

Protection against lightning —

Part 4: Electrical and electronic systems within structures

ICS 29.020; 91.120.40

National foreword

This British Standard is the UK implementation of EN 62305-4:2006, incorporating corrigendum November 2006. It is identical with IEC 62305-4:2006. This standard, together with BS EN 62305-1:2006, BS EN 62305-2:2006 and BS EN 62305-3:2006, supersedes BS 6651:1999, which will be withdrawn on 31 August 2008.

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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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 29 September 2006

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ISBN 978 0 580 60829 2

Amendments/corrigenda issued since publication

Date	Comments
30 April 2008	Implementation of CENELEC corrigendum November 2006, addition of Annex ZA

English version

Protection against lightning
Part 4: Electrical and electronic systems within structures
(IEC 62305-4:2006)

Protection contre la foudre
Partie 4: Réseaux de puissance et de
communication dans les structures
(CEI 62305-4:2006)

Blitzschutz
Teil 4: Elektrische und elektronische
Systeme in baulichen Anlagen
(IEC 62305-4:2006)

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 81/265/FDIS, future edition 1 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 2006-02-01.

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) 2006-11-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2009-02-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62305-4:2006 was approved by CENELEC as a European Standard without any modification.

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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 62305-2:

- D1 injuries to living beings due to touch and step voltages;
- D2 physical damage due to mechanical, thermal, chemical and explosive effects;
- D3 failures of electrical and electronic systems due to electromagnetic effects.

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 apparatus via connecting wiring;
- b) the effects of radiated electromagnetic fields directly into apparatus itself.

Surges to the structure can be generated externally or internally:

- surges external to the structure are created by lightning flashes striking incoming lines or the nearby ground, and are transmitted to electrical and electronic systems via these lines;
- surges internal to the structure are created by lightning flashes striking the structure or the nearby ground.

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 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 according to IEC 62305-3 or in an external spatial shield according to 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 a LEMP protection measures system (LPMS) for electrical and electronic systems within a structure, able to reduce the risk of permanent failures due to lightning electromagnetic impulse.

This standard does not cover protection against electromagnetic interference due to lightning, which may cause malfunctioning of electronic 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 and in the IEC 61000 series [1]¹.

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 60364-4-44:2001, *Electrical installations of buildings – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

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

IEC 60664-1:2002, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 61000-4-5:1995, *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*

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

¹ Figures in square brackets refer to the bibliography.

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

IEC 61643-1:1998, *Surge protective devices connected to low-voltage power distribution systems – Part 1: Performance requirements and testing methods*

IEC 61643-12:2002, *Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles*

IEC 61643-21:2000, *Low voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signalling networks – Performance requirements and testing methods*

IEC 61643-22:2004, *Low voltage surge protective devices – Part 22: Surge protective devices connected to telecommunications and signalling networks – Part 22: Selection and application principles*

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

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

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

ITU-T Recommendation K.20:2003, *Resistibility of telecommunication equipment installed in a telecommunications centre to overvoltages and overcurrents*

ITU-T Recommendation K.21:2003, *Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrent*

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 communication 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 electromagnetic impulse

LEMP

electromagnetic effects of lightning current

NOTE It includes conducted surges as well as radiated impulse electromagnetic field effects.

3.5**surge**

transient wave appearing as overvoltage and/or overcurrent caused by LEMP

NOTE Surges caused by LEMP can arise from (partial) lightning currents, from induction effects in installation loops and as a remaining threat downstream of SPD.

3.6**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 standard, only withstand voltage between live conductors and earth is considered.

3.7**lightning protection level**

LPL

number related to a set of lightning current parameters values 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.

3.8**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).

3.9**LEMP protection measures system**

LPMS

complete system of protection measures for internal systems against LEMP

3.10**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).

3.11**earth-termination system**

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

3.12**bonding network**

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

3.13**earthing system**

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

3.14**surge protective device**

SPD

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

3.15

SPD tested with I_{imp}

SPDs which withstand the partial lightning current with a typical waveform 10/350 μ s 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.

3.16

SPD tested with I_n

SPDs which withstand induced surge currents with a typical waveform 8/20 μ s 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.

3.17

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 defining the open circuit voltage U_{oc} 1,2/50 μ s and the short-circuit current I_{sc} 8/20 μ s of an 2 Ω combination wave generator.

3.18

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 SPD are sometimes called "crowbar type".

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

3.19

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.

3.20

combination type SPD

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

3.21

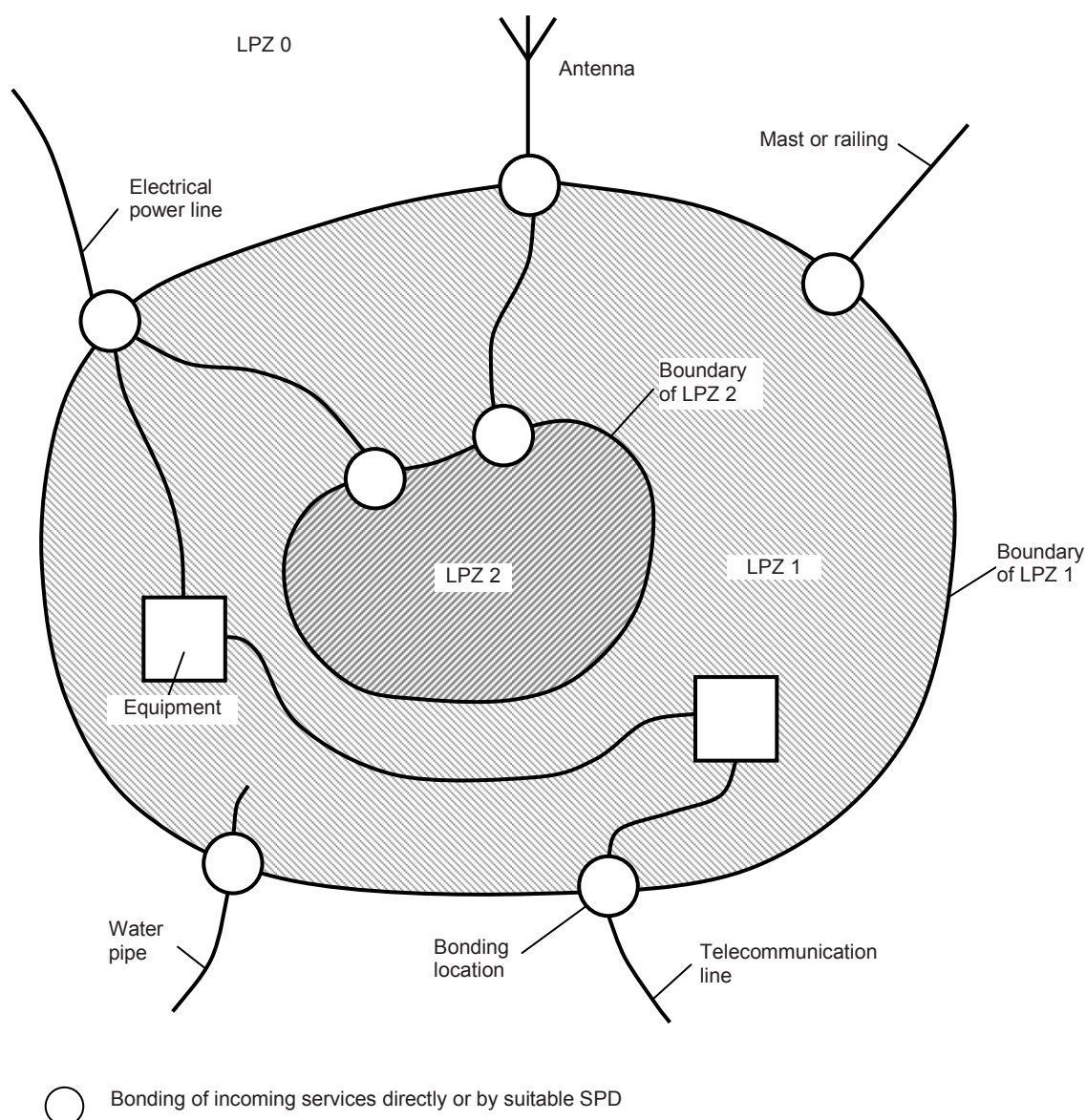
coordinated SPD protection

set of SPD properly selected, coordinated and installed to reduce failures of electrical and electronic systems

4 Design and installation of a LEMP protection measures system (LPMS)

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

Protection against LEMP is based on the lightning protection zone (LPZ) concept: the volume containing systems to be protected shall be divided into LPZ. These zones are theoretically assigned volumes of space 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).



