BS IEC 61000-5-6:2024

BSI Standards Publication

Electromagnetic compatibility (EMC)

Part 5-6: Installation and mitigation guidelines —
Mitigation of external EM influences

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National foreword

This British Standard is the UK implementation of IEC 61000-5-6:2024. It supersedes PD IEC TR 61000-5-6:2002, which is withdrawn.

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 committee manager.

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INTERNATIONAL STANDARD

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Electromagnetic compatibility (EMC) – Part 5-6: Installation and mitigation guidelines – Mitigation of external EM influences

INTERNATIONAL
ELECTROTECHNICAL
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 5-6: Installation and mitigation guidelines – Mitigation of external EM influences

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IEC 61000-5-6 has been prepared by subcommittee 77C: High power transient phenomena, of IEC technical committee 77: Electromagnetic compatibility. It is an International Standard.

This first edition cancels and replaces the first edition of IEC TR 61000-5-6 published in 2002. This edition constitutes a technical revision.

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

a) updating the whole document to include other HPEM environments including IEMI;
b) adding a new Annex A which provides details on the concept of EM resilience and includes information on HPEM detectors, recovery and restoration.

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The text of this International Standard is based on the following documents:

Draft	Report on voting
77C/339/FDIS	77C/340/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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 document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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INTRODUCTION

IEC 61000 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 several parts, 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).

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 5-6: Installation and mitigation guidelines – Mitigation of external EM influences

1 Scope

This part of IEC 61000 covers guidelines for the mitigation of external electromagnetic influences impinging upon a facility or installation, aimed at ensuring electromagnetic compatibility (EMC) among electrical and electronic apparatus or systems. These influences include lightning, RF transmitters, power-line and telecom transients, high-altitude electromagnetic pulse (HEMP) and other high-power electromagnetic transients such as those from intentional electromagnetic interference (IEMI).

This document is intended for use by installers, manufacturers and users of sensitive electrical or electronic installations or systems. It applies primarily to new installations but, where economically feasible, it can be applied to extensions or modifications to existing facilities.

While the technical principles are applicable to individual equipment or apparatus, such application is not included in the scope of this document.

2 Normative references

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

IEC 60364 (all parts), *Low-voltage electrical installations*

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

IEC 61508-1, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements*

IEC 62305 (all parts), *Protection against lightning*

IEEE Std 1848-2020, *Techniques and Measurement to Manage Functional Safety and Other Risks with Regards to Electromagnetic Disturbances*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

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

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

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3.1.1
apparatus
device or assembly of devices which can be used as an independent unit for specific functions

Note 1 to entry: In English, the term "apparatus" sometimes implies use by skilled persons for professional purposes.

[SOURCE: IEC 60050-151:2001, 151-11-22]

3.1.2
attenuation
ratio of the input to the output values of quantities of the same kind in a device or system

Note 1 to entry: When this ratio is less than unity it is usually replaced by its reciprocal, the gain.

[SOURCE: IEC 60050-312:2001, 312-06-06]

3.1.3
device
material element or assembly of such elements intended to perform a required function

Note 1 to entry: A device may form part of a larger device.

[SOURCE: IEC 60050-151:2001,151-11-20]

3.1.4
earthing
grounding, US
electric connections between conductive parts and local earth

[SOURCE: IEC 60050-195:2021, 195-01-24]

3.1.5
earth electrode
ground electrode, US
conductive part that is in electric contact with local earth, directly or through an intermediate conductive medium

[SOURCE: IEC 60050-195:2021,195-02-01]

3.1.6
earthing arrangement
grounding arrangement, US
all electrical means involved in the earthing of a system, installation or equipment

Note 1 to entry: Electric connection and devices used for earthing are examples of electrical means.

[SOURCE: IEC 60050-195:2021,195-02-20]

3.1.7
electromagnetic compatibility
EMC
ability of equipment or a system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[SOURCE: IEC 60050-161:2018,161-01-07]

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3.1.8
electromagnetic disturbance
electromagnetic phenomenon that can degrade the performance of a device, equipment or system, or adversely affect living or inert matter

Note 1 to entry: An electromagnetic disturbance can be an electromagnetic noise, an unwanted signal or a change in the propagation medium itself.

Note 2 to entry: In French, the terms "perturbation électromagnétique" and "brouillage électromagnétique" designate respectively the cause and the effect and should not be used indiscriminately.

