

Adjustable speed electrical power drive systems —

Part 3: EMC requirements and specific test methods

ICS 29.200; 33.100

National foreword

This British Standard is the UK implementation of EN 61800-3:2004+A1:2012. It is identical to IEC 61800-3:2004, incorporating amendment 1:2011. It supersedes BS EN 61800-3:2004 which is withdrawn.

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

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

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

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Amendments/corrigenda issued since publication

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Adjustable speed electrical power drive systems
Part 3: EMC requirements and specific test methods
(IEC 61800-3:2004)

Entraînements électriques de puissance
à vitesse variable
Partie 3: Exigences de CEM et méthodes
d'essais spécifiques
(CEI 61800-3:2004)

Drehzahlveränderbare elektrische
Antriebe
Teil 3: EMV-Anforderungen einschließlich
spezieller Prüfverfahren
(IEC 61800-3:2004)

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CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 22G/127/FDIS, future edition 2 of IEC 61800-3, prepared by SC 22G, Adjustable speed electric drive systems incorporating semiconductor power converters, of IEC TC 22, Power electronic systems and equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61800-3 on 2004-10-01.

This European Standard supersedes EN 61800-3:1996 + A11:2000 + corrigendum May 2001.

This European Standard introduces three main changes:

- a) the classes of distribution (unrestricted and restricted) of the PDS have been replaced by categories of PDS (C1 to C4) with definitions related to the product itself and its intended use;
- b) better coverage of emission limits;
- c) an EMC plan is generalized for category C4.

The following dates were fixed:

- latest date by which the EN has to be implemented
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with the EN have to be withdrawn (dow) 2007-10-01

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and covers essential requirements of Directive 89/336/EEC. See Annex ZZ.

Annexes ZA and ZZ have been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61800-3:2004 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60038	NOTE	Harmonized as HD 472 S1:1989 (modified).
IEC 60146-1-3	NOTE	Harmonized as EN 60146-1-3:1993 (not modified).
IEC 60146-2	NOTE	Harmonized as EN 60146-2:2000 (not modified).
IEC 61000-2-12	NOTE	Harmonized as EN 61000-2-12:2003 (not modified).
IEC 61000-4-1	NOTE	Harmonized as EN 61000-4-1:2000 (not modified).
IEC 61000-4-7	NOTE	Harmonized as EN 61000-4-7:2000 (not modified).
IEC 61000-4-9	NOTE	Harmonized as EN 61000-4-9:1993 (not modified).
IEC 61000-4-10	NOTE	Harmonized as EN 61000-4-10:1993 (not modified).
IEC 61000-6-1	NOTE	Harmonized as EN 61000-6-1:2001 (modified).
IEC 61000-6-2	NOTE	Harmonized as EN 61000-6-2:1999 (not modified).
IEC 61000-6-4	NOTE	Harmonized as EN 61000-6-4:2001 (modified).
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Foreword to amendment A1

The text of document 22G/227/FDIS, future edition 2 of IEC 61800-3:2004/A1, prepared by SC 22G, "Adjustable speed electric drive systems incorporating semiconductor power converters", of IEC/TC 22, "Power electronic systems and equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61800-3:2004/A1:2012.

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Endorsement notice

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In the official version, for Bibliography, the following note has to be added for the standard indicated:

IEC 61400-21:2008 NOTE Harmonized as EN 61400-21:2008 (not modified).

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1 Scope and object

This part of IEC 61800 specifies electromagnetic compatibility (EMC) requirements for power drive systems (PDSs). A PDS is defined in 3.1. These are adjustable speed a.c. or d.c. motor drives. Requirements are stated for PDSs with converter input and/or output voltages (line-to-line voltage), up to 35 kV a.c. r.m.s.

PDSs covered by this standard are those installed in residential, commercial and industrial locations 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. Industrial networks can also be supplied by their own electric generating equipment. 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).

The scope of this part of IEC 61800, related to EMC, includes a broad range of PDSs from a few hundred watts to hundreds of megawatts. PDSs 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 EMC for PDSs at residential, commercial and industrial locations. The requirements cannot, however, cover extreme cases which may occur with an extremely low probability. 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 according to its intended use. This standard includes immunity requirements and requirements for electromagnetic emissions.

NOTE 1 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. The emission and immunity requirements are balanced against each other and against the actual environment of the PDS.

This standard defines the minimum EMC requirements for a PDS.

Immunity requirements are given according to the environment classification. Low-frequency emission requirements are given according to the nature of the supply network. High-frequency emission requirements are given according to four categories of intended use, which cover both environment and bringing into operation.

As a product standard, this standard may be used for the assessment of PDS. It may also be used for the assessment of CDM or BDM (see 3.1), which can be marketed separately.

This standard contains:

- conformity assessment requirements for products to be placed on the market;
- recommended engineering practice (see 6.5) for cases where high frequency emissions cannot be measured before the equipment is placed on the market (such PDSs are defined in 3.2.6 as category C4).

NOTE 2 The first edition of IEC 61800-3 identified that the intended use could require engineering for putting into service. This was done by the “restricted distribution mode”. Equipment that used to be covered by the “restricted distribution mode” is covered in the second edition by categories C2 and C4 (see 3.2).

This standard is intended as a complete EMC product standard for the EMC conformity assessment of products of categories C1, C2 and C3, when placing them on the market (see definitions 3.2.3 to 3.2.5).

Radio frequency emission of equipment of category C4 is only assessed when it is installed in its intended location. It is therefore treated as a fixed installation, for which this standard gives rules of engineering practice in 6.5 and annex E, although it gives no defined emission limits (except in case of complaint).

This standard does not specify any 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. It also does not cover safety and functional safety implications of electromagnetic phenomena.

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 additional countermeasures may have to be employed to increase the immunity of the highly susceptible apparatus.

As an EMC product standard for PDSs, this standard 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 referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (131):2002, *International Electrotechnical Vocabulary (IEV) – Chapter 131: Circuit theory*

IEC 60050 (151):2001, *International Electrotechnical Vocabulary (IEV) – Chapter 151: Electrical and magnetic devices*

IEC 60050 (161):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 60146-1-1:1991, *Semiconductor convertors – General requirements and line commutated convertors – Part 1-1: Specifications of basic requirements*

IEC 60364-1:2001, *Electrical installations of buildings – Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60664-1:1992, *Insulation co-ordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 61000-1-1, *Electromagnetic compatibility (EMC) – Part 1: General – Section 1: Application and interpretation of fundamental definitions and terms*

IEC 61000-2-1:1990, *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 61000-2-2:2002, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 2: Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*

A1 IEC 61000-2-4:2002, *Electromagnetic compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low-frequency conducted disturbances* **A1**

IEC 61000-2-6:1995, *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 61000-3-2:2000, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 2: Limits for harmonic current emissions (equipment with input current ≤ 16 A per phase)*

IEC 61000-3-3:1994, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems for equipment with rated current ≤ 16 A per phase and subject to conditional connection*

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

IEC 61000-3-7:1996, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 7: Limits for fluctuating loads in MV and HV power systems – Basic EMC publication*

IEC 61000-3-11:2000, *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*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test* Basic EMC publication

IEC 61000-4-3:2002, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test* Basic EMC publication

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test* Basic EMC publication
Amendment 1 (2000)
Amendment 2 (2001)

IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test*

IEC 61000-4-6:2003, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:2001, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test* Basic EMC publication

A1 IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-13:2002, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests*

