BS EN 61000-6-5:2015

BSI Standards Publication

Electromagnetic compatibility (EMC)

Part 6-5: Generic standards — Immunity for equipment used in power station and substation environment

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National foreword

This British Standard is the UK implementation of EN 61000-6-5:2015. It is identical to IEC 61000-6-5:2015.

The UK participation in its preparation was entrusted to Technical Committee GEL/210, EMC - Policy committee.

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

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61000-6-5

November 2015

ICS 33.100.20

English Version

Electromagnetic compatibility (EMC) - Part 6-5: Generic standards - Immunity for equipment used in power station and substation environment (IEC 61000-6-5:2015)

Compatibilité électromagnétique (CEM) - Partie 6-5: Normes génériques - Immunité pour les équipements utilisés dans les environnements de centrales électriques et de postes (IEC 61000-6-5:2015)

Elektromagnetische Verträglichkeit (EMV) - Teil 6-5: Fachgrundnormen - Störfestigkeit von Betriebsmitteln, Geräten und Einrichtungen, die im Bereich von Kraftwerken und Schaltstationen verwendet werden (IEC 61000-6-5:2015)

This European Standard was approved by CENELEC on 2015-09-25. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

European foreword

The text of document 77/484/FDIS, future edition 1 of IEC 61000-6-5, prepared by IEC/TC 77 "Electromagnetic compatibility" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61000-6-5:2015.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2016-06-25
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2018-09-25

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For the relationship with EU Directive(s) see informative Annex ZZ, which is an integral part of this document.

Endorsement notice

The text of the International Standard IEC 61000-6-5:2015 was approved by CENELEC as a European Standard without any modification.

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

IEC 61000-2	NOTE	Harmonized in EN 61000-2 series.
IEC 61000-6-4	NOTE	Harmonized as EN 61000-6-4.
IEC 60255-1:2009	NOTE	Harmonized as EN 60255-1:2010 (not modified).
IEC 60255-26:2013	NOTE	Harmonized as EN 60255-26:2013 (not modified).
IEC 61439-1:2011	NOTE	Harmonized as EN 61439-1:2011 (not modified).
IEC 62271-1:2007	NOTE	Harmonized as EN 62271-1:2008 (not modified).
IEC 60870-2-1:1995	NOTE	Harmonized as EN 60870-2-1:1996 (not modified).
IEC 61000-6-2:2005	NOTE	Harmonized as EN 61000-6-2:2005 (not modified).
IEC 61326-1:2012	NOTE	Harmonized as EN 61326-1:2013 (not modified).
IEC 61812-1:2011	NOTE	Harmonized as EN 61812-1:2011 (not modified).

IEC 61000-4-1	NOTE	Harmonized as EN 61000-4-1.
IEC 61000-4-12:2006	NOTE	Harmonized as EN 61000-4-12:2006 (not modified).
IEC 61000-4-19:2014	NOTE	Harmonized as EN 61000-4-19:2014 (not modified).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 61000-4-2	-	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	EN 61000-4-2	2009
IEC 61000-4-3	-	Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	EN 61000-4-3 + A1 + A2	2006 2008 2010
IEC 61000-4-4	-	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	EN 61000-4-4	2012
IEC 61000-4-5	-	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test	EN 61000-4-5	2014
IEC 61000-4-6	-	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	EN 61000-4-6	2014
IEC 61000-4-8	-	Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test	EN 61000-4-8	2010
IEC 61000-4-11	-	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests	EN 61000-4-11	2004

Publication	Year	Title	EN/HD	Year
IEC 61000-4-16	-	Electromagnetic compatibility (EMC) - Part 4-16: Testing and measurement techniques - Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz	EN 61000-4-16 + A1 + A2	1998 2004 2011
IEC 61000-4-17	-	Electromagnetic compatibility (EMC) - Part 4-17: Testing and measurement techniques - Ripple on d.c. input power port immunity test	EN 61000-4-17 + A1 + A2	1999 2004 2009
IEC 61000-4-18	-	Electromagnetic compatibility (EMC) - Part 4-18: Testing and measurement techniques - Damped oscillatory wave immunity test	EN 61000-4-18 + corrigendum Sep. + A1	2007 2007 2010
IEC 61000-4-29	-	Electromagnetic compatibility (EMC) - Part 4-29: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests	EN 61000-4-29	2000
IEC 61000-4-34	-	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	EN 61000-4-34 + A1	2007 2009
IEC 61000-6-1	-	Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity for residential, commercial and light-industrial environments	EN 61000-6-1	2007

Annex ZZ
(informative)

Coverage of Essential Requirements of EU Directives

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers essential requirements as given in Annex I Article 1(b) of the EU Directive 2004/108/EC.

Compliance with this standard provides one means of conformity with the specified essential requirements of the Directives concerned.

WARNING: Other requirements and other EU Directives may be applicable to the products falling within the scope of this standard.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 6-5: Generic standards – Immunity for equipment used in power station and substation environment

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61000-6-5 has been prepared by committee 77: Electromagnetic compatibility (EMC).

This first edition cancels and replaces the first edition of IEC TS 61000-6-5 published in 2001. This edition constitutes a technical revision.

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

a) the scope is extended in order to cover also power generating systems in industrial facilities;
b) the locations under consideration, i.e. power stations and substations are described in more detail;
c) performance criteria and the EUT functions they apply to are reviewed;

d) immunity requirements are reviewed and more specifically related to the relevant locations;

e) informative annexes for guidance and on protected zones are added.

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

FDIS	Report on voting
77/484/FDIS	77/500/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61000 series, published under the general title *Electromagnetic compatibility (EMC)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

IEC 61000 series is published in separate parts, according to the following structure:

Part 1: General
General considerations (introduction, fundamental principles)
Definitions, terminology
Part 2: Environment
Description of the environment
Classification of the environment
Compatibility levels
Part 3: Limits
Emission limits
Immunity limits (in so far as they do not fall under the responsibility of the product committees)
Part 4: Testing and measurement techniques
Measurement techniques
Testing techniques
Part 5: Installation and mitigation guidelines
Installation guidelines
Mitigation methods and devices
Part 6: Generic standards
Part 9: Miscellaneous

Each part is further subdivided into sections which are to be published either as International Standards or as technical specifications or technical reports, some of which have already been published as sections. Others will be published with the part number followed by a dash and a second number identifying the subdivision (example: IEC 61000-6-1).

This International Standard deals with the electromagnetic compatibility (EMC) of equipment used in the generation, transmission and distribution of electricity and related telecommunication systems.

Several EMC product standards have been published by technical committees dealing with different application areas in the generation, transmission and distribution of electricity and related telecommunication systems, for example:

- fixed power supply installations and apparatus for railway applications (TC 9),
- switchgear and controlgear (TC 17),
- instrument transformers (TC 38),
- nuclear instrumentation (TC 45),
- power systems management and associated information exchange (TC 57),
- industrial-process measurement and control – system aspects (SC 65A),
- measuring relays and protection equipment (TC 95), etc.

The requirements specified in these product standards consider product-specific aspects only. It is the task of this generic standard IEC 61000-6-5 to specify a set of essential requirements, test procedures and generalized performance criteria applicable to such products or systems operating in this electromagnetic environment.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 6-5: Generic standards – Immunity for equipment used in power station and substation environment

1 Scope and object

This part of IEC 61000 specifies EMC immunity requirements which apply to electrical and electronic equipment intended for use in power stations and substations, as described below. Immunity requirements for electromagnetic phenomena with spectral contributions in the frequency range 0 Hz to 400 GHz are covered. No tests need to be performed at frequencies or for phenomena where no requirements are specified.

This international standard sets immunity test requirements for equipment intended for use in the generation, transmission and distribution of electricity and related telecommunication systems. The electromagnetic environments encompassed by this standard are those which exist at locations

- in power stations, and
- in high and medium voltage substations.

Installations to generate or convert into electrical power inside industrial facilities are also covered by this standard as long as they, at their primary electrical connection, cannot be directly connected to the LV power network, e.g. where the generator output voltage is medium voltage or higher. Power installations that directly provide power into the low voltage network (such as photovoltaic cells or combined heat power systems in private houses) are not covered by this standard.

NOTE 1 In general, power stations comprise installations which are mainly built to convert some kind of primary energy into electrical energy. Moreover, these power stations are connected to the medium or high voltage power system directly or via a step-up transformer.

The object of this standard is to define immunity test requirements for equipment defined in the scope in relation to continuous and transient, conducted and radiated disturbances, including electrostatic discharges.

The immunity test requirements are given on a port-by-port basis, and selected according to the location, with differentiated levels for equipment to be installed in power stations or substations. In special cases, situations will arise where the level of electromagnetic disturbances may exceed the levels specified in this standard; in these instances, special mitigation measures should be adopted.

The immunity requirements are suitable for satisfying the particular needs related to the functions and tasks of equipment and systems, for which reliable operation is required under realistic electromagnetic conditions; in this respect, this standard establishes performance criteria for different functional requirements.

This generic EMC immunity standard is applicable if no relevant dedicated product or product-family EMC immunity standard exists. According to IEC Guide 107, this generic standard should be considered for the preparation or revision of any EMC standard referring to specific products used in power stations and substations.

NOTE 2 Product standards covering EMC aspects for equipment to be used in power stations or substations are for example IEC 62271-1 (switchgear and controlgear), IEC 60255-26 (measuring relays and protection equipment) or IEC 62236-5 (fixed power supply installations and apparatus for railway applications).

Non-electronic high voltage and power equipment (primary system) are excluded from the scope of this standard.

Emission requirements are not within the scope of this standard and are covered by relevant product or product-family standards.

NOTE 3 Where no dedicated product or product family standard covering emission requirements exists, the generic standard IEC 61000-6-4 applies.