IEC 2187/05

NOTE This figure shows an example for 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

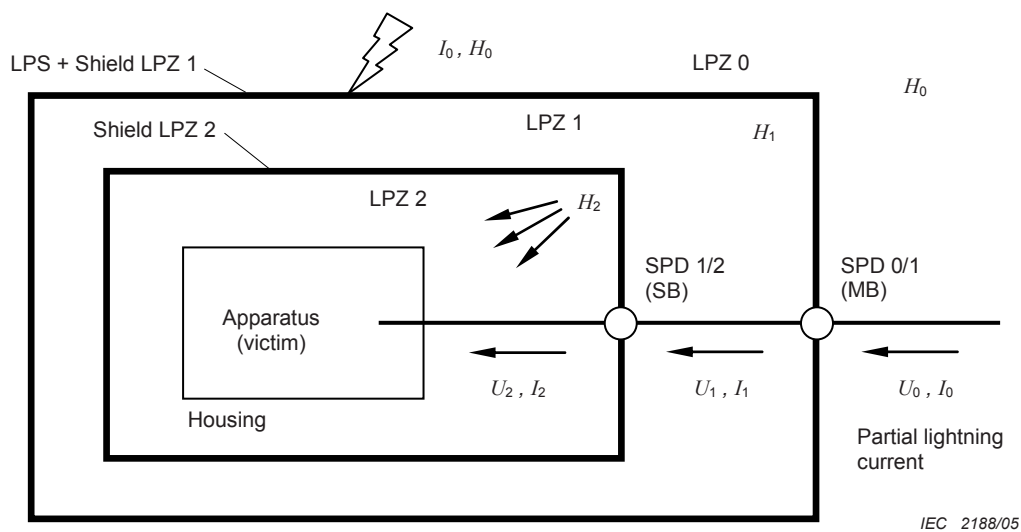


Figure 2a – LPMS using spatial shields and “coordinated SPD protection”– Apparatus well protected against conducted surges ($U_2 \ll U_0$ and $I_2 \ll I_0$) and against radiated magnetic fields ($H_2 \ll H_0$)

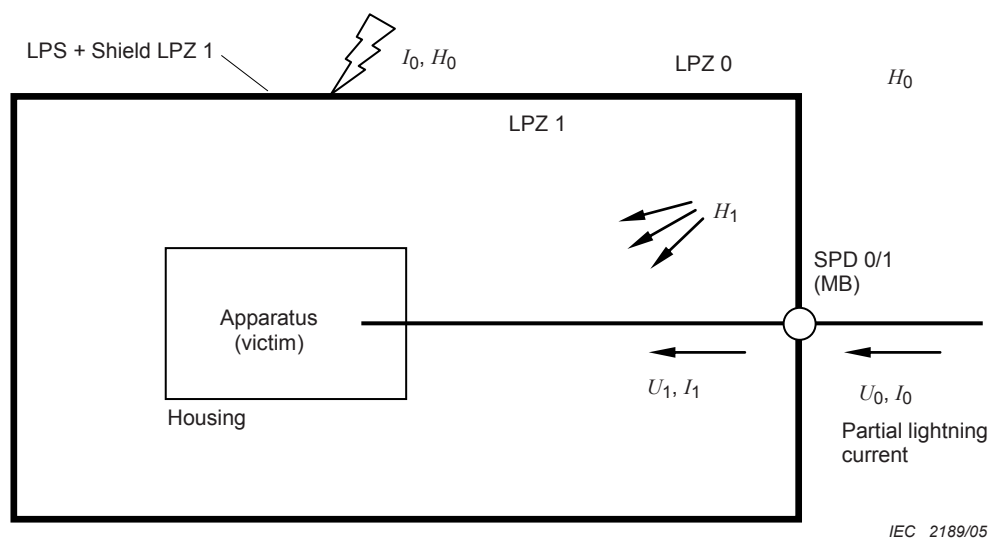


Figure 2b – LPMS using spatial shield of LPZ 1 and SPD protection at entry of LPZ 1 – Apparatus protected against conducted surges ($U_1 < U_0$ and $I_1 < I_0$) and against radiated magnetic fields ($H_1 < H_0$)

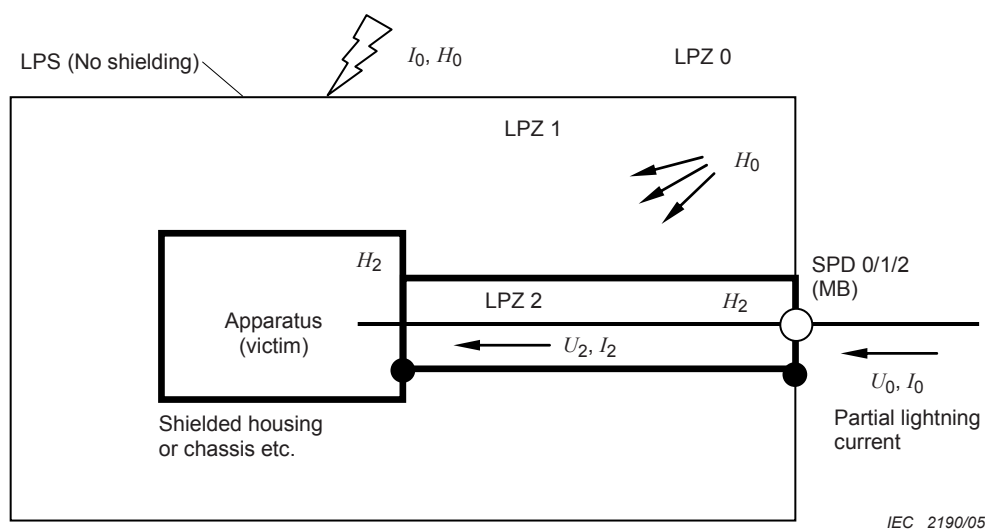


Figure 2c – LPMS using internal line shielding and SPD protection at entry of LPZ 1 – Apparatus protected against conducted surges ($U_2 < U_0$ and $I_2 < I_0$) and against radiated magnetic fields ($H_2 < H_0$)