IEC 61000-4-34:2005, *Electromagnetic compatibility (EMC) – Part 4-34: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current more than 16 A per phase* **A1**

IEC 61800-1:1997, *Adjustable speed electrical power drive systems – Part 1: Rating specifications for low voltage d.c. power drive systems*

IEC 61800-2:1998, *Adjustable speed electrical power drive systems – Part 2: General requirements – Rating specifications for low voltage adjustable frequency a.c. power drive systems*

IEC 61800-4:2002, *Adjustable speed electrical power drive systems – Part 4: General requirements – Rating specifications for a.c. power drive systems above 1000 V and not exceeding 35 kV*

CISPR 11:2003, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*

CISPR 14, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus*

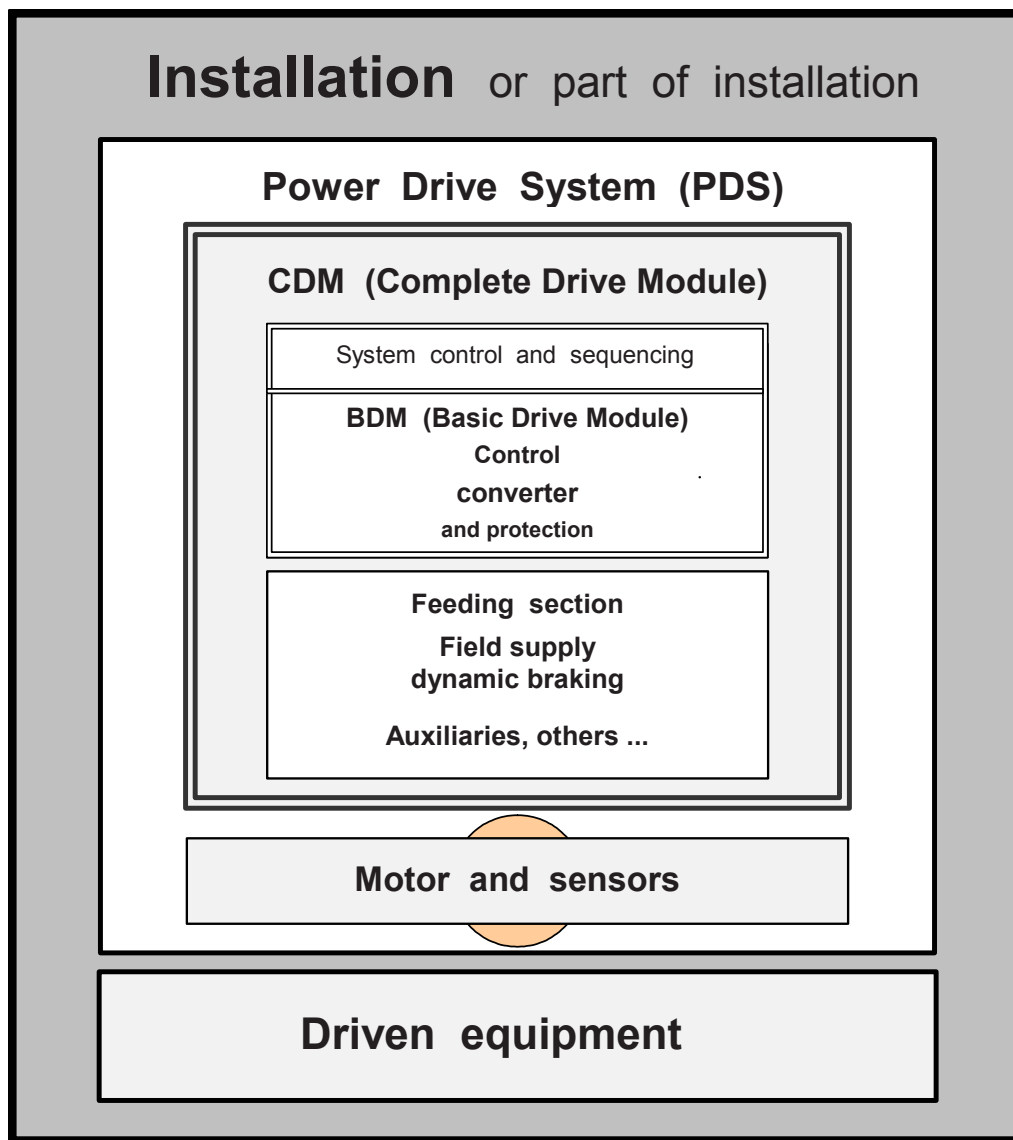
CISPR 16-1:2002, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus*

CISPR 22:2003, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

3 Terms and definitions

A1 3.1 Definition of the installation and its content

Figure 1 shows the major parts of the PDS as defined below and the rest of the installation. **A1**



IEC 923/04

Figure 1 – Definition of the installation and its content

**3.1.1****basic drive module****BDM**

electronic power converter and related control, connected between an electric supply and a motor. The BDM is capable of transmitting power from the electric supply to the motor and may be capable of transmitting power from the motor to the electric supply. The BDM controls some or all of the following aspects of power transmitted to the motor and motor output:

- current;
- frequency;
- voltage;
- speed;
- torque;
- force;
- position

3.1.2**complete drive module****CDM**

drive module consisting of, but not limited to, the BDM and extensions such as protection devices, transformers and auxiliaries. However the motor and the sensors which are mechanically coupled to the motor shaft are not included

3.1.3**power drive system****PDS**

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

3.1.4**installation**

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

3.2 Intended use**3.2.1****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

NOTE Houses, apartments, commercial premises or offices in a residential building are examples of first environment locations.

3.2.2**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

NOTE Industrial areas, technical areas of any building fed from a dedicated transformer are examples of second environment locations.

3.2.3

PDS of category C1

PDS of rated voltage less than 1 000 V, intended for use in the first environment

3.2.4

PDS of category C2

PDS of rated voltage less than 1 000 V, which is neither a plug in device nor a movable device and, when used in the first environment, is intended to be installed and commissioned only by a professional

NOTE A professional is a person or an organisation having necessary skills in installing and/or commissioning power drive systems, including their EMC aspects.

3.2.5

PDS of category C3

PDS of rated voltage less than 1 000 V, intended for use in the second environment and not intended for use in the first environment

3.2.6

PDS of category C4

PDS of rated voltage equal to or above 1 000 V, or rated current equal to or above 400 A, or intended for use in complex systems in the second environment

3.3 Location, ports and interfaces

3.3.1

in situ (for test)

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

3.3.2

test site (radiation)

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

[IEV 161-04-28]

3.3.3

port

access to a device or network where electromagnetic energy or signals may be supplied or received or where the device or network variables may be observed or measured

[IEV 131-12-60]

NOTE Figure 2 illustrates the diversity of the ports of a PDS.

