and current rating

The torque and current rating of the *BDM*/*CDM*/*PDS*, specified by the *manufacturer* according to 4.3.3.2, shall be verified by test.

NOTE Torque can be measured indirectly, e.g. calculation using power and speed, etc.

5.4.2.5.4 Frequency and speed range

The operating speed and frequency range of the *BDM*/*CDM*/*PDS*, specified by the *manufacturer* according to 4.3.3.2, shall be verified by test.

5.4.2.5.5 Overcurrent/overtorque capability

The overcurrent capability of the *BDM*/*CDM* and the overtorque of the *PDS*, specified by the *manufacturer* according to 4.3.3.3, shall be verified by test.

5.4.2.5.6 Operating *quadrants*

The operating *quadrants* of the *BDM*/*CDM*/*PDS*, specified by the *manufacturer* according to 4.3.4, shall be verified.

5.4.2.6 Checking the properties of the control equipment

It is not possible to verify the properties of the control equipment under all load conditions which may prevail in the *end user* application. However, the equipment shall be checked with a *motor* preferably of similar rated power. If this cannot be done it may be performed using a lower power *motor* with appropriate scaling of feedback quantities.

If specified by the *manufacturer*, *routine test* for the checking of the control equipment may be accomplished with an unloaded *motor* check using multiple steady state speed conditions, i.e. at minimum and maximum speed. The dynamic performances shall be checked during the transition from one speed to another. It may be useful to add inertial loads to the *motor* so that the *BDM/CDM* operates in current limit (if supplied) during the acceleration. The checking of the deceleration shall be compatible with the design of the equipment.

For steady state performance, see 5.4.2.9.

For dynamic performance and ratings, see 5.4.2.10.

5.4.2.7 Additional tests for special rating

5.4.2.7.1 General

The additional tests are indented to show compliance with certain functionality related to special applications.

5.4.2.7.2 *Power factor*

Power factor of *BDM*/*CDM*/*PDS* input measurements shall be made under rated operating conditions.

5.4.2.7.3 Current sharing

If parallel connected devices or equipment are used in the *PDS*, the current sharing shall be checked. This test shall be performed at *rated output current*.

Examples of parallel configurations are:

- a *converter* section made up by more than one *converter* bridge;
- a *converter* section made up by more than one semiconductor valve per arm;
- a *motor* section with *motor* windings in parallel.

The balance shall be adequate to ensure that no device is stressed beyond design values under worst case conditions.

5.4.2.7.4 Voltage division

If two or more *converters* and/or *motor*s, are connected in series, voltage division shall be checked so that no overvoltage occurs to *BDM* and/or *motor*s. The voltage division shall be

adequate to ensure that no device is stressed beyond design values under normal operating and single failure conditions.

5.4.2.7.5 Checking of auxiliary devices

The function of all auxiliary devices, that are not completely tested in the *BDM/CDM* or *motor* tests, shall be checked. Examples of such devices are: *motor* fans, lubricating oil pumps fed from the *CDM*, external circuit breakers, disconnect devices, etc.

If convenient, this can be done while performing light load test, see 5.4.2.3.

5.4.2.7.6 Checking of protective measures

Protective measures which are relevant for the electrical, thermal, energy or functional safety of the *BDM*/*CDM*/*PDS* shall be evaluated according to IEC 61800-5-1 and IEC 61800-5-2.

Examples of protective measures:

- *motor* overspeed,
- *motor* overvoltage,
- *motor* overload,
- *motor* temperature
- loss of speed feedback,
- main undervoltage,
- *BDM/CDM motor* output earth fault or short circuit between *motor* terminals, etc.

Due to the wide variety of protective measures and their combinations, it is not possible to state any general rules in this standard for checking these measures.

When checking the protective measures will be done as part of a *routine test* or commissioning test, it shall be done, as far as possible, without stressing the components of the equipment above their rated values.

5.4.2.7.7 Checking properties under unusual service conditions

Unusual climatic conditions may require special coating on electronic assemblies and/or cabinet. In extreme temperature conditions, an air conditioner or heater may be provided.

5.4.2.8 Additional test (effect on *motor*) for special rating

5.4.2.8.1 General

Due to the nature of the *output current* and *output voltage* of the *BDM*/*CDM,* some additional tests to verify the compatibility between *motor* and *BDM*/*CDM* can be considered.

As these effects depend on the application, no specific test for 5.4.2.8.2 to 5.4.2.8.5 can be specified in this standard.

IEC TS 61800-8 and IEC TS 62578 provide additional information about the use of filter to reduce some of these phenomena.

5.4.2.8.2 *Motor* vibration

This test may be carried out at various speeds and loads to identify any *BDM/CDM* effects on *motor* vibration.

5.4.2.8.3 Audible noise

PDS may be required to be tested for audible noise. The test should be done over the operating speed range and load range. Acceptable audible noise levels shall be specified (see IEC 60034-9).

NOTE The load is the driven equipment or a simulation of the driven equipment for test purposes.

5.4.2.8.4 Bearing current

Bearing currents may result due to common-mode effects and harmonics in *motor* voltage and current. While these currents are small in magnitude, they may cause damage to either anti-friction or sleeve bearings.

IEC TS 61800-8 provides information about bearing current including the use of a filter to reduce bearing currents

5.4.2.8.5 *Motor* insulation

IEC TS 61800-8 provides information about determination of the voltage on the *power interface* between *BDM/CDM* and motor.

5.4.2.9 Steady state performance

The *manufacturer* should verify the data given in the documentation.

5.4.2.10 Dynamic performance and rating

5.4.2.10.1 General

Under normal operating conditions the dynamic performance and rating of the *BDM*/*CDM*/*PDS* shall be verified.

The *manufacturer* and the *customer* have to agree if this test is carried out as a *type test* as an *acceptance test* at the *manufacturer* location or as a *commissioning test* on location.

5.4.2.10.2 Current limit and current loop

These tests characterize the dynamic performance of the *BDM*/*CDM* or of the *PDS* independently from the driven equipment.

Two items can be tested.

Current limit

An incremental load change is provided to require the *CDM* to reach its preset current limit point. (As an alternative, an incremental step speed change into adequate rotational inertia can provide a transient load causing the *CDM* to reach the current limit set point.) The rise time of current, overshoot magnitude and duration and damping characteristics may then be analyzed.

Step response to current reference

Current loop bandwidth can be measured with a small step change of current reference within a linear or quasi linear area. This test can include nonlinear area.

These tests shall be carried out at different speeds to be chosen near 0, 50 % *rated speed*, 100 % *rated speed*, and *maximum rated speed*.

It is usually necessary to adjust the speed by using a machine coupled to the shaft of the *motor* under test (which is itself adjusting the torque by means of current following the reference).

5.4.2.10.3 Speed loop

A step in speed reference is provided and correctly selected to accommodate the following tests. This test can be carried out under no load or light load conditions. See 5.4.2.3.

The current limitation and its value are checked with a large step change of speed reference reaching the current limit.

The drive output speed response is measured without reaching any limits (normally done within 50 % *rated speed*, at 100 % *rated speed*, and at *maximum rated speed)*.

