

Adjustable speed electrical power drive systems —

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

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee PEL/22, Static power convertor equipment, which has the responsibility to:

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- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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A list of organizations represented on this committee can be obtained on request to its secretary.

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Cross-references

Attention is drawn to the fact that CEN and CENELEC standards normally include an annex which lists normative references to international publications with their corresponding European publications. The British Standards which implement these international or European publications may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 75 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Amendments issued since publication

Amd. No.	Date	Comments

This British Standard, having been prepared under the direction of the Electrotechnical Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 December 1998

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English version

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

(IEC 61800-2:1998)

Entraînements électriques de puissance
à vitesse variable
Partie 2: Exigences générales
Spécifications de dimensionnement pour
systèmes d'entraînement de puissance à
fréquence variable en courant alternatif
et basse tension
(CEI 61800-2:1998)

Drehzahlveränderbare elektrische
Antriebe
Teil 2: Allgemeine Anforderungen
Festlegungen für die Bemessung von
Niederspannungs-Wechselstrom-
Antriebssystemen mit einstellbarer
Frequenz
(IEC 61800-2:1998)

This European Standard was approved by CENELEC on 1998-04-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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CENELEC

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

Central Secretariat: rue de Stassart 35, B-1050 Brussels

Foreword

The text of document 22G/40/FDIS, future edition 1 of IEC 61800-2, prepared by SC 22G, Semiconductor power converters for adjustable speed electric drive systems, of IEC TC 22, Power electronics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61800-2 on 1998-04-01.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1999-01-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2001-01-01

Annexes designated “normative” are part of the body of the standard.

Annexes designated “informative” are given for information only.

In this standard, Annex ZA is normative and Annex A, Annex B, Annex C, Annex D, Annex E, Annex F and Annex G are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61800-2:1998 was approved by CENELEC as a European Standard without any modification.

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1 General

1.1 Scope and object

This part of IEC 61800 applies to general purpose adjustable speed a.c. drive systems which include power conversion, control equipment, and also an a.c. motor or motors. Excluded are traction and electrical vehicle drives.

It applies to systems connected to line voltages up to 1 kV a.c., 50 Hz or 60 Hz, and load side frequency up to 600 Hz.

EMC aspects are covered in IEC 61800-3.

This part of IEC 61800 gives the characteristics of the converters and their relationship with the complete a.c. drive system. It also states their performance requirements with respect to ratings, normal operating conditions, overload conditions, surge withstand capabilities, stability, protection, a.c. line earthing, and testing. Furthermore, it deals with application guidelines, such as control strategies, diagnostics, and topologies.

This part of IEC 61800 is intended to define a complete a.c. PDS in terms of its performance and not in terms of individual subsystem functional units.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61800. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 61800 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60034-1:1996, *Rotating electrical machines — Part 1: Rating and performance*.

IEC 60034-2:1972, *Rotating electrical machines — Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles)*.

IEC 60034-9:1990, *Rotating electrical machines — Part 9: Noise limits*.

IEC 60038:1983, *IEC standard voltages*.

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

IEC 60050(151):1978, *International Electrotechnical Vocabulary (IEV) — Chapter 151: Electrical and magnetic devices*.

IEC 60050(441):1984, *International Electrotechnical Vocabulary (IEV) — Chapter 441: Switchgear, control gear and fuses*.

IEC 60050(551), *International Electrotechnical Vocabulary (IEV) — Chapter 551: Power electronics¹⁾*.

IEC 60050(601):1985, *International Electrotechnical Vocabulary (IEV) — Chapter 601: Generation, transmission and distribution of electricity – General*.

IEC 60076, *Power transformers*.

IEC 60146-1-1:1991, *Semiconductor convertors — General requirement and line commutated convertors — Part 1-1: Specification of basic requirements*.

IEC 60146-1-2:1991, *Semiconductor convertors — General requirement and line commutated convertors — Part 1-2: Application guide*.

IEC 60146-1-3:1991, *Semiconductor convertors — General requirement and line commutated convertors — Part 1-3: Transformers and reactors*.

IEC 60204-1:1992, *Electrical equipment of industrial machines — Part 1: General requirements*.

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

IEC 60664-1:1992, *Insulation coordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests*.

¹⁾ Second edition, to be published.

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 60747, *Semiconductor devices — Discrete devices and integrated circuits.*

IEC 61000-2-4:1994, *Electromagnetic compatibility (EMC) — Part 2: Environment — Section 4: Compatibility levels in industrial plants for low-frequency conducted disturbances.*

IEC 61000-4-7:1991, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 7: General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto.*

IEC 61800-3:1996, *Adjustable speed electrical power drive systems — Part 3: EMC product standard including specific test method.*

IEC Guide 106:1989, *Guide for specifying environmental conditions for equipment performance rating.*

1.3 Symbols

Table 1 lists symbols defined and/or used in this part of IEC 61800.

