

Adjustable speed electrical power drive systems —

Part 3: EMC product standard including specific test methods

The European Standard EN 61800-3:1996, with the incorporation of amendment A11:2000, has the status of a British Standard

ICS 29.33.100.01

National foreword

This British Standard is the English language version of EN 61800-3:1996, including amendment A11:2000 and corrigendum May 2001. It was derived from IEC 61800-3:1996.

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

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

The CENELEC common modifications have been implemented at the appropriate places in the text. The start and finish of each common modification is indicated in the text by tags **A1** **A1**. Where a common modification has been introduced by amendment, the tags carry the number of the amendment. For example, the common modifications introduced by CENELEC amendment A11 are indicated by **A11** **A11**.

Corrigendum May 2001 introduces the following changes to the text: the addition of a table into the Foreword, and corrections to the new subclause **B.1.4.1**.

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

Cross-references

The British Standards which implement international or European publications referred to in this document 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.

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Adjustable speed electrical power drive systems — Part 3: EMC product standard including specific test methods

(includes amendment A11:2000)
(IEC 61800-3:1996, modified)

Entraînements électriques de
puissance à vitesse variable —
Partie 3: Norme de produit relative
à la CEM incluant des méthodes
d'essais spécifiques
(inclut l'amendement A11:2000)
(CEI 61800-3:1996, modifiée)

Drehzahlveränderbare elektrische Antriebe —
Teil 3: EMV-Produktnorm einschließlich
spezieller Prüfverfahren
(enthält Änderung A11:2000)
(IEC 61800-3:1996, modifiziert)

This European Standard was approved by CENELEC on 1996-07-02. Amendment A11 was approved by CENELEC on 2000-01-01. 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.

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CENELEC

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

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Foreword

The text of document 22G/31/FDIS, future edition 1 of IEC 1800-3, 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 61800-3 on 1996-07-02.

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) 1997-04-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1997-04-01

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 and Annex E are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 1800-3:1996 was approved by CENELEC as a European Standard without any modification.

In the official version, for Annex E, Bibliography, the following notes have to be added, under E.3, for the standards indicated:

- IEC 38 NOTE Harmonized as HD 472 S1:1989 (modified).
- IEC 146-1-3 NOTE Harmonized as EN 60146-1-3:1993 (not modified).
- IEC 1000-4-1 NOTE Harmonized as EN 61000-4-1:1994 (not modified).
- IEC 1000-4-7 NOTE Harmonized as EN 61000-4-7:1993 (not modified).

Foreword to amendment A11

This amendment was prepared by the Technical Committee CENELEC TC 22X, Power electronics.

The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as amendment A11 to EN 61800-3:1996 on 2000-01-01.

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- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2002-01-01

This amendment A11 is published as common modifications.

NOTE The following table lists the valid figures and tables for EN 61800-3:1996 as modified by its amendment A11:2000.

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1 Scope and object

This International Standard specifies electromagnetic compatibility (EMC) requirements for power drive systems (PDSs). These are adjustable speed a.c. or d.c. motor drives. Requirements are stated for PDSs which are connected to mains supplies with a rated voltage of up to 1 000 V a.c. r.m.s. For supply voltages higher than 1 000 V a.c. r.m.s. EMC requirements are under consideration and, until a new publication is produced, they will result from agreement between manufacturer/supplier and user.

PDSs covered by this standard are those installed in industrial and residential environments with the exception of traction applications and electric vehicles. PDSs may be connected to either industrial or public power distribution networks. Industrial networks are supplied by a dedicated distribution transformer, which is usually adjacent to or inside the industrial location, and supplies only industrial customers. On the other hand, PDSs can be directly connected to low-voltage public mains networks which also supply domestic premises, and in which the neutral is generally earthed (grounded).

PDSs covered by this standard are often included in a larger system, the system aspect is not covered by this standard, but guidance is provided in the informative annexes.

The requirements have been selected so as to ensure an adequate level of electromagnetic compatibility (EMC) for PDSs in industrial and public locations. The levels cannot, however, cover extreme cases which are most unlikely to occur. Changes in the EMC behaviour of a PDS, as a result of fault conditions, are not taken into account.

The object of this standard is to define the limits and test methods for a PDS. It includes immunity requirements and requirements against electromagnetic emissions. Emission can cause interference in other electronic equipment (for example radio receivers, measuring and computing devices). Immunity is required to protect the equipment from continuous and transient conducted and radiated disturbances, including electrostatic discharges. For evident economic reasons, the emission and immunity requirements should be balanced against each other and against the actual environment of the PDS.

This standard defines the minimum electromagnetic compatibility requirements for a PDS.

This standard does not specify all safety requirements for the equipment, such as protection against electric shocks, insulation co-ordination and related dielectric tests, unsafe operation, or unsafe consequences of a failure.

In special cases, when highly susceptible apparatus is being used in proximity, additional mitigation measures may have to be employed to reduce the electromagnetic emission further below the specified levels, or to increase the immunity of the highly susceptible apparatus.

This product EMC standard for PDSs takes precedence over all aspects of the generic standards, and no additional EMC tests are required or necessary. If a PDS is included as part of equipment covered by a separate EMC product standard, the EMC standard of the complete equipment applies.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard 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 50(131):1978, *International Electrotechnical Vocabulary (IEV) — Chapter 131: Electric and magnetic circuits*.

IEC 50(151):1978, *International Electrotechnical Vocabulary (IEV) — Chapter 151: Electrical and magnetic devices*.

IEC 50(161):1990, *International Electrotechnical Vocabulary (IEV) — Chapter 161: Electromagnetic compatibility*.

IEC 146-1-1:1991, *Semiconductor convertors — General requirements and line commutated convertors — Part 1-1: Specifications of basic requirements*.

IEC 364-3:1993, *Electrical installations of buildings — Part 3: Assessment of general characteristics*.

IEC 664-1:1992, *Insulation coordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests*.

IEC 1000-2-1:1990, *Electromagnetic compatibility (EMC) — Part 2: Environment — Section 1: Description of the environment — Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems.*

IEC 1000-2-2:1990, *Electromagnetic compatibility (EMC) — Part 2: Environment — Section 2: Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems.*

IEC 1000-2-4:1994, *Electromagnetic compatibility (EMC) — Part 2: Environment — Section 4: Compatibility levels in industrial plants for low-frequency conducted disturbances.*

IEC 1000-2-6:1995, *Electromagnetic compatibility (EMC) — Part 2: Environment — Section 6: Assessment of the emission levels in the power supply of industrial plants as regards low-frequency conducted disturbances.*

IEC 1000-3-2:1995, *Electromagnetic compatibility (EMC) — Part 3: Limits — Section 2: Limits for harmonic current emissions (equipment input current ≤ 16 A per phase).*

IEC 1000-3-3:1994, *Electromagnetic compatibility (EMC) — Part 3: Limits — Section 3: Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current ≤ 16 A.*

A11 IEC/TS 61000-3-4:1998, *Electromagnetic compatibility (EMC) — Part 3-4: Limits — Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A.* A11

IEC 1000-3-5:1994, *Electromagnetic compatibility (EMC) — Part 3: Limits — Section 5: Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 16 A.*

A11 IEC 61000-3-11¹⁾, *Electromagnetic compatibility (EMC) — Part 3-11: Limits — Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems for equipment with rated current ≤ 75 A and subject to conditional connection.* A11