Note 3 to entry: In English, the terms "electromagnetic disturbance" and "electromagnetic interference" designate respectively the cause and the effect and should not be used indiscriminately.

[SOURCE: IEC 60050-161:2018, 161-01-05]

3.1.9
electromagnetic interference
EMI
degradation in the performance of equipment or transmission channel or a system caused by an electromagnetic disturbance

Note 1 to entry: In French, the terms "perturbation électromagnétique" and "brouillage électromagnétique" designate respectively the cause and the effect and should not be used indiscriminately.

Note 2 to entry: In English, the terms "electromagnetic disturbance" and "electromagnetic interference" designate respectively the cause and the effect and should not be used indiscriminately.

[SOURCE: IEC 60050-161:2018,161-01-06]

3.1.10
electromagnetic screen
electromagnetic shield (US)
screen of conductive material intended to reduce the penetration of a time-varying electromagnetic field into a given region

[SOURCE: IEC 60050-151:2001, 151-13-12]

3.1.11
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]

3.1.12
equipotential bonding
set of electric connections intended to achieve equipotentiality between conductive parts

[SOURCE: IEC 60050-195:2021, 195-01-10]

3.1.13
facility
entity (such as a hospital, a factory, machinery, etc.) that is built, constructed, installed or established to perform some particular function or to serve or facilitate some particular end

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3.1.14
filter
linear two-port device designed to transmit spectral components of the input quantity according to a specified law, generally in order to pass the components in certain frequency bands and to attenuate those in other bands

[SOURCE: IEC 60050-151:2001,151-13-55]

3.1.15
high-altitude electromagnetic pulse
HEMP
electromagnetic pulse produced by a nuclear explosion outside the earth's atmosphere

Note 1 to entry: This typically occurs above an altitude of 30 km.

3.1.16
intentional electromagnetic environment
IEME
totality of high-power transient radiated or conducted electromagnetic phenomena, which are generated intentionally to produce interference in electrical and electronic systems

Note 1 to entry: IEMEs can be generated for defence, law enforcement or for malicious purposes.

3.1.17
intentional electromagnetic interference
IEMI
effect of an intentional electromagnetic environment introducing noise or signals into electrical and electronic systems, thus disrupting, confusing or damaging these systems

3.1.18
installation
one apparatus or a set of devices and/or apparatuses associated in a given location to fulfil specified purposes, including all means for their satisfactory operation

[SOURCE: IEC 60050-151:2001, 151-11-26]

3.1.19
local earth
local ground, US
part of the earth that is in electric contact with an earth electrode and that has an electric potential not necessarily equal to zero

[SOURCE: IEC 60050-195:2011, 195-01-03]

3.1.20
port of entry
PoE
physical location (point) on an electromagnetic barrier, where EM energy can enter or exit a topological volume, unless an adequate PoE protective device is provided

Note 1 to entry: A PoE is not limited to a geometrical point.

Note 2 to entry: PoEs are classified as aperture PoEs or conductive PoEs according to the type of penetration. They are also classified as architectural, mechanical, structural or electrical PoEs according to the functions they serve.

3.1.21
residual current
peak current that appears at the output terminals of an SPD or filter during application of a standard stress at the input terminals

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3.1.22
residual voltage
peak value of voltage that appears at the output terminals of an SPD or filter during application of a standard stress at the input terminals

3.1.23
resilience
electromagnetic resilience
features of a system that enable the system to be prepared for, to withstand, to respond to and to recover from a transient electromagnetic disturbance(s) in a timely and efficient manner

3.1.24
screen
shield (US)
device intended to reduce the penetration of an electric, magnetic or electromagnetic field into a given region

[SOURCE: IEC 60050-151:2001, 151-13-09]

3.1.25
shielded enclosure
screened room
mesh or sheet metallic housing designed expressly for the purpose of separating electromagnetically the internal and the external environment

[SOURCE:IEC 60050-161:1990, 161-04-37]

3.1.26
shielding effectiveness
for a given external source, ratio of electric or magnetic field strength at a point before and after the placement of the shield in question

3.1.27
surge-protective device
SPD
device that is intended to protect the electrical apparatus from transient overvoltages and to divert surge currents

Note 1 to entry: A surge-protective device contains at least one non-linear component.