Table 1 — Symbols

Parameter	Symbol	Unit	Definition
Rated system voltage	U_{LN}	V	2.4.1
Rated system frequency	f_{LN}	Hz	2.4.2
Line-side converter rated a.c. voltage	U_{VN}	V	2.4.3
Line-side rated a.c. current of the CDM/BDM	I_{LN}	A	2.4.4
Rated input current of the converter	I_{VN}	A	2.4.5
Line-side harmonic content	H_L	V or A	2.4.6
Line-side total harmonic distortion	THD_L	%	2.4.8
Converter input displacement factor	$\cos \varphi_{V1}$		2.4.9
Line side displacement factor	$\cos \varphi_{L1}$		2.4.10
Input total power factor	λ_L		2.4.11
Maximum allowable a.c. system, symmetrical short-circuit current	I_{SCM}	A	2.4.13
Short-circuit ratio	R_{sc}		2.4.13
Rated continuous output current	I_{aN}	A	2.5.1
Overload current (overload capability)	I_{aM}	A	2.5.2
Load side fundamental rated a.c. voltage	U_{aN1}	V	2.5.4
Base frequency	f_o	Hz	2.5.5
Rated fundamental output current	I_{aN1}	A	2.5.6
Efficiency of drive system	η_D	%	2.5.7
Efficiency of CDM	η_C	%	2.5.7
Load side harmonic distortion	THD_a	%	2.5.9
Slip	s	p.u.	2.7.5
Rated slip	s_N	p.u.	2.7.6

Table 1 — Symbols

Parameter	Symbol	Unit	Definition
Base speed	N_o	r/min	2.7.7
Maximum operating speed	N_M	r/min	2.7.8
Minimum operating speed	$N_{\min}$	r/min	2.7.9
Maximum safe motor speed	N_{smax}	r/min	2.7.10
Torque	M	N _m	
Inertia	J	kgm ² or Nms ²	

2 Definitions

For the purpose of this part of IEC 61800, the following definitions, as well as those given in IEC 60050(111), IEC 60050(151), IEC 60050(441), IEC 60050(551), IEC 60050(601), IEC 60146-1-1, IEC 60146-1-2, IEC 60146-1-3, and IEC 60147-0, apply.

2.1 System

2.1.1

a.c. power drive system (PDS)

(see Figure 1) System consisting of power equipment (composed of converter section, a.c. motor and other equipment such as, but not limited to the feeding section), and control equipment (composed of switching control –on/off for example–, voltage, frequency, or current control, firing system, protection, status monitoring, communication, tests, diagnostics, process interface/port, etc.)

NOTE Figure 1 illustrates the main functional elements of an a.c. drive system. It also includes equipment which may be optional on many drive systems. It is intended to encompass a wide variety of a.c. drive configuration possibilities. The converter section does not illustrate or imply a specific topology, or type of switching device, due to the wide variety of both in current use. See Annex F.

2.1.2 a.c. power drive system — hardware configuration

PDS which consists of a complete drive module (CDM) and a motor or motors with sensors which are mechanically coupled to the motor shaft (the driven equipment is not included). See Figure 2 for hardware partition of the power drive system

NOTE Figure 2 illustrates the parts of equipment which can be grouped and supplied as defined and shown.

2.1.2.1

basic drive module (BDM)

drive module which consists of a converter section, a control equipment for speed, torque, current, frequency or voltage, and a power semiconductor gating system, etc

2.1.2.2

complete drive module (CDM)

drive system, without the motor and the sensors which are mechanically coupled to the motor shaft, consisting of, but not limited to, the BDM, and extensions such as feeding section, and auxiliaries