IEC 1000-4-2:1995, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 2: Electrostatic discharge immunity test — Basic EMC Publication.*

IEC 1000-4-3:1995, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 3: Radiated, radio-frequency, electromagnetic field immunity test.*

IEC 1000-4-4:1995, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 4: Electrical fast transient/burst immunity test — Basic EMC publication.*

Amendment 1 (1995)

IEC 1000-4-5:1995, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 5: Surge immunity test.*

A11 IEC 1000-4-6:1996, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 6: Immunity to conducted disturbances, induced by radio-frequency fields.* A11

IEC 1000-4-8:1993, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 8: Power frequency magnetic field immunity test — Basic EMC publication.*

IEC 1000-4-9:1993, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 9: Pulse magnetic field immunity test — Basic EMC publication.*

IEC 1000-4-10:1993, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 10: Damped oscillatory magnetic field immunity test — Basic EMC publication.*

A11

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IEC CISPR 16-1:1993, *Specification for radio disturbance and immunity measuring apparatus and methods — Part 1: Radio disturbance and immunity measuring apparatus.*

¹⁾ A11 In preparation. A11

3 Definitions

Definitions related to EMC and to relevant phenomena may be found in chapter 161 of the IEV (IEC 50), in CISPR, and other IEC publications (see clause 2). For the purpose of this International Standard, the following additional definitions apply.

A power drive system (PDS) consists of a motor and a complete drive module (CDM). It does not include the equipment driven by the motor. The CDM consists of a basic drive module (BDM) and its possible extensions, such as the feeding section or some auxiliaries (for example ventilation). The BDM contains converter, control and self protection functions. Figure 1 shows the boundary between the PDS and the rest of the installation and/or manufacturing process.

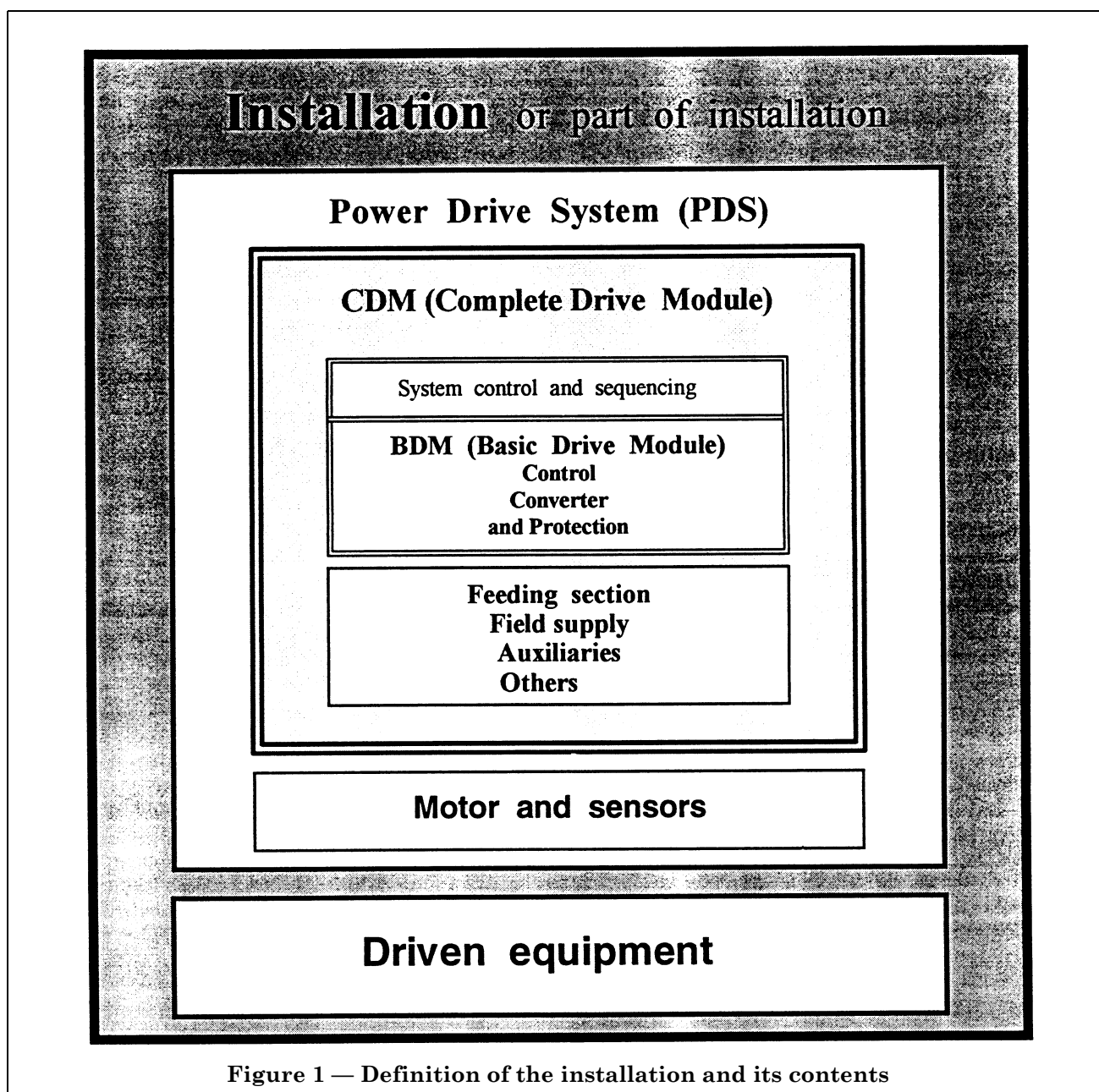


Figure 1 — Definition of the installation and its contents

If the power drive system (PDS) has its own dedicated transformer, this transformer is included as a part of the complete drive module (CDM).

3.1

unrestricted distribution

mode of sales distribution in which the supply of equipment is not dependent on the EMC competence of the customer or user for the application of drives

NOTE This implements restrictive emission limits in accordance with essential EMC protection requirements.

3.2

restricted distribution

mode of sales distribution in which the manufacturer restricts the supply of equipment to suppliers, customers or users who separately or jointly have technical competence in the EMC requirements of the application of drives

NOTE For economical reasons, the partners should ensure the essential EMC protection requirements for the specific installation, by choice of suitable emission class, by measurement *in situ* with actual boundary conditions and by exchange of technical specifications.

3.3

first environment

environment that includes domestic premises

it also includes establishments directly connected without intermediate transformers to a low-voltage power supply network which supplies buildings used for domestic purposes

3.4

second environment

environment that includes all establishments other than those directly connected to a low-voltage power supply network which supplies buildings used for domestic purposes

3.5

manufacturer's premises (for test)

location within manufacturer's workshop or laboratory, dedicated for testing the equipment they manufacture, this equipment may be PDS or CDM or BDM

3.6

in situ (for test)

location where the equipment is installed for its normal use by the end user

the equipment may be tested there

3.7

test site (radiation)

a site meeting the requirements necessary for correctly measuring, under defined conditions, electromagnetic fields emitted by a device under test

[IEV 161-04-28]

3.8

port

a particular boundary of the specified PDS with the electromagnetic environment of the process (see Figure 2)

[IEV 131-02-21 modified]

3.9

enclosure port

physical boundary of the PDS through which electromagnetic fields may radiate or impinge (see Figure 2)

3.10

port for process measurement and control

input/output (I/O) port for a conductor or cable which connects the process to the PDS as defined in clause 3 (see Figure 2)

3.11

power port

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

3.12

mechanical link

mechanical connection between the shaft of the motor of the PDS and the driven equipment of the process as defined in clause 3

3.13

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 (see Figure 2)

3.14

PCC, IPC, PC

these definitions are given in IEC 1000-2-4

NOTE Briefly:

- PCC is the point of common coupling on a public network;
- IPC is the in-plant point of coupling;
- PC is the point of coupling (for either of these cases).

