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**Adjustable speed electrical power drive systems –
Part 2: General requirements – Rating specifications for adjustable speed
AC power drive systems**

**Entraînements électriques de puissance à vitesse variable –
Partie 2: Exigences générales – Spécifications de dimensionnement pour
entraînements électriques de puissance à vitesse variable en courant alternatif**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –**Part 2: General requirements –
Rating specifications for adjustable
speed AC power drive systems**

FOREWORD

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International Standard IEC 61800-2 has been prepared by subcommittee 22G: Adjustable speed electric power drive systems (PDS), of IEC technical committee 22: Power electronic systems and equipment.

This third edition cancels and replaces the second edition published in 2015. This edition constitutes a technical revision.

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

- a) the requirements from IEC 61800-4 for high-voltage PDS are now merged with requirements from IEC 61800-2:2015, and IEC 61800-4:2002 will be withdrawn upon release of this document;
- b) Clause 1 has been updated to introduce the new concept of Clause 4;

- c) terms and definitions in Table 1 to Table 4 have been classified in logical order; classification in low voltage and high voltage has been considered in Table 5, and Figure 3 clarifies boundaries within *BDM/CDM/PDS*.
- d) Clause 4 is new and creates the methods for evaluating a product to this document;
- e) Clause 5 has been updated with respect to:
 - 1) specific content for high-voltage *BDM/CDM/PDS*;
 - 2) description of the basic topology for *BDM/CDM/PDS* (5.2);
 - 3) ratings and performance (5.3 and 5.4);
 - 4) 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), *power interface* voltage (IEC TS 61800-8), and ecodesign (IEC 61800-9 series) to avoid conflicting requirements (5.5, 5.6, 5.7, 5.10, 5.11, 5.12);
 - 5) update of requirement for ecodesign (5.8);
 - 6) update of requirement for environmental evaluation (5.9);
 - 7) implementation of requirement for explosive atmosphere (5.14);
- f) Clause 6 has been updated with test requirement in order to provide a clear link between design requirement and test requirement;
- g) Clause 7 has been updated to harmonize the marking and documentation requirement within IEC 61800 (all parts);
- h) existing Annex A and Annex B have been updated to include specific detail pertaining to *high voltage BDM/CDM/PDS*.

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

FDIS	Report on voting
22G/432/FDIS	22G/435/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 document, 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

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INTRODUCTION

0.1 General

This document is part of the IEC 61800 series specifying requirements for adjustable *speed electrical power drive systems (PDS)*. Since the publication of the second edition of IEC 61800-2, several documents of the IEC 61800 series 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 *PDSs* intended to feed AC *motors* and with rated *converter* input voltages (line-to-line voltage) up to 35 000 V AC.

PDSs intended to feed DC *motors* are covered by IEC 61800-1.

0.2 Consistency of requirement

This document specifies requirements for *PDSs* 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:

- DC *PDS* requirements are covered by IEC 61800-1;
- EMC requirements are covered by IEC 61800-3;
- general safety requirements are covered by IEC 61800-5-1;
- functional safety requirements are covered by IEC 61800-5-2;
- type of load duty guidance is covered by IEC TR 61800-6;
- interface and use of profiles requirements are covered by IEC 61800-7 (all parts);
- *power interface* voltage specification is covered by IEC TS 61800-8;
- ecodesign energy *efficiency* requirements of drive system are covered by IEC 61800-9 (all parts).

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, to avoid conflicting requirement within IEC 61800 (all parts) and to optimize future maintenance of the documents.

As part of the work inside SC 22G MT9, this document defines basic definitions used across the IEC 61800 series. For issues related to *active infeed converters*, IEC TS 62578 has been considered.

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 (all parts) has decreased dramatically.

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

This document provides a non-exhaustive list of requirements to aid in the development of a functional specification between responsible parties. Each topic should be individually specified by the *responsible party(ies)* as a compliance requirement where appropriate for the intended application. When the *manufacturer* is the only *responsible party*, for any reason, the *manufacturer* may choose to select the specific sections of this document which are relevant for the intended application.

BDM/CDM/PDS may be built into a final installation or imbedded into an extended product as a component. The following are example applications: 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*. The environmental conditions considered should include at least those defined in IEC 60721 (all parts) and EMC.

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 2: General requirements – Rating specifications for adjustable speed AC power drive systems

1 Scope

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

It applies to adjustable *speed* electric *power drive systems* intended to feed AC *motors* from a *BDM* or *CDM* connected to line-to-line voltages up to and including 35 kV AC 50 Hz or 60 Hz and/or voltages up to and including 1,5 kV DC input side.

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

This documents defines and describes a non-exhaustive list of criteria for the selection of *BDM/CDM/PDS* performance and functional attributes. This list is reviewed by the responsible parties to determine considerations for the design of device(s), equipment or system(s) with related testing specification. It also suggests a selection of performance and functional attributes for driven equipment and extended products. The performance and functional attributes focus on the following categories:

- principal parts topology and classification of the *PDS*;
- ratings, performance and functionality;
- 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*.

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

This document provides a non-exhaustive list from which minimum requirements can be used for the development of a specification between *customer* and *manufacturer* based on the application requirements. This same non-exhaustive list can be used by a *manufacturer* to determine the minimum requirements for a commoditised *BDM/CDM/PDS* without *customer* interaction based on the specified application of that *BDM/CDM/PDS*.

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 requirements are covered by IEC 61800-3;
- general safety requirements are covered by IEC 61800-5-1;
- functional safety requirements are covered by IEC 61800-5-2;
- type of load duty guidance is covered by IEC TR 61800-6;
- interface and use of profiles requirements are covered by IEC 61800-7 (all parts);
- power interface voltage specification is covered by IEC TS 61800-8;

- ecodesign energy efficiency requirements of drive system are covered by IEC 61800-9 (all parts).

2 Normative references

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

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

IEC 60038, *IEC standard voltages*

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

IEC 60050-113:2011, *International Electrotechnical Vocabulary (IEV) – Part 113: Physics for electrotechnology* (available at www.electropedia.org)

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

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

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

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

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

IEC 60068 (all parts), *Environmental testing*

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

IEC 60076 (all parts), *Power transformers*

IEC 60076-11, *Power transformers – Part 11: Dry-type transformers*

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 guidelines*

IEC 60721-3-0, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Introduction*

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

IEC 61800-5-2:2016, *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*

IEC TS 61800-8, *Adjustable speed electrical power drive systems – Part 8: Specification of voltage on the power interface*

IEC 61800-9-1, *Adjustable speed electrical power drive systems – Part 9-1: Ecodesign for power drive systems, motor starters, power electronics and their driven applications – General requirements for setting energy efficiency standards for power driven equipment using the extended product approach (EPA) and semi analytic model (SAM)*

IEC 61800-9-2, *Adjustable speed electrical power drive systems – Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their driven applications – Energy efficiency indicators for power drive systems and motor starters*

IEC TS 62578:2015, *Power electronics systems and equipment – Operation conditions and characteristics of active infeed converter (AIC) applications including design recommendations for their emission values below 150 kHz*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-112, IEC 60050-113, IEC 60050-114, 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.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

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Table 1 – List of general terms

3.4	basic drive module (BDM)	3.2	mains supply	3.96	type test
3.6	complete drive module (CDM)	3.51	port for process measurement and control	3.84	routine test
3.29	inverter	3.54	power interface	3.85	sample test
3.7	converter, <of the BDM>	3.88	signal interface	3.1	acceptance test
3.80	rectifier <of the BDM>	3.56	product packaging	3.97	witness test
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3.3	active infeed converter (AIC)	3.81	regeneration	3.89	special test
3.52	power drive system (PDS)			3.82	resolution
3.30	low-voltage BDM/CMD/PDS <for AC motor>	3.53	power factor (λ)	3.83	responsible party
3.16	high-voltage BDM/CMD/PDS <for AC motor>	3.94	total harmonic distortion (THD)	3.8	customer, <of the BDM/CDM/PDS>
3.28	integrated PDS	3.87	short circuit ratio (R_{SC})	3.14	end user
3.36	motor electric motor	3.12	efficiency <of the CDM>	3.31	manufacturer, <of the BDM/CDM/PDS>
3.27	installation	3.13	efficiency <of the PDS>	3.37	original equipment manufacturer (OEM)
3.50	port	3.46	output overload capability	3.92	system integrator
3.55	power port	3.91	stimulus		

NOTE This document contains the fundamental definitions used across IEC 61800 (all parts) 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*

3.21	input current <BDM> (I_v)	3.66	rated input voltage <CDM/PDS> (U_{LN})	3.58	rated input active power <CDM/PDS> (P_{LN})
3.61	rated input current <BDM> (I_{vN})	3.17	input active power <BDM> (P_v)	3.60	rated input apparent power <CDM/PDS> (S_{LN})
3.22	input current <CDM/PDS> (I_L)	3.19	input apparent power <BDM> (S_v)	3.23	input frequency <BDM> (f_v)
3.62	rated input current <CDM/PDS> (I_{LN})	3.18	input active power <CDM/PDS> (P_L)	3.63	rated input frequency <BDM> (f_{vN})
3.25	input voltage <BDM> (U_v)	3.20	input apparent power <CDM/PDS> (S_L)	3.24	input frequency <CDM/PDS> (f_L)
3.65	rated input voltage <BDM> (U_{vN})	3.57	rated input active power <BDM> (P_{vN})	3.64	rated input frequency <CDM/PDS> (f_{LN})
3.26	input voltage <CDM/PDS> (U_L)	3.59	rated input apparent power <BDM> (S_{vN})		