2.1.2.3

installation

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

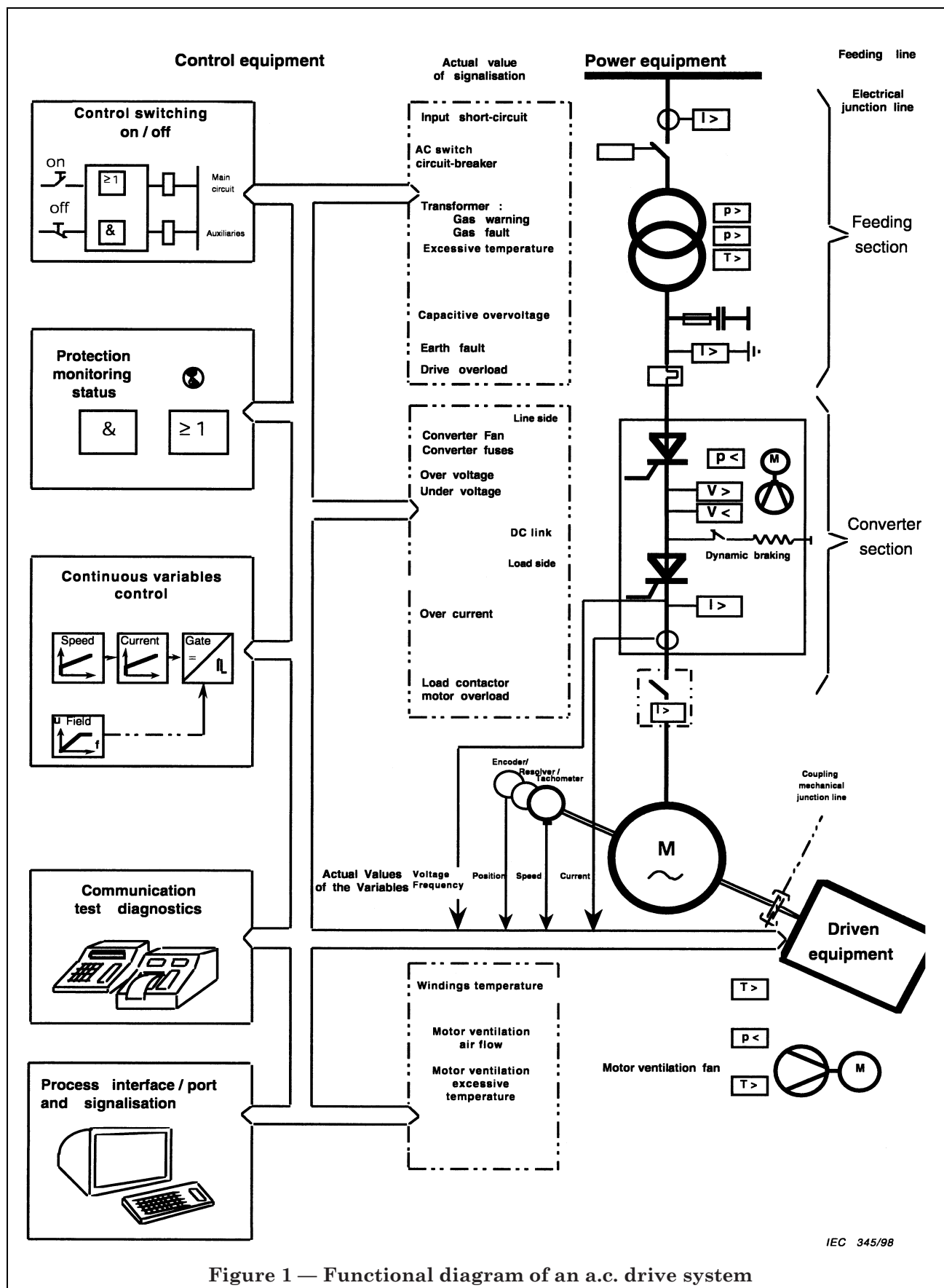
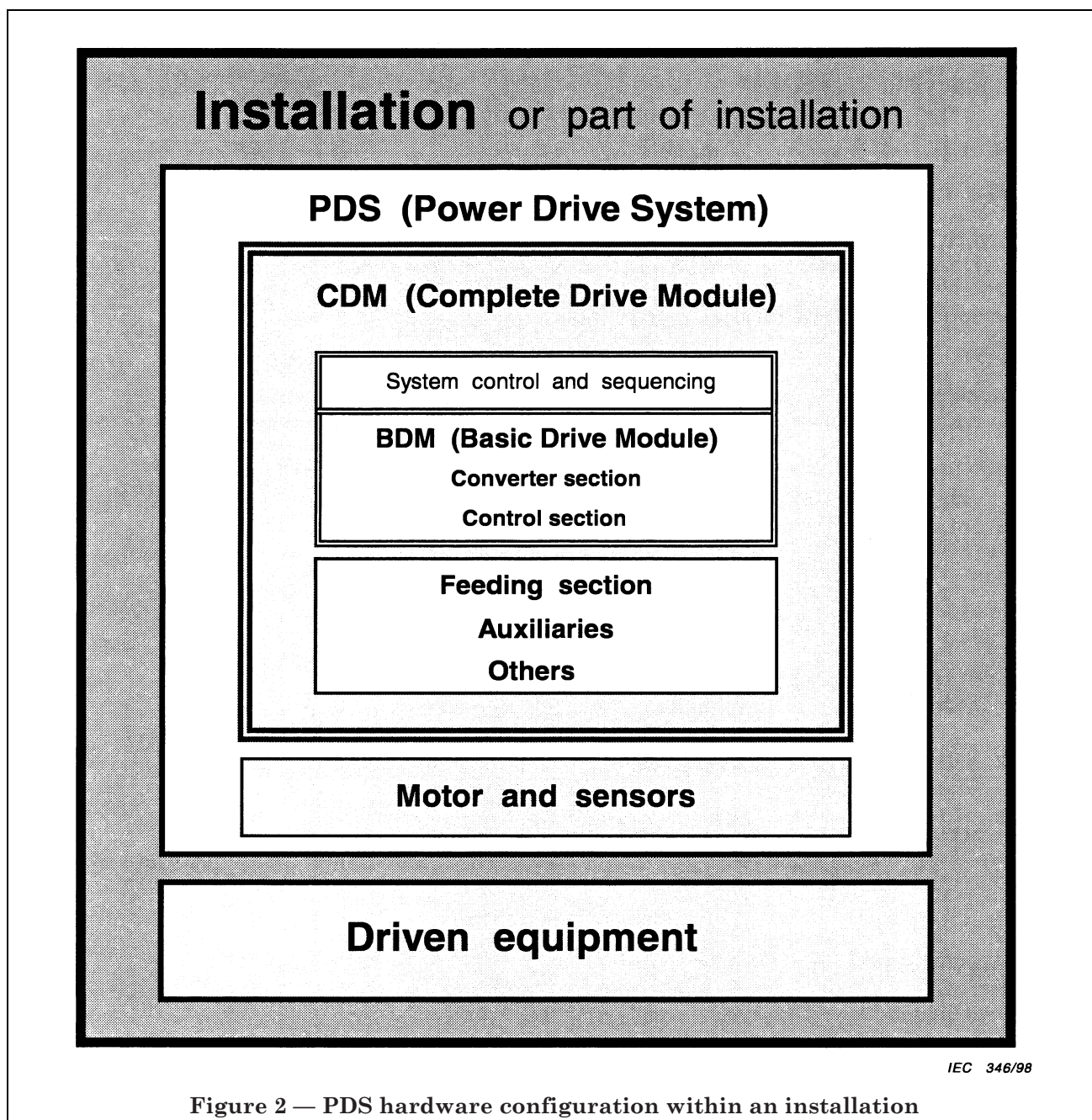


Figure 1 — Functional diagram of an a.c. drive system



2.2 Converters

2.2.1

converter, general purpose

operating unit for electronic power conversion, changing one or more electrical characteristics and comprising one or more electronic switching devices and associated components, such as transformers, filters, commutation aids, controls, protections and auxiliaries, if any

2.2.2

rectifying, rectification

converter action converting from a.c. to d.c. The rectifier can be uncontrolled or controlled [IEV 551-11-06 modified]

NOTE For the purpose of this part of IEC 61800, the line-side converter normally operates as a rectifier.