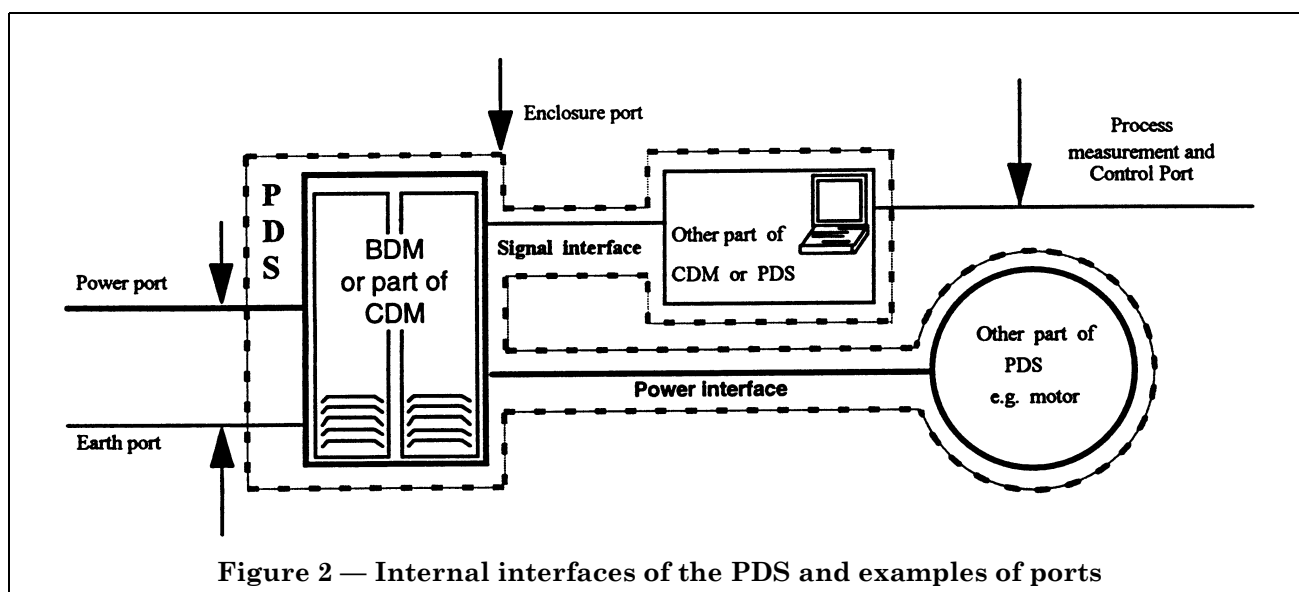


Figure 2 — Internal interfaces of the PDS and examples of ports

3.15

power interface

connections needed for the distribution of electrical power within the PDS (see Figure 3 and explanation in A.2)

NOTE The power interfaces of the PDS may have different forms and extensions:

- within the CDM/BDM

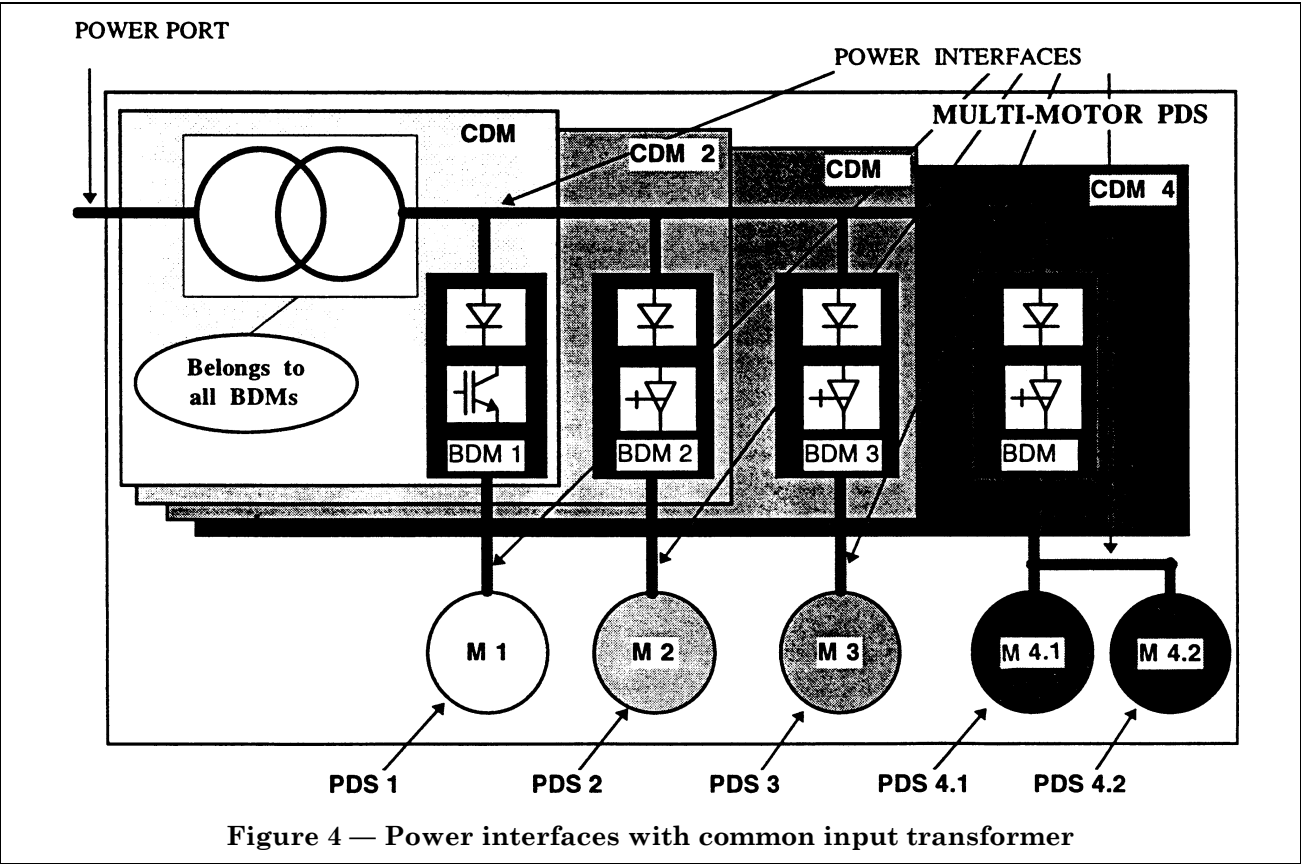
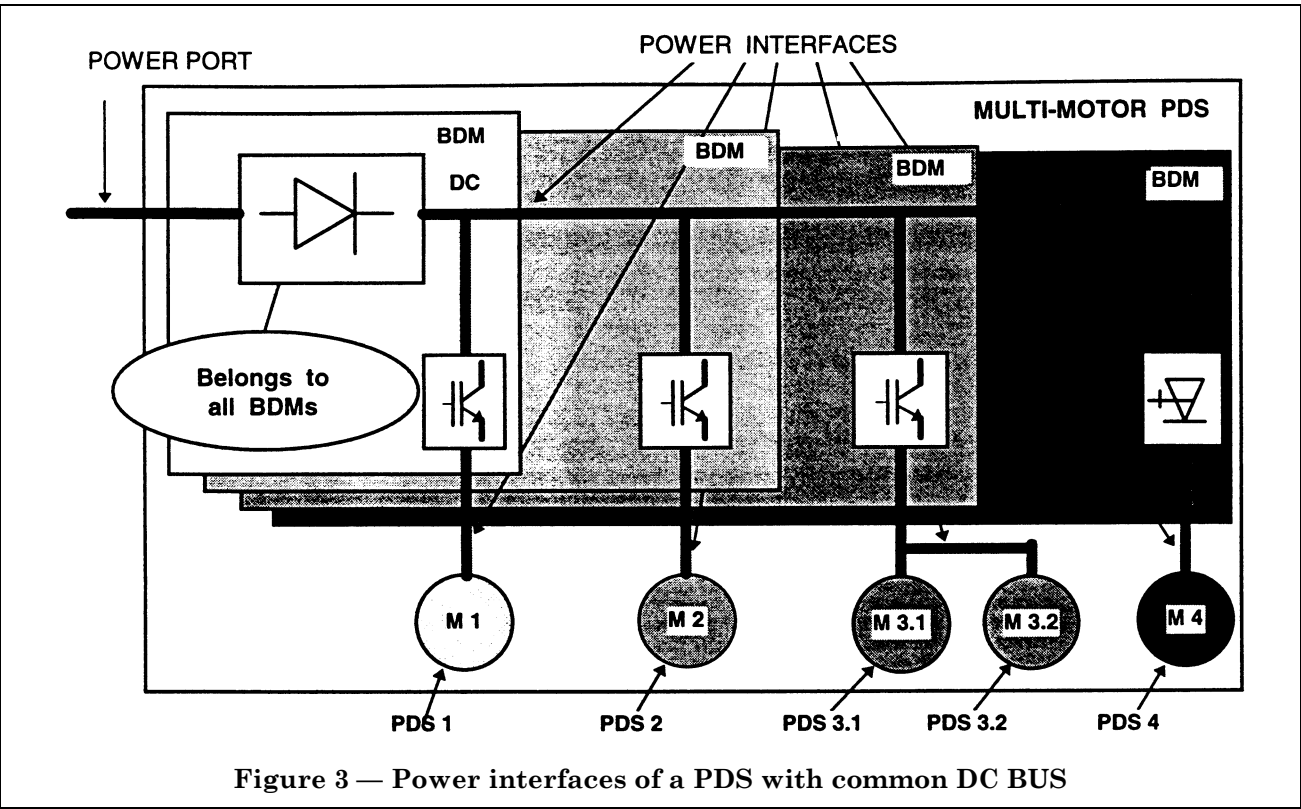
A power interface may be the connection for distribution of electrical power from one part of the BDM/CDM to another part of the BDM/CDM. One power interface may be common to different PDSs. According to clause 4, no cumulative effects have to be considered. For examples, see Figure 3 and Figure 4.