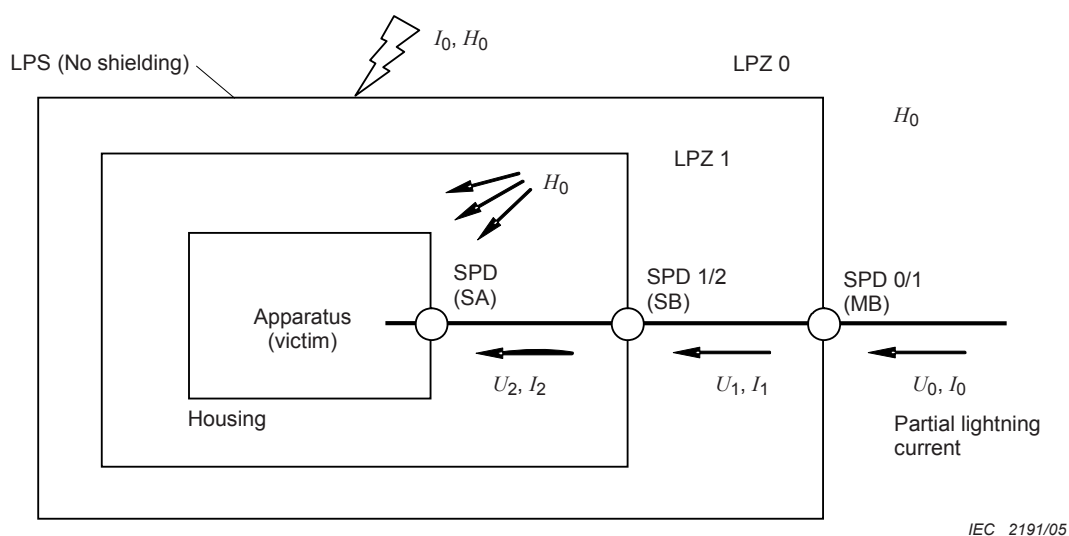


Figure 2d – LPMS using “coordinated SPD protection” only – Apparatus protected against conducted surges ($U_2 \ll U_0$ and $I_2 \ll I_0$), but not against radiated magnetic field (H_0)

NOTE 1 SPDs can be located at the following points (see also D.1.2):

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

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

NOTE 3 Shielded (—) and non shielded (——) boundary.

Figure 2 – Protection against LEMP – Examples of possible LEMP protection measures systems (LPMS)

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

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

NOTE 1 Failures due to electromagnetic fields impinging directly onto the equipment are negligible provided that the equipment complies with radio frequency emission tests and immunity tests as defined in the relevant EMC product standards.

NOTE 2 For equipment not complying with relevant EMC product standards, Annex A provides information on how to achieve protection against electromagnetic fields directly impinging onto this equipment. 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.

4.1 Design of an LPMS

An LPMS can be designed for protection of equipment against surges and electromagnetic fields. Figure 2 provides examples:

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

- An LPMS created 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 surge level, a special SPD may be required (e.g. additional coordinated stages inside) to reach a sufficient low voltage protection level.
- An LPMS created using a system of coordinated SPD protection, 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 according to Figures 2a to 2c are recommended especially for equipment, which does not comply with relevant EMC product standards.

NOTE 3 An LPS according to IEC 62305-3, which only employs 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 LPMS.

4.2 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. |

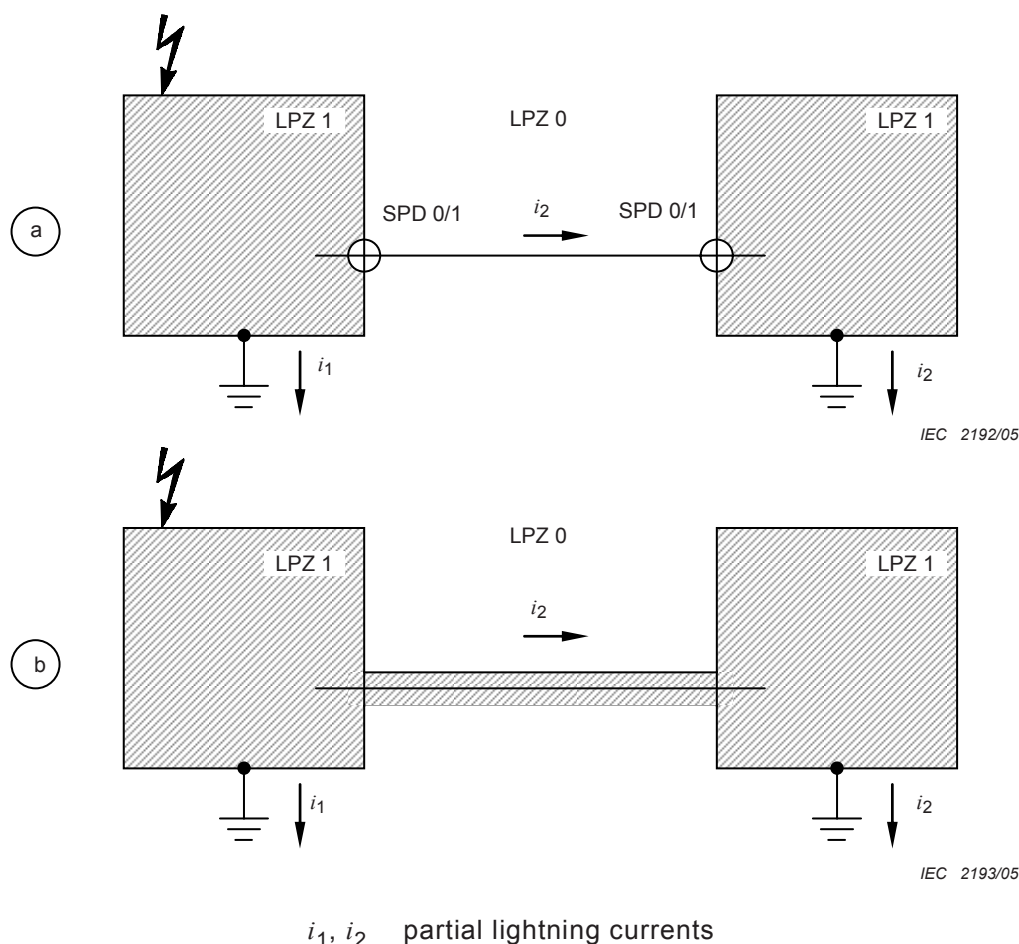
Inner zones: (protected against direct lightning flashes)

LPZ 1 Zone where the surge current is limited by current sharing and 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 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 LPMS, e.g. installation of coordinated SPDs and/or magnetic shielding (see Figure 2). Depending on 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 volume of the whole structure) (see Figure B.2).

Interconnection of LPZ 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).

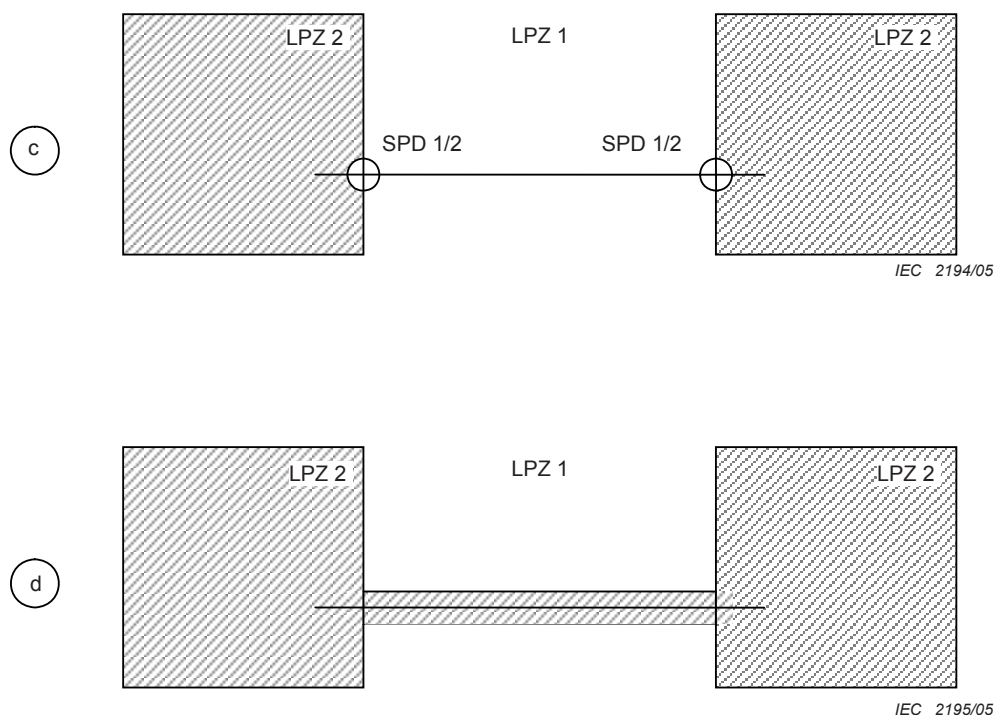


NOTE Figure 3a shows two LPZ 1 connected by electrical or signal lines. Special care should be taken if both LPZ 1 represent separate structures with separate earthing systems, spaced tens or hundreds of metres from each other. In this case, a large part of the lightning current can flow along the connecting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

Figure 3a – Interconnecting two LPZ 1 using SPD

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.