2.2.3

inverting, inversion

converter action converting from d.c. to a.c. [IEV 551-1 1-07 modified]

NOTE For the purpose of this part of IEC 61800, the load-side converter normally operates as an inverter.

2.2.4

converter, a.c.

converter for changing a.c. power of a given voltage, frequency, and phase number to a.c. power in which one or more of these parameters are different

2.2.5

converter, adjustable frequency

converter for changing frequency

2.2.6

converter, indirect a.c. (converter d.c. linked)

converter with an intermediate d.c. link

NOTE This definition is intended to include only those circuits in which the d.c. link is readily identified or explicit.

2.2.7

converter, direct a.c.

converter without an intermediate d.c. link

NOTE These circuits have an implicit link but no single pair of conductors that can be identified as the d.c. link.

2.2.8

converter, externally commutated

converter in which the commutating voltages are supplied by the a.c. supply lines, the a.c. load, or some other a.c. source outside the converter

2.2.9

converter, line-side commutated

converter in which the commutation voltages are supplied by the a.c. input

2.2.10

converter, self-commutated

converter in which the commutation is accomplished by components within the converter

NOTE In this part of IEC 61800, forced commutation refers to deliberate extinction of semiconductor devices before natural commutation can take place at zero current (natural commutation).

2.2.11

converter, load-side commutated

converter in which the commutation voltages are supplied by the a.c. load

NOTE For purposes of this part of IEC 61800, the a.c. load is an a.c. motor.

2.2.12

converter, a.c./a.c., voltage source

converter which provides an adjustable output voltage supply, essentially unaffected by the value of the load

NOTE The term “voltage stiff converter” having a similar physical background is used in the second edition of IEC 551.

2.2.13

converter, a.c./a.c., current source

converter which provides an adjustable output current supply, essentially unaffected by the value of the load

NOTE The term “current stiff converter” having a similar physical background is used in the second edition of IEC 551.

2.2.14**d.c. amplitude control**

method of converter voltage/current control whereby the d.c. link voltage (or current) amplitude is controlled resulting in a quasi-square wave with predictable harmonics. Harmonic content amplitude is a function of load characteristics

2.2.15**pulse width modulation (PWM)**

method of converter voltage/current control whereby a series of fixed amplitude, variable duration output voltage/current pulses are created

2.3 Drive system operating characteristics**2.3.1****two quadrant operation**

converter operation of a machine as a motor in two directions of machine rotation. It involves operation in quadrants I and III (see Figure 3)

2.3.2**four quadrant operation**

converter operation of a machine as a motor or a generator in either direction of machine rotation. It involves operation in quadrants I, II, III and IV as shown in Figure 3

2.3.3**dynamic braking**

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

2.3.4**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

2.3.5**regeneration**

process of converting the mechanical energy of the system to electrical energy and transferring it to the input supply. The motor is then working as a generator and the ratings of the motor may be different

2.4 CDM, BDM and converter input parameters

Symbols defined in 2.4 are included in Table 1

2.4.1**rated system voltage U_{LN}**

RMS input line-to-line voltage at the supply terminals of the customers installation to which the PDS will be connected

2.4.2**rated system frequency f_{LN}**

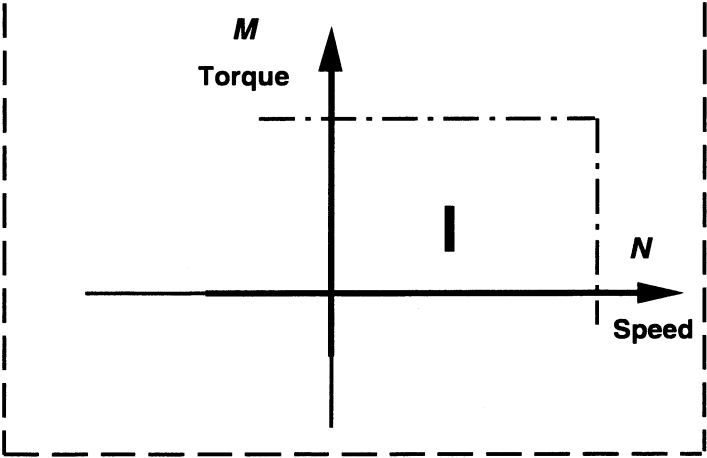
frequency in Hertz of the power input system alternating voltage