Figure 3 shows a power interface which distributes power from an input converter (where power is converted from the mains to another type [here d.c. power]) to output inverters (where power is converted from an intermediate form [here d.c.] to another type [here a.c.] which can be directly applied to a.c. motors).

Figure 4 shows a power interface which distributes power from the secondary of a transformer (which is part of the CDM) to individual BDMs.

- within the PDS

Note that the connection between the inverter and the motor or the motors is also a power interface. It is the last power interface before the conversion to mechanical power.



3.16**converter** [of the complete drive module (CDM)]

the converter of the CDM is the unit which changes voltage and/or current and/or frequency of the mains supply to the voltage and/or current and/or frequency that feed the network of the motor (see details in A.2)

NOTE 1 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 The converter can be line, load or self-commutated and can consist, for example, of one or more rectifiers or inverters.

3.17**(electric) motor**

an electric machine that converts electric energy into mechanical energy
[IEV 151-01-53]

3.18**motor** (of the PDS)

for the purpose of this standard, the motor includes all sensors which are mounted on it and which are relevant for supporting the operating mode and interacting with a complete drive module (CDM)

4 Common requirements

All phenomena, from the emission or immunity point of view, shall be considered individually. The limits are given for conditions which do not take into account cumulative effects.

4.1 System aspects

PDSs often do not have a fixed configuration. The way of converting electrical power and transforming it to mechanical power may vary depending on the customers' requirements and economical conditions in spite of, for example, identical output power ratings. Figure 1 shows that different feeding sections or auxiliaries as well as different motors and transformers can be combined inside the drive system. For these conditions, every possible arrangement need not be tested. For a realistic simulation of the EMC situation, a typical configuration for the type test as defined in 4.1 of IEC 146-1-1 shall be chosen.

The application of tests for evaluation of immunity shall depend on the particular PDS, its configuration, its ports, its technology and its operating conditions (see annexes).

4.2 Tests**4.2.1 General conditions**

All the tests specified in this standard are dedicated to ensure compliance with the essential EMC requirements and are type tests only. The test shall be performed using the manufacturer's recommended wiring practices.

The equipment shall be tested *in situ*, at the manufacturer's premises, or at a test site, depending on the economic and practical considerations. It shall meet the requirements when measured by the test methods specified.

No additional EMC tests are required or necessary beyond those stated in this standard.

Safeguards shall be taken against any unintended effects on the total process that may result from an equipment failure while an EMC test is being conducted.

For the test, unless otherwise specified by the manufacturer, the CDM shall be connected to a standard motor of adequate ratings with a cable and earthing rules defined by the manufacturer. In some cases, passive load conditions (ohmic or inductive-ohmic) may additionally be applied (for example for evaluation of the low-frequency emissions). In this case, however, the passive load configurations should be shielded to simulate the metal housing of a motor. It shall be noted that the parasitic capacitance from load to earth cannot be standardised but could be different from that of a motor (about 1 nF... 20 nF or more) for evaluation of the high-frequency emission.

The description of the tests, the test methods, the characteristics of the tests and the test set-ups are given in the referred standards and are not repeated here. If, however, modifications or additional requirements and information or specific test methods are needed for practical implementation and application of the tests, then they are given in this standard.

4.2.2 Test report

The test results shall be documented in a test report. The report shall clearly and unambiguously present all relevant information of the tests (for example load conditions, cable laying, etc.). A functional description and a definition of specification limits for the acceptance criteria shall be provided by the manufacturer and noted in the test report.

Within the test report, the chosen test arrangements shall be justified. A sufficient number of terminals shall be selected to simulate actual operating conditions and to ensure that all relevant types of termination are covered. The tests shall be carried out at the rated supply voltage and in a reproducible manner.

4.3 Documentation for the user

The manufacturer shall supply the documentation necessary for the installer of a BDM, CDM, or for the user of a PDS for the correct installation into a typical system or process. The user shall be informed if additional components are necessary, and if special measures have to be taken to achieve compliance with the EMC requirements of the dedicated environment; for example, the amount of network impedance, the use of shielded or special cables and maximum length, or the use of filters as well as the correct bonding to functional earth.

