

BS EN 62305-4:2011

Incorporating corrigendum November 2016



BSI Standards Publication

Protection against lightning

Part 4: Electrical and electronic systems
within structures (IEC 62305-4:2010)

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National foreword

This British Standard is the UK implementation of EN 62305-4:2011, incorporating corrigendum November 2016. It is identical to IEC 62305-4:2010. It supersedes BS EN 62305-4:2006, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/81, Protection against lightning.

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

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Date	Text affected
31 December 2016	Implementation of CENELEC corrigendum November 2016: Title on CENELEC cover page corrected and Annex ZA updated

English version

**Protection against lightning -
Part 4: Electrical and electronic systems within structures
(IEC 62305-4:2010)**

Protection contre la foudre -
Partie 4: Réseaux de puissance et de
communication dans les structures
(CEI 62305-4:2010)

Blitzschutz - Teil 4: Elektrische und
elektronische Systeme in baulichen
Anlagen
(IEC 62305-4:2010)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Foreword

The text of document 81/373/FDIS, future edition 2 of IEC 62305-4, prepared by IEC TC 81, Lightning protection, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 62305-4 on 2011-01-13.

This European Standard supersedes EN 62305-4:2006 + corr. Nov.2006.

This EN 62305-4:2011 includes the following significant technical changes with respect to EN 62305-4:2006 + corr. Nov.2006:

- 1) Isolating interfaces capable of reducing conducted surges on lines entering the structure are introduced.
- 2) Minimum cross-sections for bonding components are slightly modified.
- 3) First negative impulse current is introduced for calculation purposes as electromagnetic source of harm to the internal systems.
- 4) Selection of SPD with regard to voltage protection level is improved to take into account oscillation and induction phenomena in the circuit downstream of SPD.
- 5) Annex C dealing with SPD coordination is withdrawn and referred back to SC 37A.
- 6) A new informative Annex D is introduced giving information on factors to be considered in the selection of SPDs.

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

The following dates were fixed:

- | | | |
|--|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2011-10-13 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2014-01-13 |

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62305-4:2010 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:

- | | | |
|----------------------|------|---|
| [2] IEC 61000 series | NOTE | Harmonized in EN 61000 series (partially modified). |
| [8] IEC 61643-11 | NOTE | Harmonized as EN 61643-11. |
-

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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

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

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60364-5-53	2001	Electrical installations of buildings - Part 5-53: Selection and erection of electrical equipment - Isolation, switching and control	-	-
IEC 60664-1	2007	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests	EN 60664-1	2007
IEC 61000-4-5	2005	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test	EN 61000-4-5	2006
IEC 61000-4-9	1993	Electromagnetic compatibility (EMC) - Part 4-9: Testing and measurement techniques - Pulse magnetic field immunity test	EN 61000-4-9	1993
IEC 61000-4-10	1993	Electromagnetic compatibility (EMC) - Part 4-10: Testing and measurement techniques - Damped oscillatory magnetic field immunity test	EN 61000-4-10	1993
IEC 61643-1	2005	Low-voltage surge protective devices - Part 1: Surge protective devices connected to low-voltage power distribution systems - Requirements and tests	EN 61643-11:2002 +A11:2007	-
IEC 61643-12 (mod)	2008	Low-voltage surge protective devices - Part 12: Surge protective devices connected to low-voltage power distribution systems - Selection and application principles	CLC/TS 61643-12	2009
IEC 61643-21	-	Low voltage surge protective devices - Part 21: Surge protective devices connected to telecommunications and signalling networks - Performance requirements and testing methods	EN 61643-21	-
IEC 61643-22 (mod)	-	Low-voltage surge protective devices - Part 22: Surge protective devices connected to telecommunications and signalling networks - Selection and application principles	CLC/TS 61643-22	-
IEC 62305-1	2010	Protection against lightning - Part 1: General principles	EN 62305-1	2011
IEC 62305-2	2010	Protection against lightning - Part 2: Risk management	EN 62305-2	2011

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 62305-3	2010	Protection against lightning - Part 3: Physical damage to structures and life hazard	EN 62305-3	2011

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PROTECTION AGAINST LIGHTNING –

Part 4: Electrical and electronic systems within structures

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 62305-4 has been prepared by IEC technical committee 81: Lightning protection.

This second edition cancels and replaces the first edition, published in 2006, and constitutes a technical revision.

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

- 1) Isolating interfaces capable of reducing conducted surges on lines entering the structure are introduced.
- 2) Minimum cross-sections for bonding components are slightly modified.
- 3) First negative impulse current is introduced for calculation purposes as electromagnetic source of harm to the internal systems.
- 4) Selection of SPD with regard to voltage protection level is improved to take into account oscillation and induction phenomena in the circuit downstream of SPD.
- 5) Annex C dealing with SPD coordination is withdrawn and referred back to SC 37A.

- 6) A new informative Annex D is introduced giving information on factors to be considered in the selection of SPDs.

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

FDIS	Report on voting
81/373/FDIS	81/383/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, as closely as possible, in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 62305 series, under the general title *Protection against lightning*, 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.

A bilingual version of this standard may be issued at a later date.

INTRODUCTION

Lightning as a source of harm is a very high energy phenomenon. Lightning flashes release many hundreds of mega-joules of energy. When compared with the milli-joules of energy that may be sufficient to cause damage to sensitive electronic equipment in electrical and electronic systems within a structure, it is clear that additional protection measures will be necessary to protect some of this equipment.

The need for this International Standard has arisen due to the increasing cost of failures of electrical and electronic systems, caused by electromagnetic effects of lightning. Of particular importance are electronic systems used in data processing and storage as well as process control and safety for plants of considerable capital cost, size and complexity (for which plant outages are very undesirable for cost and safety reasons).

Lightning can cause different types of damage in a structure, as defined in IEC 62305-1:

- D1 injury to living beings by electric shock;
- D2 physical damage (fire, explosion, mechanical destruction, chemical release) due to lightning current effects, including sparking;
- D3 failure of internal systems due to LEMP.

IEC 62305-3 deals with the protection measures to reduce the risk of physical damage and life hazard, but does not cover the protection of electrical and electronic systems.

This Part 4 of IEC 62305 therefore provides information on protection measures to reduce the risk of permanent failures of electrical and electronic systems within structures.

Permanent failure of electrical and electronic systems can be caused by the lightning electromagnetic impulse (LEMP) via:

- a) conducted and induced surges transmitted to equipment via connecting wiring;
- b) the effects of radiated electromagnetic fields directly into equipment itself.

Surges to the structure can originate from sources external to the structure or from within the structure itself:

- surges which originate externally from the structure are created by lightning flashes striking incoming lines or the nearby ground, and are transmitted to electrical and electronic systems within the structure via these lines;
- surges which originate internally within the structure are created by lightning flashes striking the structure itself or the nearby ground.

NOTE 1 Surges can also originate internally within the structure, from switching effects, e.g. switching of inductive loads.