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, SPD at the entry into each LPZ 2 are required.

Figure 3c – Interconnecting two LPZ 2 using SPD

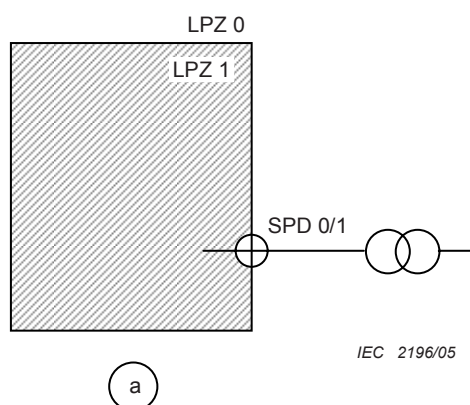
NOTE Figure 3d shows that such interference can be avoided and the SPD can be omitted, if shielded cables or shielded cable ducts are used to interconnect both LPZ 2.

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

Figure 3 – Examples for interconnected LPZ

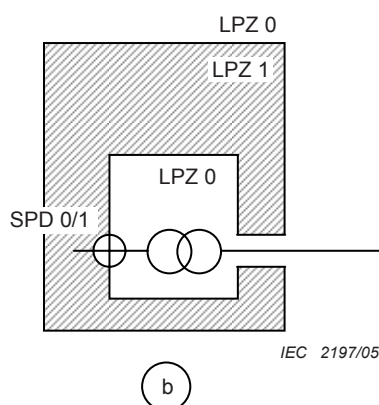
Extending an LPZ into another LPZ might be needed in special cases or can be used to reduce the number of required SPD (see Figure 4).

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



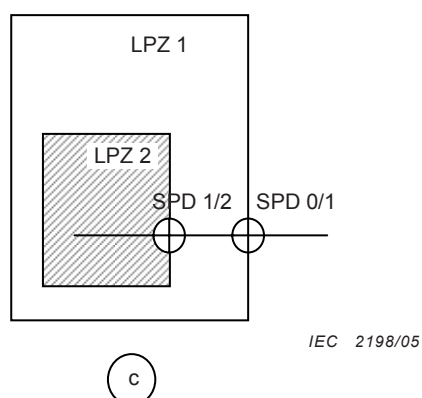
NOTE Figure 4a shows a structure powered by a transformer. If the transformer is placed outside the structure, only the low voltage lines entering the structure need protection by SPD. If the transformer should be placed inside the structure, the owner of the building often is not allowed to adopt protection measures on the high voltage side.

Figure 4a – Transformer outside the structure



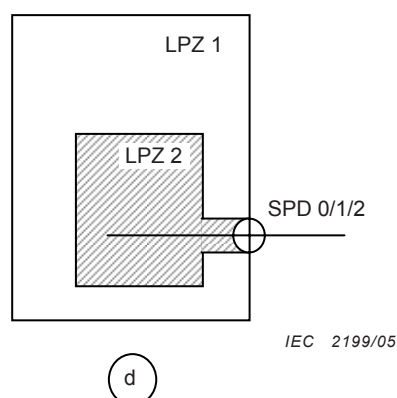
NOTE Figure 4b shows that the problem can be solved extending LPZ 0 into LPZ 1, which requires again SPDs at the low voltage side only.

Figure 4b – Transformer inside the structure (LPZ 0 extended into LPZ 1)



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 LPZ 1, the other at the boundary of LPZ 2.

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



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 (0/1/2) needed (LPZ 2 extended into LPZ 1)

Figure 4 – Examples for extended lightning protection zones

4.3 Basic protection measures in an LPMS

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 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 internal 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 protection (see Clause 7)**

Coordinated SPD protection limits the effects of external and internal surges.

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.

NOTE 2 Lightning equipotential bonding (EB) according to IEC 62305-3 will protect against dangerous sparking only. Protection of internal systems against surges requires coordinated SPD protection according to this standard.

Other LEMP protection measures can be used alone or in combination.

LEMP protection measures 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 LEMP protection measures shall be made using a risk assessment in accordance with IEC 62305-2 taking into account technical and economic factors.

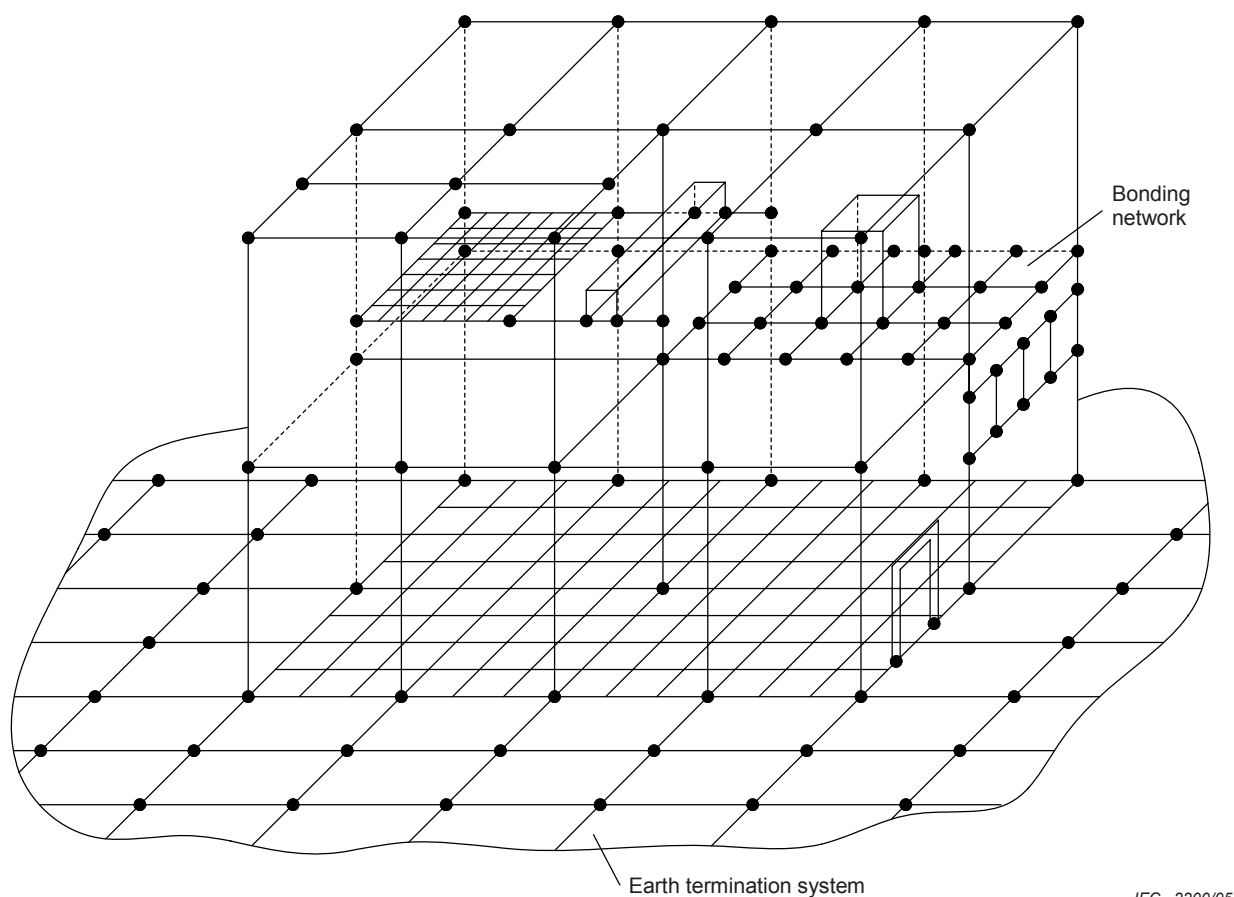
Practical information on the implementation of LEMP protection measures for electronic systems in existing structures are given in Annex B.