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

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

3.42	output current <BDM> (I_a)	3.38	Output active power <BDM> (P_a)	3.41	output apparent power <CDM> (S_a)
3.71	rated output current <BDM> (I_{aN})	3.67	rated output active power <BDM> (P_{aN})	3.70	rated output apparent power <CDM> (S_{AN})
3.43	output current <CDM> (I_A)	3.39	output active power <CDM> (P_A)	3.44	output frequency <BDM> (f_a)
3.72	rated output current <CDM> (I_{AN})	3.68	rated output active power <CDM> (P_{AN})	3.73	rated output frequency <BDM> (f_{aN})
3.48	output voltage <BDM> (U_{a1})	3.47	output power <PDS> (P_s)	3.45	output frequency <CDM> (f_A)
3.76	rated output voltage <BDM> (U_{aN1})	3.75	rated output power <PDS> (P_{sN})	3.74	rated output frequency <CDM> (f_{AN})
3.49	output voltage <CDM> (U_{A1})	3.40	output apparent power <BDM> (S_a)	3.46	output overload capability
3.77	rated output voltage <CDM> (U_{AN1})	3.69	rated output apparent power <BDM> (S_{aN})		

NOTE Subscripts follow the concept of IEC 60146-1-1

Table 4 – List of *motor speed and torque ratings*

3.95	two quadrant operation ^b	3.35	minimum speed <of a motor> (N_{Min})	3.93	torque <of a motor> (M)
3.15	four quadrant operation ^b	3.34	minimum rated speed <of a motor> (N_{NMin})	3.79	rated torque <of a motor> (M_N)
3.90	speed <of a motor> (N)	3.32	maximum rated safe speed <of a motor> (N_{SNMax})	3.9	DC braking
3.78	rated speed <of a motor> (N_N)	3.33	maximum rated speed <of a motor> (N_{NMax})	3.11	dynamic braking

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

NOTE 2 See also Figure 10, 5.3.3.2.

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" has been replaced by the word "device".]

3.2

mains supply

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

SEE Figure 3.

3.3

active infeed converter

AIC

self-commutated power electronic *converter* which can convert electric power in both directions and which can control the reactive power or the *power factor*

Note 1 to entry: An active infeed *converter* can be of any technology, topology, voltage and size containing either current or voltage source DC side which work in generation and regeneration.

Note 2 to entry: Some of them can additionally control the harmonics to reduce the distortion of an applied voltage or current.

Note 3 to entry: Basic topologies may be realized as a Voltage Source *Converter* (VSC) or a Current Source *Converter* (CSC).

Note 4 to entry: In IEC 60050-551, these terms (VSC and CSC) are defined as voltage stiff AC / DC *converter* [551-12-03] and current stiff AC / DC *converter* [551-12-04]. Most of the AICs are bi-directional *converters* and have sources on the DC side

Note 5 to entry: In some literature *active infeed converters* are also known as active front end (AFE) *converters*.

[SOURCE: IEC TS 62578:2015, 3.5, modified – Some words in the definition have been moved to Note 1 to entry.]

3.4

basic drive module

BDM

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

SEE Figure 3.

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.

3.5

commissioning test

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

[SOURCE: IEC 60050-411:1996, 411-53-06, modified – The word "machine" has been replaced by "device".]

3.6

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

SEE Figure 3.

3.7

converter

<of the *BDM*> unit which changes the form of electrical power supplied from the *mains supply* to the form required by the *motor(s)* by changing one or more of the following; voltage, current and/or frequency

SEE Figure 3.

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*.

3.8

customer

<of the *BDM/CDM/PDS*> *original equipment manufacturer (OEM)*, *system integrator* or *end user* specifying and purchasing a *BDM/CDM/PDS* from the *BDM/CDM/PDS manufacturer*

See Figure 1.

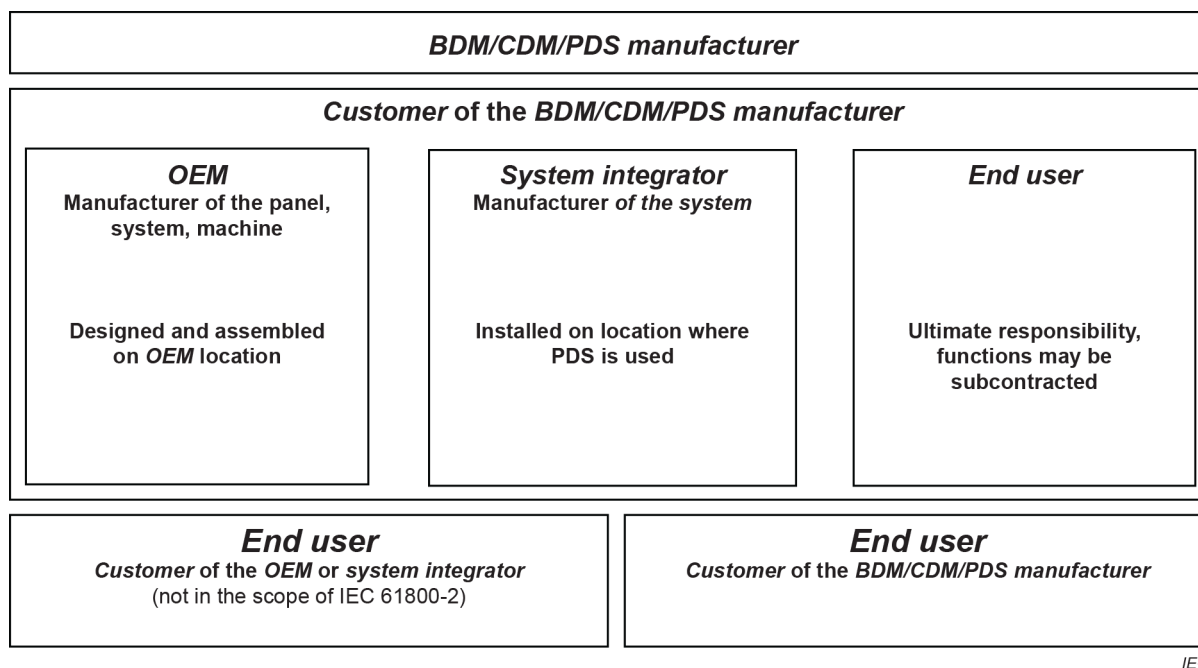


Figure 1 – BDM/CDM/PDS manufacturer/customer relationship

3.9

DC braking

process of converting the rotational energy of the load to electrical energy dissipated in the rotor by injection of DC current into the stator

3.10

DC link

power DC circuit linking the input *converter* and the output *converter* of an indirect *converter*, consisting of capacitors and/or reactors to reduce DC voltage ripple or DC current ripple

See Figure 3.

3.11

dynamic braking

method used to transfer energy generated when the load controlled by a PDS is slowed or stopped

Note 1 to entry: *Dynamic braking* includes resistive braking, regenerative braking, etc.

3.12

efficiency

<of the CDM> ratio of the total electrical power at the CDM power interface of the motor terminals to the total power at the mains supply port

Note 1 to entry: See feeding line in Figure 3.

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

Note 3 to entry: IEC 61800-9-1 and IEC 61800-9-2 define power losses of the CDM and PDS. This document will change in the next edition to consider only power losses for the BDM/CDM/PDS, not efficiency. IEC 61800-9-1 and IEC 61800-9-2 should be used for power losses consideration of CDM/PDS. Because the BDM is a portion of the CDM, it is correct to calculate power losses for the BDM as well.

3.13

efficiency

<of the PDS> ratio of the mechanical power at the motor shaft to the total electrical power at the mains supply port

Note 1 to entry: See feeding line in Figure 3.

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

Note 3 to entry: IEC 61800-9-1 and IEC 61800-9-2 define power losses of the *CDM* and *PDS*. This standard will change in the next edition to consider only power losses for the *BDM/CDM/PDS*, not efficiency. IEC 61800-9-1 and IEC 61800-9-2 should be used for power losses consideration of *CDM/PDS*. Because the *BDM* is a portion of the *CDM*, it is correct to calculate power losses for the *BDM* as well.

3.14

end user

entity who has ultimate responsibility for the *installation*, operation and maintenance of the *PDS*

SEE Figure 1.

3.15

four quadrant operation

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

See Figure 2.

Note 1 to entry: *Four quadrant operation* involves operation in quadrants I, II, III and IV as shown in Figure 2.