The coupling can arise from different mechanisms:

- resistive coupling (e.g. the earth impedance of the earth-termination system or the cable shield resistance);
- magnetic field coupling (e.g. caused by wiring loops in the electrical and electronic system or by inductance of bonding conductors);
- electric field coupling (e.g. caused by rod antenna reception).

NOTE 2 The effects of electric field coupling are generally very small when compared to the magnetic field coupling and can be disregarded.

Radiated electromagnetic fields can be generated via

- the direct lightning current flowing in the lightning channel,
- the partial lightning current flowing in conductors (e.g. in the down-conductors of an external LPS in accordance with IEC 62305-3 or in an external spatial shield in accordance with this standard).

PROTECTION AGAINST LIGHTNING –

Part 4: Electrical and electronic systems within structures

1 Scope

This part of IEC 62305 provides information for the design, installation, inspection, maintenance and testing of electrical and electronic system protection (SPM) to reduce the risk of permanent failures due to lightning electromagnetic impulse (LEMP) within a structure.

This standard does not cover protection against electromagnetic interference due to lightning, which may cause malfunctioning of internal systems. However, the information reported in Annex A can also be used to evaluate such disturbances. Protection measures against electromagnetic interference are covered in IEC 60364-4-44 ^[1] 1 and in the IEC 61000 series ^[2].

This standard provides guidelines for cooperation between the designer of the electrical and electronic system, and the designer of the protection measures, in an attempt to achieve optimum protection effectiveness.

This standard does not deal with detailed design of the electrical and electronic systems themselves.

2 Normative references

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

IEC 60364-5-53:2001, *Electrical installations of buildings – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-9:1993, *Electromagnetic compatibility (EMC) – Part 4-9: Testing and measurement techniques – Pulse magnetic field immunity test – Basic EMC Publication*

IEC 61000-4-10:1993, *Electromagnetic compatibility (EMC) – Part 4-10: Testing and measurement techniques – Damped oscillatory magnetic field immunity test – Basic EMC Publication*

IEC 61643-1:2005, *Low-voltage surge protective devices – Part 1: Surge protective devices connected to low-voltage power distribution systems – Requirements and tests*

IEC 61643-12:2008, *Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles*

¹ Figures in square brackets refer to the bibliography.

IEC 61643-21, *Low voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signalling networks – Performance requirements and testing methods*

IEC 61643-22, *Low voltage surge protective devices – Part 22: Surge protective devices connected to telecommunications and signalling networks – Selection and application principles*

IEC 62305-1:2010, *Protection against lightning – Part 1: General principles*

IEC 62305-2:2010, *Protection against lightning – Part 2: Risk management*

IEC 62305-3:2010, *Protection against lightning – Part 3: Physical damage to structures and life hazard*

3 Terms and definitions

For the purposes of this document, the following terms and definitions, as well as those given in other parts of IEC 62305, apply.

3.1

electrical system

system incorporating low voltage power supply components

3.2

electronic system

system incorporating sensitive electronic components such as telecommunication equipment, computer, control and instrumentation systems, radio systems, power electronic installations

3.3

internal systems

electrical and electronic systems within a structure

3.4

lightning protection

LP

complete system for the protection of structures and/or electrical and electronic systems in those structures from the effects of lightning, consisting of an LPS and SPM

3.5

lightning protection system

LPS

complete system used to reduce physical damage due to lightning flashes to a structure

NOTE It consists of both external and internal lightning protection systems.

3.6

lightning electromagnetic impulse

LEMP

all electromagnetic effects of lightning current via resistive, inductive and capacitive coupling which create surges and electromagnetic fields

3.7

surge

transient created by LEMP that appears as an overvoltage and/or overcurrent

3.8

rated impulse withstand voltage level

U_w

impulse withstand voltage assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against overvoltages

NOTE For the purposes of this part of IEC 62305, only withstand voltage between live conductors and earth is considered.

3.9

lightning protection level

LPL

number related to a set of lightning current parameters relevant to the probability that the associated maximum and minimum design values will not be exceeded in naturally occurring lightning

NOTE Lightning protection level is used to design protection measures according to the relevant set of lightning current parameters.

3.10

lightning protection zone

LPZ

zone where the lightning electromagnetic environment is defined

NOTE The zone boundaries of an LPZ are not necessarily physical boundaries (e.g. walls, floor and ceiling).

3.11

LEMP protection measures

SPM

measures taken to protect internal systems against the effects of LEMP

NOTE This is part of overall lightning protection.

3.12

grid-like spatial shield

magnetic shield characterized by openings

NOTE For a building or a room, it is preferably built by interconnected natural metal components of the structure (e.g. rods of reinforcement in concrete, metal frames and metal supports).

3.13

earth-termination system

part of an external LPS which is intended to conduct and disperse lightning current into the earth

3.14

bonding network

interconnecting network of all conductive parts of the structure and of internal systems (live conductors excluded) to the earth-termination system

3.15

earthing system

complete system combining the earth-termination system and the bonding network

3.16

surge protective device

SPD

device intended to limit transient overvoltages and divert surge currents; contains at least one non-linear component

3.17

SPD tested with I_{imp}

SPDs which withstand the partial lightning current with a typical waveform 10/350 μ s and require a corresponding impulse test current I_{imp}

NOTE For power lines, a suitable test current I_{imp} is defined in the Class I test procedure of IEC 61643-1:2005.

3.18

SPD tested with I_n

SPDs which withstand induced surge currents with a typical waveform 8/20 μ s and require a corresponding impulse test current I_n

NOTE For power lines a suitable test current I_n is defined in the Class II test procedure of IEC 61643-1:2005.

3.19

SPD tested with a combination wave

SPDs that withstand induced surge currents with a typical waveform 8/20 μ s and require a corresponding impulse test current I_{SC}

NOTE For power lines a suitable combination wave test is defined in the Class III test procedure of IEC 61643-1:2005 defining the open circuit voltage U_{OC} 1,2/50 μ s and the short-circuit current I_{SC} 8/20 μ s of a 2 Ω combination wave generator.

3.20

voltage-switching type SPD

SPD that has a high impedance when no surge is present, but can have a sudden change in impedance to a low value in response to a voltage surge

NOTE 1 Common examples of components used as voltage switching devices include spark gaps, gas discharge tubes (GDT), thyristors (silicon controlled rectifiers) and triacs. These SPDs are sometimes called "crowbar type".

NOTE 2 A voltage-switching device has a discontinuous voltage/current characteristic.

3.21

voltage-limiting type SPD

SPD that has a high impedance when no surge is present, but will reduce it continuously with increased surge current and voltage

NOTE 1 Common examples of components used as non-linear devices are varistors and suppressor diodes. These SPDs are sometimes called "clamping type".

NOTE 2 A voltage-limiting device has a continuous voltage/current characteristic.