3.3.4

enclosure port

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

3.3.5

port for process measurement and control

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

Text deleted

3.3.6**power port**

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

3.3.7**main power port**

power port which feeds the PDS for only the power which, after electrical power conversion, is converted by the motor into mechanical power

3.3.8**auxiliary power port**

power port which feeds only the auxiliaries of the PDS, including the field circuit if any

3.3.9**mechanical link**

mechanical connection between the shaft of the motor of the PDS and the driven equipment of the process A1 *Text deleted* A1

3.3.10**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)

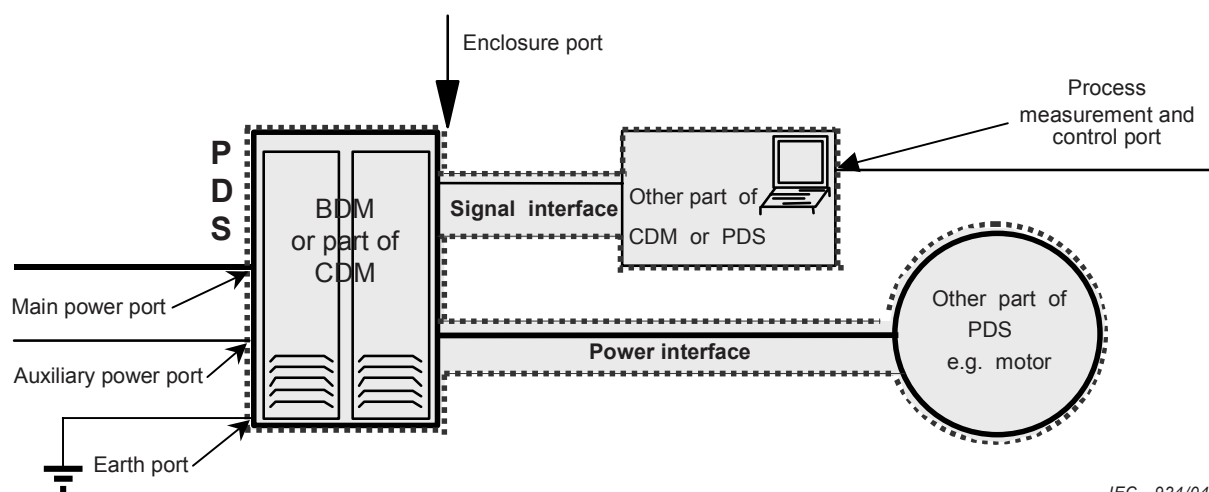


Figure 2 – Internal interfaces of the PDS and examples of ports

3.3.11**power interface**

connections needed for the distribution of electrical power within the PDS (see Figure 3 and explanation in Clause E.1)

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 components of the PDS. For examples, see Figures 3 and 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.

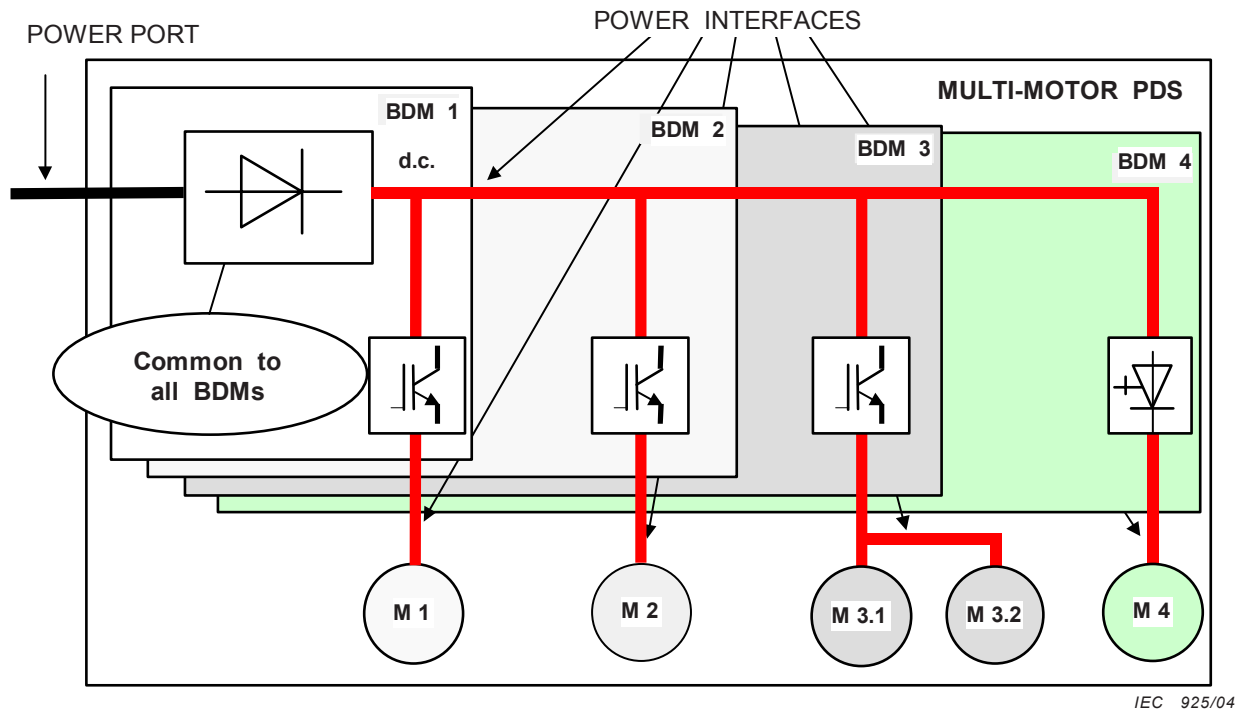


Figure 3 – Power interfaces of a PDS with common d.c. BUS

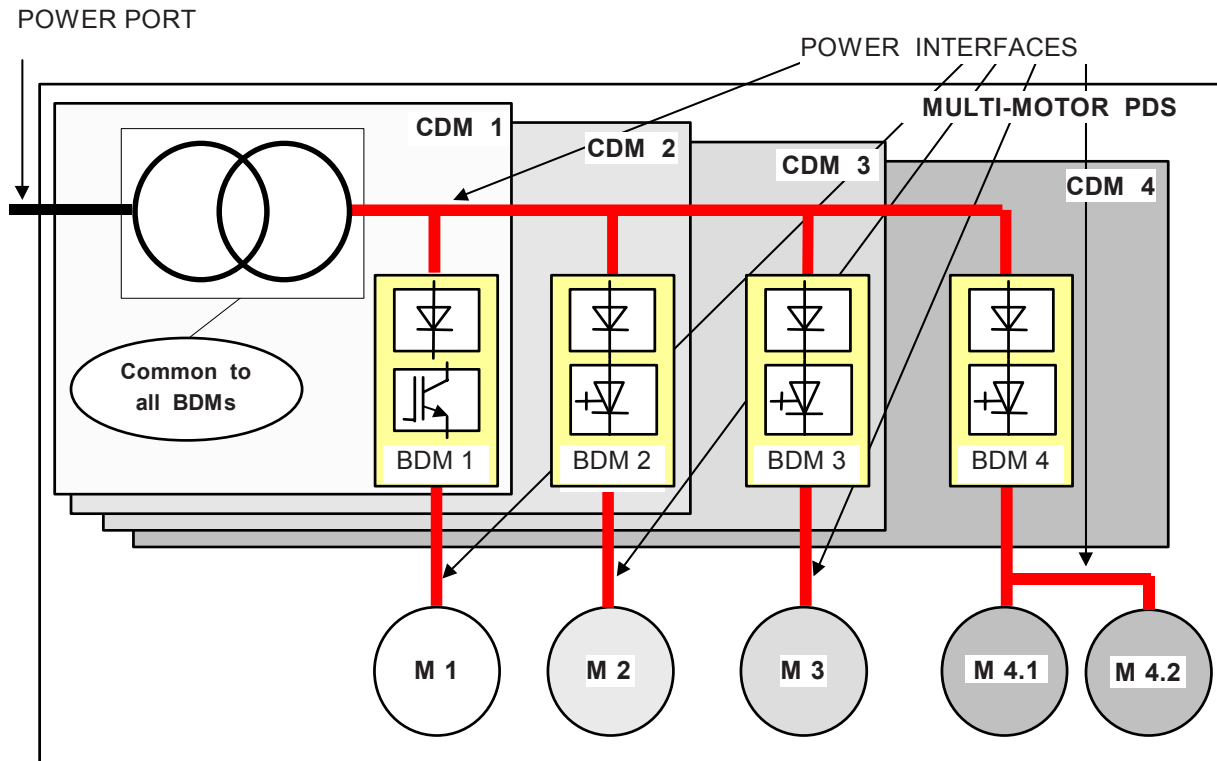


Figure 4 – Power interfaces with common input transformer

3.3.12**PCC, IPC, PC**

these definitions are given in IEC 61000-2-4

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).