2 Normative references

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

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

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

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

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

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

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

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

IEC 61000-4-16, *Electromagnetic compatibility (EMC) – Part 4-16: Testing and measurement techniques – Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz*

IEC 61000-4-17, *Electromagnetic compatibility (EMC) – Part 4-17: Testing and measurement techniques – Ripple on d.c. input power port immunity test*

IEC 61000-4-18, *Electromagnetic compatibility (EMC) – Part 4-18: Testing and measurement techniques – Damped oscillatory wave immunity test*

IEC 61000-4-29, *Electromagnetic compatibility (EMC) – Part 4-29: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests*

IEC 61000-4-34, *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*

IEC 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE The definitions related to EMC and to relevant electromagnetic phenomena can be found in IEC 60050-161 and in other IEC publications.

3.1.1
connections to HV equipment
connections from control equipment to HV equipment such as circuit breakers, current transformers, voltage transformers, power line carrier systems

3.1.2
DC distribution network
local DC electricity supply network in the infrastructure of a certain site or building intended for flexible use by one or more different types of equipment and guaranteeing continuous power supply independently from the conditions of the public mains network

Note 1 to entry: Connection to a remote local battery is not regarded as a DC distribution network, if such a link comprises only power supply for a single piece of equipment.

3.1.3
enclosure port
physical boundary of the equipment through which electromagnetic fields may radiate or impinge on

3.1.4
equipment
single apparatus or set of devices or apparatuses, or the set of main devices of an installation, or all devices necessary to perform a specific task

Note 1 to entry: Examples of equipment are a power transformer, the equipment of a substation, measuring equipment.

[SOURCE: IEC 60050-151:2001, 151-11-25]

3.1.5
field connections
cables which are intended to be connected to process equipment of the plant, within the same earth network

EXAMPLE

Examples of this category are:

– connections from control room or equipment room to the field of power stations and HV substations;
– connections to low voltage power equipment;
– connections within the relay house or telecommunication house of HV substations, where no special mitigation measures are adopted (e.g. shielding);
– field bus.

Note 1 to entry: Those cable ports of process instrumentation which are self-powered through the signal conductors (e.g. 4 mA to 20 mA) are considered as signal ports.

3.1.6
high voltage
HV
set of voltage levels in excess of medium voltage

Note 1 to entry: In the context of this standard the following terms for system voltage are used (see also 3.1.9):

– low voltage (LV) refers to $U_n \leq 1$ kV;

– medium voltage (MV) refers to 1 kV $< U_n \leq 36$ kV;

– high voltage (HV) refers to voltage above 36 kV and includes EHV and UHV.

3.1.7
installation
several combined items of equipment (including cables) put together at a given place to fulfil a specific task

3.1.8
low voltage
set of voltage levels used for the distribution of electricity and whose upper limit is generally accepted to be 1 000 V a.c.

[SOURCE: IEC 60050-601:1985, 601-01-26]

3.1.9
medium voltage
MV
any set of voltage levels lying between low and high voltage

Note 1 to entry: The boundaries between medium and high voltage levels overlap and depend on local circumstances and history or common usage. Nevertheless the band 30 kV to 100 kV frequently contains the accepted boundary.

Note 2 to entry: In the context of this standard, medium voltage is defined as the voltage range of 1 Kv $< U_n \leq 36$ kV.

[SOURCE: IEC 60050-601:1985, 601-01-28, modified – a note to entry 2 has been added.]

3.1.10
port
particular interface of the equipment which couples this equipment with, or is influenced by, the external electromagnetic environment

Note 1 to entry: Examples of ports of interest are shown in Figure 1. The enclosure port is the physical boundary of the equipment (e.g. enclosure). The enclosure port provides for radiated and electrostatic discharge (ESD) energy transfer, whereas the other ports provide for conducted energy transfer.

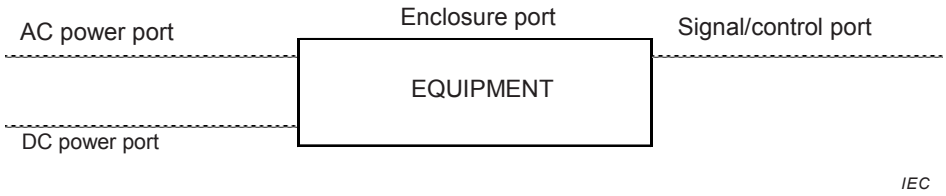


Figure 1 – Equipment ports

3.1.11
power port
port at which a conductor or cable carries the primary electrical power needed for the operation (functioning) of equipment

3.1.12
power station
installation whose purpose is to generate electricity and which includes civil engineering works, energy conversion equipment and all the necessary ancillary equipment

[SOURCE: IEC 60050-601:1985, 601-03-01]

3.1.13
protected area
area inside an installation in which electromagnetic phenomena appear in a mitigated extent compared to other areas of the same installation

Note 1 to entry: Mitigation can be provided for example by means of shielding or filtering.

3.1.14
signal/control port
port at which a conductor or cable intended to carry signals is connected to equipment

Note 1 to entry: Examples are analog inputs, outputs and control lines; data busses; communication lines, fibre-optic lines containing metallic conductors, etc.

3.1.15
substation (of a power system)
part of an electrical system, confined to a given area, mainly including ends of transmission or distribution lines, electrical switchgear and controlgear, buildings and transformers. A substation generally includes safety or control devices (for example protection)

Note 1 to entry: The substation can be qualified according to the designation of the system of which it forms a part. Examples: transmission, substation (transmission system), distribution substation, 400 kV or 20 kV substation.

[SOURCE: IEC 60050-601:1985, 601-03-02]

3.1.16
switchgear
general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures, intended in principle for use in connection with generation, transmission, distribution and conversion of electric energy

[SOURCE: IEC 60050-441:2000, 441-11-02]

3.1.17
system
several items of equipment combined to fulfil a specific task as a single functional unit

3.1.18
telecommunication connections
communication cables which reach the border of the earth network of the plant for interfacing with a telecommunication network or with a remote equipment without any particular insulation barrier

3.2 Abbreviations

AIS Air insulated switchgear
CRT Cathode ray tube
CT Current transformer
EHV Extra high voltage
ESD Electrostatic discharge
EUT Equipment under test
GIS Gas insulated switchgear
HV High voltage
MTU Master terminal unit
MV Medium voltage
PLC Power line communication
PT Power transformer
RTU Remote terminal unit
UHV Ultra high voltage
UPS Uninterruptable power systems

4 Electromagnetic environment

The typical locations covered by this international standard are power stations (see Figure 2), medium voltage (MV) and high-voltage (HV) substations, comprising air insulated switchgear (AIS) (see Figure 3), and/or gas insulated switchgear (GIS) (see Figure 4). In Figure 2, the solid lines do not represent physical boundaries between the areas where the equipment is installed. They rather indicate boundaries between electromagnetic environments. It should be kept in mind that the electromagnetic environments can be different for items of equipment installed close to each other.

For the purpose of the specifications given in this international standard, the term "HV" is taken to mean extra high voltage and high voltage of 36 kV and above.

NOTE A different limit between MV and HV can be agreed upon between the parties involved and the manufacturer.

An overview of electromagnetic phenomena to be taken into account at the locations covered by this standard is given in Table 1. For the purpose of determining the need of the corresponding phenomenon as well as of the applicable performance criterion, the phenomena are grouped with respect to their nature and probability of occurrence. A survey of these electromagnetic phenomena is given in IEC TR 61000-2-5 and IEC 61000-4-1. Additional information on the typical sources and causes of electromagnetic disturbances is given in Annex A. Typical values of electromagnetic phenomena observed in high voltage substations and power stations can be found in the publications listed in the bibliography.

Table 1 – Characterization of the electromagnetic phenomena

Continuous phenomena	Transient phenomena with high occurrence	Transient phenomena with low occurrence
Voltage variations: – a.c. power supply – d.c. power supply [a] Harmonics, interharmonics [a] Signalling voltages [a] Ripple on d.c. power supply Power frequency variation [a] Conducted disturbances in the range 2 kHz to 150 kHz [a] Conducted disturbances in the range 1,6 MHz to 30 MHz [a] Power frequency magnetic field (according to IEC 61000-4-8) Radiated, radio frequency electromagnetic field Conducted disturbances, induced by radio-frequency fields Mains frequency voltage (according to IEC 61000-4-16)	Voltage dips (duration ≤ 0,02 s): – a.c. power supply – d.c. power supply Voltage fluctuations Fast transient/burst Damped oscillatory/ring wave Damped oscillatory magnetic field Electrostatic discharge	Voltage dips (duration > 0,02 s): – a.c power supply – d.c. power supply Voltage interruptions: – a.c. power supply – d.c. power supply Short duration power frequency variation [a, b] Surge Short duration power frequency voltage Short duration power frequency magnetic fields (according to IEC 61000-4-8) Radiated pulsed disturbances

[a] Not covered in this standard by dedicated immunity requirements.

[b] In case of islanded systems (e.g. not connected to a public network), the characterization of the phenomenon changes from "low occurrence" to "high occurrence".