3.22

combination type SPD

SPD that incorporates both voltage-switching and voltage-limiting type components and that may exhibit voltage-switching, voltage-limiting or both voltage-switching and voltage-limiting behaviour, depending upon the characteristics of the applied voltage

3.23

coordinated SPD system

SPDs properly selected, coordinated and installed to form a system intended to reduce failures of electrical and electronic systems

3.24

isolating interfaces

devices which are capable of reducing conducted surges on lines entering the LPZ

NOTE 1 These include isolation transformers with earthed screen between windings, metal-free fibre optic cables and opto-isolators.

NOTE 2 Insulation withstand characteristics of these devices are suitable for this application intrinsically to the SPD.

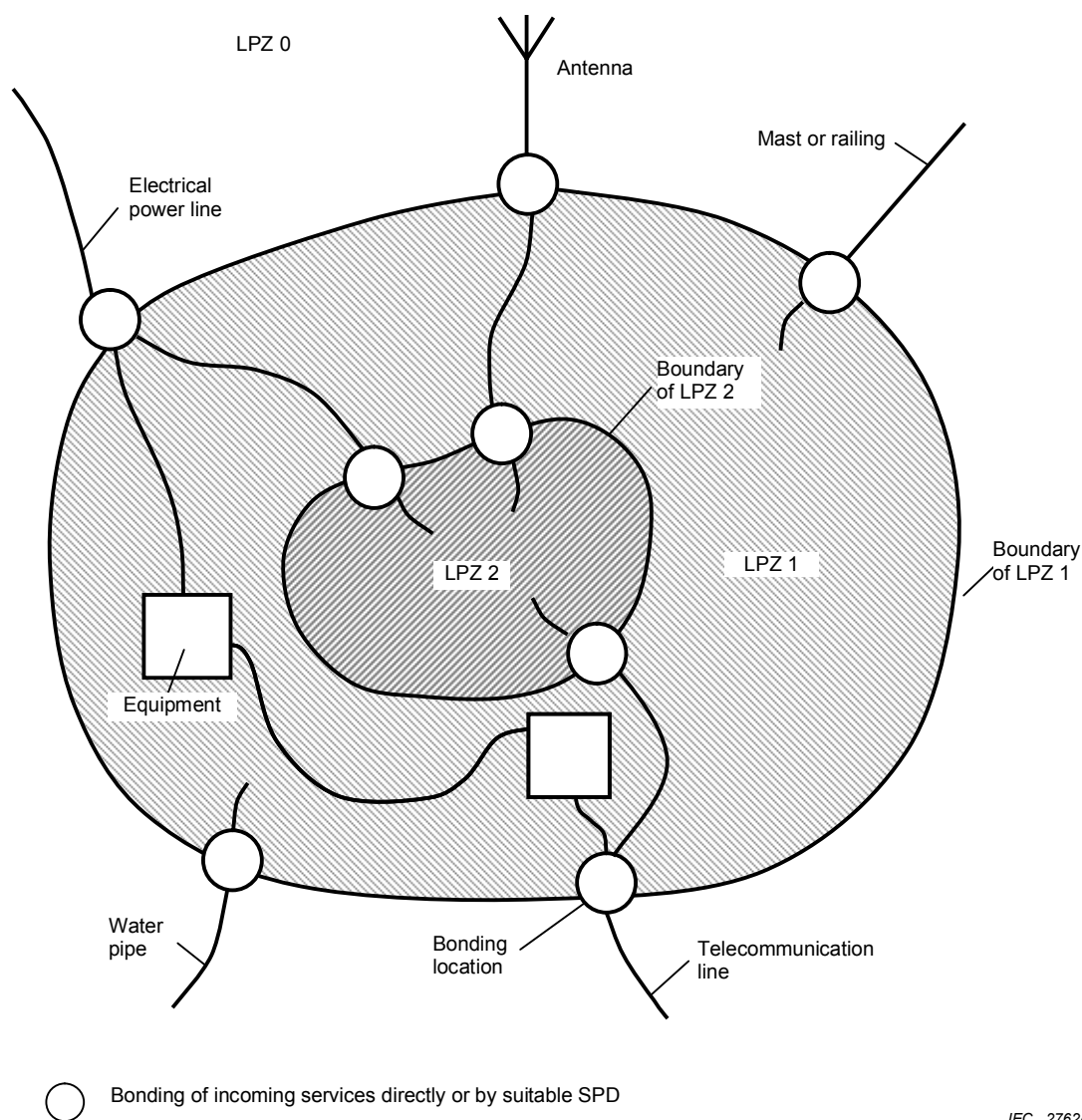
4 Design and installation of SPM

4.1 General

Electrical and electronic systems are subject to damage from a lightning electromagnetic impulse (LEMP). Therefore SPM need to be provided to avoid failure of internal systems.

The design of SPM should be carried out by experts in lightning and surge protection who possess a broad knowledge of EMC and installation practices.

Protection against LEMP is based on the lightning protection zone (LPZ) concept: the zone containing systems to be protected shall be divided into LPZs. These zones are theoretically assigned part of space (or of an internal system) where the LEMP severity is compatible with the withstand level of the internal systems enclosed (see Figure 1). Successive zones are characterized by significant changes in the LEMP severity. The boundary of an LPZ is defined by the protection measures employed (see Figure 2).



NOTE This figure shows an example of dividing a structure into inner LPZs. All metal services entering the structure are bonded via bonding bars at the boundary of LPZ 1. In addition, the conductive services entering LPZ 2 (e.g. computer room) are bonded via bonding bars at the boundary of LPZ 2.

Figure 1 – General principle for the division into different LPZ

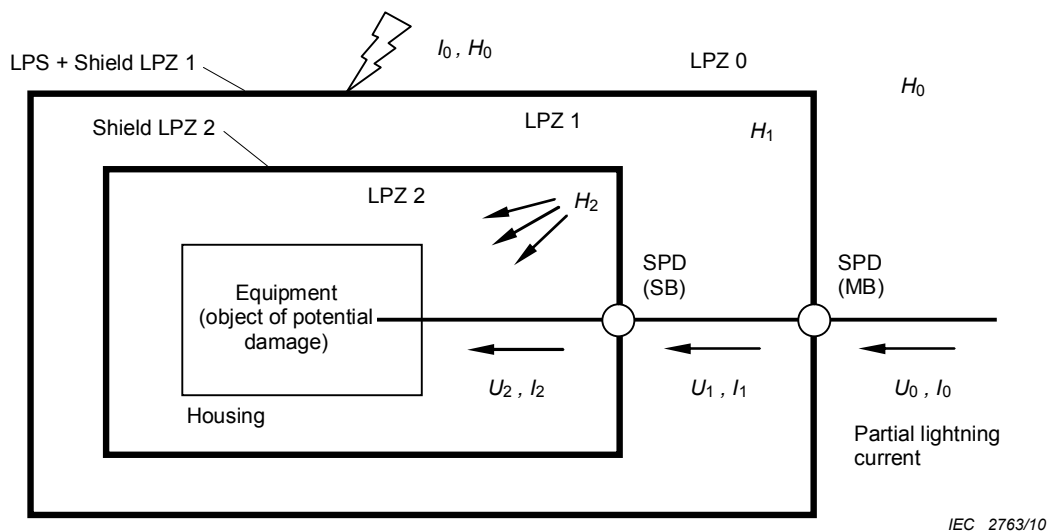


Figure 2a – SPM using spatial shields and a coordinated SPD system – Equipment well protected against conducted surges ($U_2 \ll U_0$ and $I_2 \ll I_0$) and against radiated magnetic fields ($H_2 \ll H_0$)