A step in load may be provided to allow measurement of the consequent speed response. This may be carried out while performing rating test 5.4.2.3. The load step shall be chosen so that no limitations are reached.

5.4.2.10.4 Torque pulsation

Relative levels of air-gap torque pulsation may be measured under no load conditions using speed changes, provided that adequately sensitive speed measurement devices are coupled to the shaft. Ideally, air-gap torque pulsation arising within a specific *PDS* should be measured with a known load inertia, proper load/*PDS* mechanical coupling and shaft mounted torque sensing equipment.

5.4.2.10.5 Automatic restart

If automatic restart is provided, it shall be verified for the specified power outage duration. This function shall be coordinated with emergency stop and inhibited if required.

Restriction on automatic restart may be considered.

5.4.2.11 Fault supervision

The *BDM*/*CDM*/*PDS* ability to detect internal and external faults shall be tested. This also includes the audible, visual and electronic alarm for the *customer*.

5.4.2.12 I/O devices

The functionality of all input/output *port* shall be proven.

Examples of input output *ports* are:

- analog input/output ports;
- digital input/output ports;
- relay ports;
- power supply input/output ports.

5.4.3 Electrical safety

For compliance, see IEC 61800-5-1.

5.4.4 Functional safety

For compliance, see IEC 61800-5-2.

5.4.5 EMC

For compliance, see IEC 61800-3.

5.4.6 Eco-design

NOTE No IEC standard is available at the time of development of this standard. CSA C838-13 or ANSI/AHRI 1211 or EN 50598-2 are available as reference documents. Future IEC 61800-9 series will provide requirements for the evaluation and determination of energy *efficiency*.

5.4.7 Environmental condition tests

5.4.7.1 General

The climatic tests of 5.4.7.3 to 5.4.7.11 shall be specified with the purpose of showing compliance with the static and dynamic performance and rating of the *BDM*/*CDM*/*PDS*.

Tests on sub-parts or sub-assemblies are permitted if it can be verified that the test results will not be affected compared to the tests of the complete assembled *BDM/CDM/PDS.*

The climatic tests of 5.4.7.3 to 5.4.7.11 might be referenced by other parts of the IEC 61800 series, in which case the acceptance criteria shall be specified separately.

In 5.4.7 the values of the severity levels of IEC 60068 series with dated reference are copied and provided in the relevant clause for convenience. The levels are informative and the levels of IEC 60068 series take precedence in case of deviations.

5.4.7.2 Acceptance criteria

The following acceptance criteria shall be satisfied after the environmental test.

- No mechanical damage or cracks in the enclosure which will reduce the IP classification;
- Show compliance with the static and dynamic performance and rating of the *BDM*/*CDM*/*PDS* according to 5.4.2.3.

5.4.7.3 Temperature tests

5.4.7.3.1 Temperature rise test

The test is intended to ensure that parts of the *BDM*/*CDM*/*PDS* do not exceed the specified temperature limits of any relevant components and parts, which are essential for the performance of the *BDM*/*CDM*/*PDS*.

Temperature rise test might be applicable for components and parts related to electrical and functional safety in which case this is specified in IEC 61800-5-1 and IEC 61800-5-2. Even though the test setup might be identical, the test temperature rise test might deviate in the acceptance criteria for electrical and functional safety.

Where possible, the *BDM*/*CDM*/*PDS* shall be tested at worst-case conditions of *rated* power and the *rated output current* specified for the *BDM*/*CDM*, under which it can operate continuously, taking de-rating and cooling control characteristic into account.

For equipment where the amount of heating or cooling is designed to be dependent on temperature (e.g. the equipment contains a fan that has a higher speed at a higher temperature), the temperature measurement shall be performed at the worst case ambient temperature condition within the *manufacturer's* specified operating range.

If this is not possible, it is permitted to measure the temperature rise from the ambient temperature under the test condition. If the temperature measurement at rated power is not possible and the validity of the simulation can be demonstrated by tests at lower power levels, it is permitted to simulate the temperature rise.

The temperature rise tests are continued until all temperatures are stabilized.

Manufacturer and *end user* have to agree if this test is done in a workshop test or in a *commissioning test.*

For details about the test setup, see IEC 61800-5-1:2007, 5.2.3.9.

5.4.7.3.2 Dry heat test (steady state)

To prove the ability of components and equipment to be operated, transported or stored at high temperatures the dry heat test (steady state) shall be performed according to the conditions specified in according to Table 19.

Table 19 – Dry heat test (steady state)

Subject	Test conditions
Test reference	Test Bd of IEC 60068-2-2: 2007
Requirement reference	**Error! Reference source not found.**
Preconditioning	According to 5.4.1
Operating conditions	Operating at rated conditions
Temperature	Temperature classification according to 4.9.2.1 or, for separate testing of components and sub-assemblies or *manufacturer's* specified maximum temperature, whichever is higher
Accuracy	±2 °C (see IEC 60068-2-2: 2007)
Humidity	According to IEC 60068-2-2: 2007, Test Bd
Duration of exposure	(16 ± 1) h
Recovery procedure	
– Time	1 h minimum
– Climatic conditions	
– Temperature	15 °C to 35 °C
– Relative humidity	25 % to 75 %
– Barometric pressure	86 kPa to 106 kPa
– Power supply	Power supply disconnected
Acceptance criteria	5.4.7.2

5.4.7.3.3 Load duty profile

For temperature rating of *BDM*/*CDM*/*PDS* specified for a specific load duty profile (see 4.10) the temperature test shall be performed according to the specified load duty profile.

The shaft of the *motor* is coupled to a load, which is capable of providing the specified load duty profile over a long-term run, to verify that the temperature in the equipment reaches stable conditions within ratings.

IEC TR 61800-6 provides further information about load profiles.

5.4.7.4 Damp heat test (steady state)

To prove the resistance to humidity, the *BDM/CDM/PDS* shall be subjected to a damp heat test (steady state) according to the conditions specified in according to Table 20.

Table 20 – Damp heat test (steady state)

Subject	Test conditions
Test reference	Test Cab of IEC 60068-2-78:2012
Requirement reference	Table 17 – Environmental service tests
Preconditioning	According to 5.4.1
Operating conditions	Power supply disconnected
Special precautions	Internal voltage sources may remain connected if the heat produced by them in the specimen is negligible
Temperature	*BDM/CDM/PDS manufacturer's* specified maximum humidity or according to 4.9.2.1, for separate testing of components and sub-assemblies, whichever is higher.
Accuracy	±2 °C (see Clause 5 of IEC 60068-2-78:2012)
Humidity	*BDM/CDM/PDS manufacturer's* specified maximum humidity
Accuracy	±3 % (see Clause 5 of IEC 60068-2-78:2012)
Duration of exposure	4 days
Recovery procedure	
– Time	1 h minimum
– Climatic conditions	
– Temperature	15 °C to 35 °C
– Relative humidity	25 % to 75 %
– Barometric pressure	86 kPa to 106 kPa
– Power supply	Power supply disconnected
– Condensation	All external and internal condensation shall be removed by air flow prior to re-connecting the *BDM/CDM/PDS* to a power supply
Acceptance criteria	5.4.7.2

5.4.7.5 Vibration test (*type test*)

To verify the ability against mechanical vibration strength the *BDM/CDM/PDS* in combination with its *installation* shall be evaluated by:

a) tests defined in this section according to the conditions specified in Table 21;or

b) calculation or simulation based on tests, as defined in this section, on a representative model of *BDM/CDM/PDS*.