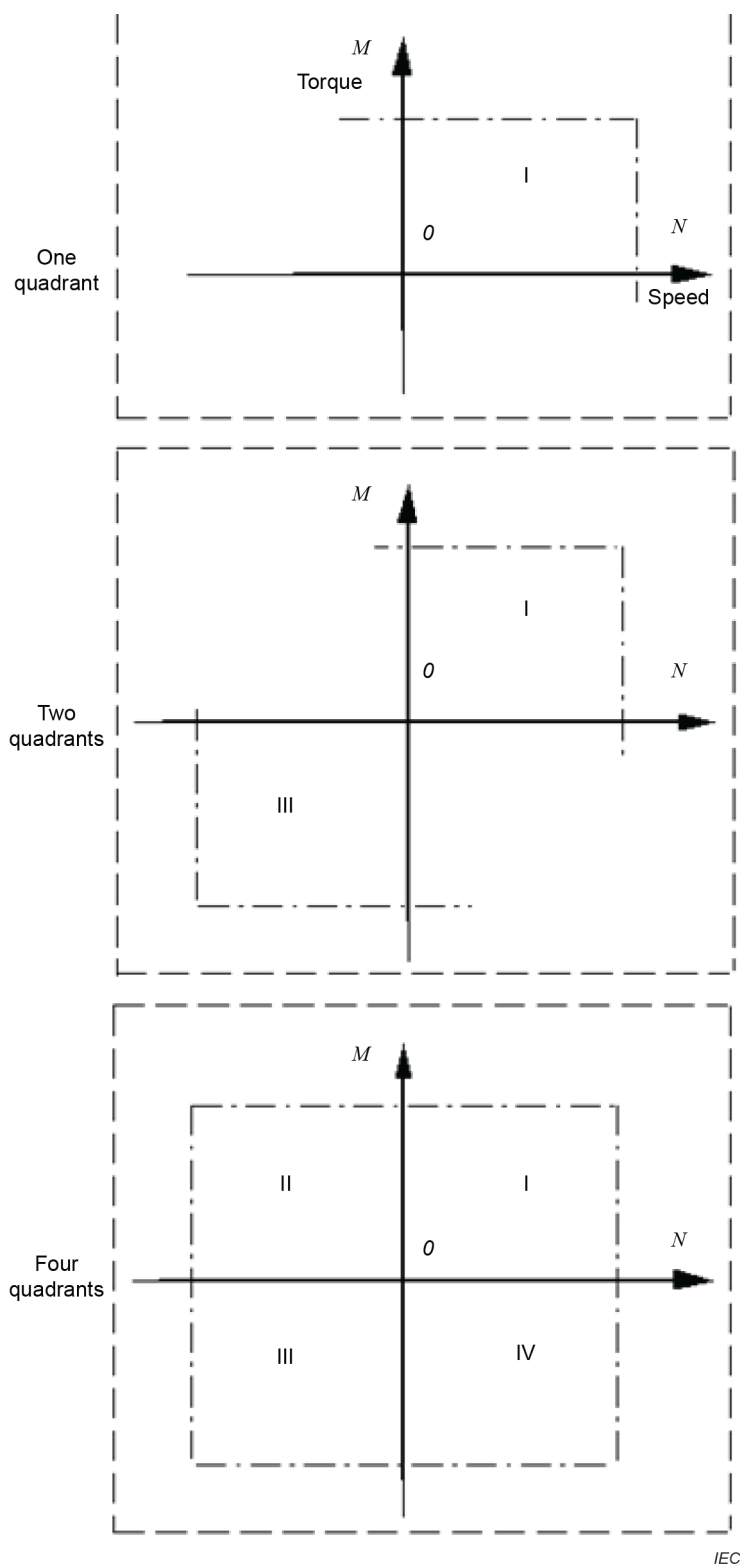


Figure 2 – Operating quadrants

3.16

high-voltage BDM/CDM/PDS

<for AC motor> basic drive module/complete drive module/power drive system having a port voltage above 1 kV AC 50 Hz or 60 Hz or above 1,5 kV DC

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

Note 2 to entry: See Table 5 for explanation.

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

Note 4 to entry: In the United States, the voltage range of the scope of this document is considered medium voltage.

Note 5 to entry: The term "high voltage" is abbreviated HV.

Table 5 – Basic classification of PDS by voltage

BDM/CDM voltage ratings		Classification of PDS by voltage
Input U_{vN}/U_{LN}	Output U_{aN1}/U_{AN1}	
Low-voltage	Low-voltage	Low-voltage
Low-voltage	High-voltage	High-voltage
High-voltage	Low-voltage	High-voltage
High-voltage	High-voltage	High-voltage

3.17

input active power

P_v

<BDM> power determined by the fundamental components of voltage and current at the supply terminals of the *BDM*

3.18

input active power

P_L

<CDM/PDS> power determined by the fundamental components of voltage and current at the supply terminals of the *CDM/PDS*

3.19

input apparent power

S_v

<BDM> power determined by the RMS values of voltage and current at the supply terminals of the *BDM*

3.20

input apparent power

S_L

<CDM/PDS> power determined by the RMS values of voltage and current at the supply terminals of *CDM/PDS*

3.21

input current

I_v

<BDM> RMS value of current at the supply terminals of the *BDM*

3.22

input current

I_L

<CDM/PDS> RMS value of current at the supply terminals of the *CDM/PDS*

3.23 input frequency

f_v

<*BDM*> frequency of the power input to the *BDM*

3.24 input frequency

f_L

<*CDM/PDS*> frequency of the power input to the *CDM/PDS*

3.25 input voltage

U_v

<*BDM*> RMS input line-to-line voltage at the supply terminals of the *BDM*

3.26 input voltage

U_L

<*CDM/PDS*> RMS input line-to-line voltage at the supply terminals of the *CDM/PDS*

3.27 installation

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

See Figure 3.

Note 1 to entry: The words "act of installing" are used in this document to denote the process of installing a *PDS*.

[SOURCE: IEC 60050-151:2001, 151-11-26, modified – The reference to Figure 3 has been added, as well as Note 1 to entry.]

3.28 integrated PDS

power drive system where *motor* and *BDM/CDM* are combined into a single unit

3.29 inverter

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

See Figure 3.

[SOURCE: IEC 60050-151:2001, 151-13-46]

3.30 low-voltage BDM/CDM/PDS

<for AC *motor*> *basic drive module/complete drive module/power drive system* having a port voltage less than or equal to 1 kV AC 50 Hz or 60 Hz or 1,5 kV DC

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

Note 2 to entry: The term "low-voltage" is abbreviated LV.

3.31 manufacturer

<of the *BDM/CDM/PDS*> entity which designs and builds all or part of a *BDM/CDM/PDS*

SEE Figure 1.

3.32

maximum rated safe speed

N_{SNMax}

<of a *motor*> 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 10 and 5.3.3.2.

3.33

maximum rated speed

N_{NMax}

<of a *motor*> 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 10 and 5.3.3.2.

3.34

minimum rated speed

N_{NMin}

<of a *motor*> 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 10 and 5.3.3.2.

3.35

minimum speed

N_{Min}

<of a *motor*> 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 10 and 5.3.3.2.

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

3.36

motor

electric motor

electric machine intended to transform electric energy into mechanical energy

SEE Figure 3.

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

3.37

original equipment manufacturer

OEM

entity which designs and manufactures series of machines, panels or systems incorporating one or more *PDSs*

SEE Figure 1.

3.38

output active power

P_a

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

3.39

output active power

P_A

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

3.40

output apparent power

S_a

<BDM> power determined by the RMS values of voltage and current at the *motor* side of the *BDM*

3.41

output apparent power

S_A

<CDM> power determined by the RMS values of voltage and current at the *motor* side of the *CDM*

3.42

output current

I_a

<BDM> RMS value of the current at the *motor* side of the *BDM*

3.43

output current

I_A

<CDM> RMS value of the current at the *motor* side of the *CDM*

3.44

output frequency

f_a

<BDM> 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*.

3.45

output frequency

f_A

<CDM> 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*.

3.46

output overload capability

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

3.47

output power

P_s

<PDS> (mechanical) power of the *PDS* determined by the *torque* and *speed* at the *motor shaft*

3.48
output voltage U_{a1}

<BDM> RMS value of the rated fundamental voltage at the *motor* side of the *BDM*

3.49
output voltage U_{A1}

<CDM> RMS value of the rated fundamental voltage at the *motor* side of the *CDM*

3.50
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

3.51
port for process measurement and control

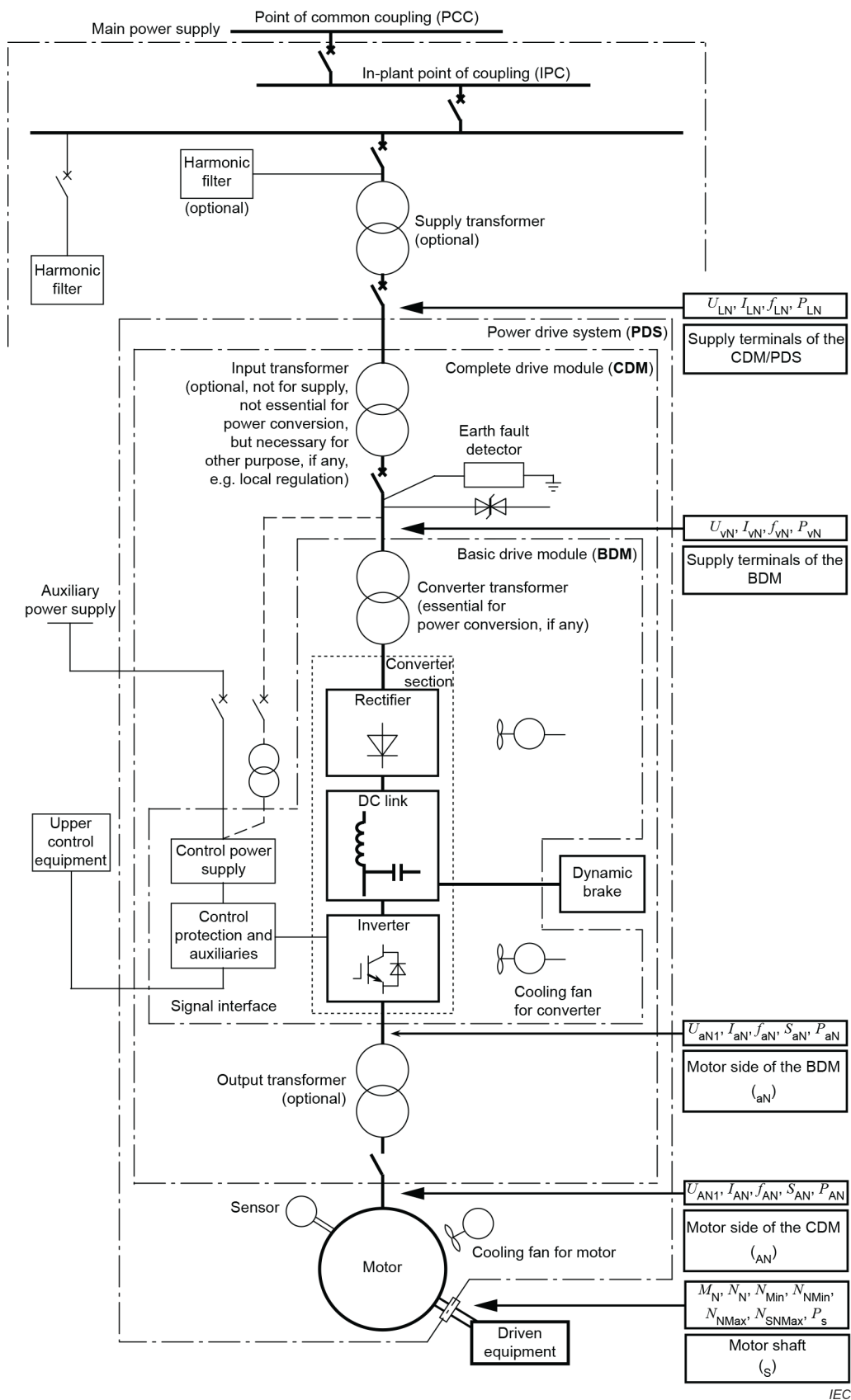
input/output (I/O) *port* for conductor or cable which connects the process to the *PDS*

3.52
power drive system
PDS

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

SEE Figure 3.