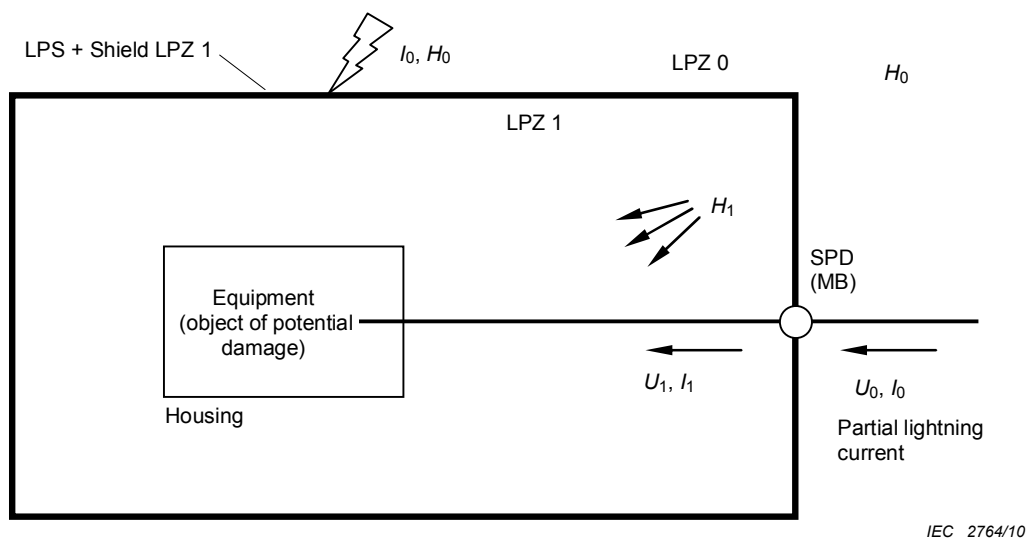


Figure 2b – SPM using spatial shield of LPZ 1 and SPD protection at entry of LPZ 1 – Equipment protected against conducted surges ($U_1 < U_0$ and $I_1 < I_0$) and against radiated magnetic fields ($H_1 < H_0$)

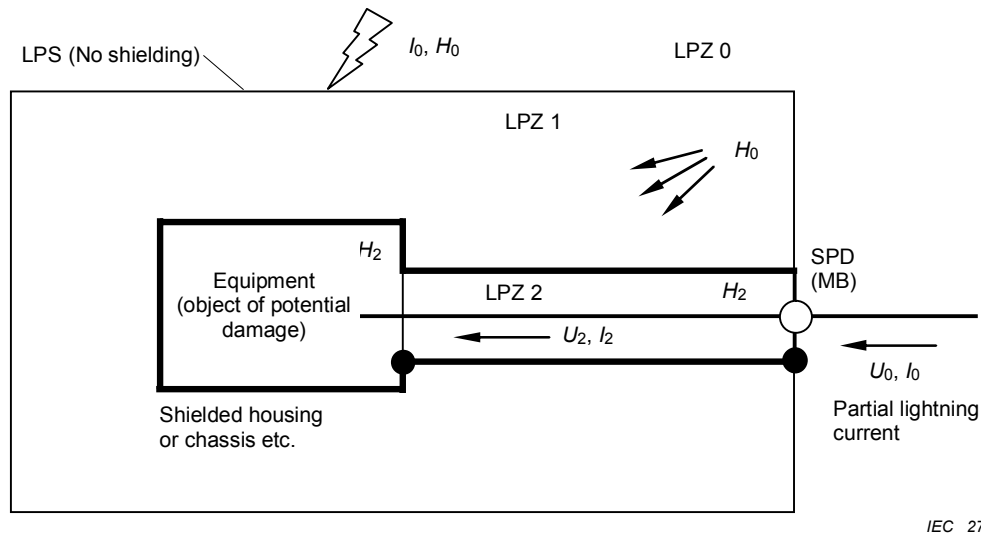


Figure 2c – SPM using internal line shielding and SPD protection at entry of LPZ 1 – Equipment protected against conducted surges ($U_2 < U_0$ and $I_2 < I_0$) and against radiated magnetic fields ($H_2 < H_0$)

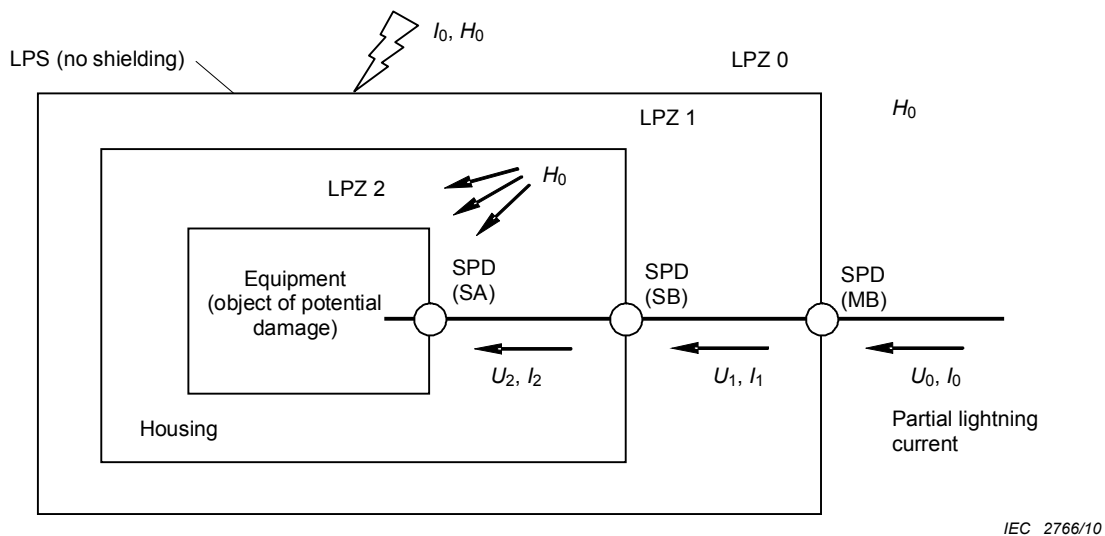


Figure 2d – SPM using a coordinated SPD system only – Equipment protected against conducted surges ($U_2 \ll U_0$ and $I_2 \ll I_0$), but not against radiated magnetic field (H_0)

Key

- shielded boundary
- non-shielded boundary

NOTE 1 SPDs can be located at the following points:

- at the boundary of LPZ 1 (e.g. at main distribution board MB);
- at the boundary of LPZ 2 (e.g. at secondary distribution board SB);
- at or close to equipment (e.g. at socket outlet SA).