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

5 Earthing and bonding

Suitable earthing and bonding is 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).



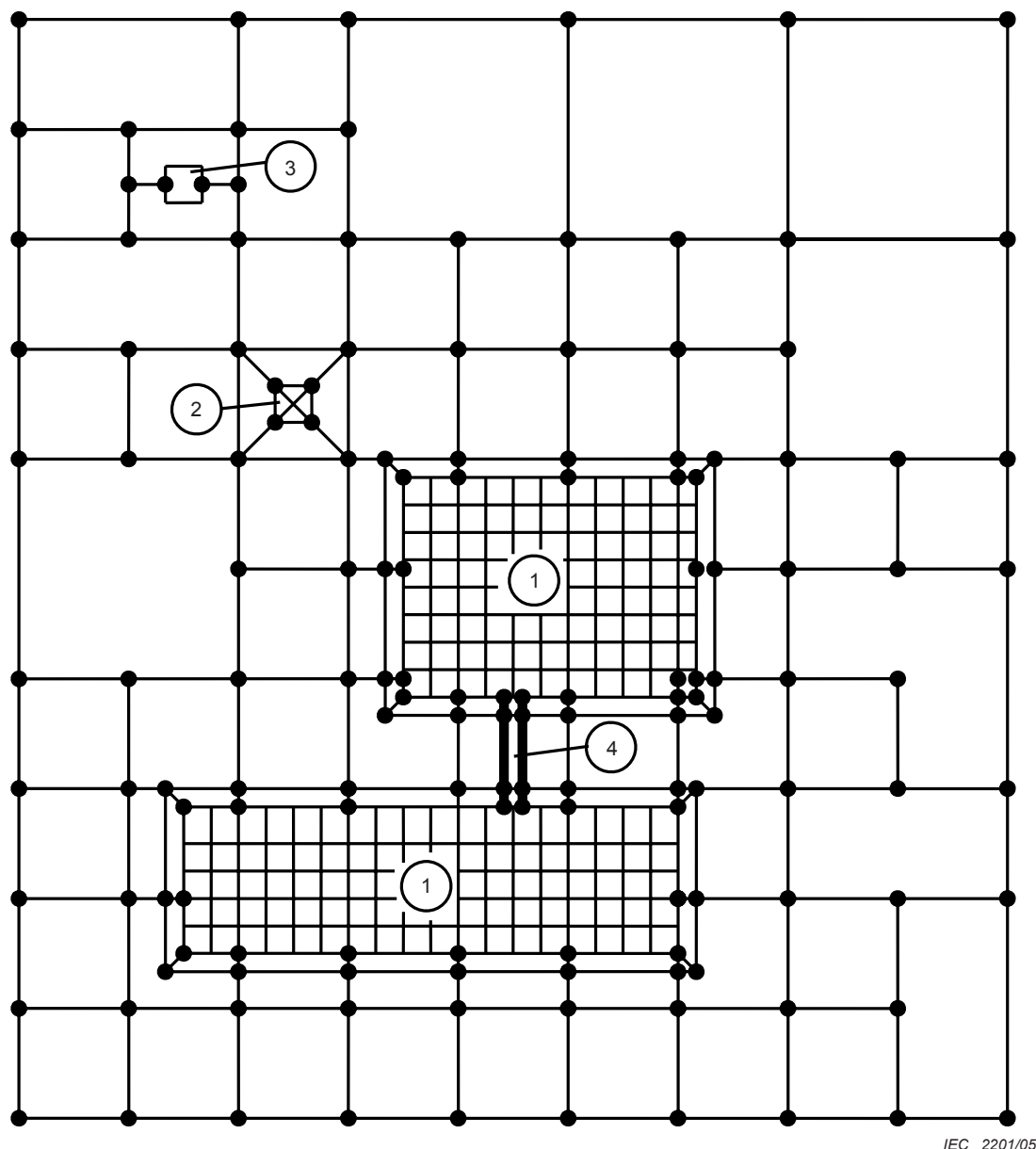
NOTE All drawn connections are either bonded structure metal elements or bonding connections. Some of them may also serve to intercept, conduct and disperse the lightning current into the earth.

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

5.1 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 2201/05

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 have been referenced 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.