A list of optional devices or equipment, which shall be added to the PDS to make it compliant with the immunity and/or emission requirements of different environments, shall be made available. A list of auxiliary equipment (for example options or enhancements) that can be added to the PDS, and which complies with the immunity and/or emission requirements shall be made available. In accordance with the completeness and the character of the delivered product; for example, whether it is a BDM, CDM or a PDS, and depending on the EMC sensitivity of the environment, the manufacturer shall be responsible for choosing the additional information which is necessary to perform the typical installation correctly.

This information may also be mentioned in some part of the test report to clarify the final recommended arrangement. For example, additional information is required, if a BDM should be installed in a domestic environment. The contents of the application guide shall also be adapted to the typical technical competence of the user.

5 Immunity requirements

5.1 General conditions

The immunity of the subcomponents of a PDS, such as power electronics, driving circuits, protection circuits, control circuits, displays and control panels, against electromagnetic disturbances may be verified by separate tests, using where necessary suitable loads instead of the missing parts. These tests verify the intrinsic performance of the subcomponents. The tests of the ports or interfaces of the PDS contained in those subcomponents may be performed by choosing the relevant test methods and levels from Table 2 and Table 3. This method is recommended to support quality assurance, and the results can be included in the test reports.

Alternatively, the specific performance of the BDM, or of the CDM, or of the PDS may be tested instead of the intrinsic performances of their subassemblies.

5.1.1 Acceptance criteria (performance criteria)

Table 1 — Criteria to prove the acceptance of a PDS against electromagnetic disturbances

Item	Acceptance/performance criterion		
	A	B	C
Specific performance General	No noticeable changes of the operating characteristic OPERATING AS INTENDED within specified tolerance	Noticeable changes (visible or audible) of the operating characteristic SELF RECOVERABLE	Shut-down, changes in operating characteristic. Triggering of protective devices (see note 1 in 5.1.1) NOT SELF RECOVERABLE
Specific performance Special Torque generating behaviour	Torque deviation within specified tolerances	Temporary torque deviation outside specified tolerances SELF RECOVERABLE	Loss of torque NOT SELF RECOVERABLE
Intrinsic performance Operating of power electronics and driving circuits	No breakdown of a power semiconductor	Temporary breakdown which cannot cause unintended shut-down of the drive	Shut-down, triggering of protective devices (see note 1, in 5.1.1) NOT SELF RECOVERABLE
Intrinsic performance Information processing and sensing functions	Undisturbed communication and data interchange to external devices	Temporarily disturbed communication, but no error reports of the internal or external devices which could cause shut-down	Errors in communication, loss of data and information NOT SELF RECOVERABLE
Intrinsic performance Operation of displays and control panels	No changes of visible display information only slight light intensity fluctuation of LEDs, or slight movement of characters	Visible temporary changes of information, undesired LED illumination	Shut down, permanent loss of information or unpermitted operating mode, obviously wrong display information

The acceptance criteria shall be used to check the performance of a PDS against external disturbances. From the EMC point of view any installation, according to Figure 1, shall be running properly. Since a PDS is part of the functional sequence of a larger process, the effect on this process caused by changes in the performance of the PDS is hard to forecast.

The main functions of a PDS are energy conversion from the electrical to mechanical form and the information processing necessary to perform this. The intrinsic performance shall be subdivided into three parts for every item:

- operation of power electronics and driving circuits;
- information processing and sensing functions;
- operation of displays and control panels.

Table 1 classifies the effects of a given disturbance into three acceptance/performance criteria: A, B and C, each of which defines a specified level of performance.

NOTE 1 Acceptance criterion C

The function can be restored by operator intervention (manual reset). Blowing of fuses is allowed for line commutated converters operating in inverting mode.

NOTE 2 Acceptance criteria A, B, C

False starts are not acceptable. A false start is an unintended change from the logical state "STOPPED" which can make the motor run.

5.1.2 Selection of intrinsic or specific performance

The general specific performance item from Table 1 shall be defined in accordance with the special application and typical configuration of the PDS. It is the responsibility of the manufacturer to select these items. Testing of subcomponents with intrinsic criteria should be used in cases when a PDS cannot be put into service on a test site because of limitation on the physical size of the PDS, on the current or rated supply capability, or load conditions. In any case, the test set-up shall be immune to the highest level of disturbance applied to the PDS or to the subcomponent under test.

Intrinsic performance tests shall be used when the specific performance item according to Table 1:

- is not sufficiently applicable; or
- is not practicable for technical or economical reasons (for example large and/or complex PDSs with separate functional units).

Testing of information processing and sensing functions, including optional accessories if any, shall be performed only in cases where the relevant ports or interfaces are available at the PDS. Testing of the intrinsic performance, according to Table 1, where the functions exist, is sufficient to determine the compliance with this standard.

The special specific performance, torque generating behaviour, shall be tested only in cases where it is clearly defined by the customer requirements. In that case, the torque generating performance can be directly or indirectly tested. The direct test uses an EMC immune torquemeter to measure torque disturbances, while the indirect test refers to current performances. The indirect test can use current or speed performance, provided the total inertia is specified. Torque performance can be defined through the ability to keep current or speed constant, within specified tolerances when a disturbance is applied (see also 5.1.3).

5.1.3 Conditions during the test

A light load test is acceptable. For example, in the case of the built-in gate drive circuit, an external disturbance could cause a failure condition in spite of small output currents (for example an undesired short circuit between two arms of the same phase, or an undesired firing of a crow-bar circuit). The same applies in the case of any electronic or microprocessor controlled equipment inside the PDS.

If a full load test is required (as a contract specific item), the specific performance test shall be used, and the test shall be carried out on the BDM as a complete unit. See A.3.

Testing the torque generating behaviour, as well as the information processing and sensing functions, requires special test equipment with adapted immunity against the parasitic coupling of the test disturbance. It can only be used if the immunity of the test set-up is provable by reference measurements. The evaluation of the torque disturbance can be performed by a torque transducer, or by measurement or calculation of the torque generating current or other indirect techniques; an adapted and immune load shall be available at the test site.

For testing the performance of the information processing or sensing function, suitable equipment shall be available to simulate the data communication or data evaluation. This equipment shall have sufficient immunity to operate correctly during the test.

Since the motor has been tested by its manufacturer according to the relevant standards, the motor section of the PDS, with exception of the sensors, does not need any additional EMC immunity test. Therefore, while the motor is connected to the BDM/CDM for the duration of the test, EMC immunity tests on the motor itself are not required.

The tests shall be applied to the relevant ports where they exist, including those of optional accessories if any, and shall be conducted in a well-defined and reproducible manner on a port-by-port basis. However if several process measurement and control ports or signal interfaces have the same physical configuration (layout), it is sufficient to test one port or interface of that type.

In the following subclauses the minimum requirements, tests and acceptance criteria are stated. The acceptance criteria refer to 5.1.1.

5.2 Basic immunity requirements — Low-frequency disturbances

The requirements in these subclauses shall be used for designing the immunity of a PDS against low-frequency disturbances. **[A1]** The corresponding methods for demonstrating compliance, tests, calculations or simulation, shall be defined by the manufacturer. The results shall be given in the user documentation.

5.2.1 Harmonics and commutation notches/voltage distortion

The PDS or BDM/CDM shall comply with the immunity levels given in Table 2.