NOTE 2 For detailed installation rules see also IEC 60364-5-53.

Figure 2 – Examples of possible SPM (LEMP protection measures)

Permanent failure of electrical and electronic systems due to LEMP can be caused by

- conducted and induced surges transmitted to equipment via connecting wiring,
- effects of radiated electromagnetic fields impinging directly onto equipment itself.

For protection against the effects of radiated electromagnetic fields impinging directly onto the equipment, SPM consisting of spatial shields and/or shielded lines, combined with shielded equipment enclosures, should be used.

For protection against the effects of conducted and induced surges being transmitted to the equipment via connection wiring, SPM consisting of a coordinated SPD system should be used.

Failures due to electromagnetic fields impinging directly onto the equipment can be considered negligible provided the equipment complies with the relevant radio frequency emission and immunity EMC product standards.

In general, equipment is required to comply with the relevant EMC product standards therefore SPM consisting of a coordinated SPD system is usually considered sufficient to protect such equipment against the effects of LEMP.

For equipment not complying with relevant EMC product standards, SPM consisting of a coordinated SPD system alone is considered inadequate to protect such equipment against the effects of LEMP. In this case, Annex A provides further information as to how to achieve best protection against directly impinging electromagnetic fields. The equipment's withstand level against radiated magnetic fields needs to be selected in accordance with IEC 61000-4-9 and IEC 61000-4-10.

If required for specific applications, a simulated system-level test which includes the SPD(s), installation wiring and the actual equipment may be performed in the laboratory to verify protection withstand coordination.

4.2 Design of SPM

SPM can be designed for protection of equipment against surges and electromagnetic fields. Figure 2 provides some examples of SPM using protection measures, such as LPS, magnetic shields and coordinated SPD systems:

- SPM employing spatial shields and a coordinated SPD system will protect against radiated magnetic fields and against conducted surges (see Figure 2a). Cascaded spatial shields and coordinated SPDs can reduce the magnetic field and surges to a lower threat level.
- SPM employing a spatial shield of LPZ 1 and an SPD at the entry of LPZ 1 can protect equipment against the radiated magnetic field and against conducted surges (see Figure 2b).

NOTE 1 The protection would not be sufficient if the magnetic field remains too high (due to low shielding effectiveness of LPZ 1), or if the surge magnitude remains too high (due to a high voltage protection level of the SPD and due to the induction effects onto wiring downstream of the SPD).

- SPM using shielded lines, combined with shielded equipment enclosures, will protect against radiated magnetic fields. The SPD at the entry of LPZ 1 will provide protection against conducted surges (see Figure 2c). To achieve a lower threat level (in one step from LPZ 0 to LPZ 2), a special SPD may be required (e.g. additional coordinated stages inside) to reach a sufficient low voltage protection level.
- SPM using a coordinated SPD system is only suitable to protect equipment which is insensitive to radiated magnetic fields, since the SPDs will only provide protection against conducted surges (see Figure 2d). A lower threat surge level can be achieved using coordinated SPDs.

NOTE 2 Solutions in accordance with Figures 2a to 2c are recommended especially for equipment which does not comply with relevant EMC product standards.

NOTE 3 An LPS in accordance with IEC 62305-3 that employs only equipotential bonding SPDs provides no effective protection against failure of sensitive electrical and electronic systems. The LPS can be improved by reducing the mesh dimensions and selecting suitable SPDs, so as to make it an effective component of the SPM.

4.3 Lightning protection zones (LPZ)

With respect to lightning threat, the following LPZ are defined (see IEC 62305-1):

Outer zones:

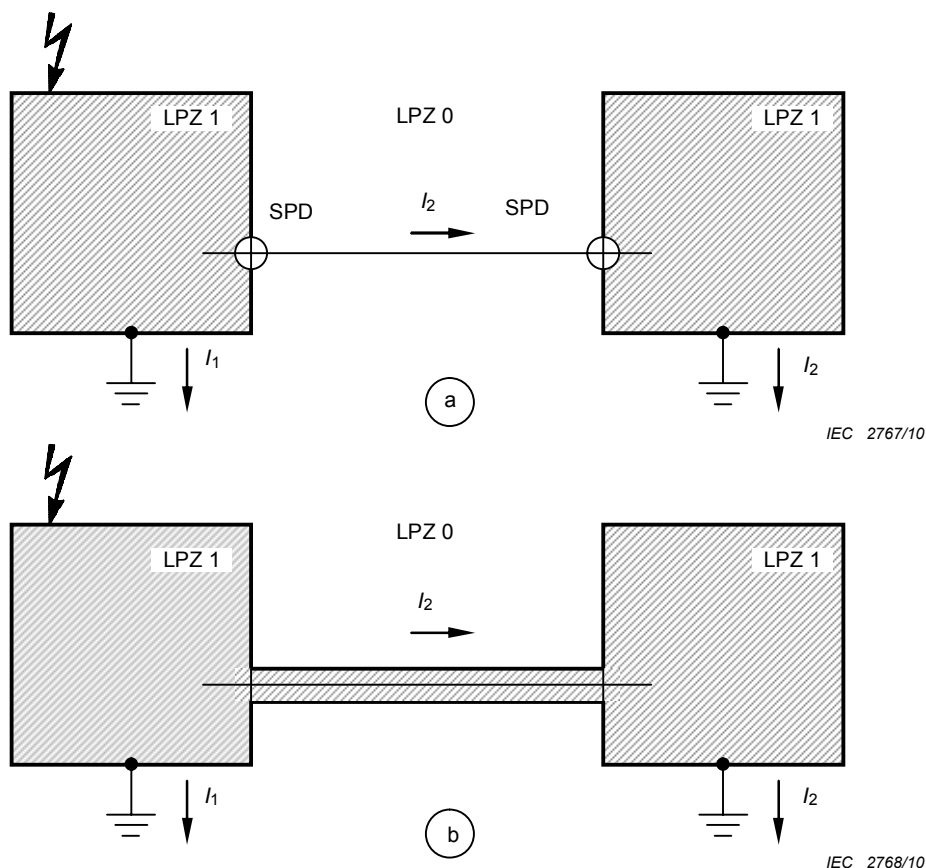
- LPZ 0 Zone where the threat is due to the unattenuated lightning electromagnetic field and where the internal systems may be subjected to full or partial lightning surge current. LPZ 0 is subdivided into:
- LPZ 0_A zone where the threat is due to the direct lightning flash and the full lightning electromagnetic field. The internal systems may be subjected to full lightning surge current.
- LPZ 0_B zone protected against direct lightning flashes but where the threat is the full lightning electromagnetic field. The internal systems may be subjected to partial lightning surge currents.