3.4 Components of the PDS**3.4.1****converter (of the BDM)**

the unit which changes the form of electrical power supplied by the mains to the form fed to the motor(s) by changing one or more of the voltage, current and/or frequency

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-commutated, load-commutated or self-commutated and can consist, for example, of one or more rectifiers or inverters.

3.4.2**(electric) motor**

electric machine intended to transform electric energy into mechanical energy

[IEV 151-13-41]

A1 NOTE For the purposes of this standard, the motor includes all sensors which are mounted on it and which are relevant for supporting the operating mode and interacting with a CDM. **A1**

A1 *Text deleted* **A1**

A1 3.4.3 A1**sub-component (of the PDS)**

for the purposes of this standard, a component of the PDS may be divided in sub-components, each of them being a physical piece of equipment which can be operated separately with an intrinsic function defined by the manufacturer

NOTE As an example, the control unit of a CDM may be a sub-component.

A1 3.5 Phenomena-related definitions**3.5.1****voltage deviation**

difference, generally expressed as a percentage, between the voltage at a given instant at a point in the system, and a reference voltage such as: nominal voltage, a mean value of the operating voltage, declared supply voltage

[IEV 604-01-17] **A1**

A1 3.5.2

voltage change

variation of the r.m.s. or peak value of a voltage between two consecutive levels sustained for definite but unspecified durations

NOTE Whether the r.m.s. or peak value is chosen depends upon the application, and which is used should be specified.

[IEV 161-08-01]

3.5.3

voltage fluctuation

series of voltage changes or a continuous variation of the r.m.s. or peak value of the voltage

NOTE Whether the r.m.s. or peak value is chosen depends upon the application, and which is used should be specified.

[IEV 161-08-05]

3.5.4

voltage dip

sudden reduction of the voltage at a point in an electrical system followed by voltage recovery after a short period of time from a few cycles to a few seconds

[IEV 604-01-25, IEV 161-08-10] **A1**

4 Common requirements

4.1 General conditions

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

For a realistic assessment of the EMC situation, a typical configuration shall be chosen.

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

4.2 Tests

4.2.1 Conditions

IEC 60146-1-1 and IEC 61800-2 distinguish between type test, routine test and special test. Unless otherwise stated, all the tests specified in this standard are type tests only. The equipment shall meet the EMC requirements when measured by the test methods specified in this standard.

A1 NOTE 1 **A1** Due to local radio transmission legislation, some immunity tests can be subject to conditions which restrict the choice of location where they can be performed.

If necessary, 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.

[A1] For the tests, the CDM shall be connected to a motor recommended by the manufacturer with a cable and earthing rules defined by the manufacturer. Alternatively, a passive test load (resistive, or resistive and inductive) may be applied (for example, for evaluation of the low-frequency emissions), if permitted by the manufacturer.

NOTE 2 For high frequency emissions, because it is necessary to simulate differential and common mode capacitances and couplings, a passive test load may not be suitable for this application. **[A1]**

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 detailed acceptance criteria provided by the manufacturer shall be 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 setting of limits and the structure of this standard are based on the understanding that the installer and user are responsible for following the EMC recommendations of the manufacturer.

[A1] The manufacturer shall supply the documentation necessary for the correct installation of a BDM, CDM or PDS into a typical system or process in the intended environment. This information includes any emission warnings required by 6.1 and Table 13. It also includes the warnings required by 5.3.2 in the case where the immunity of a BDM, CDM or PDS is not suitable for the second environment.

NOTE 1 From the emission point of view, a PDS (or BDM or CDM) with a lower emission category, such as C1, can always be used instead of one with a higher emission category, such as C3.

NOTE 2 Emission categories are independent of immunity. For example, a statement that a PDS has emission category C1 does not imply that the immunity is only suitable for the first environment. **[A1]**

If special EMC measures are necessary to fulfil the required limits, these shall be clearly stated in the user documentation. Where relevant, these can include:

- maximum and minimum acceptable supply network impedance;
- the use of shielded or special cables (power and/or control);
- cable shield connection requirements;
- maximum permissible cable length;
- cable segregation;
- the use of external devices such as filters;
- the correct bonding to functional earth.

If different devices or connection requirements apply in different environments, this shall also be stated.

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.

This information may also be covered in some part of the test report to clarify the final recommended arrangement.

5 Immunity requirements

5.1 General conditions

5.1.1 Acceptance criteria (performance criteria)

The system performance relates to the functions of the BDM, or of the CDM, or of the PDS as a whole, that are declared by the manufacturer.

The sub-component performance relates to the functions of the sub-components of the BDM, or of the CDM, or of the PDS, that are declared by the manufacturer.

The sub-component performance may be tested as an alternative instead of the system performance to show immunity (see 5.1.2).

Although this part of IEC 61800 allows tests on sub-components (components of CDM/BDM), it is not intended to be used for the separate conformity assessment of sub-components.

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 than the PDS itself, the effect on this process caused by changes in the performance of the PDS is hard to forecast. However, this important aspect for large systems should be covered by an EMC plan (see Annex E).

The main functions of a PDS are energy conversion between the electrical form and the mechanical form, and the information processing necessary to perform this.

Table 1 classifies the effects of a given disturbance into three acceptance (performance) criteria: A, B and C, both for the PDS and for its sub-components.

A1 Subclauses 5.2 and 5.3 state the acceptance criterion required for each phenomenon. **A1**

5.1.2 Selection of performance type

5.1.2.1 General or special system performance

The “general system 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.

The special system performance, torque-generating behaviour, shall be tested only in cases where it is explicitly defined in the product specification. In this case, the torque generating performance can be directly or indirectly tested. The direct test uses an EMC immune torquemeter to measure torque disturbances.

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). Therefore, a test of current performance can be used as an indirect test of torque-generating performance. For EMC assessment, and unless otherwise agreed, the output current of the power converter is deemed to represent torque with sufficient accuracy. As an alternative, the indirect test can use speed performance provided the total inertia is specified.

5.1.2.2 Sub-component performance

Testing of sub-components with sub-component performance 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 sub-component under test.

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 sub-component performance, according to Table 1, where the functions exist, is sufficient to determine the compliance with this standard.

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

Item	Acceptance (performance) criterion ^a		
	A	B	C
General system performance	No noticeable changes of the operating characteristic. Operating as intended, within specified tolerance	Noticeable changes (visible or audible) of the operating characteristic. Self-recoverable	Shutdown, changes in operating characteristics. Triggering of protective devices ^b Not self-recoverable
Special system performance Torque generating behaviour	Torque deviation within specified tolerances	Temporary torque deviation outside specified tolerances Self-recoverable	Loss of torque Not self-recoverable
Sub-component performance Operation of power electronics and driving circuits	No malfunction of a power semiconductor	Temporary malfunction which cannot cause unintended shut-down of the PDS	Shut-down, triggering of protective devices ^b No loss of stored program, No loss of user program. No loss of settings Not self-recoverable
Sub-component performance. Information processing and sensing functions	Undisturbed communication and data exchange 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. No loss of stored program, no loss of user program. No loss of settings. Not self-recoverable

Table 1 (continued)

Item	Acceptance (performance) criterion ^a		
	A	B	C
Sub-component 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. No loss of stored program, no loss of user program. No loss of settings
^a 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. ^b Acceptance criterion C – The function can be restored by operator intervention (manual reset). Opening of fuses is allowed for line-commutated converters operating in inverting mode.			