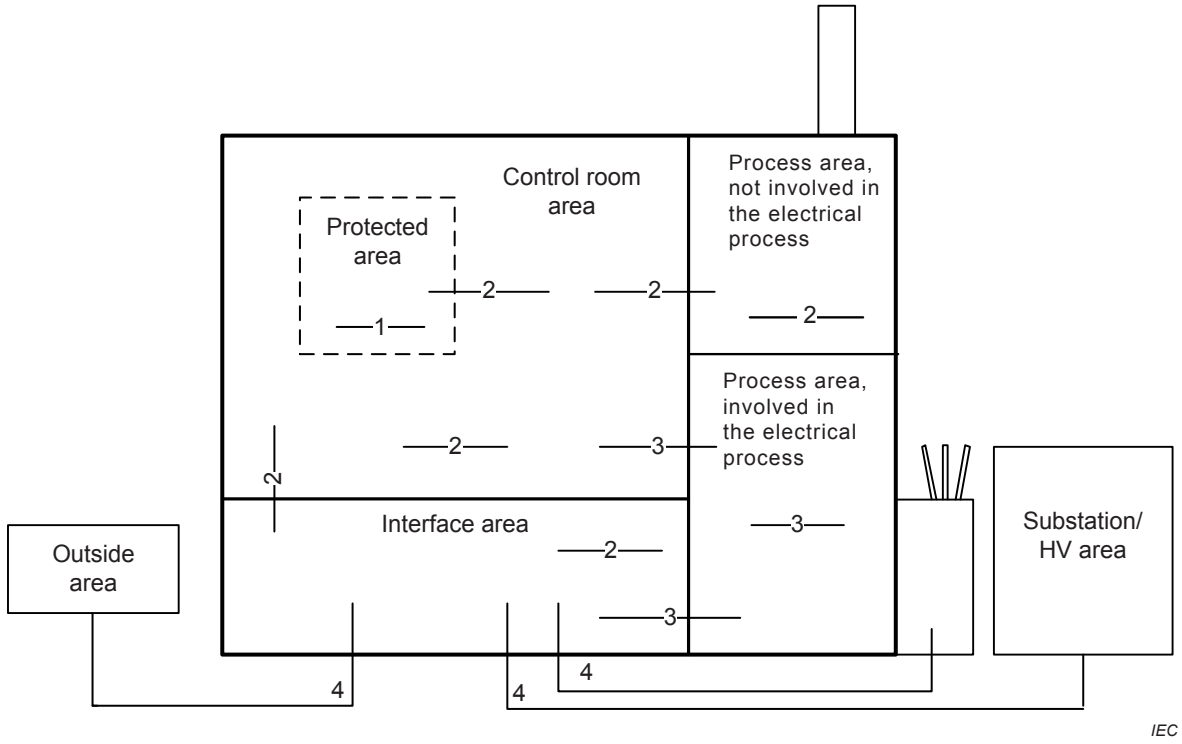
Items of equipment are installed and implemented within power stations and substations according to the rules/guidelines given by the manufacturers. It is essential that these items of equipment operate according to the specified performances when exposed to the variety of electromagnetic phenomena, conducted and radiated, typical of these installations.

In addition to the mentioned electrical plants, equipment can be installed in control centres, radio repeaters, or low voltage distribution points in industrial, commercial or residential areas. These locations are covered by other generic standards or product standards.

In some cases, special mitigation measures (e.g. use of special cabling, shielding of some areas, and/or avoidance of interference sources, etc.) are taken in order to create a “protected area” and to reduce the immunity requirements accordingly. This allows the use of equipment that does not meet the requirements of this standard.

A protected area can be created by means of mitigation measures and/or avoidance of disturbance sources in order to reduce immunity requirements to the immunity levels of product standards or generic standards.

In this document a protected area (see 3.1.13) is considered as a location where at least the requirements of IEC 61000-6-1 are sufficient to demonstrate immunity (see Annex C for further information).



Key

Interface types

1 Inside protected area

2 Inside interface and/or control room and/or process area not involved in the electrical process

3 Inside or from process area involved in the electrical process

4 Connections from outside (HV area and external telecommunication)

NOTE

The process area involved in the electrical process can contain for example MV/HV or high power equipment such as generators, large drives, converters, MV switchgear.

The process area not involved in the electrical process can contain for example turbines, boiler, pollution monitoring, fuel handling, LV switchgear.

The control room area can contain for example control systems, industrial computers, fire fighting systems, UPS, etc.

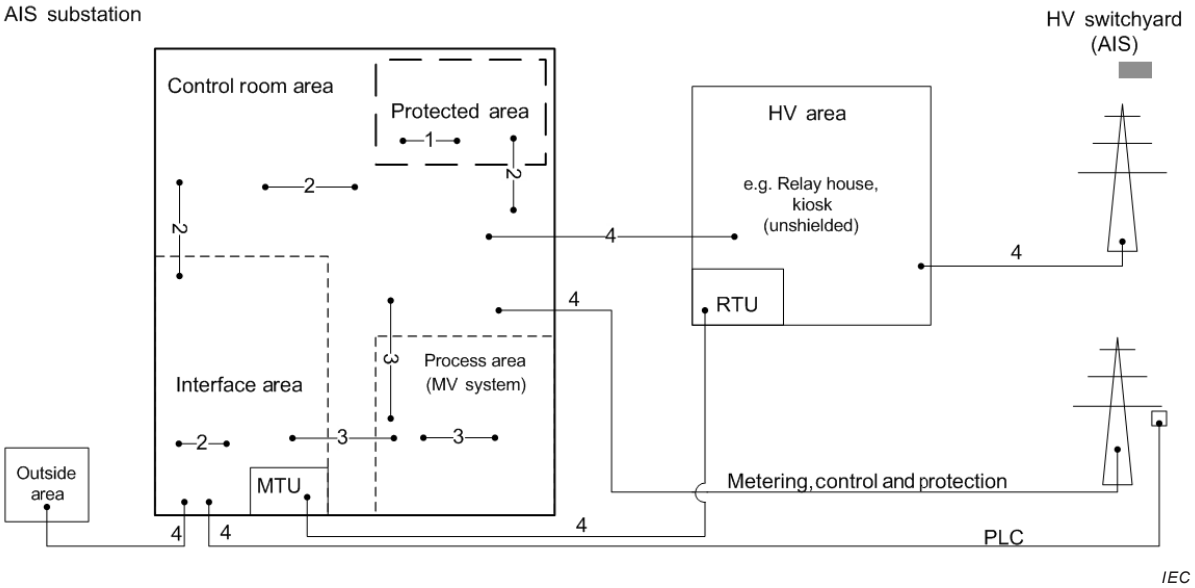
The protected area can contain for example special sensitive equipment like routers, computers, etc.

The interface area can contain for example equipment and systems connected to the outside with measures like surge protection and bonding of cable shields. This is the area where signals from the outside are collected, converted and distributed.

The outside area can contain additional process equipment, signalling, etc.

The high voltage area can contain for example circuit breakers, bus bars, disconnectors, metering etc.

Figure 2 – Example of the situation of a power station



Key

Interface types

1 Inside protected area

2 Inside interface and/or control room area

3 Inside or from process area

4 Connections from outside (HV and external telecommunication)

NOTE

The control room area can be a dedicated house or only a relay house that contains control systems, computers, fire fighting systems, UPS, etc.

The relay house / kiosk contains protection relays, marshalling kiosks for PTs/CTs.

The protected area contains for example special sensitive equipment like routers, special computers, etc.

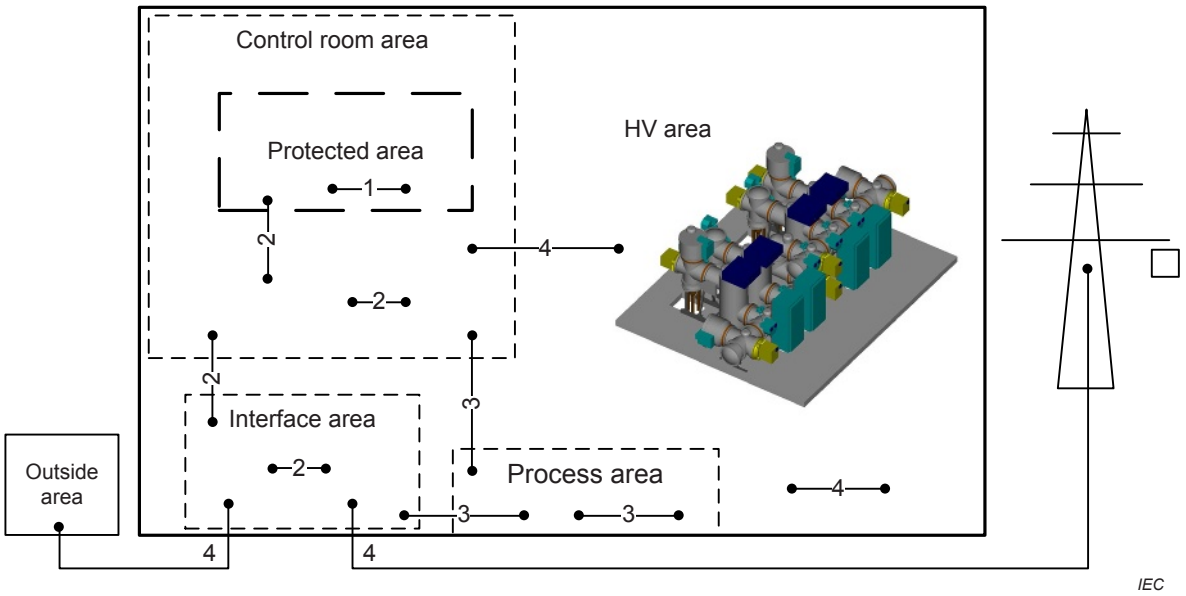
The process area contains mainly MV systems (if available) with circuit breakers and MV-bus bars.

The interface area contains equipment and systems connected to the outside with measures like surge protection and bonding of cable shields.

The high voltage area contains circuit breakers, bus bars, disconnectors, metering, UPS, etc.

The outside area contains for example control centres.

Figure 3 – Example of the situation of an air-insulated substation (AIS)



Key

Interface types

1 Inside protected area

2 Inside interface and/or control room area

3 Inside or from process area

4 Connections from outside (HV and external telecommunication)

NOTE

The control room area contains control systems, computers, fire fighting systems, UPS, etc.

The process area contains mainly MV systems (if available) with circuit breakers and MV-bus bars.

The protected area contains for example special sensitive equipment like routers, special computers, etc.

The interface area contains equipment and systems connected to the outside with measures like surge protection and bonding of cable shields.

The outside area contains for example control centres.

The HV area contains GIS, earthing bus bars, transformers, etc.

Figure 4 – Example of the situation of a gas-insulated substation (GIS)

5 Performance criteria

The performance criteria are closely related to the nature of the electromagnetic phenomena (types and occurrence), as given in Table 1 and to the applicable representative functions of the equipment concerned.