Inner zones: (protected against direct lightning flashes)

- LPZ 1 Zone where the surge current is limited by current sharing and isolating interfaces and/or by SPDs at the boundary. Spatial shielding may attenuate the lightning electromagnetic field.
- LPZ 2...n Zone where the surge current may be further limited by current sharing and isolating interfaces and/or and by additional SPDs at the boundary. Additional spatial shielding may be used to further attenuate the lightning electromagnetic field.

The LPZs are implemented by the installation of the SPM, e.g. installation of a coordinated SPD system and/or magnetic shielding (see Figure 2). Depending on the number, type and withstand level of the equipment to be protected, suitable LPZ can be defined. These may include small local zones (e.g. equipment enclosures) or large integral zones (e.g. the whole structure) (see Figure B.2).

Interconnection of LPZs of the same order may be necessary if either two separate structures are connected by electrical or signal lines, or the number of required SPDs is to be reduced (see Figure 3).



NOTE Figure 3a shows two LPZ 1 connected by electrical or signal lines. Special care should be taken if both LPZ 1 represent separate structures with separate earthing systems, spaced tens or hundreds of metres from each other. In this case, a large part of the lightning current can flow along the connecting lines, which are not protected.

Key

I_1, I_2 partial lightning currents

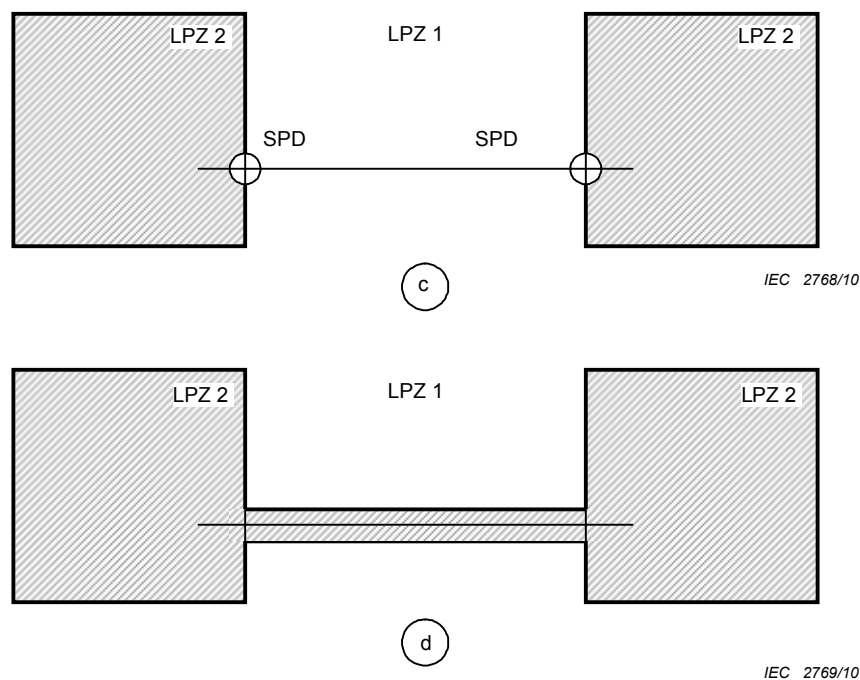
Figure 3a – Interconnecting two LPZ 1 using SPDs

NOTE Figure 3b shows, that this problem can be solved using shielded cables or shielded cable ducts to interconnect both LPZ 1, provided that the shields are able to carry the partial lightning current. The SPD can be omitted, if the voltage drop along the shield is not too high.

Key

I_1, I_2 partial lightning currents

Figure 3b – Interconnecting two LPZ 1 using shielded cables or shielded cable ducts



NOTE Figure 3c shows two LPZ 2 connected by electrical or signal lines. Because the lines are exposed to the threat level of LPZ 1, SPDs at the entry into each LPZ 2 are required.

Figure 3c – Interconnecting two LPZ 2 using SPDs

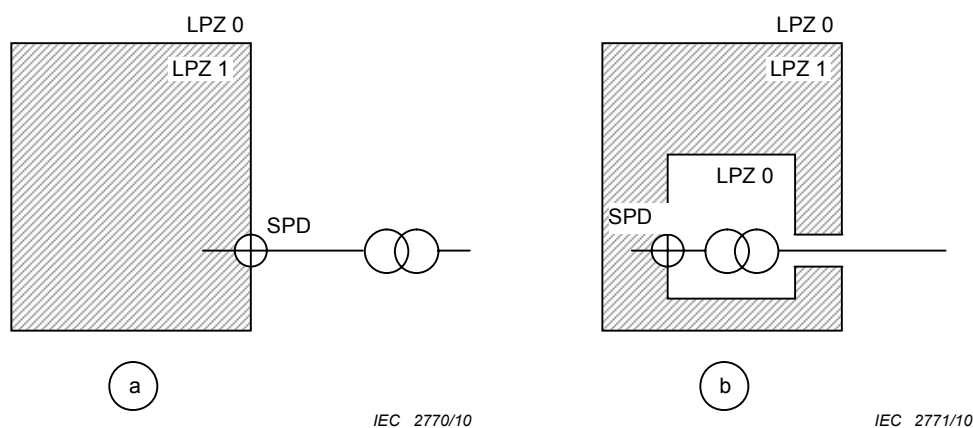
NOTE Figure 3d shows that such interference can be avoided and the SPDs can be omitted, if shielded cables or shielded cable ducts are used to interconnect both LPZ 2.

Figure 3d – Interconnecting two LPZ 2 using shielded cables or shielded cable ducts

Figure 3 – Examples for interconnected LPZ

Extending an LPZ into another LPZ might be needed in special cases or can be used to reduce the number of required SPDs (see Figure 4).

Detailed evaluation of the electromagnetic environment in an LPZ is described in Annex A.

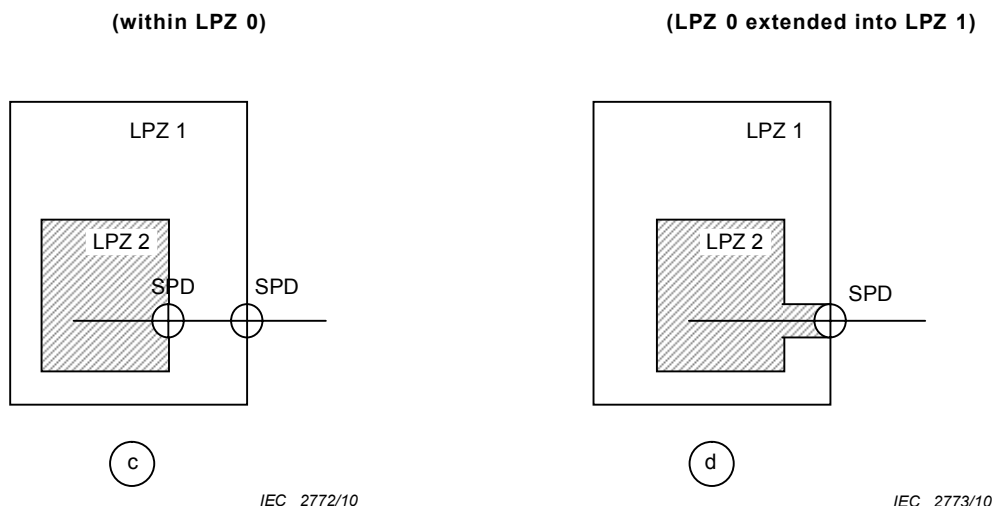


NOTE Figure 4a shows a structure powered by a transformer. If the transformer is placed outside the structure, only the low voltage lines entering the structure require protection using an SPD.