NOTE For large equipment, the possibility of using a shock test as an alternative to a vibration test is under consideration.

Table 21 – Vibration test

Subject	Test conditions
Test reference	Test Fc of IEC 60068-2-6:2007
Requirement reference	Table 17 – Environmental service tests
Preconditioning	According to 5.4.1
Conditions	Power supply disconnected
Motion	Sinusoidal
Vibration amplitude/acceleration	
10 Hz ≤ f ≤ 57 Hz	0,075 mm amplitude
57 Hz < f ≤ 150 Hz	10 m/s^2 (1 g)
Vibration duration	10 sweep cycles per axis on each of three mutually perpendicular axes
Detail of mounting	According to *BDM/CDM/PDS manufacturer's* specification
Acceptance criteria	5.4.7.2
Where the *BDM/CDM/PDS manufacturer* specifies vibration levels that are greater than those above, the higher levels shall be used for the test. The acceptance criteria shall not be changed. Where the environmental conditions are known to be lower, the *BDM/CDM/PDS manufacturer* might specify lower level or no vibration levels test than those specified in this table. The acceptance criteria shall not be changed. NOTE This test is an accelerated test which means that the level is higher than indicated in Table 12.	

5.4.7.6 Shock test (*type test*)

To verify the ability against mechanical shock strength, it is recommended to evaluate the *BDM/CDM/PDS* for use within machines by:

a) tests defined in this section according to the conditions specified in Table 22; or

b) calculation or simulation based on tests, as defined in this section, on a representative model of *BDM/CDM/PDS*.

Table 22 – Shock test

Subject	Test conditions
Test reference	Test Ea of IEC 60068-2-27: 2008
Requirement reference	Table 17 – Environmental service tests
Preconditioning	According to 5.4.1
Conditions	Power supply disconnected
Motion	Half-sine pulse
Shock amplitude/time	50 m/s^2 (5 g) 30 ms
Number of shocks	3 per axis on each of three mutually perpendicular axes
Detail of mounting	According to *BDM/CDM/PDS manufacturer's* specification
Acceptance criteria	5.4.7.2
Where the *manufacturer* specifies shock levels that are greater than those above, the higher levels shall be used for the test. The acceptance criteria shall not be changed. Where the environmental conditions are known to be lower, the *BDM/CDM/PDS manufacturer* might specify lower level or no vibration levels test than those specified in this table. The acceptance criteria shall not be changed.	

5.4.7.7 Salt mist test (*type test*)

To verify the resistance against corrosion, the *BDM/CDM/PDS* in combination with its *installation* shall be evaluated by tests defined in this section according to the conditions specified in Table 23.

Table 23 – Salt mist test

Subject	Test conditions
Test reference	Test Kb of IEC 60068-2-52:1996
Requirement reference	Table 17 – Environmental service tests
Preconditioning	According to 5.4.1
Conditions	Power supply disconnected
Severity level	Severity level 2
Acceptance criteria	5.4.7.2
Where the *BDM/CDM/PDS manufacturer* specifies salt mist levels that are greater than those above, the higher levels shall be used for the test. The acceptance criteria shall not be changed. Where the environmental conditions are known to be lower, the *BDM/CDM/PDS manufacturer* might specify lower level or no salt mist test than those specified in this table. The acceptance criteria shall not be changed.	

5.4.7.8 Dust test (*type test*)

To verify the ability to operate under the influence of dust the *BDM/CDM/PDS* in combination with its *installation* shall be evaluated by tests defined in this section under the conditions specified in Table 24 mainly to demonstrate the tightness against dust.

Table 24 – Dust test

Subject	Test conditions
Test reference	According to chosen IP class of IEC 60529
Requirement reference	Table 17 – Environmental service tests
Preconditioning	According to 5.4.1
Conditions	Power supply disconnected
Particle size	According to IEC 60529
Dust concentration	According to IEC 60529
Air velocity	According to IEC 60529
Air pressure in the specimen	According to IEC 60529
Test duration	According to IEC 60529
Acceptance criteria	5.4.7.2 and according to chosen IP classification from IEC 60529

5.4.7.9 Sand test (*type test*)

To verify the ability to operate under the influence of sand, the *BDM/CDM/PDS* in combination with its *installation* shall be evaluated by tests defined in this section under the conditions specified in Table 25 mainly to demonstrate the robustness against abrasion by sand.

Table 25 – Sand test

Subject	Test conditions
Test reference	Test Lc1 of IEC 60068-2-68:1994
Requirement reference	Table 17 – Environmental service tests
Preconditioning	According to 5.4.1
Conditions	Power supply disconnected
Particle size	Fine dust
Dust concentration	2 g/m^3
Air velocity	5 m/s
Air pressure in the specimen	Air pressure in the specimen is that of the ambient air pressure.
Test duration	24 h
Acceptance criteria	5.4.7.2

5.4.7.10 Water test (*type test)*

To verify the ability to operate under the influence of rain, snow and hail the *BDM/CDM/PDS* in combination with its *installation* shall be evaluated by tests defined in this section under the conditions specified in Table 26.

Table 26 – Water test

Subject	Test conditions
Test reference	According to chosen IP class of IEC 60529
Requirement reference	Table 17 – Environmental service tests
Preconditioning	According to 5.4.1
Conditions	Power supply disconnected (according to IEC 60529)
Acceptance criteria	5.4.7.2 and according to chosen IP classification from IEC 60529

5.4.7.11 Hydrostatic pressure test (*type test* and *routine test*)

For *type tests*, the pressure inside the cooling system of a liquid cooled *BDM/CDM/PDS* shall be increased at a gradual rate until a pressure relief mechanism (if provided) operates, or until a pressure of twice the operating value or 1,5 times the maximum pressure rating of the system is achieved, whichever is the greater.

NOTE For the purpose of this test the coolant pump can be disabled.

The pressure shall be maintained for at least one minute.

There shall be no significant leakage of coolant or loss of pressure during the test, other than from a pressure relief mechanism during a *type test*.

5.4.8 Communication profiles

Test to show compliance with commonly used bus communication profiles are defined in the IEC 61800-7 series.

5.4.9 Explosive atmosphere environment

NOTE The 2nd edition of IEC 61800-5-2[2] will contain appropriate information about *PDS* used in safety systems related to explosive atmospheres.

6 Information and marking requirements

6.1 General

This document provides a minimum number of information and markings, (see Table 27), but several other standards in the IEC 61800 series provide further requirements for marking which should be taken into consideration if applicable:

- electrical safety information according to IEC 61800-5-1;
- functional safety information according to IEC 61800-5-2 if applicable;
- EMC information according to IEC 61800-3 if applicable;
- eco design according to specified standard (See 4.8).