[SOURCE: IEC 60050-614:2016, 614-03-48, modified – "SPD" has been added to the term.]

3.1.28
system
set of interrelated elements considered in a defined context as a whole and separated from their environment

Note 1 to entry: A system is generally defined with the view of achieving a given objective, e.g. by performing a definite function.

Note 2 to entry: Elements of a system can be natural or man-made material objects, as well as modes of thinking and the results thereof (e.g. forms of organization, mathematical methods, programming languages).

Note 3 to entry: The system is considered to be separated from the environment and the other external systems by an imaginary surface, which cuts the links between them and the system.

Note 4 to entry: The term "system" should be qualified when it is not clear from the context to what it refers, e.g. control system, colorimetric system, system of units, transmission system.

[SOURCE: IEC 60050-151:2001, 151-11-27]

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3.1.29
waveguide below cut-off
evanescent waveguide (deprecated)
cut-off waveguide (deprecated)
waveguide used below the waveguide cut-off frequency

[SOURCE: IEC 60050-726:1982, 726-03-19]

3.2 Abbreviated terms

CCTV	closed circuit television
DM-DM	differential-mode-to-differential-mode
EMC	electromagnetic compatibility
EMI	electromagnetic interference
ESM	Electronic surveillance measures
HEMP	high-altitude electromagnetic pulse
HPEM	high-power electromagnetic
HVAC	heating ventilation and air conditioning
ICT	information communications technology
IEMI	intentional electromagnetic interference
PoE	port of entry
SPD	surge-protective device
UPS	uninterruptible power supply

4 Overview and general considerations

4.1 Overview

This part of IEC 61000 covers guidelines for the mitigation of external electromagnetic influences impinging upon a facility, aimed at ensuring electromagnetic compatibility (EMC) among electrical and electronic apparatus or systems. These influences include lightning, RF transmitters, power-line and telecom transients, high-altitude electromagnetic pulse (HEMP) and other high-power electromagnetic transients such as those from intentional electromagnetic interference (IEMI). More particularly, this document is concerned with a protection-led approach which includes concepts such as the arrangement of shielding and screening against radiated disturbances, and with mitigation of conducted disturbances. These arrangements include appropriate electromagnetic barriers for industrial, commercial, and residential installations. Mitigation shall be required if EMC between an apparatus and its intended operating environment is not achieved or is not likely to be achievable.

The concept of barriers installed for mitigating potentially penetrating and unwanted electromagnetic noise is applicable even when there is no designed-in electromagnetic shield. The enclosure through which power and signal (communications, control, etc.) cables can enter or exit, can be considered as a potential electromagnetic barrier that will provide some level of protection. The concept of enclosures can be understood as the perimeter walls of a building, the walls of a single room, or the housing of an apparatus, with protection installed at all points of electromagnetic penetration into the enclosure.

Where human functional safety risks (as defined in IEC 61508-1) have to be reduced to acceptable levels, it is probable that the EMI protections and mitigations described in this document will not be sufficient, and that the electromagnetic resilience approach described in IEEE Std 1848™-2020 will also be necessary.

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This document includes an informative annex (Annex A) describing the concept of a resilience-based approach for the mitigation of external high power electromagnetic environments.

4.2 General considerations

4.2.1 Elementary interference control

In its simplest form, the interference problem consists of a source of disturbance, a victim and the medium between the two. Interference control consists in suppressing the disturbance source, strengthening the victim, or impeding the source-victim interaction through the medium. When the source is not controllable (for example, lightning, portable transmitters, HEMP, etc.), and the inherent strength of the victim is dictated by other considerations (for example, circuit density and operating power), interference control is relegated to the intervening medium. Furthermore, for interference control oriented toward victim protection, control measures tend to be applied fairly close to the susceptible circuits (at the apparatus, system or subsystem levels).

Increasing the separation between them, enclosing one or the other in a shield or orientating them in the direction that reduces cross-coupling (for example, rejecting common-mode interference on differential-mode signalling lines) can reduce the interaction between source and victim. All three techniques can be combined to form a closed electromagnetic barrier between the source and the victim. For sources outside the system, the barrier can be applied at the system level. Where the system is considered to be the whole installation or facility, then the barrier can be a whole room or even the whole building. For sources inside the system, electromagnetic compatibility requires two barriers: one at the source to control emissions, and one at the victim to control susceptibility. This concept is illustrated in Figure 1. In this document, there will be a focus on sources outside the system.