Table 2 — Minimum immunity requirements for harmonics on power ports of power drive systems (PDSs)

Phenomenon	Level and reference document		Performance (Acceptance) criterion
	First environment	Second environment	
Harmonics (THD and individual harmonic orders)	IEC 61000-2-2 (THD = 8 %)	IEC 61000-2-4 – Class 3 (THD = 10 %)	A
Harmonics short term (< 15 s)	IEC 61000-2-2 1,5 times permanent levels	IEC 61000-2-4 – Class 3 1,5 times permanent levels	B
Commutation notches	No requirement	IEC 60146-1-1 – Class B (depth = 40 %, total area = 250 % × degrees)	A

The immunity of the PDS shall be verified by calculation, simulation or test, at the choice of the manufacturer.

The manufacturer shall verify that each of the above levels will not cause the ratings for the input circuits (including snubbers, phase detection circuits, input filters, etc.) to be exceeded.

Any analysis of commutation notches shall be in the time domain. A frequency domain analysis of their contribution to the total harmonic distortion will not fully identify their harmful effects (see B.1).

5.2.2 Voltage changes, fluctuations, dips and short interruptions

The PDS or BDM/CDM shall comply with the immunity levels given in Table 3.

Table 3 — Minimum immunity requirements for voltage changes on power ports of power drive systems (PDSs)

Phenomenon	Level and reference document		Performance (Acceptance) criterion
	First environment	Second environment	
Voltage variations and fluctuations	IEC 61000-2-2 ^a ±10 %	IEC 61000-2-4 ^a – Class 3 ±10%	A ^b
Voltage variations and fluctuations less than 1 min	IEC 61000-2-2 ^a ±10 %	IEC 61000-2-4 ^a – Class 3 +10 % to –15 %	A ^b
Voltage dips and short interruptions	IEC 61000-2-1 ^c 10 % to 100 %	IEC 61000-2-1 ^c 10 % to 100 %	C ^d

^a Typical shapes of voltage fluctuations are given in Figure 3 to 6 of IEC 61000-2-1.

^b When the voltage is below nominal, the maximum output power ratings – speed and/or torque – may be reduced.

^c Typical depths and durations of voltage dips are given in 8.1.2 of IEC 61000-2-1.

^d Blowing of fuses is allowed for line commutated converters operating in inverting mode.

The immunity of the PDS shall be verified by calculation, simulation or test, at the choice of the manufacturer.

NOTE 1 A PDS is used for energy conversion and a voltage dip represents a loss of available energy. It may be necessary to trip for safety reasons, even during a voltage dip of 30 % to 50 % amplitude and 0,3 s duration. **[A1]**

Ann NOTE 2 The effect of a voltage dip (energy reduction) on the process cannot be defined without detailed knowledge of the process itself. This effect is a system and rating aspect, and will generally be greatest when the power demand (including losses) on the PDS is higher than the available power.

NOTE 3 A decreasing input voltage, even with a duration of a few milliseconds, may result in blowing of fuses when applied to a line commutated thyristor converter operating under regeneration mode.

Where it is possible and not dangerous (see clause 7) the behaviour of the PDS during short interruptions may be verified by switching off and on the mains supply during the standard operating conditions of the PDS (see B.4.1).

The manufacturer shall state in the user documentation the behaviour of the PDS or BDM/CDM during voltage dips and short interruptions.

If a higher level of immunity is required, this shall be stated by the user.

NOTE 4 Improvements to the immunity (use of UPS, stand-by generator, derating, etc.) may result in a considerable increase in the size and cost of the PDS and may reduce the efficiency or power factor. Operation such as automatic restart may have safety consequences, which are the installer's or user's responsibility, and are not covered by this standard (see clause 7).

5.2.3 Voltage unbalance and frequency variations

The PDS or BDM/CDM shall comply with the immunity levels given in Table 4.

Table 4 — Minimum immunity requirements for voltage unbalance and frequency variations on power ports of power drive systems (PDSs)

Phenomenon	Level and reference document		Performance (Acceptance) criterion
	First environment	Second environment	
Voltage unbalance ^a	IEC 61000-2-2 (2 % negative sequence component)	IEC 61000-2-4 – Class 3 (3 % negative sequence component)	A
Frequency variations and Rate of change	IEC 61000-2-2 ±2 % 1 %/second	IEC 61000-2-4 ±2 % ^b 1 %/second	A
^a Voltage unbalance is explained in B.3.			
^b ±4 % with rate of change 2 %/second where the supply is separated from public supply networks.			

The immunity of the PDS shall be verified by calculation, simulation or test, at the choice of the manufacturer.

5.2.4 Supply influences — Magnetic fields

Immunity tests according to IEC 61000-4-8 are not required. (See A.4.1 for explanation.)

PDS intended to be used in the following environments may require additional tests:

- for electrical generating plants and telecontrol centres, the test to be performed is against pulse magnetic field according to IEC 61000-4-9;
- for medium or high-voltage substations, the test to be performed is against damped oscillatory magnetic field tests according to IEC 61000-4-10.

In both cases, the decision to apply the test or not shall be agreed between the manufacturer and the customer according to the actual location planned for the installation of the PDS within the site.

5.3 Basic immunity requirements— High-frequency disturbances

In Table 5 and Table 6, the minimum immunity requirements for high-frequency disturbance tests, and acceptance criteria are stated. The acceptance criteria refer to 5.1.1. Explanations are given in A.4. **Ann**

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5.3.1 First environment

The levels in Table 5 shall be applied to PDSs which are intended to be used in the first environment.

Table 5 — Minimum immunity requirements for power drive systems (PDSs) intended for use in the first environment

Port	Phenomenon	Basic standard for test method	Level	Performance (Acceptance) criterion
Enclosure port	ESD Radio-frequency electromagnetic field, amplitude modulated	IEC 61000-4-2 IEC 61000-4-3 see also 5.3.3	6 kV CD or 8 kV AD if CD impossible 80 to 1 000 MHz 3 V/m 80 % AM (1 kHz)	B A
Power ports	Fast transient-burst Surge ^b 1,2/50 µs, 8/20 µs Conducted radio-frequency common mode ^e	IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6 see also 5.3.3	1 kV/5 kHz ^a 1 kV ^c 2 kV ^d 0,15 to 80 MHz 3 V 80 % AM (1 kHz)	B B A
Power interfaces	Fast transient-burst ^e	IEC 61000-4-4	1 kV/5 kHz Capacitive clamp	B
Ports for process measurement control lines and signal interfaces	Fast transient-burst ^e Conducted radio-frequency common mode ^e	IEC 61000-4-4 IEC 61000-4-6 see also 5.3.3	1 kV/5 kHz Capacitive clamp 0,15 to 80 MHz 3 V 80 % AM (1 kHz)	B A
CD = contact discharge AD = air discharge				
^a Power ports with current rating < 100 A: direct coupling using the coupling and decoupling network. Power ports with current rating ≥ 100 A: direct coupling or capacitive clamp without decoupling network. If the capacitive clamp is used, test level shall be 2 kV/5 kHz. ^b Applicable only to power ports with current consumption < 63 A during light load test conditions as specified in 5.1.3 . The rated impulse voltage of the basic insulation shall not be exceeded (see IEC 60664-1). ^c Coupling line to line. ^d Coupling line to earth. ^e Applicable only to ports or interfaces with cables whose total length according to the manufacturer's functional specification may exceed 3 m.				

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5.3.2 Second environment

The levels in Table 6 shall be applied to PDSs which are intended to be used in the second environment.