5.1.3 Conditions during the test

The load shall be within the manufacturer's specification and the actual load shall be noted in the test report.

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 can be proven 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 component 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. They 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 5.2 and 5.3 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

5.2.1 Common principle

The requirements in this subclause shall be used for designing the immunity of a PDS against low-frequency disturbances.

For the immunity requirements, the manufacturer may demonstrate compliance using either testing, calculation or simulation. Unless otherwise stated, it is sufficient to demonstrate that the power circuit will comply with the required acceptance criterion and that the ratings of input circuits (filters, etc.) will not be exceeded.

NOTE 1 A number of these phenomena are not required by the generic standards, but are important for the dimensioning of the power circuit of the PDS. It is difficult to test immunity against many of these phenomena, particularly when the input current exceeds 16 A or the supply voltage exceeds 400 V. However, experience of many years shows that, provided the power circuit operates correctly, the control part and the auxiliaries are generally immune. This is due to natural decoupling that exists in the PDS. Examples of such decoupling are that provided by power supplies and the time constants of auxiliary processes such as fans.

The compliance with the requirements of this part of IEC 61800 shall be stated in the user documentation. Where compliance is demonstrated by tests, the relevant basic standard in the IEC 61000-4 series may be considered (see Clause B.7).

NOTE 2 The electrical service conditions for the main and the auxiliary supply if any, are already defined in the PDS service conditions in the relevant standard IEC 61800-1 or IEC 61800-2 or IEC 61800-4. These service conditions include frequency variations, frequency rate of change, voltage variations, voltage fluctuations, voltage unbalance, harmonics and commutation notches.

A1 Text deleted **A1**

5.2.2 Harmonics and commutation notches/voltage distortion

5.2.2.1 Low voltage PDSs – (voltage distortion)

A1 The BDM, CDM or PDS shall sustain the immunity levels while meeting the performance criteria given in Tables 23, 24 and 25. It shall be verified that these levels will not cause the ratings for the input circuits (filters, etc.) to be exceeded. Analysis of commutation notches shall be in the time domain. The manufacturer may verify immunity by calculation, simulation, or test, according to 5.2.1. If the chosen verification method is by test, it shall be performed using the PDS with the motor connected. For equipment rated below 16 A per phase, the test method of IEC 61000-4-13 can be applied.

NOTE Frequency domain analysis of the contribution from notches to the total harmonic distortion will not fully account for harmful effects, see B.1.

Table 23 – Minimum immunity requirements for total harmonic distortion on power ports of low voltage PDSs

Phenomenon	First environment		Second environment		Performance (acceptance) criterion
	Reference document	Level	Reference document	Level	
Harmonics – THD	IEC 61000-2-2	8 %	IEC 61000-2-4 class 3	12 %	A

A1

Table 24 – Minimum immunity requirements for individual harmonic orders on power ports of low voltage PDSs

Phenomenon	First environment		Second environment		Performance (acceptance)			
Harmonic order	Reference document	Level	Reference document	Level	criterion			
2	IEC 61000-4-13 class 2	3 %	IEC 61000-4-13 class 3	5 %	A			
3		8 %		9 %				
4		1,5 %		2 %				
5		9 %		12 %				
Even orders $6 \leq h \leq 50$		No requirement		1,5 %				
7		7,5 %		10 %				
9		2,5 %		4 %				
11		5 %		7 %				
13		4,5 %		7 %				
15		No requirement		3 %				
17		3 %		6 %				
19		2 %		6 %				
21		No requirement		2 %				
23		2 %		6 %				
25		2 %		6 %				
27		No requirement		2 %				
29		1,5 %		5 %				
31		1,5 %		3 %				
33		No requirement		2 %				
35		1,5 %		3 %				
37		1,5 %		3 %				
39		No requirement		2 %				
NOTE 1 For individual harmonic orders, levels are from Class 2 in IEC 61000-4-13 (these are approximately 1,5 times the compatibility levels of IEC 61000-2-4).								
NOTE 2 For individual harmonic orders, levels are from Class 3 in IEC 61000-4-13 (these are approximately 1,5 times the compatibility levels of IEC 61000-2-4).								

Table 25 – Minimum immunity requirements for commutation notches on power ports of low voltage PDSs

Phenomenon	First environment		Second environment		Performance (acceptance)
	Reference document	Level	Reference document	Level	criterion
Commutation notches	(None)	No requirement	IEC 60146-1-1 Class B	Depth = 40 %, total area = 250 in % degrees	A

A1

5.2.2.2 PDSs of rated voltage above 1 000 V – (voltage distortion)**5.2.2.2.1 Main power port**

The PDS or BDM/CDM shall sustain the immunity levels given in Table 3. It shall be verified that these levels will not cause the ratings for the input circuits (filters, etc.) to be exceeded. Analysis of commutation notches shall be in the time domain. The manufacturer may verify immunity by calculation, simulation, or test, according to 5.2.1.

NOTE Frequency domain analysis of notches' contribution to total harmonic distortion will not obviously reveal certain types of harmful effects, see Clause B.1.

Table 3 – Minimum immunity requirements for harmonics and commutation notches/voltage distortion on main power ports of PDSs of rated voltage above 1 000 V

Phenomenon	Reference document	Level	Performance (acceptance) criterion
Harmonics (<i>THD</i> and individual harmonic orders)	IEC 61000-2-4 Class 3	Value of the compatibility level	A ^a
Harmonics short term (< 15 s)	IEC 61000-2-4 Class 2	1,5 times the value of the permanent compatibility levels	A ^a
A1 Text deleted A1			
A1 Text deleted A1			
Commutation notches	IEC 60146-1-1	Depth = 40% U_{LWM} (class B) Area ^c = 125 in per cent degrees (class C)	A ^a
A1 Text deleted A1 A1 ^a A1 Class C of IEC 60146-1-1 is appropriate for the primary side of the transformer.			

5.2.2.2.2 Auxiliary power port

- A1** The auxiliary power ports of PDSs shall sustain the immunity levels for the second environment given in Tables 23, 24 and 25 while meeting the performance criteria in those tables. **A1** It shall be verified that these levels will not cause the ratings for the input circuits (filters, etc.) to be exceeded. Analysis of commutation notches shall be in the time domain. The manufacturer may verify immunity by calculation, simulation, or test, according to 5.2.1.

NOTE Frequency domain analysis of notches' contribution to total harmonic distortion will not obviously reveal certain types of harmful effects, see Clause B.1.

A1 Table deleted **A1**

5.2.3 Voltage deviations Text deleted , dips and short interruptions

5.2.3.1 Low voltage PDSs (voltage deviations)

The PDS or BDM/CDM shall sustain the immunity levels given in Table 5. The manufacturer may verify immunity by calculation, simulation, or test, according to 5.2.1.