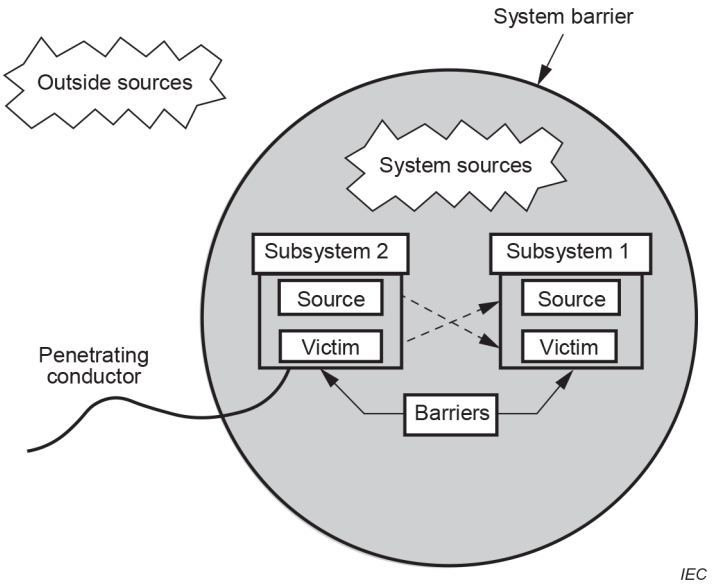

Figure 1 – System barrier topology

4.2.2 Shields and interfaces

Shields are used for attenuating the direct coupling of radiated electromagnetic disturbances from the external environment onto the internal electronics circuits and, conversely, to limit the radiation of disturbances from the internal circuits to the exterior, thus contributing to the electromagnetic compatibility (EMC) of the installation. The shields considered in this document are electromagnetically closed structures. Any form of electromagnetically open structure is not recommended for achieving a fully compliant installation. Some examples of structural shielding applications include:

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- telecom facilities, such as relay stations, multipurpose radio installations;
- datacentres;
- electrical sub-station control rooms and control houses;
- TV and broadcasting studios;
- test rooms and laboratories (telecom, metrology, high-voltage engineering);
- metrology facilities in educational institutions;
- diagnostic and therapy rooms in medical facilities;
- computer rooms for business and industry.

Interface protection devices are used for mitigating the propagation of conducted electromagnetic disturbances from the external environment into the internal electronics and can, conversely, limit the emission of disturbances from the internal electronics into the external environment. This assumes that bi-directional protection devices are applied. Thus, when installed in conjunction with a shield, these devices contribute to achieving electromagnetic compatibility for the installation. Protection devices that will be discussed in this document include filters, decoupling devices and surge-protective devices (SPDs).

The filters considered in this document are limited to low-voltage passive circuits for high-frequency disturbances that are part of an installation. Filters and other interface devices incorporated in individual apparatus are not included within the scope of this document. Low-frequency filters, such as those used to mitigate power-line harmonics, are also not included in the scope of this document.

A complete installation can include the interconnection of several properly shielded cabinets with screened cables. However, the selection of such cables and proper bonding of the cable screens is not within the scope of this document but is addressed in IEC TR 61000-5-2.

The installation of filters and other mitigation means, including shields, is predicated on the existence of a properly designed earthing system, as described in IEC TR 61000-5-2.

The recommendations and requirements presented in this document address the EMC concerns of the installation. The safety aspects of any installation are of prime importance but while not ignored, are not within the scope of this document. Reference to safety issues can be found in IEC 61508-1 and the IEC 60364 series. The efficient transportation of power within the installation is a prime function of any facility but is also excluded from the scope of this document. Nevertheless, these two issues are taken into consideration in the recommendations concerning EMC. These two issues can be implemented concurrently for enhanced EMC of the installed sensitive apparatus or systems without conflict by applying the recommended practices and requirements presented in this document and the relevant safety requirements such as those of IEC 61508-1 and the IEC 60364 series. As each installation is unique, it is the responsibility of the designer and the installer to select and abide by the relevant recommendations most appropriate to a particular installation. It is important to note that the recommendations and requirements presented in this document do not seek to preclude existing installation practices, when they have been shown to perform satisfactorily. Special mitigation methods might not be necessary when the installed equipment satisfies applicable emission and immunity standards.