Table 6 — Minimum immunity requirements for power drive systems (PDSs) intended for use in the second environment

Port	Phenomenon	Basic standard for test method	Level	Performance (Acceptance) criterion
Enclosure port	ESD	IEC 61000-4-2	6 kV CD or 8 kV AD if CD impossible	B
	Radio-frequency electromagnetic field, amplitude modulated	IEC 61000-4-3 see also 5.3.3	80 to 1 000 MHz 10 V/m 80 % AM (1 kHz)	A
Power ports	Fast transient-burst	IEC 61000-4-4	2 kV/5 kHz ^a	B
	Surge ^b 1,2/50 µs, 8/20 µs	IEC 61000-4-5	1 kV ^c 2 kV ^d	B
	Conducted radio-frequency common mode ^e	IEC 61000-4-6 but see also 5.3.3	0,15 to 80 MHz 10 V 80 % AM (1 kHz)	A
Power interfaces	Fast transient-burst ^e	IEC 61000-4-4	2 kV/5 kHz Capacitive clamp	B
Signal interfaces	Fast transient-burst ^e	IEC 61000-4-4	1 kV/5 kHz Capacitive clamp	B
	Conducted radio-frequency common mode ^e	IEC 61000-4-6 but see also 5.3.3	0,15 to 80 MHz 10 V 80 % AM (1 kHz)	A
Ports for process measurement control lines	Fast transient-burst ^e	IEC 61000-4-4	2 kV/5 kHz Capacitive clamp	B
	Conducted radio-frequency common mode ^e	IEC 61000-4-6 but see also 5.3.3	0,15 to 80 MHz 10 V 80 % AM (1 kHz)	A

CD = contact discharge

AD = air discharge

^a Power ports with current rating < 100 A: direct coupling using the coupling and decoupling network.
Power ports with current rating ≥ 100 A: direct coupling or capacitive clamp without decoupling network. If the capacitive clamp is used, test level shall be 4 kV/2,5 kHz.

^b Applicable only to power ports with current consumption < 63 A during light load test conditions as specified in 5.1.3.
The rated impulse voltage of the basic insulation shall not be exceeded (see IEC 60664-1).

^c Coupling line to line.

^d Coupling line to earth.

^e Applicable only to ports or interfaces with cables whose total length according to the manufacturer's functional specification may exceed 3 m.

5.3.3 Immunity against electromagnetic fields

If the PDS is:

- of rated voltage less than 500 V; and
- of rated current less than 200 A; and
- of total weight less than 250 kg; and
- of height, and width, and depth less than 1,9 m;

the tests of IEC 61000-4-3 and IEC 61000-4-6 shall be performed, see 5.3.1 and 5.3.2.

[A11] If the PDS is larger or of higher rating than in the above paragraph then the manufacturer shall choose either:

- to perform the tests of IEC 61000-4-3 and IEC 61000-4-6 on the PDS; or
- to perform the tests of IEC 61000-4-3 and IEC 61000-4-6 on sensitive sub-components.

If the motor is too large to be put into service on a test site, the motor may be replaced by one of smaller size, provided this does not adversely affect the operation of the CDM/BDM.

In the case where only sub-components have been tested, a test against radio-communication devices of common industrial use should be performed on the complete PDS, as described in **A.4.3.2**. This test is valid for the specific location, installed equipment and frequencies tested only. **[A11]**

5.4 Application of immunity requirements — Statistical aspect

When choosing the acceptance level for a specific test of a PDS, it shall be understood that the test result implies only a certain probability. Depending on the grade of the actual acceptance criterion and the task of a PDS, this probability shall be considered in the specification of the number of test pulses or of the duration of the test application.

Immunity requirements shall be verified by performing a type-test on a representative unit. The manufacturer or supplier shall ensure by means of his quality system that the EMC performance of the product is maintained.

Measurement results obtained for a PDS while installed in its place of use (and not on a test site) shall relate to that installation only.

6 Emission requirements

As far as possible, the configuration of the PDS should be adapted to its real environmental service conditions. To ensure essential EMC protection requirements, this standard subjects equipment, which is specified for unrestricted distribution, to more restrictive emission requirements than equipment which is specified only for restricted distribution.

For economical reasons, in the case of restricted distribution, the partners shall ensure the essential EMC protection requirements for the specific resulting installation, by choice of suitable emission class, by measurement *in situ* with the actual boundary conditions, and by exchange of technical specifications.

The measurements shall be made in the operating mode producing the largest emission in the frequency band, while being consistent with the normal application.

6.1 Basic emission limits in the low-frequency area

For these requirements, testing of a PDS is difficult or uneconomic. However, in the light of established experience of many years, compliance can be verified by calculation or simulation (numerical or analogue), unless otherwise required by contractual agreement between the user and the manufacturer.

6.1.1 Commutation notches

[A11] Commutation notches are measured on the power ports using an oscilloscope (see **B.1.1**). They are produced by controlled line commutated converters (see **2.5.4.1** of IEC 60146-1-1).

Where it is known that the input circuit of the PDS does not produce notches or only produces notches of negligible amplitude (example diode rectifiers), emission of notches need not be considered.

NOTE 1 The main practical case where emission of notches should be considered is the case of thyristor converters (line commutated). RFI filters are a practical case of equipment which can be affected by notches. They can be overloaded or subjected to repetitive over-voltages.

NOTE 2 A diode rectifier is an uncontrolled line commutated converter, which produces commutation notches of negligible amplitude. Some self-commutated converters (for example an indirect converter of the voltage source inverter type with an active front end) can produce commutation notches depending on the PWM pattern.

Where notches are to be considered, the manufacturer shall provide the following information to the user:

- value of any decoupling reactances which are included in the PDS;
- available decoupling reactances which can be externally added for mitigation (see **B.1.2** and **B.1.3**).

The recommendations of **B.1.4** should be followed. **[A11]**

6.1.2 Harmonics and interharmonics

The manufacturer shall provide in the documentation of the PDS, or on request, the current harmonic level, under rated load conditions, as a percentage of the rated fundamental current on the power port. The referenced values shall be calculated for each order at least up to the 25th. The current THD (orders up to and including 40), and its high-frequency component PHD (orders from 14 to 40 inclusive) shall be evaluated. For these standard calculations, the PDS shall be assumed to be connected to a PC with $R_{sc} = 250$ ($R_{sc} = I_{sc}/I_{1LN}$ is the short-circuit ratio between short-circuit current at the PC and rated fundamental line side current of the PDS) and with initial voltage distortion less than 1 %. The internal impedance of the network shall be assumed to be a pure reactance.

A guide for calculation of harmonics is given in IEC 1000-2-6, Annex A — parts 1 and 2. Guidelines for the summation of harmonics of different sources are also given in 6.4 of the same standard.

Effects of interharmonics are considered in 6.1.2.3. Methods for calculation are given in A.3 of IEC 1000-2-6.

A guide for the use of PDSs in systems or industrial networks is provided in B.2.

6.1.2.1 Low-voltage public supply network

[Ann] An equipment may contain one or several PDSs and also other loads.

When a PDS is an equipment within the scope of IEC 61000-3-2, the requirements of that standard apply. However, when one or more PDSs are included in equipment within the scope of IEC 61000-3-2, the requirements of that standard apply to the complete equipment and not to the individual PDS.