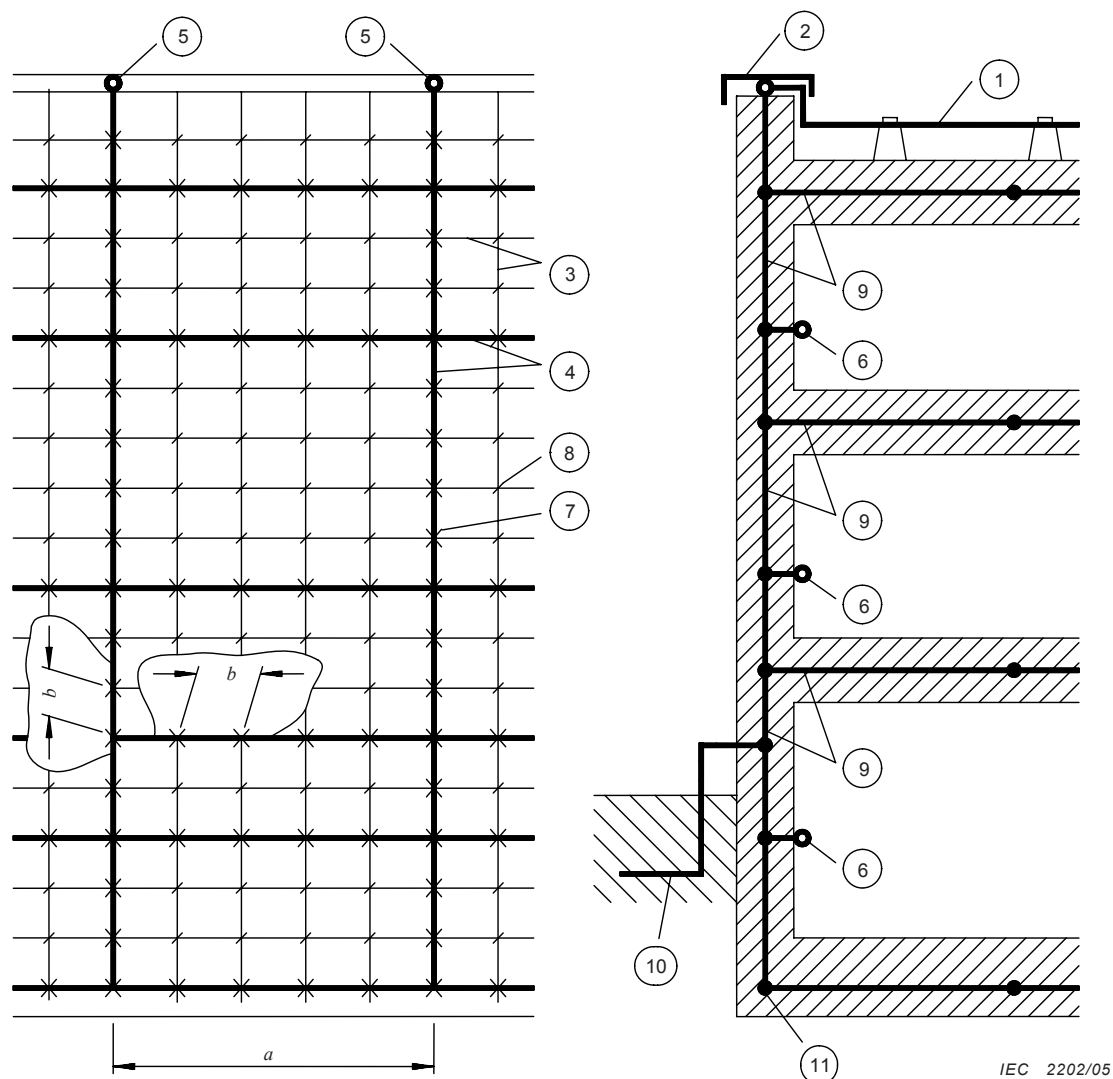
5.2 Bonding network

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.



IEC 2202/05

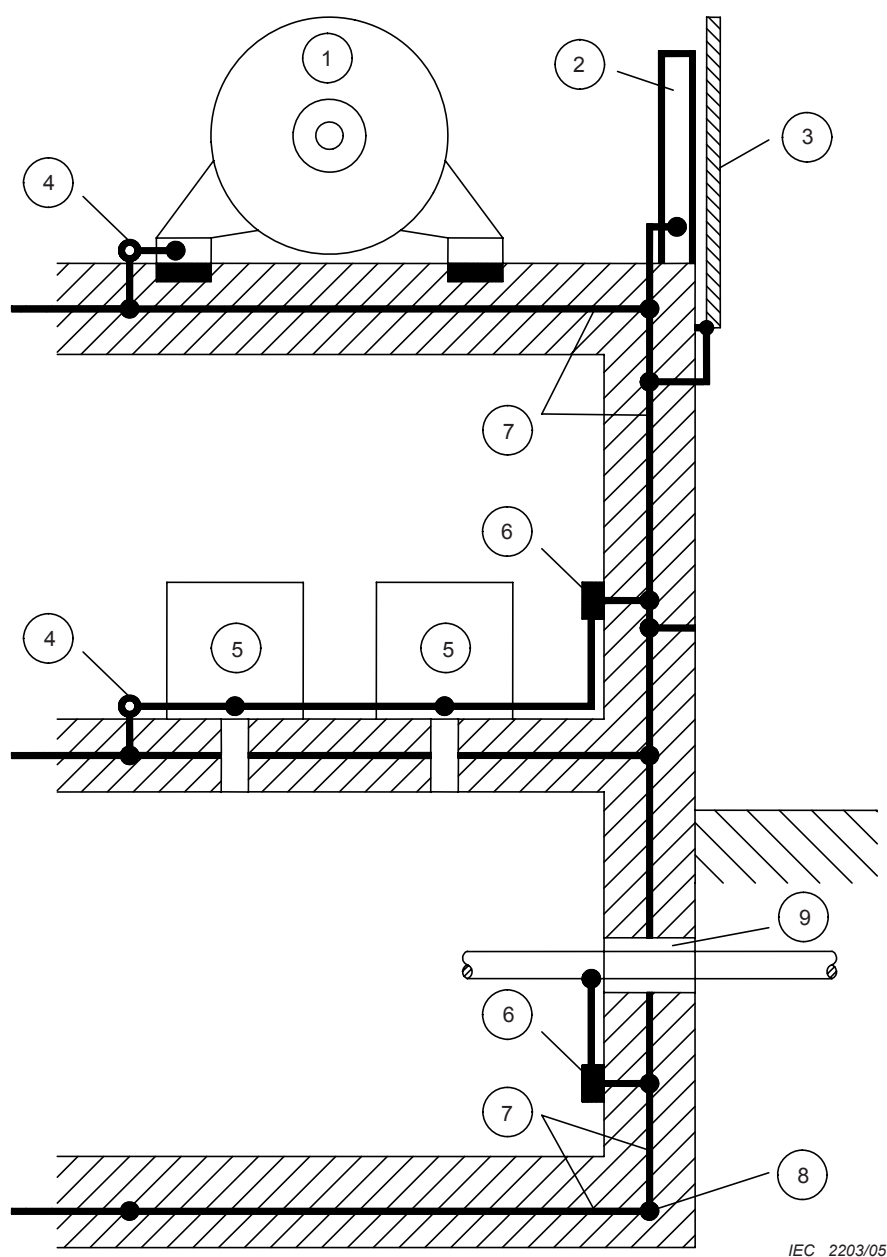
Key

- 1 air termination conductor
- 2 metal covering of the roof parapet
- 3 steel reinforcing rods
- 4 mesh conductors superimposed on the reinforcement
- 5 joint of the mesh conductor
- 6 joint for an internal bonding bar
- 7 connection by welding or clamping
- 8 arbitrary connection
- 9 steel reinforcement in concrete (with superimposed mesh conductors)
- 10 ring earthing electrode (if any)
- 11 foundation earthing electrode

a typical distance of 5 m for superimposed mesh conductors

b typical distance of 1 m for connecting this mesh with the reinforcement

Figure 7 – Utilization of reinforcing rods of a structure for equipotential bonding