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5 Mitigation of radiated and conducted disturbances

5.1 Topological concepts

As a practical matter, the apparatus, sub-system or system inside the facility to be protected is required to communicate with the outside world via conductive and non-conductive (radiating) paths that penetrate the enclosure's electromagnetic shield and thus introduce imperfections (openings) in the shield. In addition, other penetrations can be introduced for entry and egress as well as for providing internally a controlled environment for system operators as well as for the internal equipment, such as electronics, water, air, sewers, etc. Therefore, a conceptually simple problem can become quite complex electromagnetically. The concept of topological control has been introduced to account for a system's inherent electromagnetic complexity. Such a concept can be applied to simplify both the system's electromagnetic coupling problem and to develop and implement electromagnetic interference control.

In Figure 2 a generalized, but simple, system topology enclosed in a volume surrounded by the outer surface is shown. The outer surface can be fabricated from common materials (concrete, brick, steel reinforcing bars, metal, etc.) and is penetrated by conductive and non-conductive penetrations such as doors, windows, seams, electrical lines, plumbing, etc. The electronic equipment can be located in different compartments or rooms. This equipment is usually interconnected by wiring harnesses or cables. Environmental control equipment and ducts can also interconnect the equipment rooms. These conductors provide paths for electromagnetic energy to either exit or enter the enclosure.

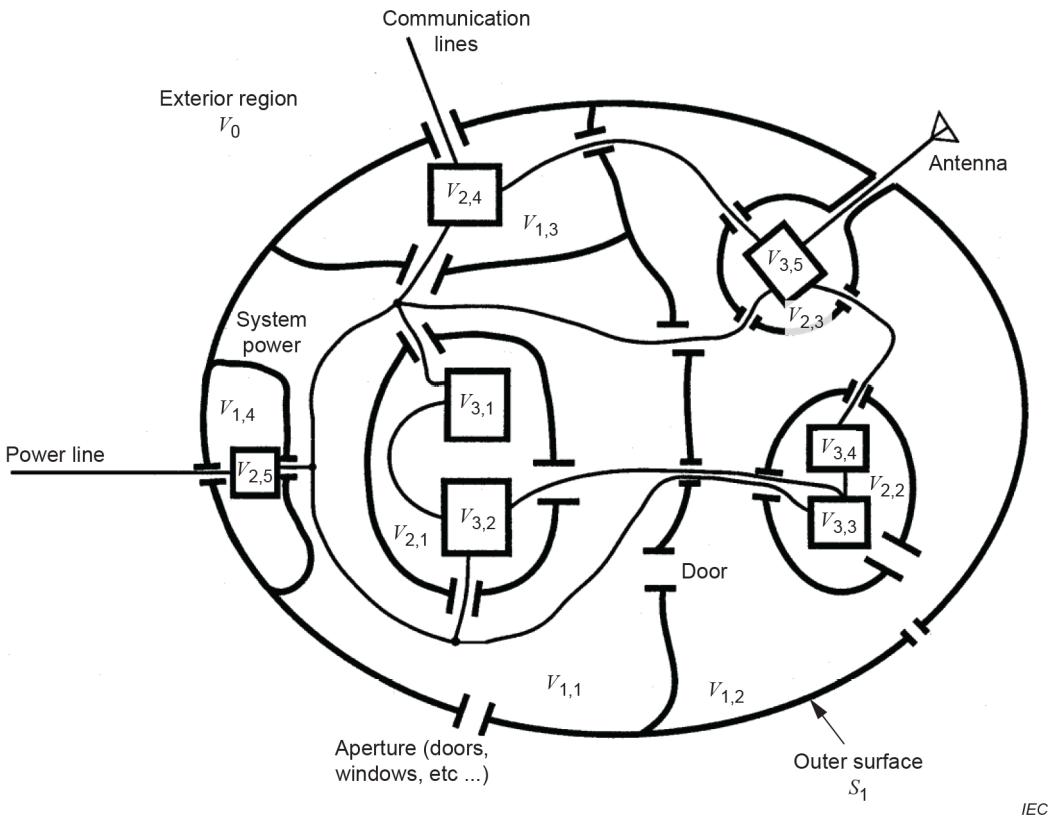

Figure 2 – Generalized system topology

All electrical devices, systems and installations produce or utilize at various frequencies energy which propagates through conductors connected to the apparatus. This energy can interfere with other equipment. Screening can be necessary either to protect a facility from an external electromagnetic environment, or to prevent the radiation of electromagnetic disturbances created by the internal equipment operation.