Table 2 lists the suggested performance criteria to be applied for the corresponding function of equipment. A functional description and a definition of performance criteria, during or as a consequence of the EMC testing, shall be provided by the manufacturer and noted in the test report, based on one of the following criteria, for each test as specified in Table 3 to Table 10.

a) **Performance criterion A:** The EUT shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the EUT is used as intended. If the performance level is not specified by the manufacturer, this may be derived from the

product description and documentation and what the user may reasonably expect from the equipment if used as intended.

b) **Performance criterion B:** The EUT shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the EUT is used as intended. The performance level may be replaced by a permissible loss of performance. However, during the test, degradation of performance is allowed but no change of actual operating state or stored data is allowed. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, either of these may be derived from the product description and documentation and what the user may reasonably expect from the equipment if used as intended.

c) **Performance criterion C:** Temporary loss of function is allowed, provided the function is self-recoverable or can be restored by the operation of the controls.

Table 2 – Suggested performance criteria for some representative functions

Functions [a]	Functional requirements versus electromagnetic phenomena		
	Continuous phenomena	**Transient phenomena with high occurrence**	**Transient phenomena with low occurrence**
Protection and teleprotection [b]	**A**	**A**	**A**
On-line processing and regulation	**A**	**A**	**A**
High speed communication	**A**	**A**	**A**
Metering	**A**	**A**	**A**
Command and control	**A**	**A**	**B** – Short delay [d]
Supervision	**A**	**A**	**B –** Temporary loss, self recovered [e]
Human-machine interface	**A**	**A**	**C –** Stop and reset [f]
Alarm	**A**	**A –** Short delay [g], temporary wrong indication	
Data transmission and telecommunication [c]	**A**	**A –** No loss, possible bit error rate degradation [h]	**B –** Temporary loss [h]
Data acquisition and storage	**A**	**B –** Temporary degradation [e, i]	
Measurement	**A**	**B –** Temporary degradation, self recovered [j]	
Off-line processing	**A**	**B –** Temporary degradation [i]	**C –** Temporary loss and reset [i]
Passive monitoring	**A**	**B –** Temporary degradation	**C –** Temporary loss
Self-diagnosis	**A**	**B –** Temporary loss, self recovered [k]	

[a] For the application of the performance criteria to equipment with multiple functions, the performance criterion related to the function under test applies.

[b] For teleprotection using a power line carrier, the "normal performance" during the switching of HV isolators may need an appropriate validation procedure.

[c] Used in automation and control systems as auxiliary function to other ones, for example to implement co-ordination.

[d] A delay of a duration which is insignificant compared to the time constant of the controlled process is acceptable.

[e] Temporary loss of data acquisition and deviation in event scheduling time is accepted, but correct events sequence shall be maintained.

[f] Manual restoration by operators is allowed.

[g] With respect to the degree of urgency (not to the process).

[h] Temporary bit error rate degradation can affect the communication efficiency; automatic restoration of any stoppage of the communication is mandatory.

[i] No effect on stored data or processing accuracy is allowed.

[j] Without affecting the measurement accuracy of analogue or digital indication.

[k] Within the system diagnostic cycle.

An overview of the effects of the electromagnetic phenomena on the functions of equipment and systems is given in Annex B.

6 Conditions during testing

The equipment under test (EUT) shall be tested in the expected most susceptible operating mode e.g. identified by performing limited pre-tests. This mode shall be consistent with normal applications. The configuration of the test sample shall be varied to achieve maximum susceptibility consistent with typical applications and installation practice.

If it is not possible to test every function of equipment, the most critical mode of operation shall be selected.

According to the basic standards, several ports may be simultaneously subjected to the test voltage.

If the EUT is part of a system, or can be connected to auxiliary equipment, then the EUT shall be tested while connected to the minimum representative configuration of auxiliary equipment necessary to exercise the ports.

If the EUT has a large number of similar ports, then a sufficient number shall be selected to simulate actual operating conditions and to ensure that all the different types of termination are covered.

In cases where a manufacturer's specification requires, in the user manual, protection devices or measures, the tests shall be applied with these protection devices or measures in place.

In particular, when the product specification requires shielded cables the test shall be performed with the shields bonded to the equipment according to the manufacturer's specifications.

The tests shall be carried out in one typical condition within the operating ranges of temperature, humidity and pressure specified for the product and at the rated supply voltage, unless otherwise indicated in the basic standard.

NOTE In particular and justified cases, where it is not possible to carry out type tests in a laboratory due to the physical dimensions of the equipment or system involved, *in situ* EMC investigations could be helpful. The investigations could be carried out with proper procedures in order not to affect the reliability of the equipment.

7 Product documentation

The manufacturer can demonstrate the compliance of the product with the specifications of this international standard by means of testing and a test report.

The results shall refer to the tests carried out on equipment having the configuration necessary to satisfy the functional requirements.

It is accepted that the compliance tests are carried out on a representative sample, which shall include all the types of sub-units, modules (hardware and software), etc., in order to fulfil all the operational functions of the final equipment.

The equipment or representative sample shall be clearly identified by the model, year of release and serial number.

The configuration and mode of operation during the tests shall be precisely noted in the test report.

The test report shall unambiguously demonstrate that the test procedures adopted correspond to those given in the basic standards related to each particular phenomenon.

8 Applicability

The application of tests for evaluation of immunity depends on the particular equipment, its configuration, its ports, its technology and its operating conditions.

Tests shall be applied to the relevant ports of equipment according to Table 3 to Table 10. Tests shall only be carried out where the relevant ports exist.

It may be determined from consideration of the electrical characteristics and usage of a particular equipment that some of the tests are inappropriate and, therefore, unnecessary. In such a case, it is required that the decision and justification not to test shall be recorded in the test report.

9 Measurement uncertainty

The guidance for the assessment of the instrumentation uncertainty of an immunity test is specified in IEC TR 61000-1-6 or in the corresponding basic standard and should be considered.

10 Immunity requirements

10.1 General

The immunity test requirements specified in 10.2 and 10.3 are based on the actual electromagnetic environment, considering the electromagnetic phenomena outlined in Annex A. They are given on a port-by-port basis.

The immunity tests shall be conducted in a well-defined and reproducible manner, as given by the relevant basic standards referred to in Table 3 to Table 10. The content of these basic standards is not repeated here; however additional information for the practical application of the tests are given in this standard.

The requirements for the enclosure and the power supply ports shall be established according to the location concerned. It is assumed that the power supply source is common to all equipment therein installed, without special EMC provisions.

The requirements for the signal ports shall be established according to the type of connections.

The tests shall be performed as type tests and carried out one at a time, as a single test.

The immunity requirements are related to conducted and radiated electromagnetic phenomena at low and high frequencies; they may be continuous, single or repetitive transient phenomena, with high and low occurrence, as given in Table 1. The performance criteria to be applied shall be derived from Table 2.

Equipment installed in "protected" areas, without direct connections to other areas, does not need to comply with the immunity specifications of this international standard, but is subjected to the relevant generic or product standards.

10.2 Immunity test requirements for equipment in power stations

The immunity test requirements for equipment intended for use in power stations reflect the situation given in Figure 2 and are given in the Table 3 to Table 6. The requirements in Table 4 to Table 6 shall be applied according to the interface types given in Figure 2.

Table 3 – Immunity requirements – Power station – Enclosure port

Test	Environmental phenomena	Basic standard	Test specifications [a] Remarks
1.1	Power frequency magnetic field [b]	IEC 61000-4-8	100 A/m (continuous) [c] 1 kA/m for 1 s
1.2	Radiated, radio frequency electromagnetic field	IEC 61000-4-3	80 MHz to 1,0 GHz 10 V/m [d] 80 % AM (1 kHz)
1.3	Radiated, radio frequency electromagnetic field	IEC 61000-4-3	1 GHz to 2,7 GHz 3 V/m [d] 80 % AM (1 kHz)
1.4	Radiated, radio frequency electromagnetic field	IEC 61000-4-3	2,7 GHz to 6 GHz 1 V/m [d] 80 % AM (1 kHz)
1.5	Electrostatic discharge	IEC 61000-4-2	6 kV (contact discharge) [e] 8 kV (air discharge) [e]

[a] Applicable performance criteria are defined in Table 2.

[b] Applicable only to equipment containing devices susceptible to magnetic fields (e.g. Hall elements, magnetic field sensors).

[c] For equipment in the control room area a test level of 30 A/m shall be applied. In case of CRT monitors which are used in protected areas, the test level 3 A/m shall be applied.

[d] The test level specified is the r.m.s. value of the unmodulated carrier.

[e] See the basic standard for applicability of contact and/or air discharge tests.

Table 4 – Immunity specifications – Power station – Signal/control ports

Test	Environmental phenomena	Basic standard	Test specifications Interface type according to Figure 2		
			2	3	4
2.1	Fast transient/burst [g]	IEC 61000-4-4	1 kV 5 kHz or 100 kHz [f]	2 kV 5 kHz or 100 kHz [f]	4 kV 5 kHz or 100 kHz [f]
2.2	Surge [a]	IEC 61000-4-5	1 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) [h] line to ground
2.3	Conducted disturbances, induced by radio-frequency fields	IEC 61000-4-6	150 kHz to 80 MHz 10 V [b] 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V [b] 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V [b] 80 % AM (1 kHz)
2.4	Mains frequency voltage [c]	IEC 61000-4-16	10 V continuous 100 V for 1 s	10 V continuous 100 V for 1 s	30 V continuous 300 V for 1 s
2.5	Conducted common mode disturbances [c, d]	IEC 61000-4-16	10 V to 1 V 15 Hz to 150 Hz 1 V 150 Hz to 1,5 kHz 1 V to 10 V 1,5 kHz to 15 kHz 10 V 15 kHz to 150 kHz	10 V to 1 V 15 Hz to 150 Hz 1 V 150 Hz to 1,5 kHz 1 V to 10 V 1,5 kHz to 15 kHz 10 V 15 kHz to 150 kHz	no test
2.6	Damped oscillatory wave	IEC 61000-4-18	no test	1,0 kV (common mode, 1 MHz) 0,5 kV (differential mode, 1 MHz)	2,5 kV (common mode, 1 MHz) [e] 1 kV (differential mode, 1 MHz) [e]

For interface type 1, at least the requirements of IEC 61000-6-1 shall be applied.

Applicable performance criteria are defined in Table 2.

[a] No test is needed for cables shorter than 10 m.