2.4.3**line-side rated a.c. voltage U_{VN}**

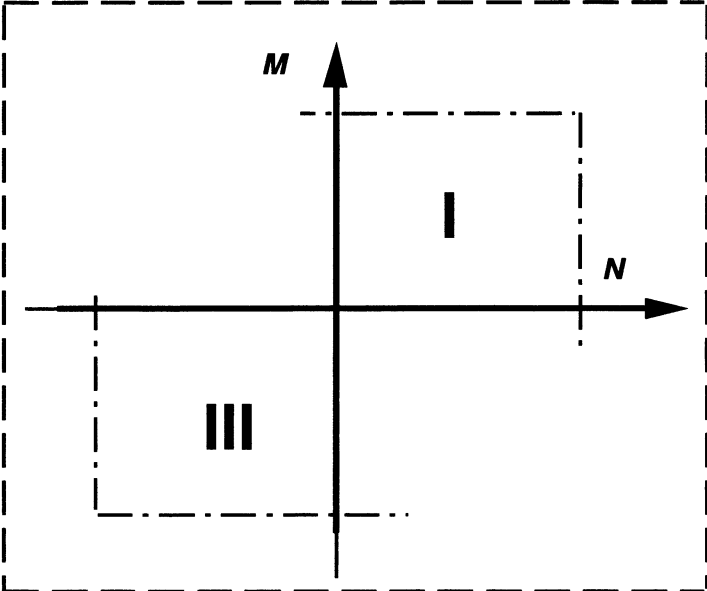
rated r.m.s. line-to-line input voltage at the a.c. terminals of the line-side converter, which has been designated as the basis for the converter rating

NOTE This voltage may differ from the rated system voltage (U_{LN}) due to the use of transformers and the effect of impedance. Some drives may have an input transformer with primary voltage higher than 1 000 V. In this case transformer and protective devices have to meet this standard and other relevant IEC standards. Capacitively coupled high voltage from primary to secondary winding must be bypassed to earth (see Annex B).

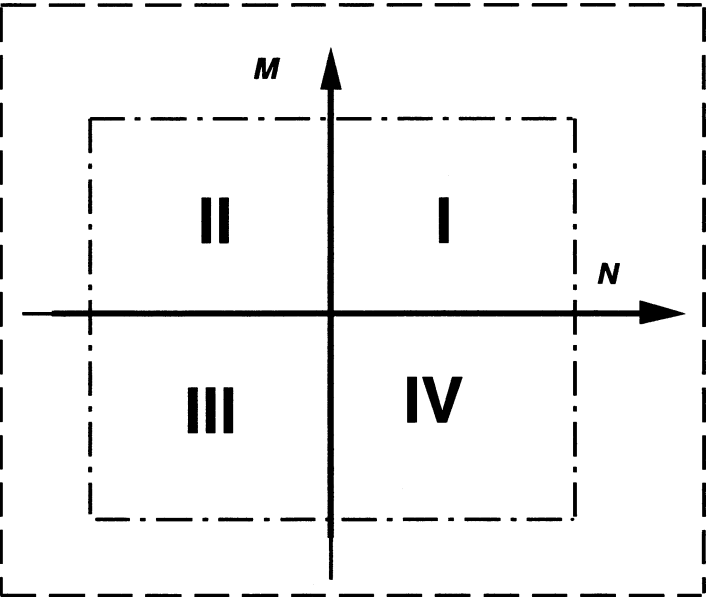
One
quadrant



Two
quadrants



Four
quadrants



IEC 347/98

Figure 3 — Operating quadrants

2.4.4

line-side rated a.c. current I_{LN}

maximum r.m.s. value of current on the line-side of the CDM/BDM under rated conditions. 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

NOTE This current includes currents supplied to the auxiliary circuits of the CDM/BDM. It takes into account the effect of d.c. current ripple and circulating current, if any.

2.4.5

rated input current I_{VN}

maximum r.m.s. value of current on the valve side of the converter under rated conditions. 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

2.4.6

line-side harmonic content

quantity obtained by subtracting, from an alternating quantity, its fundamental component [IEV 551-17-04, applied to the line-side of the system]

NOTE For example, for voltage (from a practical approach and with interharmonics neglected), the r.m.s. value of the harmonic content is:

$$U_{Hn} = \left(\sum_{h=2}^{h=n} U_h^2 \right)^{0,5}$$

2.4.7

characteristic current harmonics

orders of the current harmonics produced by converter equipment in the course of normal operation. For example, in a 6-pulse converter the characteristic current harmonics are the non triple, odd harmonics, $h = 6k \pm 1$ (k any integer)

NOTE In addition to power system frequency harmonics, there can be other harmonics resulting from interaction with the converter load. They are called interharmonics.

2.4.8

harmonic distortion

according to common practice, the total harmonic distortion coefficient is relative to the fundamental component of the quantity which is considered. The harmonic factor is relative to the r.m.s. value of the quantity which is considered [IEV 551-17-05 and IEV 551-17-06, modified]

the total harmonic distortion (THD) and the total harmonic factor (THF) are defined by:

$$\text{THD} = \frac{\sqrt{Q^2 - Q_1^2}}{Q_1} \quad \text{and} \quad \text{THF} = \frac{\sqrt{Q^2 - Q_1^2}}{Q}$$

where

Q_1 is the r.m.s. value of the fundamental;

Q is the total r.m.s. value;

h is the harmonic order;

Q_n is the r.m.s. value of harmonic component of order h ;

Q can represent either current or voltage.

for the purpose of this standard and for clarity, limits are referred to the corresponding rated value limits for THD and THF are defined by:

$$\text{THD} = \frac{\sqrt{Q^2 - Q_1^2}}{Q_{1N}} \quad \text{and} \quad \text{THF} = \frac{\sqrt{Q^2 - Q_1^2}}{Q_N}$$

NOTE 1 These definitions are in accordance with the second edition of IEC 551 and with common practice. The network voltage waveform is much less distorted than the injected current. Therefore, application of both definitions, total harmonic distortion coefficient THD or total harmonic factor THF, to the voltage provides the same result while the difference is significant when current is considered.