The safety marking requirement of IEC 61800-5-1 and IEC 61800-5-2 and EMC marking requirement of IEC 61800-3 should be taken into consideration where applicable.

In case of conflicting requirements, the requirements from a specific standard in other parts of the IEC 61800 series takes precedence.

In general marking and information can be provided by marking on product and/or information in paper form or electronic form (WEB, CD-ROM or similar)

Considerations should be given to the fact that IEC 61800 series or local/national regulations may not allow information to be provided by electronic media to the *end customer*. In the latter case the information shall be provided in paper format.

---

2 Under consideration.

Table 27 – Information requirements

Information	Subclause reference	Location [a, b]					Technical subclause reference
		1	2	3	4	5	
Marking on product	**6.2**						
Manufacturer's name or trademark		X					
Equipment identification		X					
Input/output ratings		X					
Information to be supplied with the *PDS* or *BDM/CDM*	**6.3**						
EMC marking according to IEC 61800-3							See IEC 61800-3
Electrical safety marking according to IEC 61800-5-1							See IEC 61800-5-1
Functional safety marking according to IEC 61800-5-2							See IEC 61800-5-2
Eco design according to (TBD)							See (TBD)
Acceptable supply systems earthing conditions					X		
Operating instructions					X		
Device substitution				X			
Environmental rating				X	X		
Information to be supplied or made available	**6.4**						
Maintenance and service instructions						X	
Energy absorption rating				X			
Speed range				X			
Safety and warning labels	**6.5**						
Warning labels	6.5.1						
Additional safety consideration of a *PDS*	6.5.2						

[a] Location: 1. On product (see 6.2); 2. On packaging; 3. In *installation* manual; 4. In user's manual; 5. In maintenance manual.

[b] The *installation*, user's and maintenance manuals may be combined as appropriate and, if acceptable to the *customer*, may be supplied in electronic format. When more than one of any product is supplied to a single *customer*, it is not necessary to supply a manual with each unit, if acceptable to the *customer*.

6.2 Marking on product

Marking on the product shall provide the necessary information needed to make a safe *installation* of the *BDM/CDM/PDS* and ensure full identification and traceability of the *manufacturer*.

The following minimum information shall be supplied on the rating plate of the *BDM/CDM*/ *PDS*:

- the *manufacturer's* name;
- equipment identification (model number, serial number, and year of manufacture).

Input and output ratings:

- as specified by IEC 61800-5-1;

- for *PDS* in addition the *rated output power* (P_N), *rated torque* (M_N) and *rated speed* (N_N) shall be marked.

NOTE The word “Marking” also includes labelling on the product.

6.3 Information to be supplied with the *PDS* or *BDM/CDM*

The following information shall be supplied with the furnished equipment:

- information necessary for calibrating components, devices, and subassemblies which are intended to be adjusted by the *end user*;
- operating instructions, including all information necessary to operate the *BDM*/*CDM*/*PDS*;
- acceptable supply systems earthing conditions for the *BDM/CDM/PDS*. The unacceptable systems shall be indicated as:
  - forbidden; or
  - with modification of performance, which shall be quantified through *type test*;
- device substitution;
- environmental rating.

If required by Table 9 the environmental rating shall be indicated in the documentation.

If required by 4.9.2.1.1 or 4.9.2.2.1 the specific environmental conditions shall be identified in the operating manual.

6.4 Information to be supplied or made available

The following information shall be supplied or made available:

- maintenance and service instructions, including information for locating and replacing faulty components or subassemblies;
- energy absorption rating of the *dynamic braking* (slowdown) and *dynamic braking* (stop) circuits.

For *PDS* speed, information shall be supplied, including:

- *rated speed* (N_N) *[r/min];*
- *maximum rated speed* (N_{NMax}) *[r/min];*
- *minimum rated speed* (N_{Min}) [r/min];
- *maximum rated safe speed* (N_{SNMax}) [r/min].

Information may be supplied by an electronic media if specified.

6.5 Safety and warning labels

6.5.1 Warning labels

Safety labels shall meet the requirement in

- IEC 61800-5-1 for electrical safety,
- IEC 61800-5-2 for functional safety (only if applicable),
- IEC 61800-3 EMC (only if applicable).

6.5.2 Additional safety considerations of a *PDS*

The *PDS* is coupled to a driven equipment, which has to comply with safety standards and rules. All protection systems of the driven equipment, including the shaft of the *motor*, are defined by the *customer*. The *customer* shall provide to the *manufacturer* of the *PDS* all the

necessary specifications which are consequences of machinery safety and have to be included in the control of the *PDS*.

The *PDS* is mainly an electrical equipment and the safety risk is mainly electrical. The safety risk is predominantly electrical for the *BDM/CDM*.

For these reasons, the *BDM/CDM*/*PDS* shall comply with IEC 61800-5-1.

Compliance with IEC 61800-5-1 does not, in itself, ensure compliance with all safety requirements for the final system or application. Detailed safety requirements for the final system or application are defined in their products standards.

Following standards may be applicable:

- IEC 60204-1 for electrical equipment on machinery;
- IEC 60364 series for low-voltage electrical installations;
- IEC 61439-1 for switchgears.

Annex A
(informative)

Classification of *PDS* into low-voltage system and high-voltage system

A.1 General

The purpose of this annex is to classify *PDS* with a.c. power input into low-voltage system and high-voltage system.

NOTE See definition 3.19 and 3.43 for *low voltage PDS* and *high voltage PDS*.

A.2 Classification of *PDS* by voltage

A low-voltage *PDS* is basically defined as that the *rated input voltage* of the *BDM*, i.e. U_{vN} shown in Figure A.1, is below or equal to 1 000 V a.c. This *PDS* is covered by the scope of IEC 61800-2.

A high-voltage *PDS* is also basically defined as that where the *rated input voltage* of the *BDM* is above 1 kV a.c. and not exceeding 35 kV a.c. This *PDS* is covered by the scope of IEC 61800-4.

For *PDS* having series-connected *converter* sections, the sum of the series-connected *rated input voltage*s is used as the equivalent *rated input voltage* of the *BDM*.

Table A.1 shows the basic classification of *PDS* by voltage.