[b] The test level specified is the r.m.s. value of the unmodulated carrier.

[c] Only in case of long-distance lines (> 30 m). This test does not need to be applied to equipment for which by design and installation instructions occurrence of this phenomenon is avoided.

[d] The test level specified is the r.m.s. value.

[e] Applicable only to telecommunication lines connected to power line carrier.

[f] The use of 5 kHz repetition frequency is traditional, however, 100 kHz is recommended as this is closer to reality. See also Annex D.

[g] No test is needed for cables shorter than 3 m.

[h] The surge waveform 10/700 μs is recommended for testing signal ports intended to be connected to telecom network or remote equipment via unshielded outdoor symmetrical communication lines.

Table 5 – Immunity specifications – Power station – Low voltage a.c. input and output power ports

Test	Environmental phenomena	Basic standard	Test specifications Interface type according to Figure 2		
			2	3	4
3.1	Fast transient/burst	IEC 61000-4-4	2 kV 5 kHz or 100 kHz [f]	4 kV 5 kHz or 100 kHz [f]	4 kV 5 kHz or 100 kHz [f]
3.2	Surge	IEC 61000-4-5	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground
			1 kV (1,2/50 μs) line to line	1 kV (1,2/50 μs) line to line	1 kV (1,2/50 μs) line to line
3.3	Conducted disturbances, induced by radio-frequency fields	IEC 61000-4-6	150 kHz to 80 MHz 10 V [a] 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V [a] 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V [a] 80 % AM (1 kHz)
3.4	Voltage dips and voltage interruptions [b]	IEC 61000-4-11 [c] IEC 61000-4-34 [d]	70 % U_T, 1 period 40 % U_T, 50 periods [e] 0 % U_T, 5 periods 0 % U_T, 50 periods [e]	70 % U_T, 1 period 40 % U_T, 50 periods [e] 0 % U_T, 5 periods 0 % U_T, 50 periods [e]	70 % U_T, 1 period 40 % U_T, 50 periods [e] 0 % U_T, 5 periods 0 % U_T, 50 periods [e]
3.5	Damped oscillatory wave	IEC 61000-4-18	no test	1,0 kV (common mode, 1 MHz) 0,5 kV (differential mode, 1 MHz) 0,5 kV (differential mode, 10 MHz)	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)

For interface type 1, at least the requirements of IEC 61000-6-1 shall be applied.

For equipment with input current rating > 16 A, the tests should be limited to the power port of electronic units/modules, etc.

Applicable performance criteria are defined in Table 2.

[a] The test level specified is the r.m.s. value of the unmodulated carrier.

[b] Not applicable to low voltage a.c. output power ports.

[c] Applicable to equipment with mains current ≤ 16 A per phase.

[d] Applicable to equipment with mains current more than 16 A per phase.

[e] Applicable only to power ports directly connected to public low voltage supply network.

[f] The use of 5 kHz repetition frequency is traditional, however, 100 kHz is recommended as this is closer to reality. See also Annex D.

Table 6 – Immunity specifications – Power station – Low voltage d.c. input and output power ports

Test	Environmental phenomena	Basic standard	Test specifications Interface type according to Figure 2		
			2	3	4
4.1	Fast transient/burst	IEC 61000-4-4	2 kV 5 kHz or 100 kHz [d]	4 kV 5 kHz or 100 kHz [d]	4 kV 5 kHz or 100 kHz [d]
4.2	Surge	IEC 61000-4-5	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground
			1 kV (1,2/50 μs) line to line	1 kV (1,2/50 μs) line to line	1 kV (1,2/50 μs) line to line
4.3	Conducted disturbances, induced by radio-frequency fields	IEC 61000-4-6	150 kHz to 80 MHz 10 V [a] 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V [a] 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V [a] 80 % AM (1 kHz)
4.4	Mains frequency voltage [b]	IEC 61000-4-16	10 V continuous 100 V for 1 s	10 V continuous 100 V for 1 s	30 V continuous 300 V for 1 s
4.5	Ripple on d.c. power supply	IEC 61000-4-17	10 % U_n	10 % U_n	10 % U_n
4.6	Damped oscillatory wave	IEC 61000-4-18	no test	1,0 kV (common mode, 1 MHz) 0,5 kV (differential mode, 1 MHz) 0,5 kV (differential mode, 10 MHz)	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)
4.7	Voltage dips and voltage interruptions [c]	IEC 61000-4-29	70 % U_T, 0,1 s 40 % U_T, 0,1 s 0 % U_T, 0,05 s	70 % U_T, 0,1 s 40 % U_T, 0,1 s 0 % U_T, 0,05 s	70 % U_T, 0,1 s 40 % U_T, 0,1 s 0 % U_T, 0,05 s

DC ports which are not intended to be connected to a d.c. distribution network shall be tested as signal ports.

For interface type 1, at least the requirements of IEC 61000-6-1 shall be applied.

For equipment with input current rating > 16 A, the tests should be limited to the power port of electronic units/modules, etc.

Applicable performance criteria are defined in Table 2.

[a] The test level specified is the r.m.s. value of the unmodulated carrier.

[b] The test level specified is the r.m.s. value.

[c] Not applicable to low voltage d.c. output power ports.

[d] The use of 5 kHz repetition frequency is traditional, however, 100 kHz is recommended as this is closer to reality. See also Annex D.

10.3 Immunity test requirements for equipment in substations

The immunity test requirements for equipment intended for use in substations reflect the situation given in Figure 3 and Figure 4 and are given in Table 7 to Table 10. The

requirements in Table 8 to Table 10 shall be applied according to the interface types given in Figure 3 and Figure 4.

Table 7 – Immunity specifications – Substation – Enclosure port

Test	Environmental phenomena	Basic standard	Test specifications [a] Remarks
1.1	Power frequency magnetic field [b]	IEC 61000-4-8	100 A/m (continuous) [c] 1 kA/m for 1 s
1.2	Radiated, radio frequency electromagnetic field	IEC 61000-4-3	80 MHz to 1,0 GHz 10 V/m [d] 80 % AM (1 kHz)
1.3	Radiated, radio frequency electromagnetic field	IEC 61000-4-3	1 GHz to 2,7 GHz 3 V/m [d] 80 % AM (1 kHz)
1.4	Radiated, radio frequency electromagnetic field	IEC 61000-4-3	2,7 GHz to 6 GHz 1 V/m [d] 80 % AM (1 kHz)
1.5	Electrostatic discharge	IEC 61000-4-2	6 kV (contact discharge) [e] 8 kV (air discharge) [e]

[a] Applicable performance criteria are defined in Table 2.

[b] Applicable only to equipment containing devices susceptible to magnetic fields (e.g. Hall elements, magnetic field sensors).

[c] In case of CRT monitors which are used in protected areas, the test level 3 A/m (continuous) shall be applied.

[d] The test level specified is the r.m.s. value of the unmodulated carrier.

[e] See the basic standard for applicability of contact and/or air discharge tests.

Table 8 – Immunity specifications – Substation – Signal/control ports

Test	Environmental phenomena	Basic standard	Test specifications Interface type according to Figure 3 and Figure 4		
			2	3	4
2.1	Fast transient/burst [f]	IEC 61000-4-4	2 kV 5 kHz or 100 kHz [e]	4 kV 5 kHz or 100 kHz [e]	4 kV 5 kHz or 100 kHz [e]
2.2	Surge [a]	IEC 61000-4-5	1 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) [g] line to ground
2.3	Conducted disturbances, induced by radio-frequency fields	IEC 61000-4-6	150 kHz to 80 MHz 10 V [b] 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V [b] 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V [b] 80 % AM (1 kHz)
2.4	Mains frequency voltage [c]	IEC 61000-4-16	30 V continuous 300 V for 1 s	30 V continuous 300 V for 1 s	30 V continuous 300 V for 1 s
2.6	Damped oscillatory wave	IEC 61000-4-18	1 kV (common mode, 1 MHz) 0,5 kV (differential mode, 1 MHz)	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz)	2,5 kV (common mode, 1 MHz) [d] 1 kV (differential mode, 1 MHz) [d]

For interface type 1, at least the requirements of IEC 61000-6-1 shall be applied.

Signal port includes lines used for functional earth port.

Applicable performance criteria are defined in Table 2.

[a] No test is needed for cables shorter than 10 m.

[b] The test level specified is the r.m.s. value of the unmodulated carrier.

[c] The test level specified is the r.m.s. value.

[d] Applicable only to telecommunication lines connected to power line carrier.

[e] The use of 5 kHz repetition frequency is traditional, however, 100 kHz is recommended as this is closer to reality. See also Annex D.

[f] No test is needed for cables shorter than 3 m.

[g] The surge waveform 10/700 μs is recommended for testing signal ports intended to be connected to telecom network or remote equipment via unshielded outdoor symmetrical communication lines.

Table 9 – Immunity specifications – Substation – Low voltage a.c. input and output power ports

Test	Environmental phenomena	Basic standard	Test specifications Interface type according to Figure 3 and Figure 4		
			2	3	4
3.1	Fast transient/burst	IEC 61000-4-4	2 kV 5 kHz or 100 kHz [e]	4 kV 5 kHz or 100 kHz [e]	4 kV 5 kHz or 100 kHz [e]
3.2	Surge	IEC 61000-4-5	2 kV (1,2/50 μs) line to ground	4 kV (1,2/50 μs) line to ground	4 kV (1,2/50 μs) line to ground
			1 kV (1,2/50 μs) line to line	2 kV (1,2/50 μs) line to line	2 kV (1,2/50 μs) line to line
3.3	Conducted disturbances, induced by radio-frequency fields	IEC 61000-4-6	150 kHz to 80 MHz 10 V [a] 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V [a] 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V [a] 80 % AM (1 kHz)
3.4	Voltage dips and voltage interruptions [b]	IEC 61000-4-11 [c] IEC 61000-4-34 [d]	70 % U_T, 1 period 0 % U_T, 5 periods	70 % U_T, 1 period 0 % U_T, 5 periods	70 % U_T, 1 period 0 % U_T, 5 periods
3.5	Damped oscillatory wave	IEC 61000-4-18	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)

For interface type 1, at least the requirements of IEC 61000-6-1 shall be applied.