Note 1 to entry: Any sensors which are mechanically coupled to the *motor* shaft are also part of the *PDS*; however, the driven equipment is not included.



IEC

Figure 3 – Example of a power drive system

3.53 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 – The note to entry has been deleted.]

3.54 power interface

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

3.55 power port

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

3.56 product packaging

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

3.57 rated input active power

P_{VN}

<*BDM*> rated power determined by the fundamental components of voltage and current at the supply terminals of the *BDM*

3.58 rated input active power

P_{LN}

<*CDM/PDS*> rated power determined by the fundamental components of voltage and current at the supply terminals of the *CDM/PDS*

3.59 rated input apparent power

S_{VN}

<*BDM*> rated power determined by the RMS values of voltage and current at the supply terminals of the *BDM*

3.60 rated input apparent power

S_{LN}

<*CDM/PDS*> rated power determined by the RMS values of voltage and current at the supply terminals of the *CDM/PDS*

3.61 rated input current

I_{VN}

<*BDM*> maximum RMS value of current at the supply terminals of the *BDM* 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, for example line voltage and frequency deviations.

3.62
rated input current I_{LN}

<CDM/PDS> maximum RMS value of current at the supply terminals of the *CDM/PDS* 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, for example line voltage and frequency deviations.

3.63
rated input frequency f_{VN}

<BDM> rated value of the frequency at the supply terminals of the *BDM*

3.64
rated input frequency f_{LN}

<CDM/PDS> rated value of the frequency at the supply terminals of the *CDM/PDS*

3.65
rated input voltage U_{VN}

<BDM> RMS value of the rated input line-to-line voltage at the supply terminals of the *BDM*

3.66
rated input voltage U_{LN}

<CDM/PDS> RMS value of the rated input line-to-line voltage at the supply terminals of the *CDM/PDS*

3.67
rated output active power P_{aN}

<BDM> rated power determined by the fundamental components of voltage and current at the *motor* side of the *BDM*

3.68
rated output active power P_{AN}

<CDM> rated power determined by the fundamental components of voltage and current at the *motor* side of the *CDM*

3.69
rated output apparent power S_{aN}

<BDM> rated power determined by the RMS values of voltage and current at the *motor* side of the *BDM*

3.70
rated output apparent power S_{AN}

<CDM> rated power determined by the RMS values of voltage and current at the *motor* side of the *CDM*

3.71**rated output current** I_{aN}

<*BDM*> maximum RMS value of the current at the *motor* side of the *BDM* which can be supplied continuously without exceeding established limitations, under rated operating conditions

3.72**rated output current** I_{AN}

<*CDM*> maximum RMS value of the current at the *motor* side of the *CDM* which can be supplied continuously without exceeding established limitations, under rated operating conditions

3.73**rated output frequency** f_{aN}

<*BDM*> range of fundamental frequency at the *motor* side of the *BDM*

3.74**rated output frequency** f_{AN}

<*CDM*> range of fundamental frequency at the *motor* side of the *CDM*

3.75**rated output power** P_{sN}

<*PDS*> rated (mechanical) power of the *PDS* determined by the *torque* and *speed* at the *motor* shaft

3.76**rated output voltage** U_{aN1}

<*BDM*> RMS value of the rated fundamental voltage at the *motor* side of the *BDM*

3.77**rated output voltage** U_{AN1}

<*CDM*> RMS value of the rated fundamental voltage at the *motor* side of the *CDM*

3.78**rated speed** N_N

<of a *motor*> 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 10 and 5.3.3.2.

3.79**rated torque** M_N

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

[SOURCE: IEC 60050-411:1996, 411-48-05, modified – The symbol " M_N " has been added, as well as the word "power" and the domain.]

3.80

rectifier

<of the *BDM*> electric energy *converter* that changes single-phase or polyphase alternating electric currents to unidirectional current

See Figure 3.

[SOURCE: IEC 60050-151:2001, 151-13-45, modified – The domain and the reference to Figure 3 have been added.]

3.81

regeneration

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

3.82

resolution

minimum obtainable variation of the controlled variable

Note 1 to entry: It may be represented by an absolute value or a percentage of the maximum value.

3.83

responsible party

supplier, *manufacturer*, *OEM*, *system integrator*, *end user*, or *customer* of *BDM*, *CDM*, *electric motor*, *PDS*, driven equipment or extended product

3.84

routine test

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

[SOURCE: IEC 60050-411:1996, 411-53-02, modified – The word "machine" has been replaced by "device".]

3.85

sample test

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

[SOURCE: IEC 60050-411:1996, 411-53-05, modified – The word "sampling" has been replaced by "sample" in the term. The word "machines" has been replaced by "devices".]

3.86

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.

3.87

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*

3.88

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*

3.89**special test**

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

3.90**speed** N

<of a *motor*> rotational velocity of the *motor*

Note 1 to entry: See IEC 60050-811:1991, 811.13.03.

3.91**stimulus**

change, variation or fluctuation of parameter which may cause deviation of performance or behaviour of the *PDS*

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

3.92**system integrator**

entity with responsibility to design the complete system of the application incorporating one or more *PDSs*

SEE Figure 1.

3.93**torque** M

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

Note 1 to entry: This definition has been adapted from the note of IEC 60050-113:2011, 113.03.26.

3.94**total harmonic distortion****THD**

ratio of the RMS value of the harmonic content of an alternating quantity to the RMS value of the fundamental component of the quantity

[SOURCE: IEC 60050-551:2001, 551-20-13, modified – The definition has been rephrased and the notes to entry removed.]

3.95**two quadrant operation**

converter operation of a machine as a *motor* operation in either direction of machine rotation

Note 1 to entry: Two quadrant operation involves operation in quadrants I and III as shown in Figure 2.

3.96**type test**

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

[SOURCE: IEC 60050-411:1996, 411-53-01, modified – The word "machines" has been replaced by "devices".]

3.97

witness test

tests performed in the presence of the *customer* or the representative of the *customer*

4 Guidance for specification of BDM/CDM/PDS and methodologies for compliance

4.1 General

This document provides a non-exhaustive list of requirements for performance, ratings or functionality to aid in the development of a functional specification between responsible parties. Each topic should be individually specified by the responsible party(ies) as a compliance requirement where appropriate for the intended application. When the *manufacturer* is the only *responsible party*, for any reason, the *manufacturer* may choose to select the specific sections of this document which are relevant for the intended application.

A list of performance, ratings and functionalities for consideration is provided in Table 6. This table contains all topics addressed by this document. The topics covered by this document and in the Performance/functionality requirement column may not be sufficient for the specific application under consideration and are provided as guidance. The columns for Responsible party and all suggestions underneath those headings are intended to encourage consideration of the related topics. They do not provide a definitive or exclusive answer of responsibility for a topic and are provided as guidance and not a rule. Absence of a suggestion under the Responsible party column does not imply the topic is never applicable, nor does the selection of a topic under the Responsible party imply it is applicable in all cases. The Subclause requirement/test specification columns are provided to link to the topics throughout the document, to provide guidance, but not to define absolute requirements. Information contained within the complete table is not intended to be exhaustive. There may be additional items of performance/rating/functionality, responsible parties, requirements and testing not defined within this document. If an application needs an additional requirement, it should be added to a working copy of this table as a new row; all information for this requirement shall be added, and then the requirement shall be addressed in accordance with 4.2.

4.2 Methodology for compliance

4.2.1 Agreement between *customer* and *manufacturer*

The *customer* is required to provide a detailed specification of the requirements of the application. This specification may or may not directly correlate with the contents of this document.

- A list of performance, ratings and functionalities for consideration is provided in Table 6. The *customer* and the *manufacturer* shall develop a list of requirements derived from Table 6 and other *customer* defined requirements appropriate for the application. This should be used as the basis for a contract. Consideration shall be given to the fact that the responsible parties may select some or all topics of this list as required by the application.
- The responsible parties may add supplementary requirements to this list if a mutual agreement is in place based on the requirement of the application.

In either case, it is the responsibility of the *manufacturer* to:

- define the test procedure, simulation, model, design specific solution, or other method used to create evidence that the means used is capable of proving the performance and/or functionality requirement of the item being validated in this manner;
- provide evidence of test, if required by the *customer*, proving the performance and/or functionality of the item.

All useful information should be made available by both parties.

NOTE This document makes no suggestion on how to build an agreement between the manufacturer and the customer.

4.2.2 Methodology to state compliance without *customer* input

The *manufacturer* is required to create a detailed specification of the requirements of the application.