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A formal topological approach can be used

a) to describe the system, and

b) to design a consistent approach to protect the equipment.

A formal approach for decomposing a system into its smaller, more tractable, parts is possible. Following the notation provided in Figure 2 the generalized system is subdivided into volumes and surfaces. The exterior region or volume is identified as V_0; interior volumes or layers are identified as $V_{j,k}$, where the first subscript indicates the surface traversed (outside to inside) and the second subscript indicates the volume within that (j^{th}) surface. The topological approach aids in identifying the various surfaces and volumes in a particular system and is very useful in describing and accounting for system electromagnetic shields. The notation can be used for further analysis. For example, in Figure 2, the surface of volume 2 can have different characteristics in the boundaries to volume 1 and volume 3. This approach also aids in accounting for the assessment of every penetration in all surfaces.

5.2 Mitigation needs

Mitigation is required if EMC between an apparatus and its intended operating environment is not achieved or is not likely to be achievable. However, if EMC has been achieved then no further mitigation is required. Mitigation can be achieved by using several different approaches described in this document as well as others, including through the use of a barrier between the source and the victim. For conducted disturbances this barrier is typically a combination of SPDs and filters or other decoupling devices, and for radiated disturbances it can be a screen and perhaps a filter as necessary, the attenuation of which is compatible with that of the screen in the frequency range considered.

The attenuation provided by a barrier shall be compatible with the need, that is, be at least equal to the difference between the disturbance level and the immunity level of the apparatus to that disturbance. For verification purposes, in most of the cases, disturbances are simulated and the immunity of an apparatus is compared against a standard. Thus, the barrier performance required shall correspond 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 uncertainties on disturbance level(s) and immunity level(s), a margin shall be considered as well, and added to the basic barrier performance required. This margin generally depends on the criticality of the equipment. For most low-risk domestic or industrial applications of equipment satisfying applicable EMC requirements, it is not necessary to have additional mitigation.

Where it is necessary to reduce human functional safety risks (as defined in IEC 61508-1) to acceptable levels, it is probable that the EMI protections and mitigations described in this document will not be sufficient, and that the electromagnetic resilience approach described in IEEE Std 1848-2020 will also be necessary.

5.3 The general concept of enclosure

As discussed in IEC TR 61000-5-1, it is useful to extend the concept of enclosure as being the boundary of a facility. An enclosure can be envisaged as a complete building, a room, a rack, a single cabinet and even, by extension of the concept, as an individual apparatus or a circuit board within an apparatus. This facility interfaces with its environment by "ports-of-entry" as shown in Figure 3. IEC TR 61000-5-1 provides further discussion of the concept of ports.

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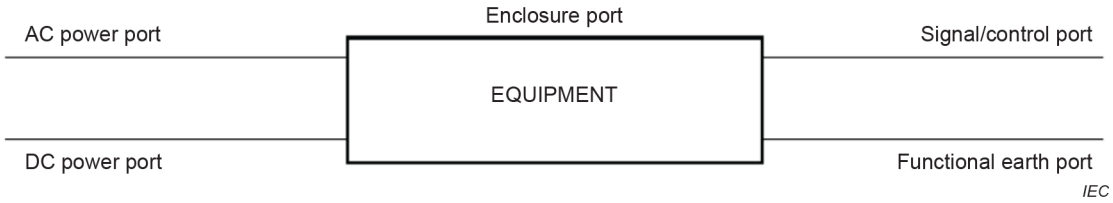

Figure 3 – Ports of an apparatus or facility

The scope of this document is restricted to the practices involved in the implementation of the electrical installation in a facility. These activities involve the selection of functional elements of the system and the relevant interconnections. This shall also include the interconnection to external sensors, actuators, telecommunication networks and the power supply.