For equipment with input current rating > 16 A, the tests should be limited to the power port of electronic units/modules, etc.

Applicable performance criteria are defined in Table 2.

[a] The test level specified is the r.m.s. value of the unmodulated carrier.

[b] Not applicable to low voltage a.c. output power ports.

[c] Applicable to equipment with mains current ≤ 16 A per phase.

[d] Applicable to equipment with mains current more than 16 A per phase.

[e] The use of 5 kHz repetition frequency is traditional, however, 100 kHz is recommended as this is closer to reality. See also Annex D.

Table 10 – Immunity specifications – Substation – Low voltage d.c. input and output power ports

Test	Environmental phenomena	Basic standard	Test specifications Interface type according to Figure 3 and Figure 4		
			2	3	4
4.1	Fast transient/burst	IEC 61000-4-4	2 kV 5 kHz or 100 kHz [d]	4 kV 5 kHz or 100 kHz [d]	4 kV 5 kHz or 100 kHz [d]
4.2	Surge	IEC 61000-4-5	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground
			1 kV (1,2/50 μs) line to line	1 kV (1,2/50 μs) line to line	1 kV (1,2/50 μs) line to line
4.3	Conducted disturbances, induced by radio-frequency fields	IEC 61000-4-6	150 kHz to 80 MHz 10 V [a] 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V [a] 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V [a] 80 % AM (1 kHz)
4.4	Mains frequency voltage [b]	IEC 61000-4-16	30 V continuous 300 V for 1 s	30 V continuous 300 V for 1 s	30 V continuous 300 V for 1 s
4.5	Ripple on d.c. power supply	IEC 61000-4-17	10 % U_n	10 % U_n	10 % U_n
4.6	Damped oscillatory wave	IEC 61000-4-18	no test	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)
4.7	Voltage dips and voltage interruptions [c]	IEC 61000-4-29	70 % U_T, 0,1 s 40 % U_T, 0,1 s 0 % U_T, 0,05 s	70 % U_T, 0,1 s 40 % U_T, 0,1 s 0 % U_T, 0,05 s	70 % U_T, 0,1 s 40 % U_T, 0,1 s 0 % U_T, 0,05 s

DC ports which are not intended to be connected to a d.c. distribution network shall be tested as signal ports.

For interface type 1, at least the requirements of IEC 61000-6-1 shall be applied.

For equipment with input current rating > 16 A, the tests should be limited to the power port of electronic units/modules, etc.

Applicable performance criteria are defined in Table 2.

[a] The test level specified is the r.m.s. value of the unmodulated carrier.

[b] The test level specified is the r.m.s. value.

[c] Not applicable to low voltage d.c. output power ports.

[d] The use of 5 kHz repetition frequency is traditional, however, 100 kHz is recommended as this is closer to reality. See also Annex D.

Annex A
(informative)

Information on electromagnetic phenomena, typical sources and causes

Annex A provides examples of electromagnetic phenomena as well as their sources as they can be faced in power stations and substations (see Table A.1). These phenomena are further characterized in Table 1 and most of them are considered by means of immunity tests.

Table A.1 – Electromagnetic phenomena – Sources and causes

Examples of electromagnetic phenomena (see IEC 61000-4-1)		**Sources and causes**
Low frequency	Harmonics	Loads with non-linear voltage/current characteristics: rectifiers, cycloconverters, induction motors, welding machines, etc.
	Interharmonics	
	Mains signalling	Signal voltages in the low voltage supply network
	Voltage fluctuations	Variations and on/off switching of loads, step voltage change
	AC voltage dips, short interruptions and voltage variations	Faults and switching in the power supply network
	Variation of power frequency	Rare fault conditions producing a large block of load or generation disconnection with a resultant change in frequency outside the normal tolerance band
	DC voltage dips, short interruptions and voltage variations	Power supply fault and switching, lack of battery charging
	Ripple on d.c. power supply	AC rectification, battery charging
	Conducted disturbances in the range d.c. to 150 kHz (including the power frequency)	Induction from industrial electronics, filters leakage current, fault current at the power frequency, etc.
Conducted transients, high frequency	Surge 100/1 300 μs	Blowing of fuses
	Surge 1,2/50 μs	Fault in power network, lightning
	Surge 10/700 μs	Effect of lightning on telecommunication lines
	Ring wave	Switching phenomena, indirect effect of lightning
	Fast transient/burst	Switching of reactive loads, relay contact bouncing, switching in SF_6
	Damped oscillatory wave	HV switching by isolators
	Conducted disturbances, induced by radio-frequency fields	Radiation by radio-frequency emitters
ESD	Electrostatic discharge	Discharge of static electricity by operator, furniture, etc.
Magnetic fields	Power frequency magnetic field	Current in power circuits, earth circuits and network
	Pulse magnetic field	Lightning current in earth conductors and network
	Damped oscillatory magnetic field	MV and HV switching by isolators
EM fields	Radiated, radio-frequency electromagnetic field	Radiation by radio-frequency emitters Corona discharge Overhead power lines, electron multiplication or avalanche formation

Annex B
(informative)

Overview of the effect of the electromagnetic phenomena on the functions of equipment and systems

The effects and consequences of the different classes of electromagnetic phenomena on electronic systems installed in power stations and substations are directly related to the different kinds of functions carried out by a specific control system, and to the process involved.

In the evaluation of these effects and consequences, it is useful to identify the "main functions" of the electrical plant's equipment and systems.

The following functions are considered of particular relevance to electronic equipment and systems:

– protection and teleprotection;
– on-line processing and regulation;
– metering;
– command and control;
– supervision;
– human-machine interface;
– alarm;
– data transmission and telecommunication;
– data acquisition and storage;
– measurement;
– off-line processing;
– passive monitoring;
– self-diagnosis.

Combinations of different functions are in general present in equipment and systems.

Depending on the types of electromagnetic phenomena (conducted and radiated, low and high frequency) and the equipment port involved, the effect (interference) may be limited to one function or to an unforeseeable number of them.

The total effect of the electromagnetic phenomena on electronic equipment and systems, and the related consequences on the process, can therefore be described as a collection of possible influences on the different functions involved.

A short description of the different functions, together with the related possible degradation due to electromagnetic phenomena, is reported in the following.

For each function, considerations on the relevance of such degradation, in terms of consequences to the process, are given, taking into account the electromagnetic phenomena present in the plants.

a) Protection and teleprotection

   Protection is of particular relevance to power systems and to the safety and security of both substations and power stations.

   Protection involves detection of abnormal conditions and appropriate action.

A teleprotection equipment is specially designed to be used in conjunction with a protection system. The teleprotection equipment, which is connected to a telecommunication link between both ends of the protected circuit, transforms the information given by the protection equipment into a form suitable for transmission.

A teleprotection system is composed of teleprotection equipment and an associated telecommunication system between the ends of a protected circuit.

The precision and rapidity of electronic protection equipment shall not be subjected to degradation of performance as a consequence of electromagnetic phenomena, such as:

– lack of protection function, with the consequences of critical conditions, including damage of power system components;
– delay in the protection operation, with consequent overstress of power system components;
– spurious operation, with unavailability of the process or discontinuous working conditions, depending on the type of electrical plant;
– loss of operational sequence recording, with unavailability of fault location and analysis.

Any degradation of a protection function is unacceptable, consequently immunity against electromagnetic phenomena with proper margin is essential in achieving EMC of protection systems.

b) On-line processing and regulation

On-line processing and regulation systems give the process a working condition as defined by control/telecontrol systems or by operators. The optimum running of the process is achieved by these functions taking into account relevant process parameters.

Degradation of on-line processing and regulation could occur due to lack of immunity of the equipment and related input/output interfaces or of the process instrumentation involved. A possible consequence is unnecessary stress or damage of the process and degradation of performance.

The immunity of on-line processing and regulation systems to electromagnetic phenomena, including transient phenomena with low probability of occurrence, is of particular importance.

c) Metering

The function of measuring the electrical energy generated or passing through an electrical plant as well as fuel supplies, can be of particular significance due to the contractual aspects which may be involved.

This applies to traditional watt-hour meters for electrical energy measurement, and to similar equipment based on advanced technology, having a capability for setting operating conditions and storing data. This function should be highly reliable and therefore immunity against continuous and transient phenomena is mandatory.

For metering equipment, immunity against differential mode conducted disturbances in the range from 2 kHz to 150 kHz is also relevant for metering functions due to the presence of disturbances in this frequency band.

d) Command and control

Command and control functions are important to all operating conditions of electrical plants, including partial operation of the plant or temporary out of service conditions.

Electrical equipment is controlled by dedicated equipment/systems with different levels of complexity which are connected as necessary to other systems in order to provide full automated control or manual control by direct action of the operator. The co-ordination of all sources of command and control actions is ensured by the provision of priority levels.

Insufficient reliability of the command and control functions due to lack of immunity could result in:

– improper operation of electrical equipment, involving safety aspects;

– wrong operation sequence or procedure, with possible damage/overstress of the controlled equipment;

– unavailability of the process equipment and then of the process or part of it.

Command and control units are required to operate properly in actual environmental conditions, for example for continuous phenomena or high-occurrence transient phenomena.

Electromagnetic phenomena with a low probability of occurrence, having only minor influence, may be observed on a control system and accepted. For example: a delay in the execution of a command may be insignificant compared to the time constant of the controlled process, so that the main function is not affected.

e) Supervision

Supervision systems collect data from the process and related equipment for diagnostic purposes, for maintenance programme purposes and evaluation of the process. They generally do not interact with the process itself.

The performance degradation or temporary unavailability of the supervision systems causes loss of information on the process and deviation in the event scheduling time. Such effects may be acceptable, for example in the case of transient phenomena with low probability of occurrence affecting acquisition of cycling measurements.

The acquisition of event data shall however be recorded in actual sequence.

f) Human-machine interface

The human-machine interface function allows the operators to directly interact with the process from operator desks or to manage the information from the plant. Control and regulation systems interface with the process, and the manual command to process equipment has higher priority.