A list of performance, ratings and functionalities for consideration is provided in Table 6. The *manufacturer* shall determine the required items from this list, based on the application requirements and *manufacturer's* specifications. The resulting list shall become the basis of the statement of compliance. Consideration shall be given to the following:

- it is permissible to select some or all portions of this list as required by the application.
- it is permissible to add supplementary requirements to this list based on the requirement of the application.

In either case, it is the responsibility of the *manufacturer* to perform the following.

- Define the test procedure, simulation, model, design specific solution, or other method used to create evidence that the means used is capable of proving the performance and/or functionality requirement of the item being validated in this manner. There is no requirement to communicate this information.
- Maintain evidence of test, proving the performance and/or functionality of the item. There is no requirement to communicate this information.
- Provide detail of the functions and/or performance item in their product documentation. This is required to help customers in the selection of the product (see Clause 7).
- Produce evidence of test method and test execution upon request prior to purchase of equipment. The *manufacturer* is required to determine what information is required.

NOTE Evidence could be the selected list of application specific requirements created during the process, with verification of completion of each requirement, signed to validate that the requirements are met.

Table 6 – Selection of equipment rating, performance, functionality by responsible parties with corresponding test specification

Performance/ functionality requirement	Responsible party										Subclause requirement/ test specification	Type test	Routine test	Sample test
	End user	Transformer supplier	Reactor supplier	Filter supplier	BDM supplier	CDM supplier	Motor supplier	System integrator (PDS supplier)	Driven equipment supplier	Extended product supplier				
Application specification	X				X	X		X			4.2.1; 4.2.2/ 6.1	X		
Visual inspection	X	X	X	X	X	X	X	X	X	X	6.6.1	X	X	X
Cooling system redundancy		X	X	X	X	X	X		X		5.2.4.1	X		
Air filtering		X	X	X	X	X	X		X		5.2.4.2	X		
Input ratings		X	X	X	X	X	X				5.3.2; 5.3.2.1 /6.6.3	X		
Input voltage		X	X	X	X	X	X				5.3.2.2 / 6.6.3.1	X		
Input frequency		X	X	X	X	X	X				5.3.2.2/ 6.6.3.1	X		
Input current		X	X	X	X	X	X				5.3.2.3 / 6.6.3.1	X		
Harmonic current					X	X	X	X			5.3.2.3 / 6.6.3.4.4	X		
Harmonic current HV (category 4)					X	X	X	X			5.3.2.3/ 6.6.3.4.4	X		
SCPD					X	X	X	X			5.3.2.4	X		
Output ratings		X	X	X	X	X	X	X			5.3.3 / 6.6.3.5	X		
BDM/CDM continuous output rating					X	X					5.3.3.1/ 6.6.3.1	X		
Harmonic current					X	X		X			5.3.3.1/ 6.6.3.1	X		
Harmonic voltage					X	X		X			5.3.3.1/ 6.6.3.1	X		
PDS continuous operation								X			5.3.3.2/ 6.6.3.1, 6.6.3.5.3	X		
Overcurrent								X			5.3.3.3/ 6.6.3.5.5	X		
Torque								X			5.3.3.3/ 6.6.3.5.3	X		
Overtorque								X			5.3.3.3/ 6.6.3.5.5	X		
Duty cycle derating	X								X	X	5.3.3.3/ 6.6.3.5.5	X		
Repetitive load duty	X								X	X	5.3.3.3/ 6.6.3.5.5	X		
Continuous duty	X								X	X	5.3.3.3/ 6.6.3.5.5	X		

Performance/ functionality requirement	Responsible party										Subclause requirement/ test specification	Type test	Routine test	Sample test
	End user	Transformer supplier	Reactor supplier	Filter supplier	BDM supplier	CDM supplier	Motor supplier	System integrator (PDS supplier)	Driven equipment supplier	Extended product supplier				
Operating quadrants					X	X					5.3.4/ 6.6.3.5.6	X		
Operation in II and IV quadrant input and output ratings					X	X					5.3.4.2/ 6.6.3.5.6	X		
Control equipment rating					X	X		X	X	X	5.3.5 / 6.6.3.6	X		
Special ratings		X	X	X	X	X	X	X	X	X	5.3.6, 5.3.6.1; 6.6.3.7	X		
Special ratings transformer		X	X	X	X	X		X		X	5.3.6.2	X		
Transformer rating		X	X	X	X	X		X		X	5.3.6.2.1	X		
Core losses due to voltage harmonics		X	X	X	X	X		X		X	5.3.6.2.1	X		
Stray losses due to current		X	X	X	X	X		X		X	5.3.6.2.1	X		
Voltage waveform characteristics		X	X	X	X	X		X		X	5.3.6.2.1	X		
Compliance with product relevant standard		X	X	X							5.3.6.2.1	X		
Transformer load and overload ratings		X	X	X							5.3.6.2.1	X		
Harmonic voltage and current		X	X	X				X			5.3.6.2.3.1	X		
Transformer winding insulation stress		X	X	X				X			5.3.6.2.3.1	X		
Winding arrangement		X	X	X							5.3.6.2.3.2	X		
Phase offset requirements		X									5.3.6.2.3.3	X		
Rating plate requirements		X	X	X							5.3.6.2.3.4	X		
Ambient temperature		X	X	X							5.3.6.2.3.5	X		
Impedance		X	X	X							5.3.6.2.4.1	X		
Commutating reactance		X	X	X							5.3.6.2.4.2	X		
Impedance with self-commutated <i>converters</i>		X	X	X							5.3.6.2.4.3	X		
Common mode and DC voltages		X	X	X							5.3.6.2.5	X		
Cooling systems		X	X	X							5.3.6.2.6.1	X		
Voltage accuracy		X	X	X							5.3.6.2.6.2	X		
Parallel connection of bridges		X	X	X							5.3.6.2.6.3	X		
Shielding between primary and secondary wiring		X	X	X							5.3.6.2.6.4	X		
Short-circuit requirements		X	X	X							5.3.6.2.6.5	X		

Performance/ functionality requirement	Responsible party										Subclause requirement/ test specification	Type test	Routine test	Sample test
	End user	Transformer supplier	Reactor supplier	Filter supplier	BDM supplier	CDM supplier	Motor supplier	System integrator (PDS supplier)	Driven equipment supplier	Extended product supplier				
Oversvoltage limitation		X	X	X							5.3.6.2.7	X		
Special ratings – Motor							X	X		X	5.3.6.3	X		
Design requirements							X	X		X	5.3.6.3.2	X		
Performance requirements							X	X		X	5.3.6.3.3.1	X		
Input ratings							X	X		X	5.3.6.3.3.2	X		
Output ratings							X	X		X	5.3.6.3.3.1 5.3.6.3.3.3	X		
Protection against shaft voltage and current							X	X		X	5.3.6.3.4.1	X		
Vibration and lateral resonance							X	X		X	5.3.6.3.4.2/ 6.6.3.8.2	X		
<i>Torque</i> pulsations and torsion considerations							X	X		X	5.3.6.3.4.3	X		
Voltage stress of the motor winding insulation system							X	X		X	5.3.6.3.5.1, 5.3.6.3.5.2/ 6.6.3.8.5	X		
Functional evaluation of motor winding insulation systems							X	X		X	5.3.6.3.5.4	X		
Designation of essential data							X	X		X	5.3.6.3.6	X		
Bearing currents							X	X		X	5.3.6.3.7/ 6.6.3.8.4	X		
Performance											5.4	X		
Features					X	X	X	X		X	5.4.1.1	X		
Steady state performance					X	X	X	X		X	5.4.1.2.1/ 6.6.3.9	X		
Selection of deviation band					X	X	X	X		X	5.4.1.2.3	X		
Service deviation band – Limits					X	X	X	X		X	5.4.1.2.4	X		
Operating deviation band – Limits					X	X	X	X		X	5.4.1.2.5	X		
Dynamic performance					X	X	X	X		X	5.4.1.3.1/ 6.6.3.10.2; 6.6.3.10.3; 6.6.3.10.4; 6.6.3.10.5;	X		
Time response					X	X	X	X		X	5.4.1.3.2.1	X		
Response time					X	X	X	X		X	5.4.1.3.2.2	X		
Rise time					X	X	X	X		X	5.4.1.3.2.3	X		
Settling time					X	X	X	X		X	5.4.1.3.2.4	X		
Control bandwidth					X	X	X	X		X	5.4.1.3.3.2	X		
Dynamic braking					X	X	X	X		X	5.4.1.4	X		