For equipment not covered by IEC 61000-3-2, (example: rated current above 16 A) recommendations are given in the technical specification IEC 61000-3-4 and in B.2.3.

NOTE Harmonics of the different electrical components of the equipment can be summed using the more exact analytical physical law suitable to the nature of the PDS and to the nature of the other components (see B.2.3.3). **[Ann]**

6.1.2.2 Industrial networks

If a PDS is to be used in an industrial installation for which the above standards are not relevant, a reasonable economical approach which considers the total installation shall be used (see B.2.3).

The user shall be aware of the values of the harmonic currents and voltages occurring within his power supply system before connecting the PDS, as well as the internal impedance of his supply system. The supplier of the PDS shall provide the values of the harmonic current emissions, within the documents of the PDS or on request. Because the harmonic current emission of a PDS can be dependent (for second order terms) on the harmonic impedance of the network at the PC, a conventional case should be defined and used by the manufacturer and user (if it is different from the standard case recommended in 6.1.2).

6.1.2.3 Harmonics and interharmonics in the frequency range 2 kHz to 9 kHz

Requirements in this frequency range are under consideration.

6.1.3 Voltage fluctuations

[Ann] An equipment may contain one or several PDSs and also other loads.

When a PDS is an equipment within the scope of IEC 61000-3-3, the requirements of that standard apply. However, when one or more PDSs are included in equipment within the scope of IEC 61000-3-3, the requirements of that standard apply to the complete equipment and not to the individual PDS.

For equipment not covered by IEC 61000-3-3, (example: rated current above 16 A) recommendations are given in the technical reports IEC 61000-3-5 and IEC 61000-3-11.

NOTE 1 Voltage fluctuations may be caused, for instance, by frequently changing the load of a PDS, or by sub-harmonics of slip energy recovery of asynchronous motors (or also by cyclo converters or current source inverters used in high power PDSs not directly connected to a public mains network).

NOTE 2 PDSs are used for energy conversion. Voltage fluctuations are dependent on the impedance of the installation and the duty cycle of the load. In some applications the user may reduce voltage fluctuations by adjusting the load duty cycle for example by changing speed ramp rate.

NOTE 3 Most voltage fluctuations are relevant to the installation. Therefore, this system aspect should be the responsibility of the user or of the installer. The compatibility levels given in IEC 61000-2-4 for voltage changes should not be exceeded considering cumulative effects from all equipment. **[Ann]**

6.1.4 Common mode harmonic emission (low-frequency common mode voltage)

The switching frequency of the converter of the PDS is often in the audible frequency range and, in particular, the frequency range commonly used by telephone systems (300 Hz – 3 400 Hz). This shall be considered when installing the PDS. Therefore, to avoid the risk of crosstalk to sensitive signal cables of telephones, intercommunication systems and the like, the power interface cable should be separated from sensitive signal cables, unless other instructions are given by the manufacturer.

6.2 Conditions during high-frequency tests

[A11] The rate of change of voltage or current is expected to be the main source of high-frequency emission. For this type of emission the dv/dt values of the PDS are mostly relevant and these can be achieved with output currents lower than the rated current of the PDS. Therefore, these tests are light load tests. The tests shall be applied to the relevant ports where they exist and shall be performed in a well-defined and reproducible manner on a port-by-port basis. The test method shall comply with 6.2, 6.3, 6.4 and clause 7 of CISPR 11, paying particular attention to earth connections.

6.2.1 General measurement requirements

6.2.1.1 Conducted emissions measurement

The measurement equipment for evaluation of high-frequency mains terminal (power port) disturbance voltage emission is either the artificial mains network (50 Ω /50 μ H, see CISPR 16-1) where it can be applied, or the voltage probe according to CISPR 16-1, where the artificial mains network is not applicable.

For *in situ* measurement of the mains disturbance voltage, a voltage probe without an artificial mains network shall be used (see 6.2.3 of CISPR 11). The same can be applied if the PDS has an input current greater than 100 A or if the input voltage is greater than or equal to 500 V, or if the PDS contains a line commutated converter (see A.5.1.2).

6.2.1.2 Radiated emissions measurement

Equipment to be connected to a public low-voltage power supply network which also supplies buildings used for domestic purposes, shall be measured on a test site.

Equipment to be connected to an industrial power supply network, or public network which does not supply buildings used for domestic purposes, may be measured either on a test site or *in situ* as preferred by the manufacturer.

In the case of *in situ* measurement:

- measurements are made with the distance measured “from the exterior wall outside the building in which the PDS is situated”, according to clause 9 of CISPR 11;
- if the PDS is located in more than one building, the distance shall also be kept from the power interfaces.

NOTE 1 If the field strength measurement at 30 m cannot be made because of high ambient noise levels or for other reasons, measurement of the PDS may be made at a closer distance. In between 30 m and 10 m, a correction of 20 dB per decade of distance should be used to normalize the measurement data to the specified distance for determining compliance:

$$L_x = L_{30} + 20 \cdot \log_{10}\left(\frac{30}{x}\right)$$

where

x is the actual measurement distance in metres;

L_x is the limit to be applied at distance x ;

L_{30} is the limit at 30 m.

If the measurement distance is less than 30 m, care should be taken to avoid near field effects, particularly when the PDS is not of an appropriately small size, and at frequencies near 30 MHz.

NOTE 2 If ambient noise, even at 10 m, is too high apply 7.1.3 of CISPR 11. **[A11]**

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6.2.2 Connection requirements

If the PDS is measured on a test site, the test set up (for example length and position of power and control cables) shall be representative of intended application(s), as defined by the manufacturer and described in the user documentation. The test set-up shall be stated in the test report.

If the PDS is measured *in situ*, the cable and the earthing arrangements are those of that application. A11

6.3 Basic emission limits in the high-frequency area

Many PDSs are working correctly without filters in the industrial environment, and do not disturb other apparatus or equipment, therefore they are compatible. So, for both conducted and radiated emissions, the principle is that the higher the probability of interference, the stricter the emission limits.

Table 7 — *deleted*Table 8 — *deleted***6.3.1 First environment**

A11 Equipment for the first environment shall comply with the limits of Table 9 and Table 10.

6.3.1.1 Conducted emission limits

Limits for mains terminal disturbance voltage (power ports) are given in Table 9.

**Table 9 — Limits for mains terminal disturbance voltage in the frequency band
150 kHz to 30 MHz — PDS in the first environment**

Frequency band MHz	Unrestricted distribution		Restricted distribution	
	Quasi peak dB(μV)	Average dB(μV)	Quasi peak dB(μV)	Average dB(μV)
$0,15 \leq f < 0,50$	66 Decrease with log of frequency down to 56	56 Decrease with log of frequency down to 46	79	66
$0,5 \leq f \leq 5,0$	56	46	73	60
$5,0 < f < 30,0$	60	50	73	60

For PDSs of the restricted sales distribution class, which exceed the emission limits in the “unrestricted distribution” columns of Table 9, the following shall be included in the instructions for use:

Warning

This is a product of the restricted sales distribution class according to IEC 61800-3.
In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

NOTE High-frequency common mode filtering introduces capacitive coupling paths to earth. In the case of a supply system in which the neutral is isolated from earth or connected to earth through a high impedance (IT supply network as defined in IEC 60364-3), these capacitive coupling paths can be harmful (see D.2.1).

6.3.1.2 Radiated emission limits

Limits for electromagnetic radiation disturbance (enclosure port) are given in Table 10. A11