This function may be activated by the operator by using this interface; high priority commands to the running process are generally available, and are given by the operator through the use of dedicated devices.

The immunity to transient phenomena having a low probability of occurrence can therefore be considered as not binding; the operator presence allows manual restoration.

g) Alarm

The alarm function includes all local or remote indications able to give information on any kind of temporary or non-temporary degradation of the operating conditions of equipment and systems.

Alarms can have different urgency, depending on whether there is the need of immediate intervention or if the system can still operate in an acceptable mode (e.g. thanks to redundancy).

In case of self-recovery after temporary degradation, the alarm status may disappear. Where a chronological list (trace) of the alarms is automatically generated and stored, the alarm function shall not be affected by the electromagnetic phenomena.

h) Data transmission and telecommunication

Data transmission and telecommunication functions are auxiliary to other functions. They allow the data acquisition and the remote control of systems installed within an electrical plant; the control functions of the process are controlled by local systems. Voice communications are not considered here.

Through data transmission and telecommunication, the telecontrol systems can co-ordinate the operating condition of different electrical plants, improving the overall efficiency of the electrical network.

Interference on data transmission and telecommunications has the effect of delaying the transfer of command and control, affecting the telecontrol efficiency.

Depending on the telecommunication medium adopted, electromagnetic phenomena can influence the communication link or affect the terminal equipment, producing a bit error

rate degradation; immunity against electromagnetic phenomena can be obtained only with particular communication supports, for example optical fibre.

Temporary loss of the communication function is occasionally tolerated, provided that the link is automatically restored within an acceptable time. However, the receipt of corrupted data cannot be tolerated.

i) Data acquisition and storage

Data acquisition and storage of relevant parameters from electrical plants allow, by data processing, an off-line analysis, comparison with reference condition and computation, etc. These functions are generally assigned to "in-field" equipment, and are complementary to supervision.

Proper design of the data acquisition system interfaces, including hardware and/or software filtering actions, gives to data acquisition the required immunity to electromagnetic phenomena.

Temporary deviation from precise analogue data acquisition or incorrect time allocation of digital data, due to transient phenomena, is sometimes acceptable due to the possibility of identifying these effects through data validation.

No corruption of locally stored data is allowed.

j) Measurement

Measuring some relevant parameters of the process gives direct evidence of their values and trend. This function is carried out by using analogue or digital instruments. These instruments are located for example on a control system panel, on display panels or in the proximity of electrical equipment.

Temporary deviation of analogue or digital indications as a consequence of a transient disturbance may be accepted. No degradation due to continuous phenomena is allowed.

k) Off-line processing

The off-line processing function allows simulation of the process, planning of power generation, study of models and analysis of critical working conditions, etc. This function implies the use of data coming from the process or stored data. It does not interact with the on-line process itself.

Temporary degradation of this function due to transient phenomena is accepted in principle, on condition that no corruption of stored data or processing accuracy occurs.

l) Passive monitoring

The process is monitored on displays, showing the entire setting and operating condition of the plants. Information technology equipment is used to represent the process and its parameters at different levels of detail.

Temporary degradation of this function (e.g. in the image quality) can be accepted, provided that the consistency of the monitoring with the process condition is resumed.

Temporary loss of display with restoration within a given time, e.g. a few seconds, allowing for possible intervention by operators, can also be accepted.

m) Self-diagnosis

Self-diagnostic capability is increasing in complex electronic systems and is of particular relevance for the reliability of the system.

Self-diagnostic test cycles are generally assigned low priority in the tasks sequence.

Temporary loss of the self-diagnostic function can generally be considered as acceptable if it is self-recovered within the system working cycle and if it gives rise only to a delay in warning an operator of a system failure condition. Such a loss of function should also not produce spurious alarm conditions which could necessitate attendance at unmanned remote locations.

Annex C
(informative)

Guidelines for protected zones – Mitigation of radiated and conducted disturbances

C.1 General

The information in Annex C has been adapted from IEC TR 61000-5-6. If additional information is required, that document should be consulted.

Mitigation of radiated and conducted disturbances may be required if EMC between an equipment and its environment is not achieved. Mitigation can be achieved by using an electromagnetic barrier between the source and the victim. For conducted disturbances this barrier can be a filter or other decoupling device, and for radiated disturbances it can be an electromagnetic shield and perhaps a filter as needed, the attenuation of which is compatible with that of the shield in the frequency range considered.

The attenuation provided by a barrier has to be compatible with the need to be at least equal to the difference between the disturbance level and the immunity level of the equipment to that disturbance. Thus, the attenuation provided corresponds to the difference between the disturbance level (expected or measured) and the immunity level determined in a laboratory test or by reference to an established immunity level.

According to variations on disturbance level(s) and immunity level(s), a margin should be considered as well, and added to the basic attenuation needed. This margin generally depends on the criticality of the equipment.

As discussed in IEC 61000-5-1, it is useful to extend the concept of enclosure as being the boundary of a facility. An enclosure may be envisioned as a complete building, a room, a rack, a single cabinet and even, by extension of the concept, as an individual equipment or a circuit board within an equipment. This facility interfaces with its environment by "ports" as shown in Figure C.1. IEC 61000-5-1 provides further discussion of the concept of ports.

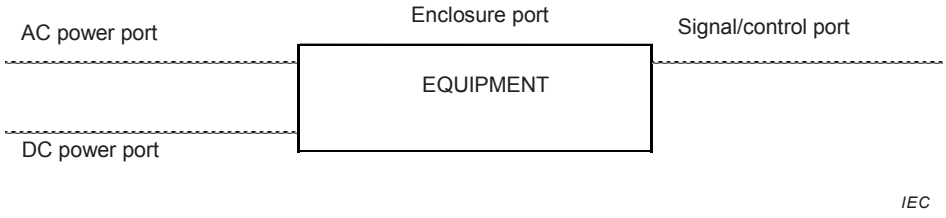


Figure C.1 – Equipment ports

C.2 General approach

Electromagnetic shielding of buildings, rooms, compartments, cabinets, rack chassis and equipment makes it possible to ensure compliance with the EMC for equipment exposed to radiated disturbances. IEC TR 61000-2-5 may be used as a guide for determination of disturbance levels within each zone. Low-frequency electric fields are relatively easy to mitigate. Low-frequency magnetic fields are more difficult to shield and will involve a shield with a large wall thickness and/or a high permeability.

Shielding of rooms and cabinets with appropriate penetration protection is only one of several actions that may be used to limit the effects of radiated electromagnetic disturbances. For

instance, maintaining appropriate distances between emitters and victims is a relatively effective means of mitigation for radiated disturbances. Obtaining a satisfactory result also requires other aspects to control the conducted penetrations such as:

a) selecting correct cabling and wiring (adding a shield jacket over cables or wires or by using shielded cables (braided shields));
b) applying good cable layout management, for example cable laying on metal trays or in closed metal trays; and
c) implementing good earthing and bonding practices consistent with the frequency content to be controlled.

Refer to IEC 61000-5-1 on general considerations and IEC 61000-5-2 on earthing and cabling, for guidelines concerning these actions.

The objective of Clauses C.3 to C.5 is to present the main arrangements used in mitigation methods involving the shielding of installations, including the introduction of the concept of mitigation zones, a review of the corresponding types of shielded enclosures, and generic information on the implementation of shielding, progressing from the sensitive equipment to the complete building, as well as on the means of dealing with the unavoidable apertures/penetrations.

C.3 Classification of protection zones

C.3.1 General

For the purpose of designing and applying appropriate mitigation measures, it is useful to consider a hierarchy of zones of protection, from the unprotected environment to the strong protection of especially sensitive equipment. For the purposes of Annex C, the particular zones are defined as follows:

- zone 0: no protection;
- zone 1: buildings protected by reinforced concrete outdoor walls or metal bolted construction;
- zone 2: rooms shielded by special materials;
- zone 3: internal equipment shielded by metallic materials or metalised enclosures and located in zone 1 or zone 2;
- zone 4: sensitive apparatus enclosed within a special shielded rack and located in zone 1 or zone 2

Figure C.2 shows a schematic representation of the hierarchy of the classification for protection of zones 0 through 4. Note that not all barriers may be present in a given installation. Zones may be selected in a manner to provide the required attenuation of the external disturbances and also with cost aspects in mind.