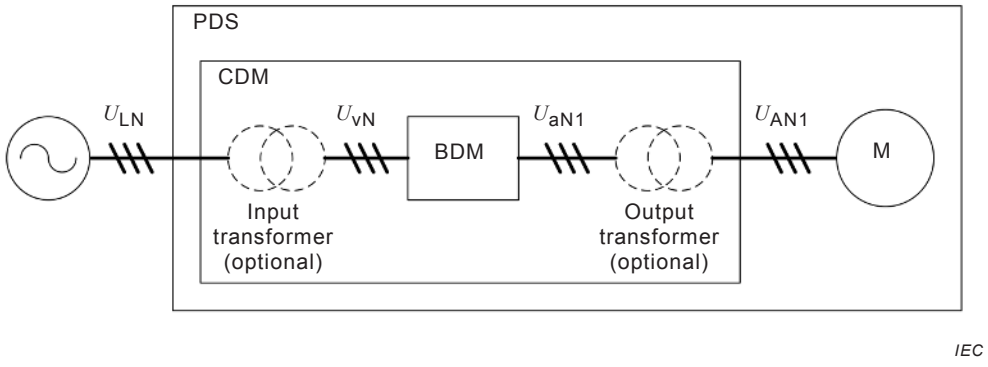


Figure A.1 – Basic configuration of *PDS*

Table A.1 – Basic classification of *PDS* by voltage

***CDM* voltage ratings**				**Classification of *PDS* by voltage**	**Applicable standard**
Input U_{LN}	***BDM* voltage ratings**		**Output U_{AN1}**		
	Input U_{vN}	**Output U_{aN1}**			
LV/HV	LV	LV	LV/HV	low-voltage	IEC 61800-2
LV/HV	LV	HV	LV/HV	low-voltage	IEC 61800-2
LV/HV	HV	LV	LV/HV	high-voltage	IEC 61800-4
LV/HV	HV	HV	LV/HV	high-voltage	IEC 61800-4
LV means low-voltage, i.e. below or equal to 1 000 V a.c., and HV means high-voltage, i.e. above 1 kV a.c. below 35 kV a.c. LV/HV means LV or HV, i.e. any voltage below 35 kV a.c. In case of no input transformer, $U_{LN} = U_{vN}$, and also in case of no output transformer, $U_{aN1} = U_{AN1}$.					

NOTE For *BDM* with a certain type of *converter* such as an *active infeed converter* or a step-up chopper, the *d.c. link* voltage in *BDM* can be higher than the peak voltage of the input line-to-line voltage of *BDM*, or the *rated output voltage* of *BDM* can be higher than the *rated input voltage* of *BDM*. These do not affect the classification of *PDS* by voltage, because this classification is based on only the *rated input voltage* of *BDM*.

A.3 Examples

A.3.1 *PDS* with an input transformer

Figure A.2 shows an example of *PDS* with an input step-down transformer and no output transformer as one of typical configurations.

The *rated input voltage* of *BDM* is 440 V a.c. This *PDS* is classified into low-voltage system.

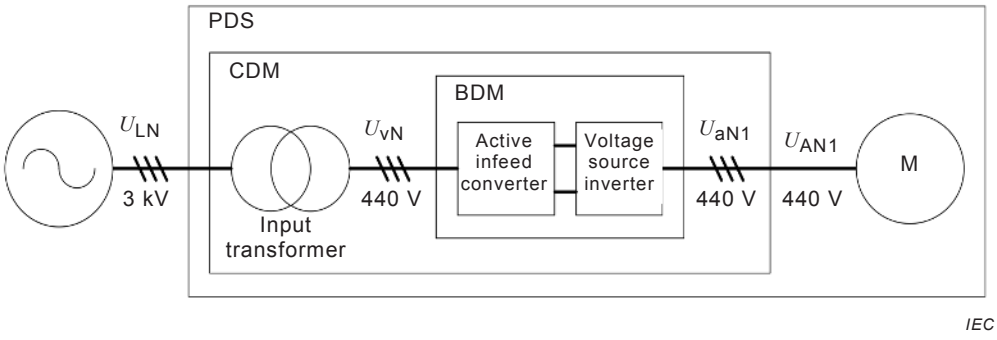


Figure A.2 – An example of low-voltage *PDS* with an input transformer

A.3.2 *PDS* with an input transformer and an output transformer

Figure A.3 shows an example of *PDS* with an input step-down transformer and an output step-up transformer.

The *rated input voltage* of *BDM* is 440 V a.c. This *PDS* is classified into low-voltage system.

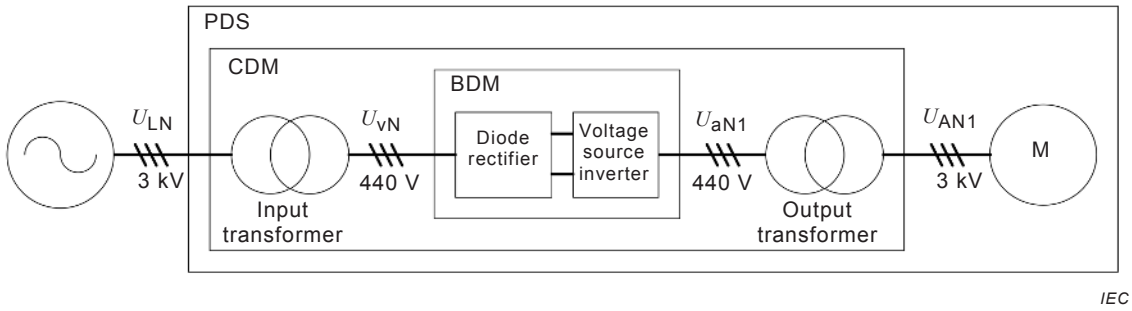


Figure A.3 – An example of low-voltage *PDS* with an input/output transformer

A.3.3 *PDS* with a step-up chopper

Figure A.4 shows an example of *PDS* with a step-up chopper.

The *rated input voltage* of *BDM* is 690 V a.c. This *PDS* is classified into low-voltage system.

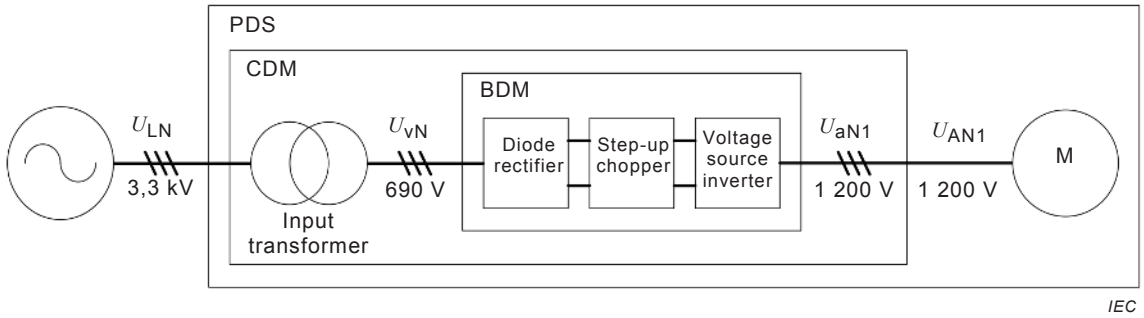


Figure A.4 – An example of low-voltage *PDS* with a step-up chopper

A.3.4 *PDS* with parallel-connected line-side *converters*

Figure A.5 shows an example of *PDS* with two parallel-connected line-side *converter*s.

The *rated input voltage* of each diode *rectifier* is 660 V a.c. This *PDS* is classified into low-voltage system.