5.4 Interactions at the enclosure boundary

Interactions at the enclosure boundary involve two directions of propagation:

- disturbances originating in the external environment that can enter the enclosure;
- disturbances generated within the enclosure that can exit the enclosure;

This document presents the fundamental concepts for installation practices that limit radiated disturbances by shielding and screening and limiting the propagation of conducted disturbances across the enclosure boundaries through the use of filters, decoupling devices, and overvoltage protective devices.

6 Shielding

6.1 General

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. A topological concept is shown in Figure 4.

IEC TR 61000-2-5 can be used as a guide for EMC limits within each zone, and IEC 61000-2-11 and IEC TR 61000-5-3 together can be used as a guide to develop HEMP limits within each zone. Low-frequency electric fields are relatively easy to mitigate. Low-frequency magnetic fields are more difficult to screen and will involve a shield with a large wall thickness or a high permeability, or both. IEC 61000-5-7 can be used to qualify the protection levels for equipment enclosures once the level of desired protection is identified.

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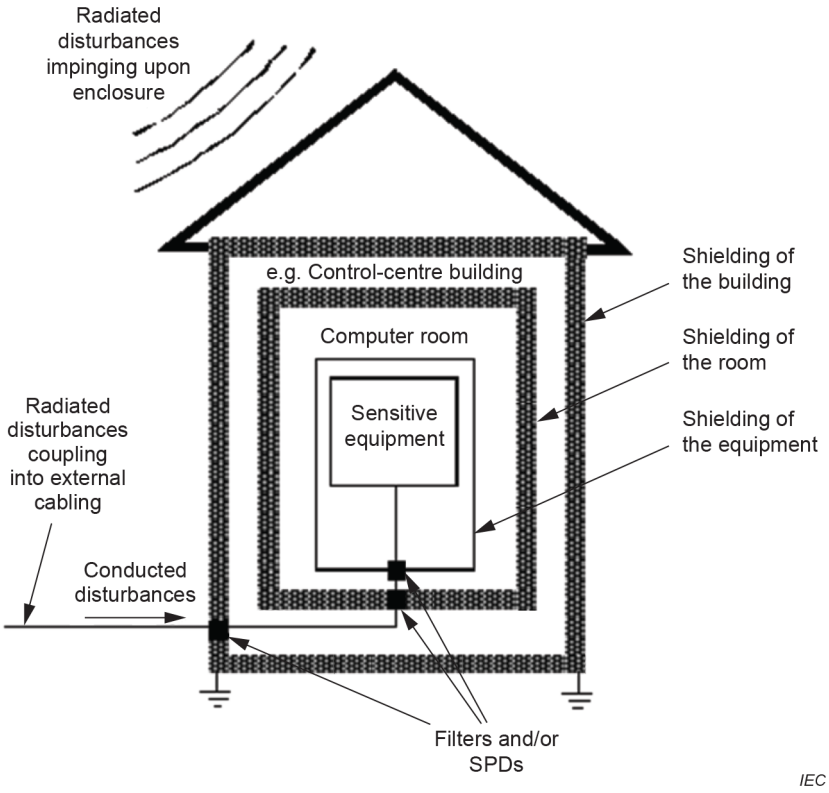

Figure 4 – Topological concept of shields with interfaces at penetration points

Screening of rooms and cabinets with appropriate penetration protection is only one of several actions that can be used to limit the effect 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 can involve other actions such as:

a) selecting correct cabling and wiring (adding a screen jacket over cables or wires, selecting and correctly terminating shielded cable);

b) applying good cable layout and cable management;

c) implementing good earthing and bonding practices;

d) using devices limiting transient disturbances or increasing equipment immunity.

IEC TR 61000-5-1 and IEC TR 61000-5-2 can be referred to for additional guidelines concerning these actions.

The objective of Clause 6 is to present the main arrangements used in mitigation methods involving shielding of installations, such as:

- introduction of the concept of mitigation zones and review of the corresponding types of shielded enclosures;
- guidance on preservation of shielding effectiveness for housings with apertures based on a set of generic EMC rules;
- generic information on the implementation of screening, progressing from the sensitive apparatus to the complete building, as well as on the means of dealing with the unavoidable apertures or penetrations.

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6.2 Classification of protection zones

6.2.1 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 this document, the particular zones are defined as follows:

- zone 0 – no protection
- zone 1 – buildings protected by reinforced concrete outdoor walls
- zone 2 – rooms shielded by special materials
- zone 3 – internal equipment shielded by metallic materials or metallized enclosures
- zone 4 – sensitive apparatus enclosed within a special shielded rack

Figure 5 shows a schematic representation of the hierarchy of the classification for protection of zones 0 through 4. Note that it is possible that not all barriers are present in a given installation. Zones can be selected in a more arbitrary manner.