 **Table 5 – Minimum immunity requirements for voltage deviations, dips and short interruptions on power ports of low voltage PDSs**

Phenomenon	First environment			Second environment			Performance (acceptance) criterion
	Reference document	Level		Reference document	Level		
Voltage deviations (> 60 s)	IEC 61000-2-2	± 10 % ^a		IEC 61000-2-4 Class 2	± 10 % ^a		A ^b
Voltage dips ^e	IEC 61000-4-11 Class 2 or IEC 61000-4-34 Class 2 ^f	Volts remaining 0 % 70 %	Cycles 1 25/30 ^c	IEC 61000-4-11 Class 3 or IEC 61000-4-34 Class 3 ^f	Volts remaining 0 % 40 % 70 % 80 %	Cycles 1 10/12 ^c 25/30 ^c 250/300 ^c	C ^d
Short interruptions	IEC 61000-4-11 Class 2 or IEC 61000-4-34 Class 2 ^f	Volts remaining 0 %	Cycles 250/300 ^c	IEC 61000-4-11 Class 3 or IEC 61000-4-34 Class 3 ^f	Volts remaining 0 %	Cycles 250/300 ^c	C ^d
^a “Voltage deviation” is a supply voltage variation from the nominal supply voltage. Testing of voltage deviations for three phase PDS requires increasing or reducing the voltage of all three phases simultaneously. ^b When the voltage is below nominal, the maximum output power ratings – speed and/or torque – may be reduced, because they are voltage dependent. ^c “x/y cycles” means “x cycles for 50 Hz test” and “y cycles for 60 Hz test”. ^d Opening of fuses is allowed for line-commutated converters operating in inverting mode. ^e Power ports with current rating ≥75 A, the method of the voltage drop test according to 7.5 of IEC 61400-21:2008 may be used. ^f IEC 61000-4-11 applies to equipment rated less than or equal to 16 A and IEC 61000-4-34 to equipment rated above 16 A.							



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.

NOTE 2 A decreasing input voltage, even with few milliseconds duration, may result in blowing of fuses when applied to a line commutated thyristor converter operating under regeneration mode.

NOTE 3 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.

Where it is possible and not dangerous, 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.6.1).

The manufacturer shall state in the user documentation the degradation of performance resulting from voltage dips or short interruptions.

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, and are not covered by this standard.

5.2.3.2 PDSs of rated voltage above 1 000 V (voltage deviations)

5.2.3.2.1 Main power port

Main power ports of PDSs shall sustain the immunity levels given in Table 6. The manufacturer may verify immunity by calculation, simulation, or test, according to 5.2.1.

Table 6 – Minimum immunity requirements for voltage deviations, dips and short interruptions on main power ports of rated voltage above 1 000 V of PDSs

Phenomenon	Reference document	Level		Performance (acceptance) criterion
Voltage deviations exceeding 1 min	IEC 61000-2-4 Class 3	$\pm 10 \%$		A ^a
Voltage deviations not exceeding 1 min	IEC 61000-2-4 Class 3	$+ 10 \%$ / $- 15 \%$		A ^a
Voltage dips	IEC 61000-4-34 ^b	Volts remaining 0 % 40 % 70 % 80 %	Cycles 1 10/12 ^c 25/30 ^c 250/300 ^c	C ^d
Short interruptions	IEC 61000-4-34 ^b	Volts remaining 0 %	Cycles 250/300 ^c	C ^d

^a "Voltage deviation" is a supply voltage variation from the nominal supply voltage. Testing of voltage deviations for three phase PDSs requires increasing or reducing the voltage of all three phases simultaneously.

When considering voltage deviations, any voltage steps shall not exceed $\pm 12 \%$ of nominal voltage and the time between steps shall not be less than 2 s.

When the voltage is below nominal, the maximum output power ratings – speed and/or torque – may be reduced, because they are voltage dependent.

^b Typical depths and durations of voltage dips are given in IEC 61000-2-8.

^c "x/y cycles" means "x cycles for 50 Hz test" and "y cycles for 60 Hz test".

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

A1

The manufacturer shall state in the user documentation the degradation of performance resulting from voltage dips or short interruptions.

5.2.3.2.2 Auxiliary power port

The auxiliary power ports of PDSs shall sustain the immunity levels given in Table 7. The manufacturer may verify immunity by calculation, simulation, or test.

Table 7 – Minimum immunity requirements for voltage deviations, dips and short interruptions on auxiliary low voltage power ports of PDSs

Phenomenon	Reference document	Level		Performance (acceptance) criterion
Voltage deviations exceeding 1 min	IEC 61000-2-4 Class 3	$\pm 10 \%$		A
Voltage deviations not exceeding 1 min	IEC 61000-2-4 Class 3	+10 % to -15 %		A
Voltage dips	IEC 61000-4-11 or IEC 61000-4-34 ^b	Volts remaining 0 % 40 % 70 % 80 %	Cycles 1 10/12 ^a 25/30 ^a 250/300 ^a	C
Short interruptions	IEC 61000-4-11 Class 3 or IEC 61000-4-34 Class 3 ^b	Volts remaining 0 %	Cycles 250/300 ^a	C

^a "x/y cycles" means "x cycles for 50 Hz test" and "y cycles for 60 Hz test".

^b IEC 61000-4-11 applies to equipment less or equal to 16 A and IEC 61000-4-34 applies to equipment above 16 A.

A1

5.2.4 Voltage unbalance and frequency variations

5.2.4.1 Low voltage PDSs

Definition and assessment of voltage unbalance are explained in B.5.2.

The PDS or BDM/CDM shall comply with the immunity levels given in Table 8. The manufacturer may verify immunity by calculation, simulation, or test. **A1** During verification, the rated load condition shall be used. **A1**

Table 8 – Minimum immunity requirements for voltage unbalance and frequency variations on power ports of low voltage PDSs

Phenomenon	First environment		Second environment		Performance (acceptance) criterion
	Reference document	Level	Reference document	Level	
Voltage unbalance ^a	IEC 61000-2-2	2 % negative sequence component	IEC 61000-2-4 Class 3	3 % negative sequence component	A
Frequency variations	IEC 61000-2-2	$\pm 2 \%$	IEC 61000-2-4	$\pm 2 \%$ $\pm 4 \%$ where the supply is separated from public supply networks	A
Frequency rate of change		1 %/second		$\pm 1 \%/s$ 2 %/s where the supply is separated from public supply network	A

^a Not relevant for single phase PDSs.

5.2.4.2 PDSs of rated voltage above 1 000 V

5.2.4.2.1 Main power port

Definition and assessment of voltage unbalance are explained in B.5.2.

The PDS or BDM/CDM shall sustain the immunity levels given in Table 9. The manufacturer may verify immunity by calculation, simulation, or test. ^{A1} During verification, the rated load condition shall be used. ^{A1}

Table 9 – Minimum immunity requirements for voltage unbalance and frequency variations on main power ports of rated voltage above 1 000 V of PDSs

Phenomenon	Reference document	Level	Performance (acceptance) criterion
Voltage unbalance	IEC 61000-2-4 Class 2	2 % negative sequence component	A ^a
Frequency variations	IEC 61000-2-4	±2 % ±4 % where the supply is separated from public supply networks	A ^b A ^c
Frequency rate of change		±1 %/s 2 %/s where the supply is separated from public supply networks	A ^b A ^c
^{A1} Text deleted ^{A1}			

5.2.4.2.2 Auxiliary power port

Definition and assessment of voltage unbalance are explained in B.5.2.

The auxiliary power ports of PDSs shall sustain the immunity levels given in Table 10. The manufacturer may verify immunity by calculation, simulation, or test.