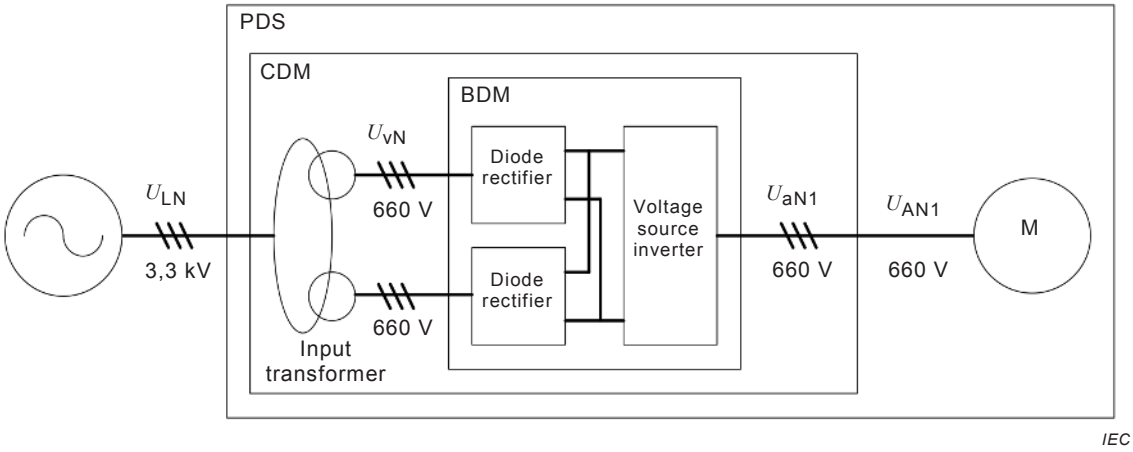


Figure A.5 – An example of low-voltage *PDS* with parallel-connected *rectifiers*

Figure A.6 shows another example of *PDS* with two parallel-connected line-side *converter*s. *BDM* has a diode *rectifier* and an *active infeed converter*.

The *rated input voltage* of the diode *rectifier* is 1 100 V a.c. and that of the *active infeed converter* is 900 V a.c., and the equivalent *rated input voltage* of *BDM* is the higher *rated input voltage* of the *converter*s, i.e. 1 100 V a.c. This *PDS* is classified into high-voltage system.

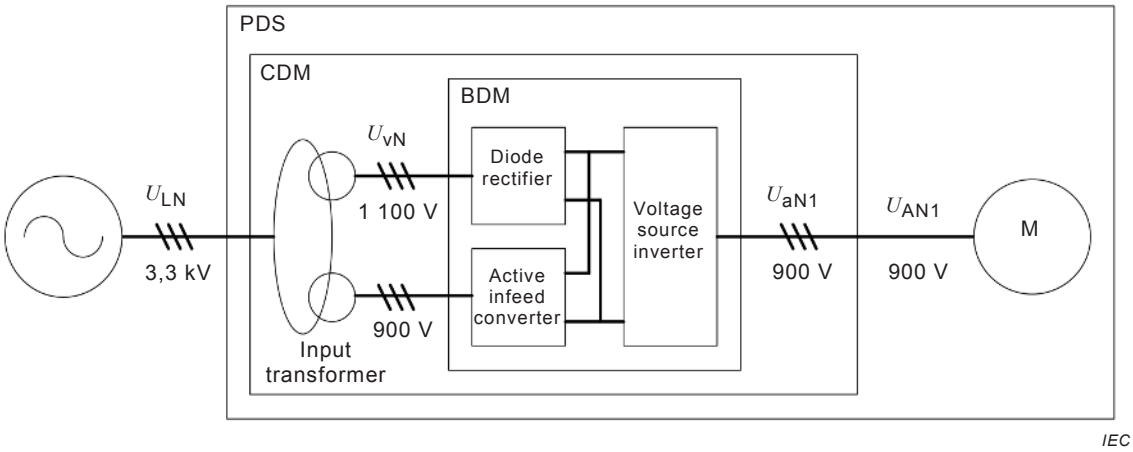


Figure A.6 – An example of high-voltage *PDS* with parallel-connected line-side *converter*s

A.3.5 *PDS* with series-connected line-side *converters*

Figure A.7 shows an example of *PDS* with two series-connected *rectifiers.*

The *rated input voltage* of each diode *rectifier* is 440 V a.c., and the equivalent *rated input voltage* of *BDM* is a sum of *rated input voltage*s of two diode *rectifiers*, i.e. 2 × 440 V a.c. = 880 V a.c. This *PDS* is classified into low-voltage system.

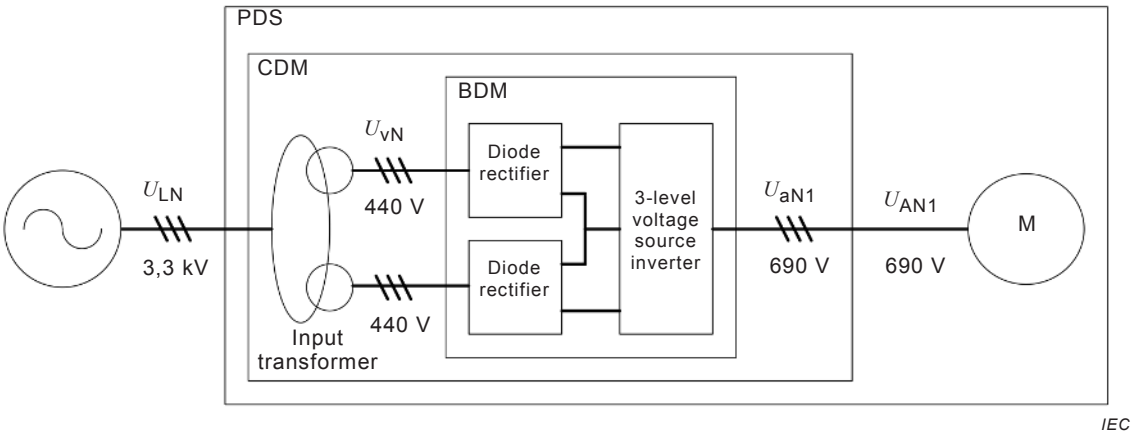


Figure A.7 – An example of low-voltage *PDS* with series-connected *rectifiers*

Figure A.8 shows another example of *PDS* with two series-connected *rectifiers.*

The *rated input voltage* of each diode *rectifier* is 660 V a.c., and the equivalent *rated input voltage* of *BDM* is a sum of *rated input voltage*s of two diode *rectifiers*, i.e. 2 × 660 V a.c. = 1 320 V a.c. This *PDS* is classified into high-voltage system.