Performance/ functionality requirement	Responsible party										Subclause requirement/ test specification	Type test	Routine test	Sample test
	End user	Transformer supplier	Reactor supplier	Filter supplier	BDM supplier	CDM supplier	Motor supplier	System integrator (PDS supplier)	Driven equipment supplier	Extended product supplier				
Application requirements					X	X	X	X		X	5.4.1.5.1	X		
Supply connection requirements					X	X	X	X		X	5.4.1.5.2	X		
Rating requirements					X	X	X	X		X	5.4.1.5.3	X		
Fault supervision					X	X	X	X		X	5.4.2	X		
BDM/CDM/PDS protection interface					X	X	X	X		X	5.4.2	X		
Minimum status indication required					X	X	X	X		X	5.4.3	X		
I/O devices					X	X	X	X		X	5.4.4.1	X		
Process control interface/port					X	X	X	X		X	5.4.4.2.1	X		
Analog input					X	X	X	X		X	5.4.4.2.2	X		
Analog output					X	X	X	X		X	5.4.4.2.3	X		
Digital input					X	X	X	X		X	5.4.4.2.4	X		
Digital output					X	X	X	X		X	5.4.4.2.5	X		
Communication interface/ports					X	X	X	X		X	5.4.4.2.6	X		
Environmental impact					X	X	X	X		X	5.8.3	X		
Environ-mental condition for service, transport and storage		X	X	X	X	X	X	X	X	X	5.9.1	X		
Operation		X	X	X	X	X	X	X	X	X	5.9.2.1.1	X		
Mechanical installation service conditions and requirements		X	X	X	X	X	X	X	X	X	5.9.2.2.1	X		
Fixed <i>installations</i>		X	X	X	X	X	X	X	X	X	5.9.2.2.2	X		
Fixed <i>installations</i> as part of stationary machine		X	X	X	X	X	X	X	X	X	5.9.2.2.3	X		
Unusual environmental service conditions		X	X	X	X	X	X	X	X	X	5.9.2.3	X		
Sonic pressure and sound level		X	X	X	X	X	X		X		5.9.2.5 / 6.6.3.8.3	X		
Storage and transport of equipment		X	X	X	X	X	X		X		5.9.3	X		
Climatic conditions		X	X	X	X	X	X		X		5.9.3.1	X		
Unusual climatic conditions		X	X	X	X	X	X		X		5.9.3.2	X		
Ambient temperature		X	X	X	X	X	X		X		5.9.3.1	X		
Relative humidity		X	X	X	X	X	X		X		5.9.3.1	X		
Mechanical conditions		X	X	X	X	X	X		X		5.9.4	X		

Performance/ functionality requirement	Responsible party										Subclause requirement/ test specification	Type test	Routine test	Sample test
	End user	Transformer supplier	Reactor supplier	Filter supplier	BDM supplier	CDM supplier	Motor supplier	System integrator (PDS supplier)	Driven equipment supplier	Extended product supplier				
Specific storage hazards		X	X	X	X	X	X		X		5.9.5	X		
Driven equipment interface					X	X	X	X	X	X	5.13	X		
Critical speeds					X	X	X	X	X	X	5.13.1	X		
Torsion analysis					X	X	X	X	X	X	5.13.2	X		
Explosive environment		X	X	X	X	X	X	X	X	X	5.14	X		
Bypass and redundant configurations		X	X	X	X	X	X	X		X	5.2.5	X		
Earthing requirements		X	X	X	X	X	X	X		X	5.15	X		

4.3 Applicable standards

This document makes many references to the following standards. These references are not intended to be exhaustive. These references are the best guidance of this document for the particular topic they are focussing on for the *BDM/CDM/PDS*. The user of this document is always responsible to determine the applicability of all of these standards to the product being considered, based on the intended application of the product.

- EMC requirements are covered by IEC 61800-3.
- General safety requirements are covered by IEC 61800-5-1.
- Functional safety requirements are covered by IEC 61800-5-2.
- Type of load duty guidance is covered by IEC TR 61800-6.
- Interface and use of profiles requirements are covered by IEC 61800-7 (all parts).
- *Power interface* voltage specification is covered by IEC TS 61800-8.
- Ecodesign energy *efficiency* requirements of drive system are covered by IEC 61800-9 (all parts).

5 Performance and functionality criteria

5.1 General

The detail in 5.3 to 5.15 provide a list of potential requirements relevant for the specification of a *BDM/CDM/PDS* based on what is selected from Table 6. More severe requirements might be specified if considered relevant for the application.

A *BDM/CDM/PDS* is typically designed for a specific application, in a specific environment, for use under specific conditions, in which the product needs to operate, be transported or stored. These conditions include, but are not limited to, the electrical, electro-magnetic, mechanical, climatic, 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.

In order to ensure consistency and avoid conflicting requirements across IEC 61800 (all parts), some of the subclauses in 5.3 to 5.15 refer directly to other parts of the IEC 61800 series (see 4.3).

5.2 BDM/CDM/PDS characteristics and topology

5.2.1 General

Subclauses 5.2.2 and 5.2.3 are intended to be informative regarding common characteristics and topology for *PDSs*. The information in these subclauses shall not be understood as requirements.

Examples of commonly used drive system topologies are shown in Annex A.

5.2.2 BDM/CDM/PDS characteristics

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

Some significant characteristics of *BDM/CDM/PDSs* include the following.

- *BDM/CDM/PDSs* are commonly available with *output power* ranging from 0,2 kW to several thousand kW.
- Most industrial *BDM/CDM/PDSs* are designed to be powered from a 3 phase AC supply.
- Some low power *BDM/CDM/PDSs* are designed to be powered from single phase AC supply.
- Many *BDM/CDM/PDSs* are designed to receive DC power from a connecting *DC link power port* of more than one *PDS*. Many *PDSs* may receive power from both an AC and DC *mains supply*.
- *BDM/CDM/PDSs* vary the *speed* of an AC *motor* by controlling the frequency and voltage of the power provided to the *motor*.
- The most common *BDM/CDM/PDSs* are designed to control 3 phase induction *motors* with voltage ratings such as 240 V, 400 V, 480 V, 600 V, and 690 V.
- Some *BDM/CDM/PDSs* are designed for use with stepper or switched reluctance *motors*.
- Many *BDM/CDM/PDSs* are designed for use with permanent magnet *motors*.
- The properly designed *PDS* or extended product can achieve improved energy *efficiency* from the very low power losses of the AC *BDM/CDM* when used at the correct operating points. In general, it is beneficial to reduce energy lost to heating effects in order to minimize size and operating cost.
- Most AC *PDSs* return electric power from the *motor* to the *DC link* during periods when the *motor* operates as a power generator (operation in quadrant II and *quadrant* IV).
- Some AC *PDSs* are provided with a dynamic brake (also called "chopper brake" or "brake chopper") in order to manage electric power returned from the *motor* to the *DC link* during periods when the *motor* operates as a power generator.
- Regenerative *PDSs* are designed to return power from the *DC link* of the *BDM/CDM/PDSs* to the AC supply.
- *BDM/CDM/PDSs* for use with AC induction *motors* are available with different control algorithms which optimize *speed/torque* regulation and overall cost 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.

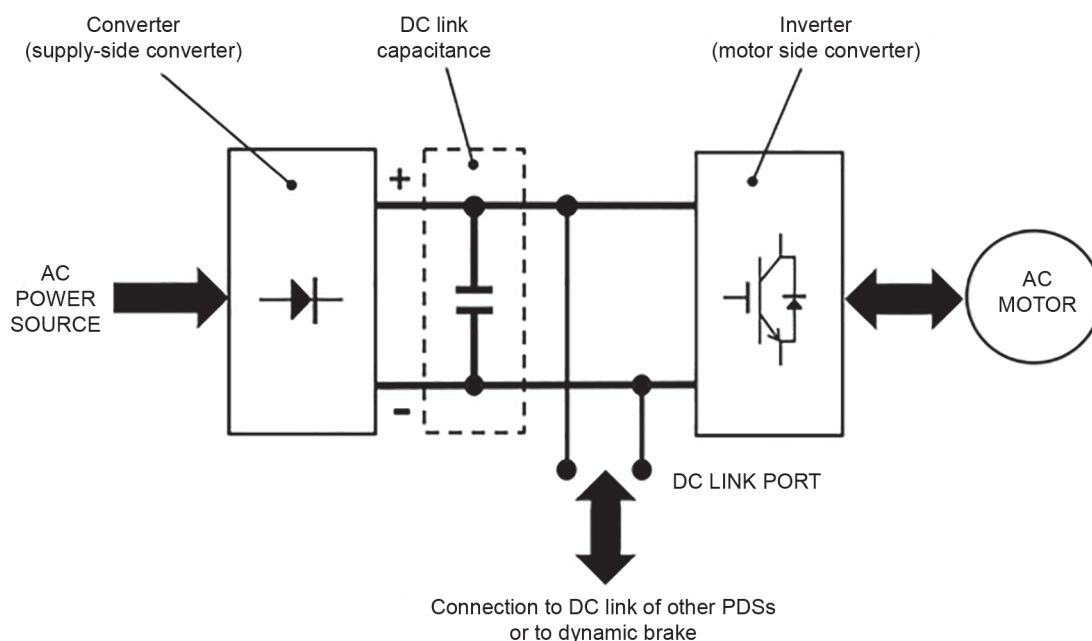
5.2.3 Basic topology for *BDM/CDM/PDSs*

The most commonly used topology for low-voltage *BDM/CDM/PDSs* is that of the voltage source *converter* (VSC). In a VSC, a supply-side *converter* changes electricity from the AC to DC. Capacitance is used to smooth the DC output of the *converter* and provide short-term energy storage. The DC output of the supply-side *converter*, sometimes referred to as the *DC link*, supplies energy to the *motor-side converter*, also known as an *inverter*. The *inverter* typically uses PWM (pulse width modulation) to provide the precise power requirements for an AC *motor* and permit control of *motor speed* and *torque*.

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

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

The *DC link* connection should be well designed and protected. In poorly designed *DC 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 *DC link* connection has been provided, for example by fuses, fault conditions can lead to the destruction of one or more units connected to the common *DC link*.