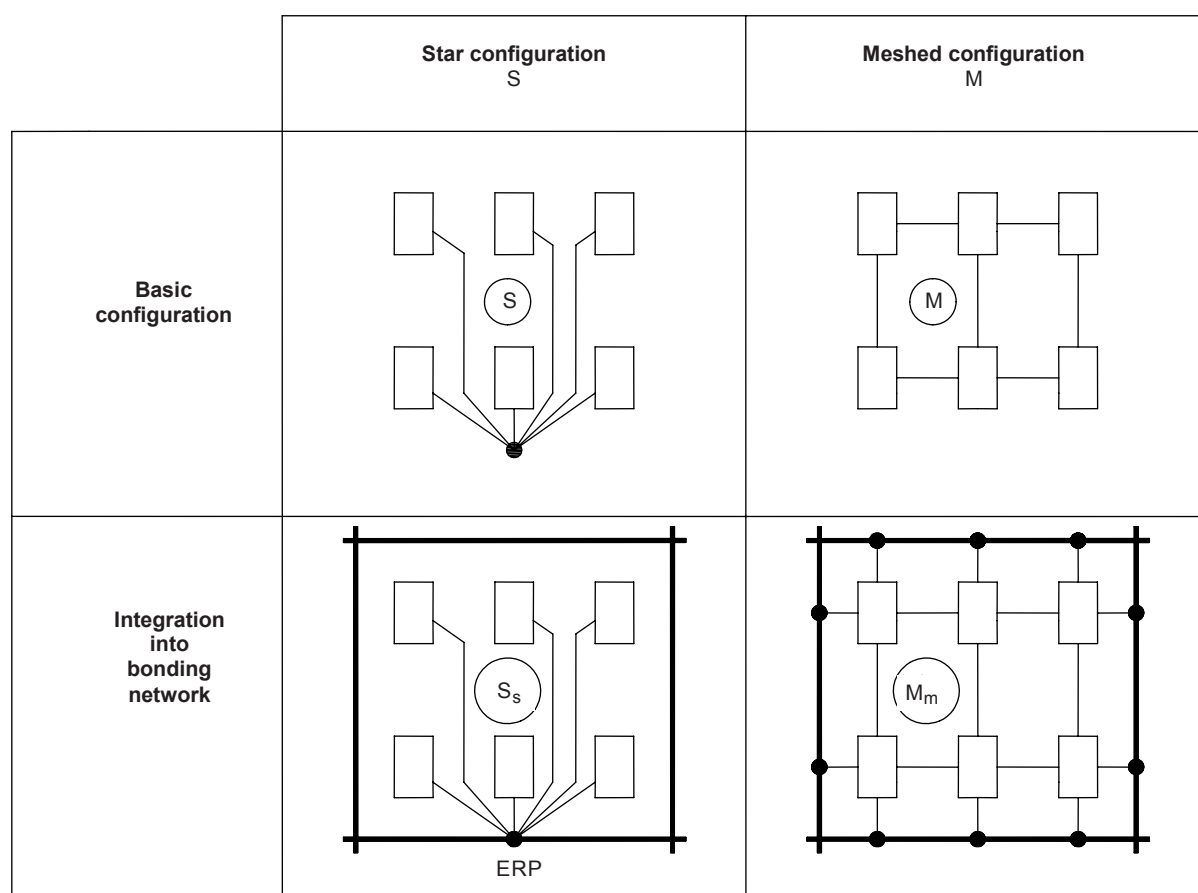
IEC 2203/05

Key

- 1 electrical power equipment
- 2 steel girder
- 3 metal covering of the facade
- 4 bonding joint
- 5 electrical or electronic equipment
- 6 bonding bar
- 7 steel reinforcement in concrete (with superimposed mesh conductors)
- 8 foundation earthing electrode
- 9 common inlet for different services

Figure 8 – Equipotential bonding in a structure with steel reinforcement

Conductive parts (e.g. cabinets, enclosures, racks) and the protective earth conductor (PE) of the internal systems shall be connected to the bonding network according to the following configurations (see Figure 9):



IEC 2204/05

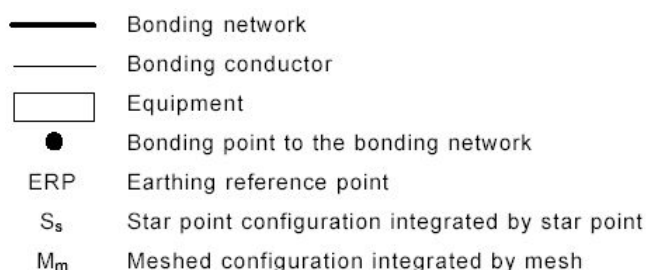
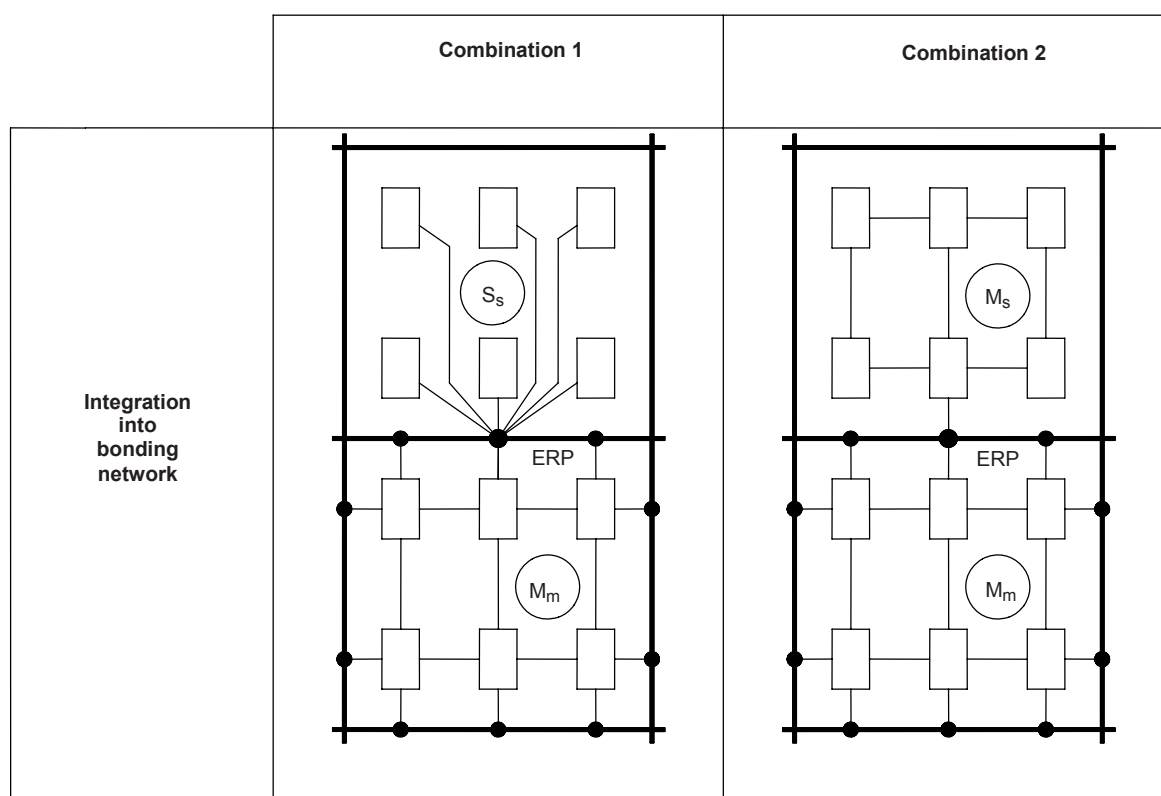


Figure 9 – Integration of electronic systems into the bonding network

If the configuration S is used, all metal components (e.g. cabinets, enclosures, racks) of the internal systems shall be isolated from the earthing system. The configuration S shall be integrated into the earthing system only by a single bonding bar acting as the earth reference point (ERP) resulting in type S_s . When configuration S is used, all lines between the individual equipment shall run in parallel with the bonding conductors following the star configuration in order to avoid induction loops. Configuration S can be used where internal systems are located in relatively small zones and all lines enter the zone at one point only.

If configuration M is used, the metal components (e.g. cabinets, enclosures, racks) of the internal systems are not to be isolated from the earthing system, but shall be integrated into it by multiple bonding points, resulting in type M_m . Configuration M is preferred for internal systems extended over relatively wide zones or over a whole structure, where many lines run between the individual pieces of equipment, and where the lines enter the structure at several points.

In complex systems, the advantages of both configurations (configuration M and S) can be combined as illustrated in Figure 10, resulting in combination 1 (S_s combined with M_m) or in combination 2 (M_s combined with M_m).



IEC 2205/05

- Bonding network
- Bonding conductor
- Equipment
- Bonding point to the bonding network
- ERP Earthing reference point
- S_s Star point configuration integrated by star point
- M_m Meshed configuration integrated by mesh
- M_s Meshed configuration integrated by star point

Figure 10 – Combinations of integration methods of electronic systems into the bonding network

5.3 Bonding bars

Bonding bars shall be installed for bonding of

- all conductive services entering a LPZ (directly or by using suitable SPDs),
- the protective earth conductor PE,
- metal components of the internal systems (e.g. cabinets, enclosures, racks),
- the magnetic shields of the LPZ at the periphery and inside the structure.