NOTE 2 It is important to note that these definitions include interharmonics. When interharmonics are present the wave form is no longer periodical, which can produce more complex effects than those produced by harmonics. If interharmonics are negligible, these equations simplify to:

$$\text{THD} = \frac{\sqrt{\sum_{h=2}^{h=40} Q_h^2}}{Q_{1N}} \quad \text{and} \quad \text{THF} = \frac{\sqrt{\sum_{h=2}^{h=40} Q_h^2}}{Q_N}$$

where

Q_{1N} is the rated r.m.s. value of the fundamental;

Q_N is the rated total r.m.s. value.

The summation is extended to and includes order 40, according to IEC common practice.

NOTE 3 For particular use, the highest frequency content of THD (order h from 14 to 40 inclusive) is named partial harmonic distortion coefficient PHD, and the even content (where order h is only even) is named even harmonic distortion coefficient EHD. Applied to current this gives:

$$\text{PHD} = \frac{\sqrt{\sum_{h=14}^{h=40} I_h^2}}{I_{1N}} \quad \text{and} \quad \text{EHD} = \frac{\sqrt{\sum_{h=2, \text{even}}^{h=40} I_h^2}}{I_{1N}}$$

2.4.9

converter input displacement factor $\cos \varphi_{V1}$

cosine of the phase displacement angle between the fundamental phase components of the voltage and current on the input a.c. side of the input power converter

2.4.10

line-side displacement factor $\cos \varphi_{L1}$

cosine of the phase displacement angle between the fundamental phase components of the voltage and current on the input a.c. side of the CDM

2.4.11

input total power factor, λ_L

ratio of the total power input, to the apparent power, as determined at the connection of the CDM to the supply

example: in a three-phase system where the voltage is considered sinusoidal

$$\begin{aligned} \lambda_L &= (U_L I_{L1} \sqrt{3} \cos \varphi_{L1}) / (U_L I_L \sqrt{3}) \\ &= (I_{L1} / I_L) \times \cos \varphi_{L1} \end{aligned}$$

NOTE 1 The power factor includes the effect of displacement $\cos \varphi_1$ and of harmonics by means of the deformation factor $v = \lambda / \cos \varphi$.

NOTE 2 The definition applies to the converter input (subscript V) or to the CDM input line side (subscript L).

2.4.12

d.c. current I_d

average value of the current in the d.c. link over one full period of the input power system frequency

2.4.13

maximum allowable a.c. system, symmetrical short-circuit current I_{SCM}

maximum allowable symmetrical short-circuit current (I_{SCM}), as specified on the rating plate can be related to the fundamental component of the line-side rated a.c. current (I_{LN1}) by means of the short-circuit ratio (R_{sc})

R_{sc} is the ratio of the short-circuit power of the source to the fundamental apparent power on the line-side of the converter(s) (See IEC 60146-1-1)

$$R_{sc} = S_{sc} / S_{LN1} = I_{SC} / I_{LN1}$$

the maximum allowable symmetrical short-circuit current (I_{SCM}) is of importance in the definition of the protection of the converter. At the point of common coupling (PCC), the relative short-circuit power shall be considered (see 1.5.35. of IEC 60146-1-1). This R_{sc} has to be limited to the following R_{SCM} :

$$R_{scM} = (I_{SCM}) / I_{LN1}$$

where I_{LN1} is equal to the fundamental content of I_{LN}

2.5 CDM, BDM and converter output parameters

Symbols defined in 2.5 are included in Table 1.

2.5.1

rated continuous output current I_{aN}

total r.m.s. output current which can be supplied continuously without exceeding established limitations, under prescribed operating conditions

2.5.2

overload capability I_{aM}

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

2.5.3

operating frequency range

range of fundamental frequency over which the converter's output can be controlled

2.5.4

load-side converter a.c. rated voltage U_{aN1}

RMS value of the rated fundamental voltage at the a.c. terminals of the load-side converter

NOTE This is the voltage which appears at the a.c. terminals of the load-side converter and is not necessarily the fundamental voltage of the motor.

2.5.5

base frequency f_0

base frequency of an adjustable frequency drive system is the lowest frequency at which it is capable of delivering maximum output power

2.5.6

rated fundamental output current I_{aN1}

RMS value of the fundamental component of the output current which can be supplied continuously without exceeding established limits

2.5.7

efficiency of power conversion η_D, η_C

efficiency η_D of the drive system is the ratio of the power delivered by the motor shaft to the total power drawn from the input power supply (see feeding line in Figure 1), and is usually expressed as a percentage. Efficiency of the CDM (complete drive module) η_C is the ratio of the total output power delivered by the CDM to the motor and auxiliaries (motor ventilation fan, etc.) to the total power drawn from the input power supply (see feeding line in Figure 1), and is usually expressed as a percentage

2.5.8

load-side harmonic content

this definition is identical to line-side harmonic content (2.4.6) but determined at the output side of the BDM

$$I_{aHn} = \left(\sum_{h=2}^{h=n} I_h^2 \right)^{0,5}$$

NOTE Load-side harmonic content is a function of the converter waveform and load reactance.

2.5.9

load-side total harmonic distortion THD_a

the definition of harmonic distortion (2.4.8) can be applied to the output of the BDM yielding THD_a

NOTE Load-side voltage total harmonic distortion is expressed as THD_{ua} and load side current total harmonic distortion is expressed as THD_{ia} . The difference between THD and THF is significant for both voltage and current.