Figure 4a – Transformer outside the structure

NOTE If the transformer is placed inside the structure and does not have an SPD installed on the HV side (since the owner of the building is often not permitted to adopt protection measures on the high voltage side) then Figure 4b applies. Figure 4b shows that the problem can be solved by extending LPZ 0 into LPZ 1, which again requires SPDs to be installed on the low voltage side only.

Figure 4b – Transformer inside the structure



NOTE Figure 4c shows an LPZ 2 supplied by an electrical or signal line. This line needs two coordinated SPDs: one at the boundary of LPZs 0/1, the other at the boundary of LPZs 1/2.

Figure 4c – Two coordinated SPDs needed – SPD (between zones 0/1) and SPD (between zones 1/2)

NOTE Figure 4d shows that the line can enter immediately into LPZ 2 and only one SPD is required, if LPZ 2 is extended into LPZ 1 using shielded cables or shielded cable ducts. However this SPD will reduce the threat immediately to the level of LPZ 2.

Figure 4d – Only one SPD needed – SPD (between zones 0/2) (LPZ 2 extended into LPZ 1)

Figure 4 – Examples for extended lightning protection zones

4.4 Basic SPM

Basic protection measures against LEMP include:

- **Earthing and bonding (see Clause 5)**

The earthing system conducts and disperses the lightning current into the earth.

The bonding network minimizes potential differences and may reduce the magnetic field.

- **Magnetic shielding and line routing (see Clause 6)**

Spatial shielding attenuates the magnetic field inside the LPZ, arising from lightning flashes direct to or nearby the structure, and reduces internal surges.

Shielding of internal lines, using shielded cables or cable ducts, minimizes internally-induced surges.

Routing of internal lines can minimize induction loops and reduce internal surges.

NOTE 1 Spatial shielding, shielding and routing of internal lines can be combined or used separately.

Shielding of external lines entering the structure reduces surges from being conducted onto the internal systems.

- **Coordinated SPD system (see Clause 7)**

A coordinated SPD system limits the effects of externally originated and internally created surges.

- **Isolating interfaces (see Clause 8)**

Isolating interfaces limits the effects of conducted surges on lines entering the LPZ.

Earthing and bonding should always be ensured, in particular, bonding of every conductive service directly or via an equipotential bonding SPD, at the point of entry to the structure.

Other SPM can be used alone or in combination.

SPM shall withstand the operational stresses expected in the installation place (e.g. stress of temperature, humidity, corrosive atmosphere, vibration, voltage and current).

Selection of the most suitable SPM shall be made using a risk assessment in accordance with IEC 62305-2, taking into account technical and economic factors.

Practical information on the implementation of SPM for internal systems in existing structures is given in Annex B.

NOTE 2 Lightning equipotential bonding (EB) in accordance with IEC 62305-3 will protect against dangerous sparking only. Protection of internal systems against surges requires a coordinated SPD system in accordance with this standard.

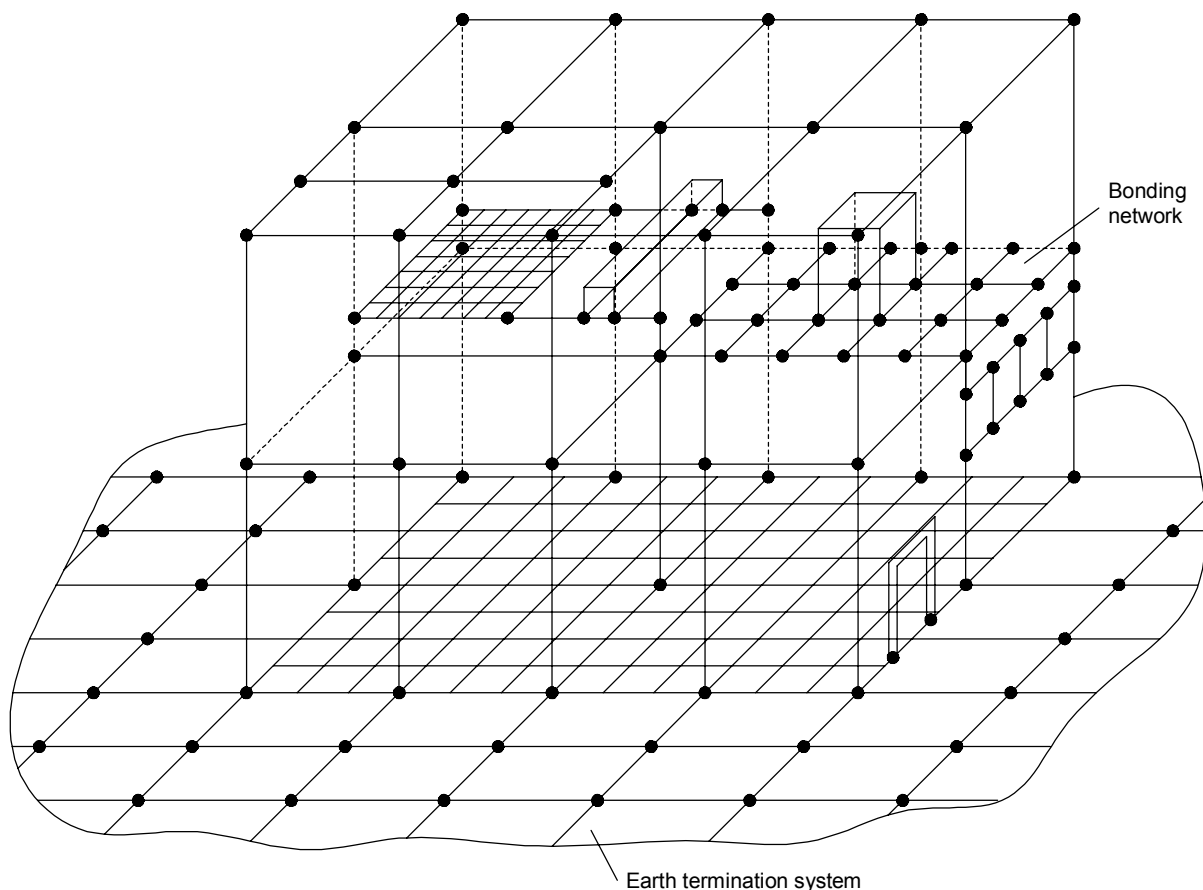
NOTE 3 Further information on the implementation of SPM can be found in IEC 60364-4-44.