Table 10 – Minimum immunity requirements for voltage unbalance and frequency variations on auxiliary low voltage power ports of PDSs

Phenomenon	Reference document	Level	Performance (acceptance) criterion
Voltage unbalance	IEC 61000-2-4 Class 3	3 % negative sequence component	A ^a
Frequency variations	IEC 61000-2-4	±2 % ±4 % where the supply is separated from public supply networks	A ^b A ^c
^{A1} Text deleted ^{A1}			

5.2.5 Supply influences – Magnetic fields

Immunity tests according to IEC 61000-4-8 are not required (see A.3.1 for explanation).

5.3 Basic immunity requirements – High-frequency disturbances

5.3.1 Conditions

In the following Table 11 and Table 12, 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 Clause A.3.

5.3.2 First environment

The levels in Table 11 shall be applied to PDSs which are intended to be used in the first environment.

If a CDM/BDM is designed to have immunity according to Table 11, it shall include a written warning in the instructions for use which indicates that it is not intended to be used in an industrial installation.

Table 11 – Minimum immunity requirements for PDSs intended for use in the first environment

Port	Phenomenon	Basic standard for test method	Level	Performance (acceptance) criterion
Enclosure port	ESD	IEC 61000-4-2	4 kV CD or 8 kV AD if CD impossible	B
	Radio-frequency electromagnetic field, amplitude modulated	IEC 61000-4-3 see also 5.3.4	80 MHz to 1 000 MHz 3 V/m 80 % AM (1 kHz)	A
	Radio-frequency electromagnetic field, amplitude modulated	IEC 61000-4-3 See also 5.3.4	1,4 GHz to 2,0 GHz 3 V/m 80 % AM (1 kHz)	A
	Radio-frequency electromagnetic field, amplitude modulated	IEC 61000-4-3 See also 5.3.4	2,0 GHz to 2,7 GHz 1 V/m 80 % AM (1 kHz)	A
Power ports (except auxiliary DC power ports below 60 V)	Fast transient-burst	IEC 61000-4-4	1 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	IEC 61000-4-6 see also 5.3.4	0,15 MHz to 80 MHz 3 V 80 % AM (1 kHz)	A
Power interfaces	Fast transient-burst ^e	IEC 61000-4-4	1 kV/5 kHz Capacitive clamp	B
Ports for process measurement	Fast transient-burst ^e	IEC 61000-4-4	0,5 kV/5 kHz Capacitive clamp	B
control lines and signal interfaces Auxiliary DC power ports below 60 V	Conducted radio-frequency common mode ^e	IEC 61000-4-6 see also 5.3.4	0,15 MHz to 80 MHz 3 V 80 % AM (1 kHz)	A

CD : contact discharge AD: air discharge AM : amplitude modulation

^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.

5.3.3 Second environment

The levels in Table 12 shall be applied to PDSs which are intended to be used in the second environment. This also applies to the low voltage ports, or the low voltage interfaces (power, signal) of PDSs of rated voltage above 1 000 V.

NOTE Examples of low voltage ports and interfaces of a PDS of rated voltage above 1 000 V are as follows:

LV enclosure port	enclosure of auxiliaries, control and protection;
LV power ports	LV power supply of PDS;
LV power interfaces	auxiliary supply distribution within main components of PDS;
LV signal interfaces	LV signal interfaces within main components of PDS;
LV process port	signal port of the PDS.

Table 12 – Minimum immunity requirements for 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	4 kV CD or 8 kV AD if CD impossible	B
	Radio-frequency electromagnetic field, amplitude modulated	IEC 61000-4-3 see also 5.3.4	80 MHz to 1 000 MHz 10 V/m 80 % AM (1 kHz)	A
	Radio-frequency electromagnetic field, amplitude modulated	IEC 61000-4-3 see also 5.3.4	1,4 GHz to 2,0 GHz 3 V/m 80 % AM (1 kHz)	A
	Radio-frequency electromagnetic field, amplitude modulated	IEC 61000-4-3 see also 5.3.4	2,0 GHz to 2,7 GHz 1 V/m 80 % AM (1 kHz)	A
Power ports (except auxiliary DC power ports below 60 V)	Fast transient-burst	IEC 61000-4-4	2 kV/5 kHz ^a	B
	Surge ^b 1,2/50 μ s, 8/20 μ s	IEC 61000-4-5	1 kV ^c 2 kV ^d	B
	Conducted radio-frequency common mode ^e	IEC 61000-4-6 see also 5.3.4	0,15 MHz 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 see also 5.3.4	0,15 MHz to 80 MHz 10 V 80 % AM (1 kHz)	A
Ports for process measurement control lines Auxiliary DC power ports below 60 V	Fast transient-burst ^e	IEC 61000-4-4	2 kV/5 kHz Capacitive clamp	B
	Surge ^f 1,2/50 μ s, 8/20 μ s	IEC 61000-4-5	1 kV ^{d,f}	B
	Conducted radio-frequency common mode ^e	IEC 61000-4-6 see also 5.3.4	0,15 MHz to 80 MHz 10 V 80 % AM (1 kHz)	A

CD : contact discharge AD : air discharge AM : amplitude modulation

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- 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, the test level shall be 4 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.
- f Applicable only to ports with cables whose total length according to the manufacturer's functional specification may exceed 30 m. In the case of a shielded cable, a direct coupling to the shield is applied. This immunity requirement does not apply to fieldbus or other signal interfaces where the use of surge protection devices is not practical for technical reasons. The test is not required where normal functioning cannot be achieved because of the impact of the coupling/decoupling network on the equipment under test (EUT).

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These phenomena are not relevant for application to the ports of rated insulation voltage above 1 000 V. For simplicity, such ports are named HV ports of PDSs of rated voltage above 1 000 V.

NOTE Examples of HV ports and interfaces of a PDS of rated voltage above 1 000 V are as follows:

HV enclosure port	enclosure of transformer, converter section and motor;
HV power port	primary side of transformer;
HV power interfaces	HV distribution within main components of PDS;
HV signal interfaces	HV signal interfaces within main components of PDS.

5.3.4 Immunity against electromagnetic fields

If the PDS is:

- of rated voltage not more than 500 V;
- of rated current not more than 200 A;
- of total mass not more than 250 kg, and
- of height, width, and depth not more than 1,9 m,

the tests of IEC 61000-4-3 and IEC 61000-4-6 shall be performed, see 5.3.2 and 5.3.3.

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.3.2.2. This test is only valid for the specific location, installed equipment and frequencies tested.

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 probability of performance. Depending on the acceptance criterion and the application of a PDS, this probability shall be considered in specifying the number of test pulses or duration of the test.

Immunity requirements in 5.3 shall be verified by performing a type-test on a representative unit. The manufacturer or supplier shall ensure the EMC performance of the product is maintained in production by using some form of quality control.

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

6 Emission

6.1 General emission requirements

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

Table 13 summarises the requirements, according to the classification of the PDS (see 3.2).