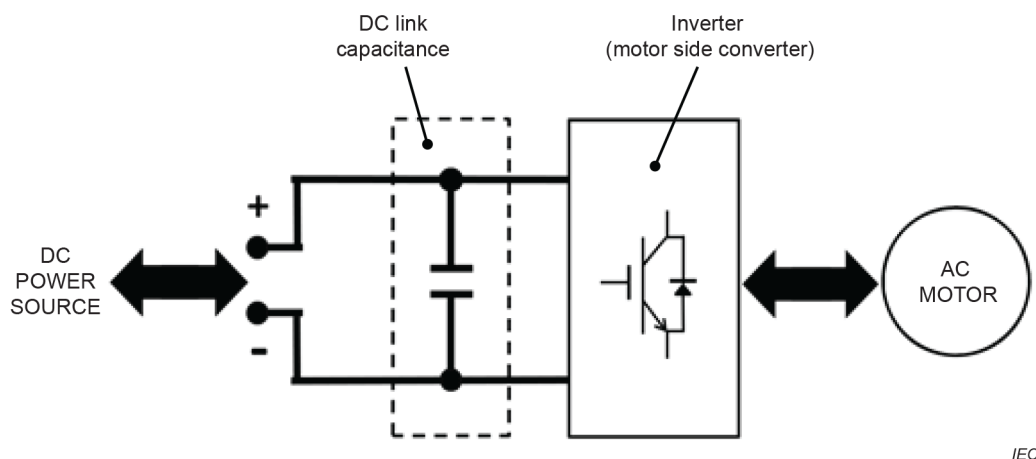
IEC

Figure 4 – Typical *BDM/CDM/PDS*

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

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

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



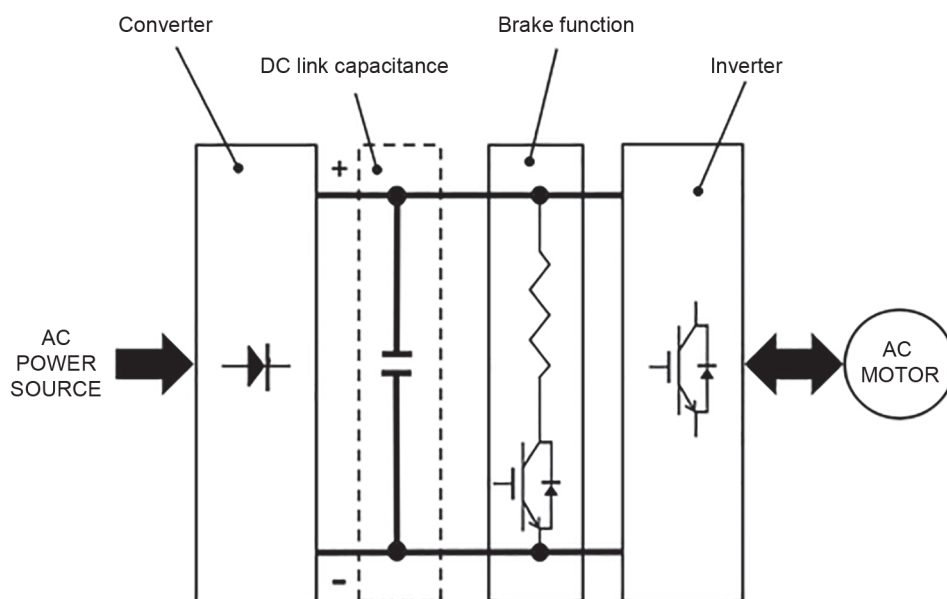
IEC

Figure 5 – Common *DC 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 *DC link port*. During these periods, the energy returned to the *DC link port* is often managed using one or more of the following options:

- *BDM/CDM/PDS(s)* with *DC link* ports which use(s) energy available from the *DC link* to power other *motors*;
- *dynamic braking* which dissipates excess energy from the *DC link* using resistors (Figure 6);
- return of energy in the *DC link* to an AC power system for use by other loads (see Figure 7).

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 *DC link port*.

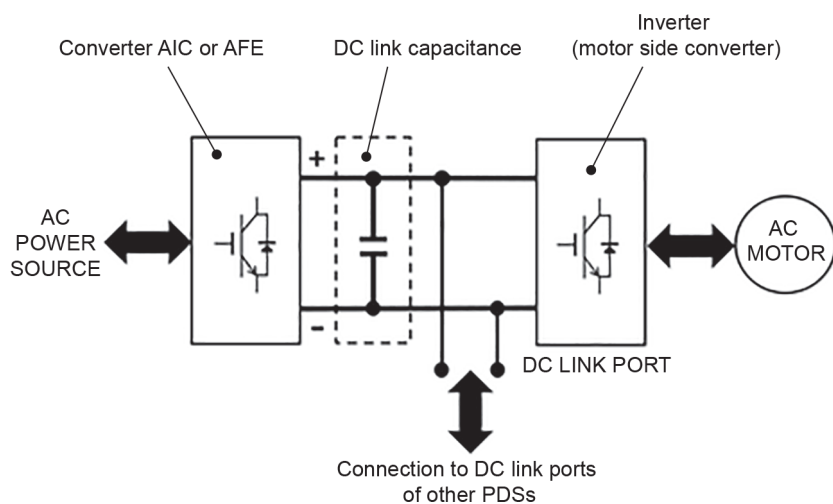


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Figure 6 – BDM/CDM/PDS with brake

Figure 7 illustrates a regenerative *PDS* which can return energy to the *mains supply* using a supply-side *converter* which also can operate as an *inverter*, also known as *active infeed converters* (AICs) or as active front end *converter* (AFE).

Additional information regarding AIC and AFE are available in IEC TS 62578.



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Figure 7 – BDM/CDM/PDS with AIC

5.2.4 Cooling topology

5.2.4.1 General

Common methods of cooling are forced air, liquid, heat exchangers, and evaporative cooling. Redundancy is recommended for critical applications.

Other cooling types are allowed.

Apply IEC 61800-5-1 for safety considerations.

5.2.4.2 Air-cooling

When the air supply has the potential to contain particles that could interrupt the *BDM/CDM/PDS* cooling paths, air filtering may be required to ensure the proper operation of an air-cooled system.

5.2.4.3 Liquid-cooling

When considering the proper operations of a liquid cooling system, the main considerations are monitoring and control of:

- conductivity,
- flow,
- condensation
- temperature,
- pressure, and
- maintenance of the system to prevent scale and corrosion.

Manufacturer should provide appropriate warnings and maintenance instructions for the cooling system. It is important to adhere to the assigned warnings and to *manufacturer's* recommendations regarding intervals of cooling system maintenance. It is also important to ensure that the *BDM/CDM/PDS* is installed and operated in the environmental conditions for which it is designed.

Apply IEC 61800-5-1 for safety requirements.

5.2.4.4 Heat exchangers

This type of cooling system can either be configured air to air, air to liquid, liquid to air, or liquid to liquid. These terms define the method by which the heat is transferred (exchanged) out of the product where the cooling is required. Typical considerations for heat exchangers include those listed in 5.2.4.2 and 5.2.4.3. Special considerations should be given to the interface between the internal and external loop. This is especially true for an air to liquid or liquid to liquid heat exchangers. For air to liquid system, the concern is that liquid could enter into the air system through a leak. For the liquid to liquid system, the concern is that contaminated/conductive liquid could enter the inner loop from the outer loop.

Apply IEC 61800-5-1 for safety requirements.

5.2.4.5 Evaporative-cooling

This type of cooling is a special case of liquid cooling. This will typically involve having a portion of the cooling system inside and a portion outside. It is unlikely that this type of cooling system would be contained within the *BDM/CDM* and would likely be part of the *PDS* or even the extended system. Consideration should be given to overall size and expense of this method. This case is not specifically detailed in IEC 61800-5-1. The *manufacturer* would be responsible for the considerations required for the proper system operation.

5.2.5 Bypass and redundant configurations

BDM/CDM may have bypass and/or redundant configurations to satisfy different aims, among which are the following:

- normal changing from a *BDM/CDM* supply to a *mains supply* at the end of the system starting procedure;

- emergency switching from a *BDM/CDM* supply to a *mains supply*, in case of power converter failures, in such a way as to allow operation of the system at a fixed speed;
- maximum system availability and reliability, obtainable by including multiple power converter channels, acting as selectively separable subsystems – each of them allowing the operation of the system in case of partial failure, sometimes at reduced power, each drive subsystem acting therefore as an adjustable frequency bypass channel.

When bypass technology is used, it is important to consider if it is possible to start the motor directly from the *mains supply*.

Figure 8 shows an example of a bypass configuration for a PDS with indirect conversion: the bypass channel for the *BDM/CDM* may include a transformer for voltage level matching.

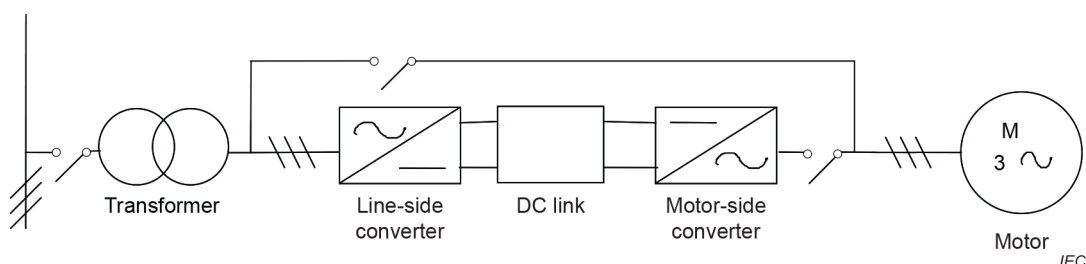


Figure 8 – Bypass configuration for system with indirect converter

An example of a redundant configuration is given in Figure 9.