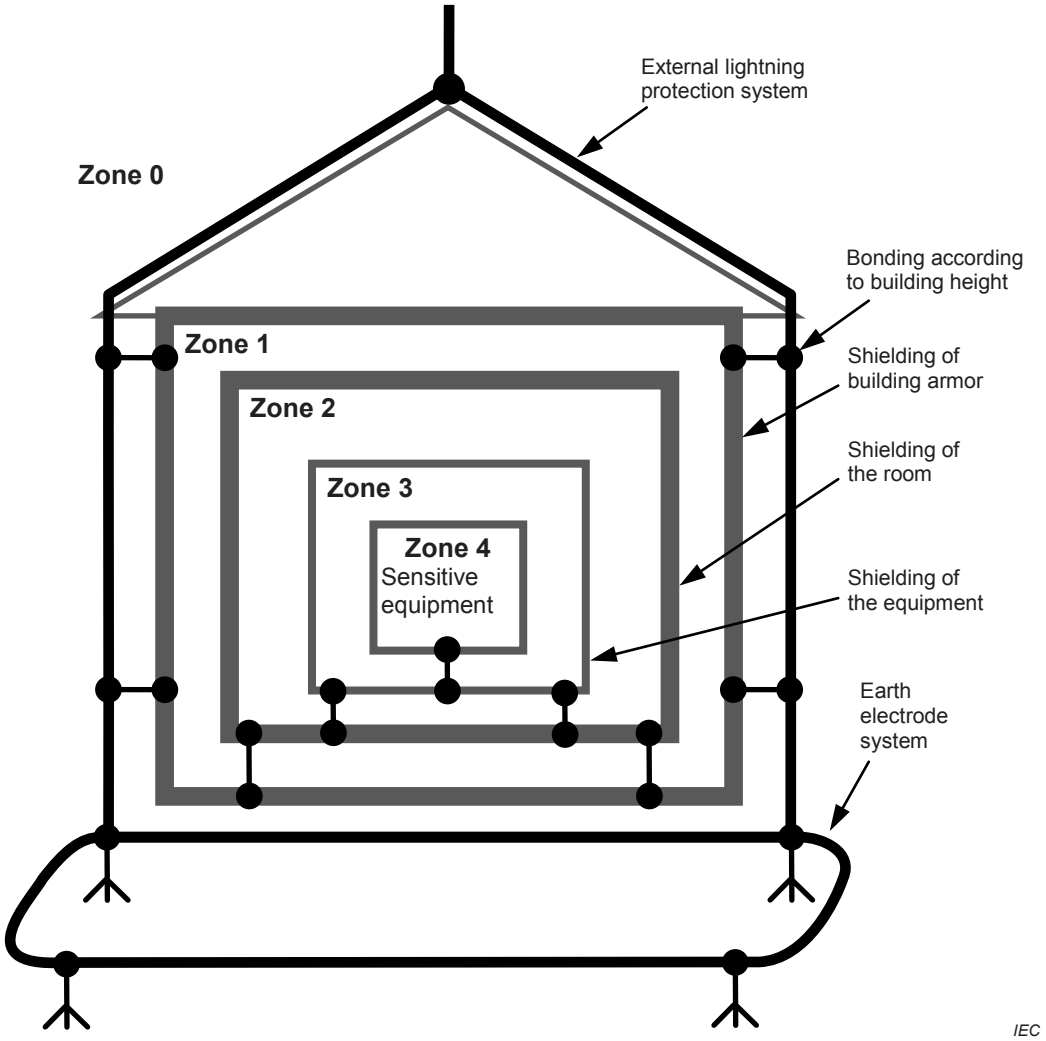


Figure C.2 – Zones of protection of shielding and earthing systems

C.3.2 Zone 1 – Building shield

Zone 1 applies to buildings containing welded iron reinforcing bars for concrete outdoor walls or with additional metal bars which are interconnected by welds or clamps. The reinforcement bars should be interconnected preferentially by as many welds as feasible. Thus the reinforcement forms a good earthing structure. Note that steel-reinforcing bars may not always be interconnected so that a good electrical bond is made. In such situations the steel reinforcing bars may not represent an adequate electromagnetic shield at the higher frequencies. An important first measure is a well-designed and implemented lightning conductor with conductive connections to the earth. Conductive penetrations which are likely to be exposed to high levels of electromagnetic fields should be protected with appropriate limiting (surge-protective device) and filtering, preferably as they penetrate zone 1. An alternative to reinforced concrete is metal bolted construction, which will usually provide more attenuation than a concrete outer wall.

C.3.3 Zone 2 – Room shield

Zone 2 applies to indoor facilities with protection measures. In this case the shield is effective when it consists of continuously connected (welded) sheet-metal walls or walls with a metal surface. Bolted or otherwise interconnected walls will result in some degradation of the shielding effectiveness. All the shields of leads entering this zone shall have a short connection to the metal walls (to reduce the inductance for high-frequency transients). The

penetrating leads should also be protected against overvoltages with appropriate limiting (surge-protective device) and filtering.

C.3.4 Zone 3 – Equipment shield

Zone 3 applies where individual equipment is protected by metal cabinets or metalized enclosures. The earth connection should be a short lead to the earthing arrangement. Conductive penetrations should be protected with appropriate limiting (surge-protective device) and filtering.

C.3.5 Zone 4 – Additional protection

Zone 4 applies at the individual equipment level; it is not expected that the best approach would be to shield each item of equipment, although this zone might also include highly sensitive equipment that may require additional protection.

C.4 Design principles for shielding

The design principles presented in Clause C.4 are not intended to serve as a comprehensive guide for the detailed design of a specific installation; rather, they are offered as an overview of design considerations that can serve as useful checks for a proposed installation. Providing effective shielding techniques requires a design by specialists, taking into consideration the specifics of the installation. By application of different materials it is possible to obtain a good shielding effectiveness over the whole spectrum of electromagnetic fields. Shielding can be provided by the following materials and constructions:

- metallic enclosure or cabinets;
- rooms with continuous metallic walls;
- clamped or welded iron mats, grids and sheets inside of walls;
- metallic meshed wire or meshed shield;
- metallic or metalled fabric;
- metallic foil;
- metal sheets (copper or aluminium or other good conductive metals);
- metalized plastics with undamaged surfaces and a good contact across all seams;
- window glass with wire mesh fused in the glass or metalized glass, both continuously bonded to the wall shield.

Note that for shielding against low frequency electric fields, metalized plastic might be adequate. However, shielding against low frequency magnetic fields requires metal walls of sufficient thickness, conductivity and permeability. The electrical continuity of the walls shall be ensured, especially in the case of the lower frequency magnetic fields.

C.5 Shielding effectiveness

The effectiveness of a shielded enclosure depends on many parameters. In theory, a shielded enclosure may be designed to produce attenuation ranging from a few dB to over 100 dB in a frequency range up to 10 GHz and beyond. However, in practice, the effectiveness of an enclosure with penetrations of all types will be reduced and limited by these penetrations. For practical purposes, the shielding effectiveness of a solid metallic cabinet or enclosure is mainly determined by the following factors:

- the transfer impedance of the cabinet or enclosure should be as low as possible;

- the installation of penetrating cables: for good performance all cables penetrating the cabinet should either be filtered/limited and/or their shields should be earthed directly to the cabinet (see IEC 61000-5-2);
- the electrical length of seams of all parts of the enclosure should be as small as possible, preferably smaller than one-tenth of the wavelength of the impinging disturbance (this conditional limit is not applicable to low frequency magnetic fields);
- the size of holes should be as small as possible relative to the incident wavelength or should be fitted with pipes (waveguide beyond cutoff).

Annex D
(informative)

Guidance for the user of this standard

According to IEC Guide 107, generic immunity standards specify a set of requirements, test procedures and generalized performance criteria applicable to such products or systems intended to be operated in the respective electromagnetic environment. The normative part of this document considered the most essential electromagnetic phenomena relevant for that environment.

However, there are further electromagnetic phenomena for which the probability of interference is expected to increase in the future. EMC committees should provide advice and support to the product committees in the setting of corresponding immunity levels.

The purpose of informative Annex D is to indicate tests and test parameters which might be relevant for such future situations. Product committees or other users of this standard are requested to be aware of those tests given in Table D.1 which could be relevant for future EMC specifications.

Table D.1 – Immunity tests and test levels to be considered in the future or for particular product families

Electromagnetic phenomenon	Basic standard	Test levels/test parameters according to basic standard	Remarks
Radiated, radio frequency electromagnetic field	IEC 61000-4-3	Amplitude modulation	Other modulation schemes are being considered and probably higher field strengths (e.g. 30 V/m) for close proximity situations.
Electric fast transient, burst	IEC 61000-4-4	Burst repetition frequencies: 5 kHz and/or 100 kHz	It should be noted that future editions of this standard might consider the 100 kHz repetition frequency only, as this is closer to reality compared to the traditional 5 kHz repetition frequency.
Ring wave	IEC 61000-4-12	3	This should be considered for equipment which is likely exposed to oscillatory transients, induced in low voltage cables due to the switching of electrical networks and reactive loads, faults and insulation breakdown of power supply circuits or lightning.
Differential mode conducted disturbances below 150 kHz	IEC 61000-4-19	3	Should be considered for equipment sensitive to a.c. power supply disturbances in the frequency range 2 kHz to 150 kHz, generated for example by PLC systems or power electronic equipment.

Bibliography

The following publications listed have been considered as relevant for this standard.

Publications [1] to [4] deal with installation guidelines, electromagnetic environments and mitigation methods.

Publications [5] to [16] are IEC generic or product standards referring to specific products used in power plant and substation environments.

[1] IEC 61000-5-1:1996, *Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 1: General considerations – Basic EMC publication*

[2] IEC 61000-5-2:1997, *Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling*

[3] IEC 61000-2 (all parts), *Electromagnetic compatibility (EMC) – Part 2: Environment*

[4] CIGRE Guide N. 535, *EMC within Power Plants and Substations*, Working Group C4.208, April 2013

[5] IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

[6] IEC 60255-1:2009, *Measuring relays and protection equipment – Part 1: Common requirements*

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[10] IEC 60870-2-1:1995, *Telecontrol equipment and systems – Part 2: Operating conditions – Section 1: Power supply and electromagnetic compatibility*

[11] IEC TR 61000-5-6:2002, *Electromagnetic compatibility (EMC) – Part 5-6: Installation and mitigation guidelines – Mitigation of external EM influences*

[12] IEC 61000-6-2:2005, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

[13] IEC 61326-1:2012, *Electrical equipment for measurement, control and laboratory use – Part 1: General requirements*

[14] IEC 61800-3:2012, *Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods*

[15] IEC 61812-1:2011, *Time relays for industrial and residential use – Part 1: Requirements and tests*

[16] CISPR/TR 18-1:2010, *Radio interference characteristics of overhead power lines and high-voltage equipment – Part 1: Description of phenomena*

IEC 60050-161, *International Electrotechnical Vocabulary (IEV) – Part 161: Electromagnetic compatibility*

IEC 60050-441, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses*

IEC TR 61000-1-6, *Electromagnetic compatibility (EMC) – Part 1-6: General – Guide to the assessment of measurement uncertainty*

IEC TR 61000-2-5, *Electromagnetic compatibility (EMC) – Part 2-5: Environment – Description and classification of electromagnetic environments*

IEC 61000-4-1, *Electromagnetic compatibility (EMC) – Part 4-1: Testing and measurement techniques – Overview of IEC 61000-4 series*

IEC 61000-4-12:2006, *Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques – Ring wave immunity test*

IEC 61000-4-19:2014, *Electromagnetic compatibility (EMC) – Part 4-19: Testing and measurement techniques – Test for immunity to conducted, differential mode disturbances and signalling in the frequency range 2 kHz to 150 kHz at a.c. power ports*

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