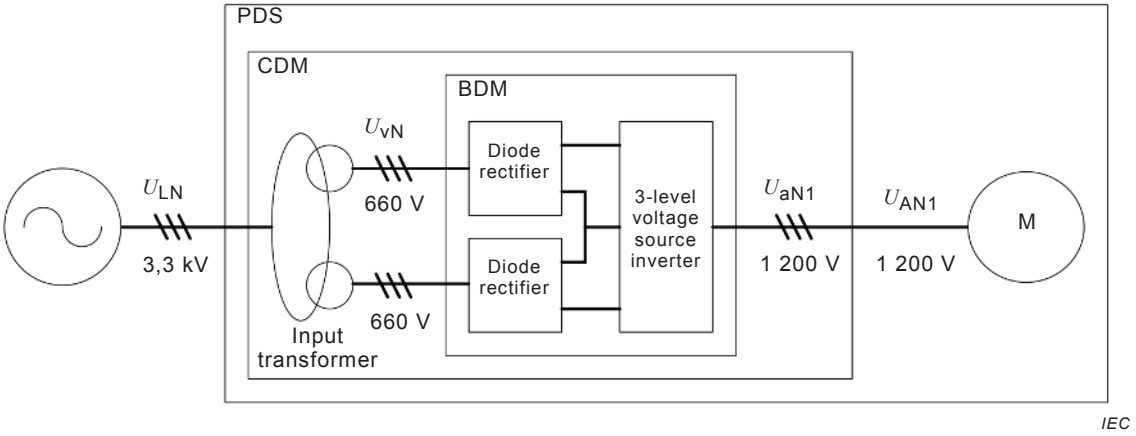


Figure A.8 – An example of high-voltage *PDS* with series-connected *rectifiers*

A.3.6 *PDS* with star-connected *inverters*

Figure A.9 shows an example of *PDS* with star-connected *inverter*s.

The *rated input voltage* of each diode *rectifier* is 660 V a.c., and the equivalent *input voltage* of *BDM* is a sum of *rated input voltage*s of two diode *rectifiers*, i.e. 2 × 660 V a.c. = 1 320 V a.c., because each one of two output lines of three voltage source i*nverter*s is connected in common and two diode *rectifiers* can be connected in series by the *inverter* operation. This *PDS* is classified into high-voltage system.

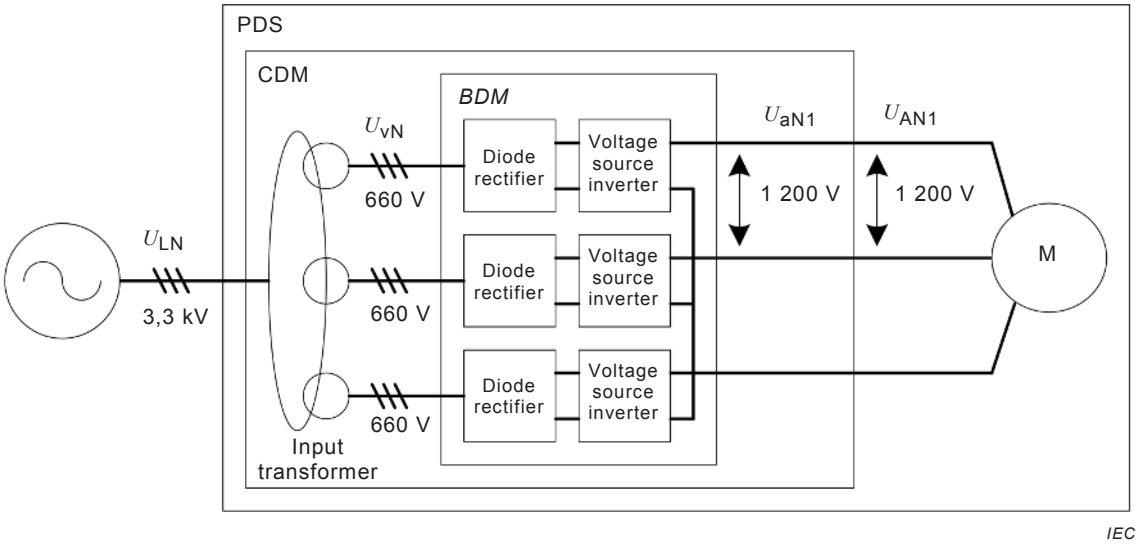


Figure A.9 – An example of high-voltage *PDS* with star-connected *inverter*s

A.3.7 *PDS* with a multilevel *inverter*

Figure A.10 shows an example of *PDS* with a multilevel *inverter* which has cascaded power modules and Figure A.11 shows an example of the power module.

The *rated input voltage* of each power module is 600 V a.c., and the equivalent *rated input voltage* of *BDM* is a sum of *rated input voltage*s of six power modules, i.e. $2 \times 3 \times 600$ V a.c. = 3 600 V a.c., because each one of two output lines of power modules A1, B1 and C1 is connected in common and six power modules can be connected in series by the power module operation. This *PDS* is classified into high-voltage system.