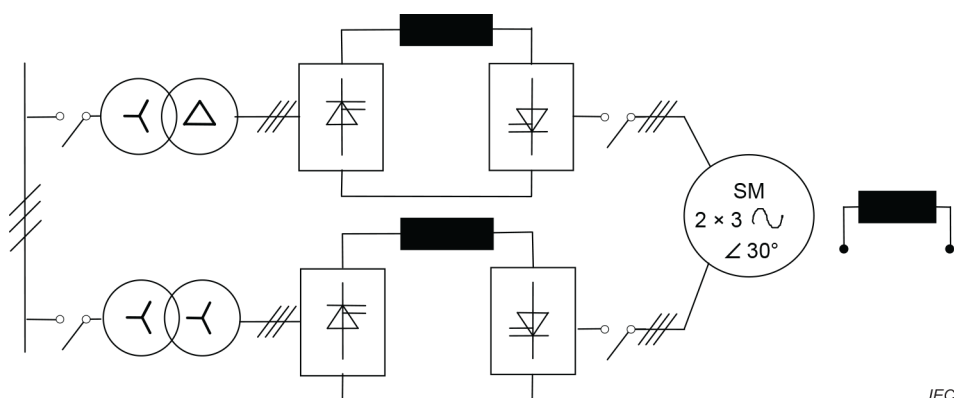


Figure 9 – Load commutation *inverters* LCI-synchronous motor in a partly redundant configuration

5.3 Ratings

5.3.1 General

The input and output ratings shown in Table 7 are acceptable for defining *BDM/CDM/PDS* proper operation.

When considering the safety requirements, apply IEC 61800-5-1.

For EMC considerations, apply IEC 61800-3.

For energy *efficiency*, apply IEC 61800-9-2.

Table 7 – Overview of input and output ratings of the *BDM/CDM/PDS*

Input ratings			Output ratings		
<i>BDM</i>	<i>CDM</i>	<i>PDS</i>	<i>BDM</i>	<i>CDM</i>	<i>PDS</i>
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]	<i>Torque</i> (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]	<i>Speed</i> (N_N and N_{NMax}) [r/min]
NOTE 1 In case no transformer nor other optional device such a filter is installed between supply mains input (i.e. <i>CDM/PDS</i> input) and <i>BDM</i> input, the ratings of <i>CDM/PDS</i> input and those of <i>BDM</i> 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 is installed between <i>BDM</i> output and <i>motor</i> input (i.e. <i>CDM</i> output), the ratings of <i>CDM</i> output and those of <i>BDM</i> output are same values, i.e. $U_{aN1} = U_{AN1}$ and so on. NOTE 3 The <i>BDM/CDM output power</i> 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 <i>BDM/CDM/PDS</i> current, voltage and frequency ratings can be provided within a range of values.					

5.3.2 Input ratings

5.3.2.1 General

The *system integrator* can consider whether the harmonic current, the harmonic voltage, and other input attributes of the *BDM/CDM* are important design considerations for the *PDS*.

5.3.2.2 Input voltage and input frequency

The rating(s) of the *BDM/CDM/PDS input voltage* and *input frequency* should be specified by the *manufacturer* to allow for proper selection of the *BDM/CDM/PDS*.

The rated *input voltage* is not adequate to determine that the supply is capable of sourcing the rated output load alone. The available current of the supply is important as well.

Standard voltage values are specified in IEC 60038. Different, non-standard voltage values may be specified for system optimization or special application needs.

For compliance, see 6.6.3.4.2.

5.3.2.3 Input current

The *BDM/CDM/PDS input current* rating should be specified by the *manufacturer* to allow for proper selection of the *BDM/CDM/PDS*. If multiple *input voltage* ratings or a range of voltages are specified in accordance with 5.3.2.2, the associated *input current* ratings should also be specified.

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

The harmonic current spectrum of the PDS, considering from the fundamental to the 50th harmonic is possible. The first 25 harmonics have the greatest energy; therefore, they are the most significant. These harmonics can also affect the auxiliaries and should be considered (see 6.6.3.4.4).

If the *BDM/CDM/PDS* is a category C4 equipment as defined by IEC 61800-3, then harmonic current spectrum should be stated by the PDS *manufacturer* at the minimum specified AC line impedance (including the *BDM/CDM/PDS* supply transformer), and with no background supply-voltage distortion. For all other *BDM/CDM/PDS*, this requirement is covered by IEC 61800-3.

For compliance, see 6.6.3.4.3.

5.3.2.4 Short-circuit protective devices (SCPD)

A short-circuit protective device is likely required and should be considered. This device is specifically selected based on safety.

Apply IEC 61800-5-1 for definition and requirements.

5.3.3 Output ratings

5.3.3.1 *BDM/CDM* continuous operation

Continuous output operation of the *BDM/CDM* should be stated by the *manufacturer* and, if selected as a requirement, it shall be in terms of the *motor* requirements:

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

If 5.3.3 is selected from Table 6, the operating frequency and voltage range shall be considered for the specified or typical output impedance. This would include all contributing impedances of the output like motor, transformer, filter, etc, if present or applicable.

NOTE Continuous, essentially equivalent to maximum steady state operation. See IEC 811-11-05.

The *system integrator* may wish to consider whether the harmonic current, the harmonic voltage, and other output attributes of the *BDM/CDM* are important design considerations for the PDS.

For compliance, see 6.6.3.5.2, 6.6.3.5.3, 6.6.3.5.4.

When CDM and *motor* are not provided by the same *manufacturer/supplier*, the *system integrator* should ensure proper performance and compatibility of CDM and *motor* as it pertains to operation for the specific system.

For safety, apply IEC 61800-5-1.

For EMC, apply IEC 61800-3.

For energy *efficiency*, apply IEC 61800-9-2.

5.3.3.2 PDS continuous output

Continuous output ratings should be stated by the *manufacturer*. If selected in Table 6, continuous output ratings shall be in terms of the *motor* shaft of the *PDS* (see Figure 10):

- *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].

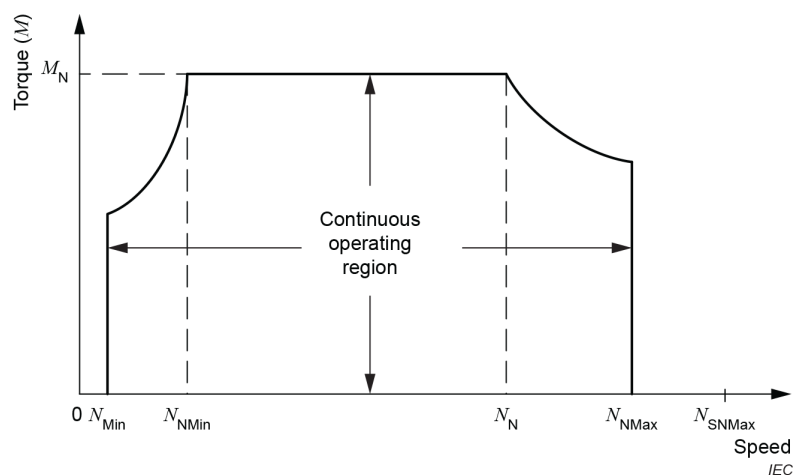


Figure 10 – Example of operating region of a PDS

For compliance, see 6.6.3.5.3, 6.6.3.5.4

5.3.3.3 Overcurrent and torque capability

Overcurrent, torque and overtorque should be considered when selecting a *BDM/CDM/PDS*. The defined minimum levels for safety listed as an overload requirement in IEC 61800-5-1 establish a range of acceptable overcurrent, *torque* and overtorque conditions. *Manufacturers* typically create products that operate well within the maximum stated values in IEC 61800-5-1. Examples of typical overload magnitudes and duration are given in 5.10, IEC 60146-1-1 and IEC TR 61800-6. Non-typical overcurrent, *torque* and overtorque values are possible and the *customer* should consult the *manufacturer's* product information for guidance on this topic to ensure the *BDM/CDM/PDS* meets the requirements of the application.

The performance of overload, *torque* and overtorque should be validated by test at the level the *manufacturer* specifies. These performance levels may be different than what is defined in IEC 61800-5-1 as long as they provide greater protection.

A good design rule for any type of duty cycle is that the RMS value of the current over the complete cycle should not exceed the rated current. Table 8 and Figure 11 show six typical examples of a 1 min overload with a 10 min and 60 min load cycle.

Table 8 – 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

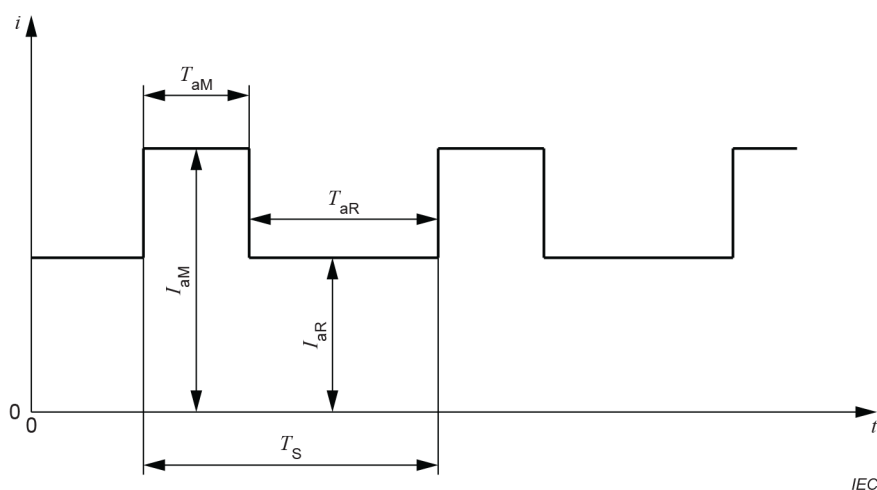


Figure 11 – Overload cycle example

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

For continuous duty, the *rated output current* (I_{aN}) should correspond, as a minimum, to the continuous *motor* current necessary to supply the specified continuous *motor* torque.

For safety considerations of this topic, apply IEC 61800-5-1.

For testing options, see 6.6.3.5.5.

5.3.4 Operating quadrants

5.3.4.1 General

The above ratings of 5.3.2 and 5.3.3 should be given for all operating quadrants (I, II, III, IV) that are provided for operation of the *BDM/CDM*. Quadrants do not always require identical values/levels of performance.