Table 13 – Summary of emission requirements

Category	Low-frequency (power port)	Disturbance voltage (power port)	Radiated emissions (enclosure port and others)
Category C1	Product assessment, requirements: 6.2.2, ~~A1~~ 6.2.3.1 or 6.2.3.2 or 6.2.3.3 ~~A1~~ 6.2.4, 6.2.5 load conditions B.2.3.3 and B.3.2. 1 st environment	Product assessment 6.4.1.1 – Table 14	Product assessment 6.4.1.3 – Table 15; and 6.4.1.2; and 6.4.1.4.
Category C2	Product assessment, requirements: 6.2.2, ~~A1~~ 6.2.3.1 or 6.2.3.2 or 6.2.3.3 ~~A1~~ 6.2.4, 6.2.5 load conditions B.2.3.3 and B.3.2 1 st environment or public network.	Product assessment 6.4.1.1 – Table 14 Warning in the instruction for use	Product assessment 6.4.1.3 – Table 15; and 6.4.1.2; and 6.4.1.4 Warning in the instruction for use
Category C3	Requirements: 6.2.2, ~~A1~~ 6.2.3.4, ~~A1~~ 6.2.4, 6.2.5 load conditions B. 2.3.3 and general rules B.3.3 and B.4 2 nd environment	Product assessment 6.4.2.1 and 6.4.2.2 – Table 17 Warning in the instruction for use	Product assessment 6.4.2.3 and 6.4.2.4 – Table 18 Warning in the instruction for use
Category C4	Engineering practice requirements: 6.2.2, ~~A1~~ 6.2.3.4, ~~A1~~ 6.2.4, 6.2.5 load conditions B.2.3.3 and general rules B.3.3 and B.4 2 nd environment	Engineering practice either 6.4.2.1 and 6.4.2.2 – Table 17 or 6.5.1 – EMC plan and 6.5.2 – Tables 19 and 20	Engineering practice either 6.4.2.1 and 6.4.2.3 – table 18 or 6.5.1 – EMC plan and 6.5.2 – Tables 21 and 22

6.2 Basic low-frequency emission limits

6.2.1 Compliance method

Compliance can be verified by calculation, simulation or test.

6.2.2 Commutation notches

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 (for 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 practical cases of equipment which can be affected by notches. They can be overloaded or subjected to repetitive overvoltages.

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).

The recommendations of B.1.3 should be followed.

6.2.3 Harmonics and interharmonics

6.2.3.1 Low-voltage public supply network – Equipment covered by IEC 61000-3-2

Equipment may contain one or several PDSs and also other loads.

When a PDS A_1 within the scope A_1 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. It is the responsibility of the equipment manufacturer to define the boundary of the system or sub-system to which IEC 61000-3-2 applies, and the method which demonstrates compliance of the equipment.

A_1 6.2.3.2 Low-voltage public supply network – Equipment covered by IEC 61000-3-12

When a PDS is within the scope of IEC 61000-3-12, the requirements of that standard apply. However, when one or more PDSs are included in equipment within the scope of IEC 61000-3-12, the requirements of that standard apply to the complete equipment and not to the individual PDS. It is the responsibility of the equipment manufacturer to define the boundary of the system or sub-system to which IEC 61000-3-12 applies, and the method which demonstrates compliance of the equipment. A_1

A_1 6.2.3.3 A_1 Low-voltage public supply network – Equipment not covered by IEC 61000-3-2 A_1 or IEC 61000-3-12 A_1

For equipment not covered A_1 IEC 61000-3-2 or IEC 61000-3-12 (rated current above 75 A), A_1 recommendations may be found in the technical report IEC 61000-3-4 and in Clause B.4. Where, for technical or economic reasons as explained in Annexes B and C of this standard, stage 1 or stage 2 of IEC 61000-3-4 cannot be applied, the approach of stage 3 is facilitated by Annex B.

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. These may be produced by calculation, simulation or test.

For the purpose of calculation or simulation, the applied voltage shall be assumed to have a *THD* less than 1 %. The internal impedance of the network shall be assumed to be purely inductive. If the specific location of the PDS is not known, the harmonic currents shall be calculated assuming that the PDS is connected to a PC with the highest value of R_{SI} permitted by the PDS manufacturer.

$$R_{SI} = \frac{I_{SC}}{I_{LN}}$$

where

I_{SC} is the short circuit current at the considered PC,

I_{LN} is the rated input current of the PDS.

If the manufacturer does not state a maximum value of R_{SI} , a value of 250 shall be assumed. If the specific location of the PDS is known, the supply impedance at that location should be used.

The PDS manufacturer shall calculate the harmonic currents for each order up to the 40th. The current *THD* (orders up to and including 40) shall also be calculated.

A guide for calculation of harmonics is given in Clause A.1 and Clause A.2 of IEC 61000-2-6. Guidelines for the summation of harmonics of different sources are also given in 7.4 of the same standard.

Effects of interharmonics are considered in B.4.3. Methods for calculation are given in Annex C of IEC 61000-2-6.

A1 6.2.3.4 A1 Industrial networks

If a PDS is to be used in an installation which is not directly supplied from a public low voltage network, IEC 61000-3-2 and A1 IEC 61000-3-12 A1 are not applicable. Therefore, a reasonable approach which considers the total installation should be used (see Clause B.4).

NOTE For network voltages above 1 000 V, the total installation may be subject to rules from the utility, usually based on IEC 61000-3-6. These rules apply to the installation as a whole, not to individual equipment. These rules usually take the existing harmonic currents and voltage distortion within the system into account. An efficient and simplified approach is provided by Table B.2.

In the case of a PDS of rated voltage above 1 000 V, harmonic emissions from the main power port and the auxiliary power port shall be considered separately.

6.2.4 Voltage fluctuations

6.2.4.1 Conditions

An equipment may contain one or several PDSs and also other loads which are capable of causing voltage fluctuations.

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. Voltage fluctuations may also be caused by interharmonics at frequencies slightly different from the fundamental or from predominant harmonics. The emission is typically generated by cyclo-converters or current source inverters. See B.4.3 and B.6.2. Interharmonics are covered by compatibility levels given in IEC 61000-2-4 or in IEC 61000-2-12.

NOTE 2 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 by changing speed ramp rate or using other techniques.

NOTE 3 Most voltage fluctuations depend upon 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.

A1 6.2.4.2 PDS in the scope of IEC 61000-3-3 and IEC 61000-3-11 A1

When A1 a PDS is within the scope A1 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.

When A1 a PDS is within the scope A1 of IEC 61000-3-11, the requirements of that standard apply. However, when one or more PDSs are included in equipment within the scope of IEC 61000-3-11, the requirements of that standard apply to the complete equipment and not to the individual PDS.

A1 NOTE Application of the voltage fluctuation limits of IEC 61000-3-3 and 61000-3-11 is only possible when the characteristics of the load provided by the driven equipment are known. For that reason, only the machine builder and/or end user are capable of characterizing compliance with regard to the voltage fluctuation limits. A1

6.2.4.3 PDS not in the scope of IEC 61000-3-3 and IEC 61000-3-11

For equipment not in the scope of IEC 61000-3-3 and IEC 61000-3-11 emissions of voltage fluctuations are generally dependent on the loading conditions and this standard cannot give requirements.

NOTE Local rules given by local authorities can apply to the complete installation. 

6.2.5 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 and data systems. To avoid the risk of crosstalk to signal cables, the installation instructions shall either recommend that the power interface cable be segregated from signal cables or state alternative mitigation methods.

6.3 Conditions related to high-frequency emission measurement

6.3.1 General requirements

6.3.1.1 Common conditions

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 to 6.4 and clause 7 of CISPR 11, paying particular attention to earth connections.

The load shall be within the manufacturer's specification and the actual load shall be noted in the test report.

6.3.1.2 Conducted emissions

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 and CISPR 11) 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.4.1.2).

6.3.1.3 Radiated emissions

Equipment of category C1 and category C2 shall be measured on a test site compliant with requirements of CISPR 16-1.