2.5.10

rated load power factor

cosine of the angle between the motor phase voltage and current, at rated load, with sinusoidal voltage applied

2.5.11**load-side displacement factor**

this definition is identical to line-side displacement factor (2.4.10) but determined at the output side of the BDM

2.5.12**quasi-square wave**

stepped waveform as obtained from the difference of two phase-shifted square waves (one square wave per half period) of equal amplitude. The wave form applies to either voltage or current

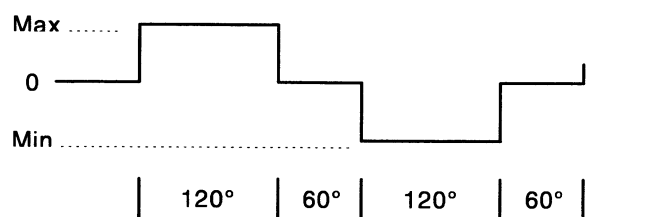


Figure 4 — Quasi-square wave

2.5.13**stepped wave**

waveform obtained from the summation of any number of square waves of the same frequency, each displaced in time from the others

2.6 Converter circuitry and circuit elements**2.6.1****commutating capacitor**

capacitor which provides commutating energy for circuit-commutated thyristors in a self-commutated converter

2.6.2**commutating inductor**

inductor having one or more windings which modifies or couples the transient current produced during commutation

2.6.3**a.c. filter network**

network designed to reduce the flow of harmonic currents into the associated power system

2.6.4**power factor correction network**

network designed to improve the power factor of the associated power system. This network will frequently also reduce the flow of harmonic currents

2.6.5**d.c. filter capacitor**

capacitor connected across the rectifier output within a converter to reduce voltage ripple

2.6.6**d.c. filter inductor**

inductor connected in series with the output of the rectifier to reduce ripple current

2.6.7**d.c. filter network**

combination of d.c. filter capacitor and d.c. filter inductor applied to the d.c. link to reduce voltage ripple and input line harmonics

2.7 Induction motor parameters

The following parameter definitions are essential to define induction motor operation with an adjustable frequency converter. Symbols defined in 2.7 are included in Table 1

2.7.1

rated motor voltage

rated a.c. input voltage as specified on the rating plate of the motor. It is the line-to-line, r.m.s. sinusoidal, motor terminal voltage

2.7.2

rated frequency

frequency at which rated motor voltage is defined and which appears on the rating plate

2.7.3

rated motor current

a.c. r.m.s. current at rated operating conditions as specified on the rating plate

2.7.4

rated power factor

power factor under rated conditions of voltage, frequency, and load

2.7.5

slip s

per-unit, relative rotor speed difference between synchronous speed at the operating frequency (N_a) and the actual rotor speed (N), defined as:

$$s = \frac{(N_a - N)}{N_a}$$

2.7.6

rated slip s_N

motor slip under rated load conditions

2.7.7

base speed N_0

motor synchronous speed at base frequency

2.7.8

maximum operating speed N_M

motor speed at maximum inverter frequency

2.7.9

minimum operating speed $N_{\min}$

motor speed at minimum inverter frequency

2.7.10

maximum safe motor speed $N_{\max}$

maximum designed speed of the motor under which no permanent abnormal mechanical deformation or weakness is introduced (see clause 21 of IEC 60034-1)

NOTE The maximum safe speed of the driven equipment may be more restrictive.

2.7.11

equivalent circuit constants

NOTE For dynamic performance it is necessary to have the equivalent circuit constants of the individual motor. In addition, for field weakened operation, the ratio between pull-out torque and rated torque at rated flux needs to be known. See Annex A for typical values.

2.7.12

rated voltage to rated frequency ratio U_{aN}/f_{aN}

ratio at which rated air-gap flux exists, providing rated torque per ampere

2.7.13

torque, pulsation

cyclic fluctuation of a steady state motor torque measured as a peak-to-peak variation

2.8 Control systems

2.8.1

controlled variable

system variable in the feedback control of adjustable frequency a.c. drives. Some examples of controlled variables are voltage, stator current, frequency, speed, slip, and torque

2.8.2

service variable

specified variable, usually related to ambient conditions (e.g. temperature), for which the feedback control system is to correct in attempting to maintain the ideal value of the controlled variable

2.8.3

operating variable

specified variable (e.g. load torque for a speed controlled drive), other than those arising from service conditions and drift, for which the feedback control system is to correct in attempting to maintain the ideal value of the controlled variable

2.8.4

feedback control system variables

range of service and operating variables covering the total deviations for which the feedback system attempts to correct by means of the controlled variables. The accuracy of this control is then defined as the width of the band of allowable deviation within which the feedback system will regulate the controlled variable

3 Functional features

3.1 Operational

CDM shall include specified features which may include, but are not limited to, one or more of the following features.

- timed acceleration;
- timed deceleration;
- jog;
- adjustable current limit(s);
- dynamic braking;
- reversing;
- regeneration;
- line filtering;
- input/output data processing (analog/digital);
- automatic restart;
- boost;
- d.c. braking;
- precharge circuit.

3.2 Fault supervision

The CDM shall provide specified fault indication. 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 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 over/under voltage;
- supply phase loss;
- internal control system fault;
- regulator/power circuit diagnostics.