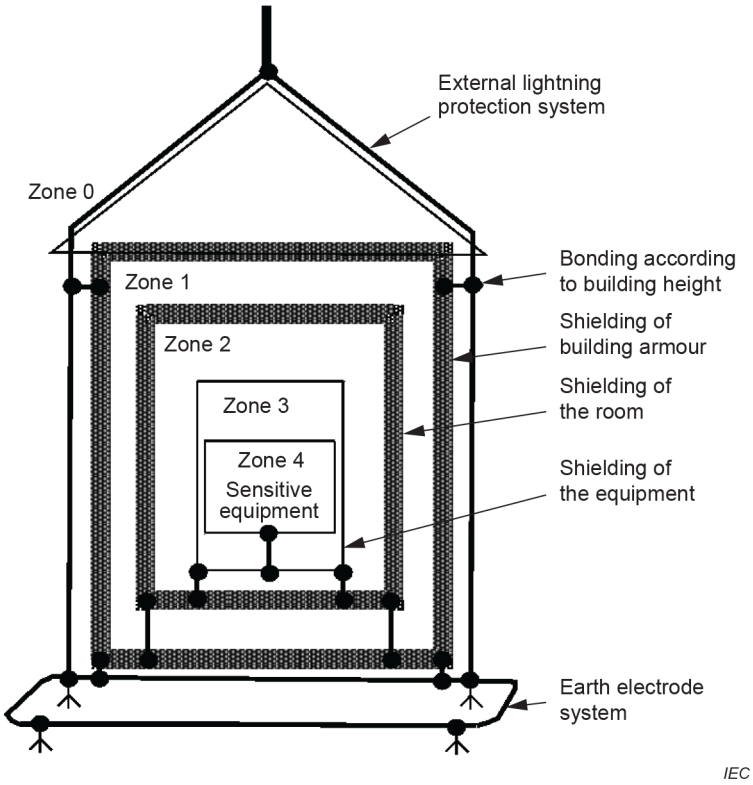

Figure 5 – Zones of protection of shielding and earthing systems

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6.2.2 Zone 1 – Building shield

Zone 1 applies to buildings containing welded iron reinforcing bars for concrete outdoor walls. The reinforcement bars should be interconnected preferentially by as many welds as feasible. Thus, the reinforcement forms a good earthing structure. Note that it is possible that steel reinforcing bars are not always interconnected so that a good electrical bond is made. In such situations it is possible that the steel reinforcing bars do not represent an adequate shield. An important first measure is a well-designed and implemented lightning conductor with conductive connections to the earth. Unshielded or non-screened cables and other conductive penetrations shall be protected with appropriate mitigations such as limiting (surge-protective device) and filtering. Shielded or screened cables entering this zone shall have a 360° circumferential, galvanically bonded connection to a metal plate, which in turn is galvanically bonded to the conductors in the walls.

6.2.3 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 screens of cables entering this zone shall have a 360° circumferential, galvanically bonded connection to the metal walls. The penetrating cables shall also be protected against overvoltages with appropriate mitigations such as limiting (surge-protective device) and filtering.

6.2.4 Zone 3 – Equipment shield

Zone 3 applies where individual apparatus is protected by metal cabinets or metallized enclosures. The earth connection shall be a low impedance connection to the earthing arrangement. Conductive penetrations shall be protected with appropriate mitigations such as limiting (surge-protective device) and filtering.

6.2.5 Zone 4 – Apparatus shield

Zone 4 applies at the individual apparatus level; it is not within the scope of this document, but is the responsibility of the apparatus manufacturer. This zone can also include highly sensitive equipment that can require additional protection.

6.3 Design principles for screening

6.3.1 General

The design principles presented in 6.3 are not intended to serve as comprehensive guidelines 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 screening 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 disturbance spectrum of electromagnetic fields. Screening 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 screen;
- metallic or metalled fabric;
- metallic foil;
- metal sheets (copper or aluminium or other good conductive metals);
- metallized plastics with undamaged surfaces and a good contact across all seams;

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