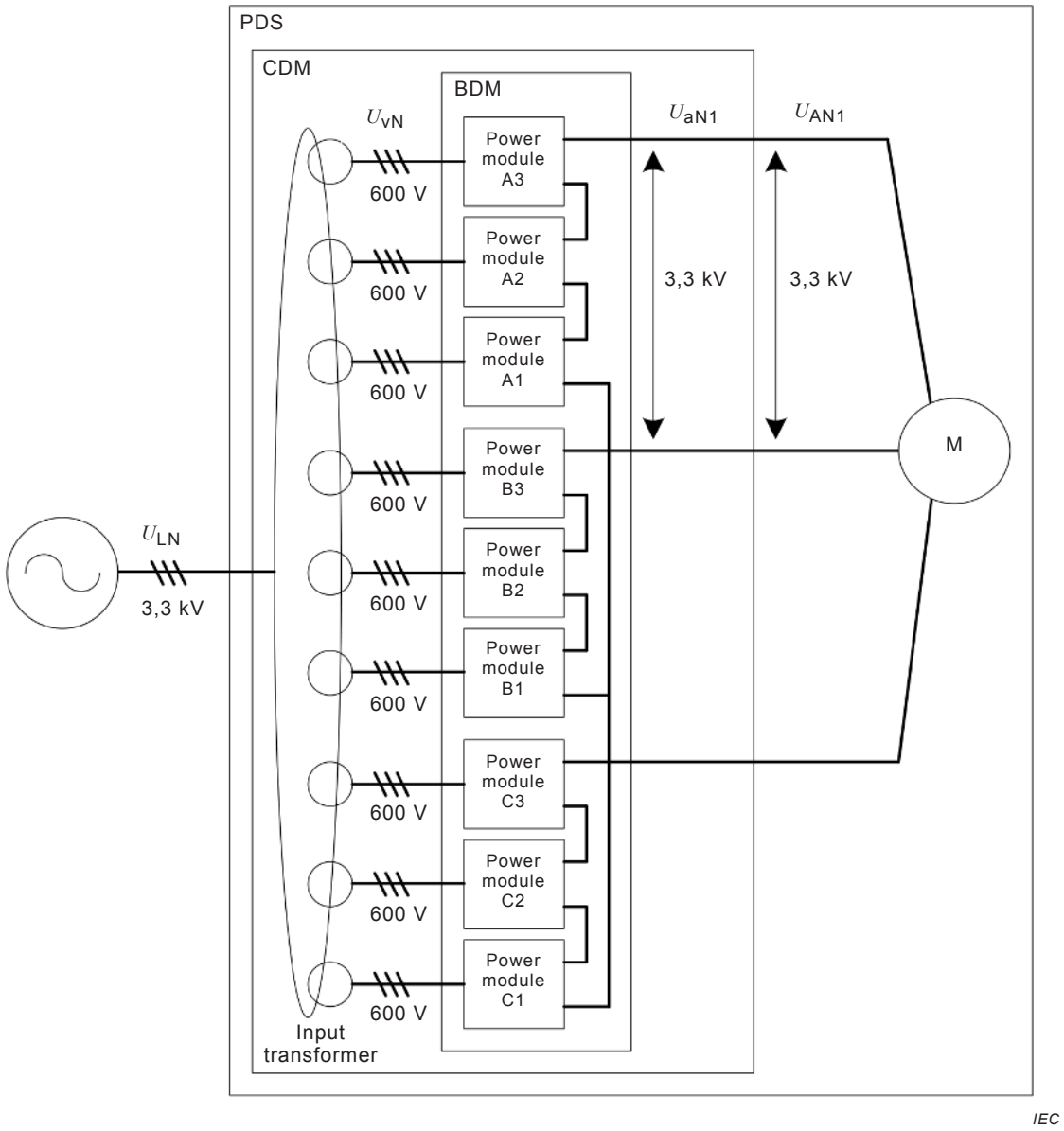


Figure A.10 – An example of high-voltage *PDS* with a multilevel *inverter*

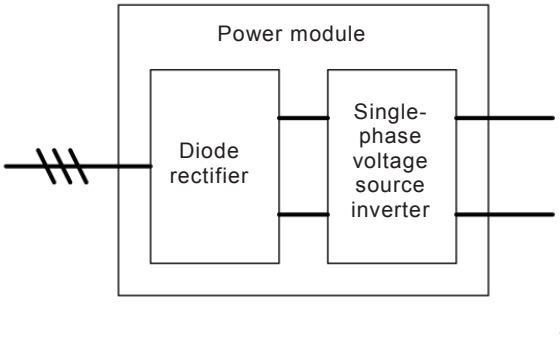


Figure A.11 – An example of a power module

Annex B
(informative)

Determination of the *input current* of *BDM/CDM/PDS*

This annex provides information about determination of the r.m.s. value of the steady state *input current* according to 4.3.2.2 and the load duty profile *input currents* according to 4.10.

The r.m.s. value of the *input current* I_{vN} of *BDM/CDM/PDS* has to be provided to the *system integrator* for dimensioning of the input wire and the upstream protection elements. The wave shape of the *input current* is non-sinusoidal depending on the topology of the *rectifier* and the source impedance of the supply. Figure B.1 shows an example of an *input current.*

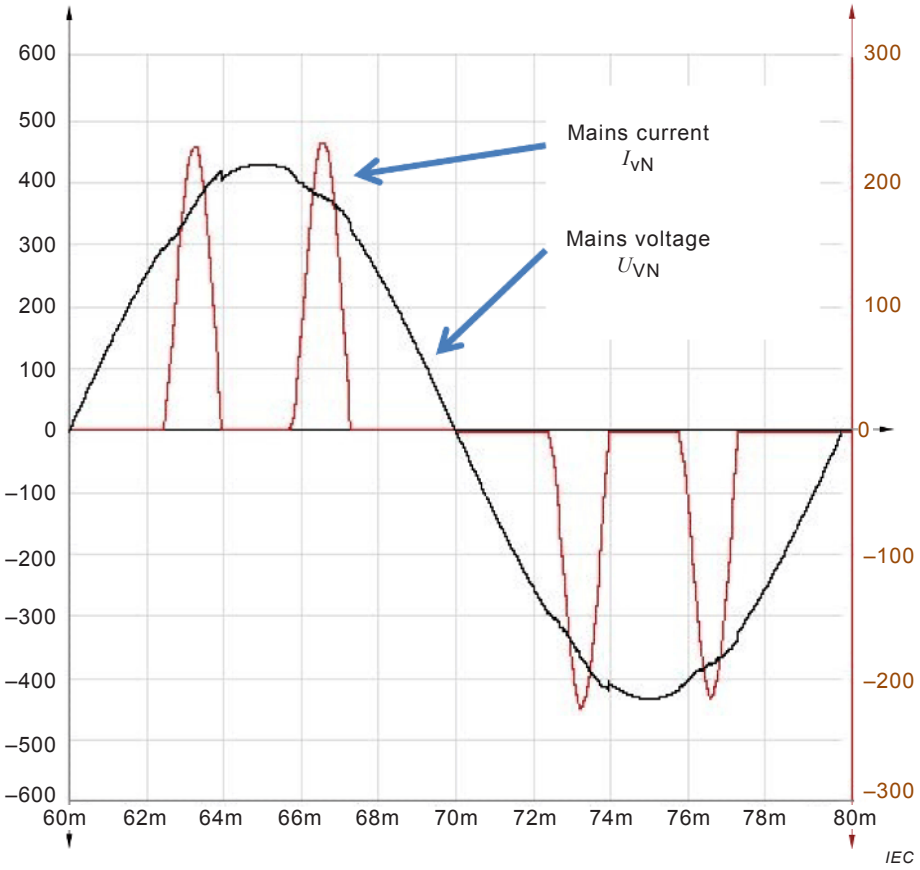


Figure B.1 – Example of distortion effect of the *input current* affected by a three-phase *converter* with capacitive load

Determination can be done by simulation, calculation or test taking into account following parameters.

- The *BDM/CDM/PDS* shall be equipped and installed to fulfil the requirement of IEC 61800-5-1 with respect to electrical safety.
- The *BDM/CDM/PDS* shall be equipped and installed according to *manufacturer's* specification with respect to electromagnetic compatibility.
- For *BDM/CDM/PDS* rated with multiple *input voltage*s, the *input voltage* shall be the lowest rated value.
- For *BDM/CDM/PDS* rated with multiple *input frequency*, the *input frequency* shall be within the specified range of the *BDM/CDM/PDS.*

- *Short circuit ratio* R_{SC} of the supply network to the *BDM/CDM/PDS* nominal current shall be in the range from 50 to 200 up to 90 kW and from 5 to 50 above 90 kW.

NOTE Simulation or calculation can be used to determine the highest value of the *input current* based on the measured value during the test considering the maximum or minimum *short circuit ratio* R_{SC}.

- Switching frequency and pulse pattern of the *BDM/CDM* shall be factory setting as defined by the *manufacturer* and are to be documented.
- Unless otherwise specified in case of *BDM/CDM* testing, the *BDM/CDM* shall be loaded with a *motor*
  - delivering the *rated output current* (I_{aN}/I_{AN}) of the *BDM/CDM* [A], or
  - delivering the *rated output power* (P_S) of the *motor* [kW] according to the specified *motor* type, or
  - delivering the *rated apparent output power* (S_{AN} *or* S_{aN}) of the *BDM/CDM* [kVA].
- Unless otherwise specified the *BDM/CDM/PDS* shall be measured with shielded *motor* cable having the maximum cable length according to *manufacturer's* specification.
- The tests can be done at any ambient temperature.
- If no suitable load is available extrapolation for the current is permitted in the range from nearly 80 % up to 100 %.
- Simulation or calculation is permitted to be used to determine the highest value of the *input current* based on the measured value during the test.

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