5 Earthing and bonding

5.1 General

Suitable earthing and bonding are based on a complete earthing system (see Figure 5) combining

- the earth-termination system (dispersing the lightning current into the soil), and
- the bonding network (minimizing potential differences and reducing the magnetic field).



IEC 2774/10

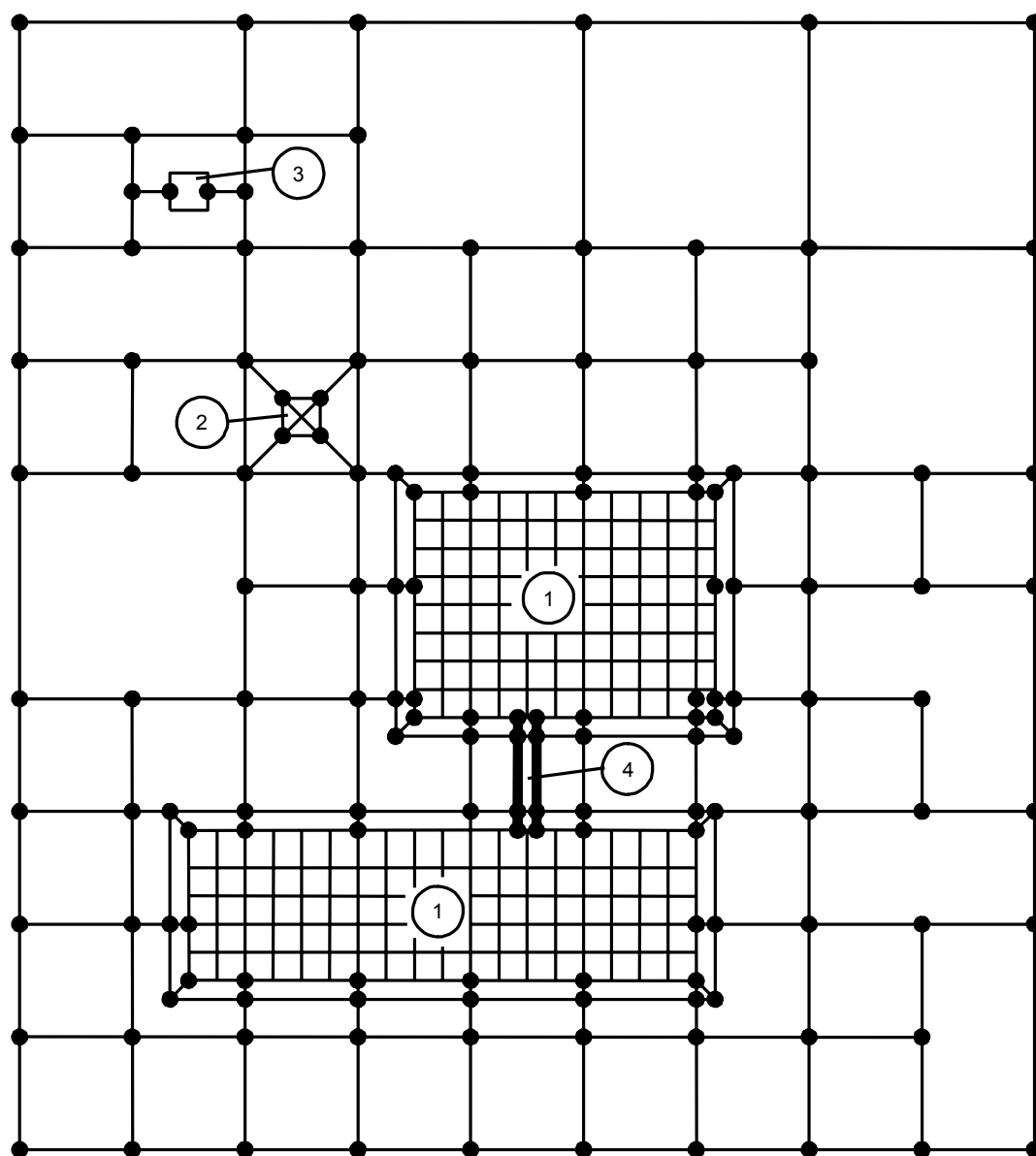
NOTE All drawn conductors are either bonded structural metal elements or bonding conductors. Some of them may also serve to intercept, conduct and disperse the lightning current into the earth.

Figure 5 – Example of a three-dimensional earthing system consisting of the bonding network interconnected with the earth-termination system

5.2 Earth-termination system

The earth-termination system of the structure shall comply with IEC 62305-3. In structures where only electrical systems are provided, a type A earthing arrangement may be used, but a type B earthing arrangement is preferable. In structures with electronic systems, a type B earthing arrangement is recommended.

The ring earth electrode around the structure, or the ring earth electrode in the concrete at the perimeter of the foundation, should be integrated with a meshed network under and around the structure, having a mesh width of typically 5 m. This greatly improves the performance of the earth-termination system. If the basement's reinforced concrete floor forms a well defined interconnected mesh and is connected to the earth-termination system, typically every 5 m, it is also suitable. An example of a meshed earth-termination system of a plant is shown in Figure 6.



IEC 2775/10

Key

- 1 building with meshed network of the reinforcement
- 2 tower inside the plant
- 3 stand-alone equipment
- 4 cable tray

Figure 6 – Meshed earth-termination system of a plant

To reduce potential differences between two internal systems, which may be referenced in some special cases to separate earthing systems, the following methods may be applied:

- several parallel bonding conductors running in the same paths as the electrical cables, or the cables enclosed in grid-like reinforced concrete ducts (or continuously bonded metal conduit), which have been integrated into both of the earth-termination systems;
- shielded cables with shields of adequate cross-section, and bonded to the separate earthing systems at either end.

5.3 Bonding network

A low impedance bonding network is needed to avoid dangerous potential differences between all equipment inside the inner LPZ. Moreover, such a bonding network also reduces the magnetic field (see Annex A).

This can be realised by a meshed bonding network integrating conductive parts of the structure, or parts of the internal systems, and by bonding metal parts or conductive services at the boundary of each LPZ directly or by using suitable SPDs.

The bonding network can be arranged as a three-dimensional meshed structure with a typical mesh width of 5 m (see Figure 5). This requires multiple interconnections of metal components in and on the structure (such as concrete reinforcement, elevator rails, cranes, metal roofs, metal facades, metal frames of windows and doors, metal floor frames, service pipes and cable trays). Bonding bars (e.g. ring bonding bars, several bonding bars at different levels of the structure) and magnetic shields of the LPZ shall be integrated in the same way.

Examples of bonding networks are shown in Figures 7 and 8.