3.3 Minimum status indication required

The CDM shall be equipped with a status indication signal for “drive on” (whether rotating or at standstill). The CDM may also be equipped with a status indication signal “drive ready for operation”.

3.4 I/O devices

Number and nature of I/O shall be stated by the manufacturer. Any modification shall be agreed upon between the manufacturer and user.

NOTE 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 communicated through serial or parallel links according to various communications standards. Both analog and digital variables can be manually set by use of a control panel and can be read on displays. Variables and parameters are treated in the same manner.

4 Service conditions

4.1 Installation and operation

Unless modified, the equipment which is within the scope of this part of IEC 61800 shall be capable of operation under the conditions listed in 2.2 and 2.3 of IEC 60146-1-1 and IEC Guide 106.

4.1.1 Electrical service conditions

Unless otherwise specified, the CDM or BDM shall be designed to operate under the service conditions specified below. The values specified include the effect of the drive system being considered.

EMC requirements for power drive systems are stated in IEC 61800-3.

NOTE The limits specified in 4.1.1.1 to 4.1.1.5 link the EMC standards to existing practice in semiconductor converters given in 2.5.1, 2.5.2, and 2.5.3 of IEC 60146-1-1, and correspond generally to class B.

4.1.1.1 Frequency variations

Frequency $f_{LN} \pm 2\%$ ($\pm 4\%$ for separated supply network) according to class 3 defined in IEC 61000-2-4.

Rate of change of frequency $\leq 2\% f_{LN}/s$.

(See also 5.2.3.2 of IEC 61800-3.)

4.1.1.2 Voltage changes

Voltage limits for uninterrupted operation

PDS rated input voltage $\pm 10\%$ (at the point of coupling, PC), according to class 2, defined in IEC 61000-2-4 (see also 5.2.2.1 and 5.2.2.2 of IEC 61800-3).

NOTE Short time voltage variation beyond the levels specified, may result in interruption of operation or tripping. If continuous operation is necessary, an agreement is required between the user and the supplier/manufacturer.

Voltage limits for rated performance

Rated converter performance shall be maintained when the steady state fundamental component of the line a.c. supply voltage is equal to or greater than 100 % and equal to or less than 110 % of the rated value measured at the terminals of the BDM. Rated operation at voltages below 100 % of rated voltage shall be subject to agreement between the user and the supplier/manufacturer.

NOTE Also refer to 5.2.1.

4.1.1.3 Voltage unbalance

PDS shall operate with a line voltage unbalance (at the point of coupling, PC) up to, but not exceeding 3 % of the fundamental rated input voltage (U_{LN1}). See 5.2.3.1 and Annex B.3 of IEC 61800-3, for definitions and calculations.

4.1.1.4 Source impedance

The minimum R_{sc} ratio for the PDS to meet rated performance shall be 20, determined at the point of common coupling (PC).

NOTE 1 A larger source impedance may cause snubbers to have a poor damping ratio resulting in possible failure condition and excessive notch size.

NOTE 2 See the manufacturer's documentation to determine the maximum design R_{sc} ratio.

4.1.1.5 Harmonics and commutation notches

a) Harmonics

Unless otherwise agreed to, the equipment within the scope of this part of IEC 61800 shall be designed to operate with a voltage total harmonic distortion (THD) of 10% under steady state conditions (at the point of coupling, PC), and of 15 % during transient periods of less than 15 s, according to class 3, defined in IEC 61000-2-4 (see also 5.2.1 of IEC 61800-3).

NOTE Compatibility levels for individual harmonic voltages are given in Tables 3, 4, and 5 of IEC 61000-2-4.

A theoretical example of harmonic distortion illustrates, in Annex B.5, a practical assessment of the relationship between emission and immunity, to take into account the effect of the drive itself as stated in 4.1.

b) Commutation notches

The equipment shall meet the rated performance with the following notching limits at the line side terminals of the CDM/BDM (see 2.5.4.1 of IEC 60146-1-1, immunity class B).

- Commutation notch depth 40 % of U_{LWM}
- Commutation notch area 250 % × degrees

4.1.1.6 Repetitive and non-repetitive transients

A typical a.c. voltage waveform containing repetitive and non-repetitive transients is shown in Figure 5. The transients are caused by converter commutation, switching on the network, and disturbances on the power system.

The BDM shall be designed to operate in an environment with non-repetitive transients caused by transformer switching provided that the supply transformer is sized for no more than five times the apparent power of the drive under consideration. Where transformers are sized for greater capacity, additional transient energy absorption capacity shall be provided external to the BDM.

The energy E (in Joules) of the non-repetitive transient caused by switching of the transformer is directly related to the magnetization energy of the transformer feeding the BDM. The energy can be calculated by the equation:

$$E = 400 \times S_N$$

where S_N is expressed in MVA and is equal to:

$$S_N = \sqrt{3} \times U_{LN} \times I_{LN} \times 10^{-6}$$

where

U_{LN} is the rated system voltage;

I_{LN} is the line-side rated a.c. current.

The following assumptions are made:

- the magnetization current is 5 %;
- switching occurs at the point of maximum energy release.

NOTE If the transformer characteristics are known, a specific calculation can be made.

4.1.1.7 Unusual conditions

Particular conditions such as unusual operating duty, unbalanced a.c. system impedance, unusually strong magnetic fields, unusually high levels of radio frequency interference (such as from communication transmitters), and additional impedance outside the CDM or BDM added after the acceptance test shall be communicated where known or specified.