For efficient bonding the following installation rules are important:

- the basis for all bonding measures is a low impedance bonding network;
- bonding bars should be connected to the earthing system by shortest possible route (using bonding conductors not longer than 0,5 m);
- material and dimensions of bonding bars and bonding conductors shall comply with 5.5;
- SPD should use the shortest possible connections to the bonding bar as well as to the live conductors thus minimizing inductive voltage drops;
- on the protected side of the circuit (after an SPD), mutual induction effects should be minimized, either by minimizing the loop area or using shielded cables or cable ducts.

5.4 Bonding at the boundary of an LPZ

Where an LPZ is defined, bonding shall be provided for all metal parts and services (e.g. metal pipes, power lines or signal lines) penetrating the boundary of the LPZ.

NOTE Bonding of services entering LPZ 1 should be discussed with the service network providers involved (e.g. electrical power or telecommunication authorities), because there could be conflicting requirements.

Bonding shall be performed via bonding bars, which are installed as close as possible to the entrance point at the boundary.

Where possible, incoming services should enter the LPZ at the same location and be connected to the same bonding bar. If services enter the LPZ at different locations, each service shall be connected to a bonding bar and these bonding bars shall be connected together. To this end, bonding to a ring bonding bar (ring conductor) is recommended.

Equipotential bonding SPD(s) are always required at the entrance of the LPZ to bond incoming lines, which are connected to the internal systems within the LPZ, to the bonding bar. Using an interconnected or extended LPZ can reduce the number of required SPDs.

Shielded cables or interconnected metal cable ducts, bonded at each LPZ boundary, can be used either to interconnect several LPZ of the same order to one joint LPZ, or to extend an LPZ to the next boundary.

5.5 Material and dimensions of bonding components

Material, dimensions and conditions of use shall comply with IEC 62305-3. The minimum cross-section for bonding components shall comply with Table 1.

Clamps shall be dimensioned in accordance with the lightning current values of the LPL (see IEC 62305-1) and the current sharing analysis (see Annex B, IEC 62305-3).

SPD shall be dimensioned in accordance with Clause 7.

Table 1 – Minimum cross-sections for bonding components

Bonding component		Material	Cross-section mm ²
Bonding bars (copper or galvanized steel)		Cu, Fe	50
Connecting conductors from bonding bars to the earthing system or to other bonding bars		Cu	14
		Al	22
		Fe	50
Connecting conductors from internal metal installations to bonding bars		Cu	5
		Al	8
		Fe	16
Connecting conductors for SPD	Class I	Cu	5
	Class II		3
	Class III		1
NOTE Other material used should have cross-sections ensuring equivalent resistance.			

6 Magnetic shielding and line routing

Magnetic shielding can reduce the electromagnetic field as well as the magnitude of induced internal surges. Suitable routing of internal lines can also minimize the magnitude of induced internal surges. Both measures are effective in reducing permanent failure of internal systems.

6.1 Spatial shielding

Spatial shields define protected zones, which may cover the whole structure, a part of it, a single room or the equipment enclosure only. These may be grid-like, or continuous metal shields, or comprise the "natural components" of the structure itself (see IEC 62305-3).

Spatial shields are advisable where it is more practical and useful to protect a defined zone of the structure instead of several individual pieces of equipment. Spatial shields should be provided in the early planning stage of a new structure or a new internal system. Retrofitting to existing installations may result in higher costs and greater technical difficulties.

6.2 Shielding of internal lines

Shielding may be restricted to cabling and equipment of the system to be protected: metallic shield of cables, closed metallic cable ducts and metallic enclosure of equipment are used for this purpose.

6.3 Routing of internal lines

Suitable routing of internal lines minimizes induction loops and reduces the creation of surge voltages internal to the structure. The loop area can be minimized by routing the cables close to natural components of the structure which have been earthed and/or by routing electrical and signal lines together.

NOTE Some distance between power lines and unshielded signal lines may still be needed to avoid interference.

6.4 Shielding of external lines

Shielding of external lines entering the structure includes cable shields, closed metallic cable ducts and concrete cable ducts with interconnected reinforcement steel. Shielding of external lines is helpful, but often not within the responsibility of the LPMS planner (since the owner of external lines is normally the network provider).

6.5 Material and dimensions of magnetic shields

At the boundary of LPZ 0_A and LPZ 1, materials and dimensions of magnetic shields (e.g. grid-like spatial shields, cable shields and equipment enclosures) shall comply with the requirements of IEC 62305-3 for air termination conductors and/or down conductors. In particular:

- minimum thickness of sheet metal parts, metal ducts, piping and cable shields shall comply with Table 3 of IEC 62305-3;
- layouts of grid-like spatial shields and the minimum cross-section of their conductors, shall comply with Table 6 of IEC 62305-3.

For magnetic shields not intended to carry lightning currents, the dimensioning of these shields in accordance with Tables 3 and 6 of IEC 62305-3 is not required:

- at the boundary of zones LPZ 1/2 or higher, provided that the separation distance s between magnetic shields and the LPS is fulfilled (see 6.3 of IEC 62305-3),
- at the boundary of any LPZ, if the risk component R_D due to lightning flashes to the structure is negligible (see IEC 62305-2).

7 Coordinated SPD protection

The protection of internal systems against surges may require a systematic approach consisting of coordinated SPDs for both power and signal lines. The basic approach to the coordination of SPDs (see Annex C) is the same in both cases, but because of the extensive diversity of electronic system and their characteristics (analog or digital, d.c. or a.c., low or high frequency), the rules for the selection and installation of a coordinated SPD protection system are different to those which apply to the choice of SPDs for electrical systems only.

In an LPMS using the lightning protection zones concept with more than one LPZ (LPZ 1, LPZ 2 and higher), SPD(s) shall be located at the line entrance into each LPZ (see Figure 2).

In an LPMS using LPZ 1 only, SPD shall be located at the line entrance into LPZ 1 at least.

In both cases, additional SPDs may be required if the distance between the location of the SPD and the equipment being protected is long (see Annex D).

The SPD's test requirements shall comply with

- IEC 61643-1 for power systems,
- IEC 61643-21 for telecommunication and signalling systems.

Selection and installation of a coordinated SPD protection shall comply with

- IEC 61643-12 and IEC 60364-5-53 for protection of power systems,
- IEC 61643-22 for protection of telecommunications and signalling systems.

Some basic information about the selection and installation of a coordinated SPD protection is given in Annex D.

Information on the magnitude of surges created by lightning for the purpose of dimensioning SPDs, at different installation points in the structure, is given in Annex E of IEC 62305-1.

8 Management of an LPMS

To achieve a cost effective and efficient protection system, the design of the protection system for the internal systems should be carried out during the building design stage and before construction. This allows one to optimize the use of the natural components of the structure and to choose the best compromise for the cabling layout and equipment location.

For retrofit to existing structures, the cost of LPMS is generally higher than that the cost for new structures. However, it is possible to minimize the investment cost by a proper choice of LPZ and by using existing installations or by upgrading them.

Proper protection can only be achieved if

- provisions are defined by a lightning protection expert,
- good coordination exists between the different experts involved in the building construction and in the LPMS (e.g. civil and electrical engineers),
- the management plan of 8.1 is followed.

The LPMS shall be maintained by inspection and maintenance. After relevant changes to the structure or to the protection measures, a new risk assessment should be carried out.

8.1 LPMS management plan

Planning and coordination of an LPMS requires a management plan (see Table 2), which begins with an initial risk assessment (IEC 62305-2) to determine the required protection measures needed to reduce the risk to a tolerable level. To accomplish this, the lightning protection zones shall be determined.