INTERNATIONAL STANDARD

IEC 60364-4-44

2001

AMENDMENT 2
2006-08

Amendment 2

Electrical installations of buildings –

Part 4-44:
Protection for safety –
Protection against voltage disturbances and electromagnetic disturbances

*This **English-language** version is derived from the original **bilingual** publication by leaving out all French-language pages. Missing page numbers correspond to the French-language pages.*

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FOREWORD

This amendment has been prepared by IEC technical committee 64: Electrical installations and protection against electrical shock.

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

FDIS	Report on voting
64/1533/FDIS	64/1547/RVD

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

The committee has decided that the contents of this amendment and the base publication will remain unchanged until the maintenance result 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- withdrawn,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.

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440 Introduction

Replace the existing Introduction by the following new Introduction:

440 Introduction

Part 4-44 of IEC 60364 covers the protection of electrical installations and measures against voltage disturbances and electromagnetic disturbances.

The requirements are arranged into three sections as follows:

Clause 442 Protection of low-voltage installations against temporary overvoltages and faults between high-voltage systems and earth

Clause 443 Protection against overvoltages of atmospheric origin or due to switching

Clause 444 Measures against electromagnetic influences

Part 4-44 (2001) brings together these clauses, which were previously published separately.

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440.1 Scope

Replace the existing text by the following:

The rules of this part of IEC 60364 are intended to provide requirements for the safety of electrical installations in the event of voltage disturbances and electromagnetic disturbances generated for different specified reasons.

The rules of this part do not apply to systems that are wholly or partly under the control of public power supply companies (see scope of IEC 60364-1) although voltage and electromagnetic disturbances may be conducted or induced into electrical installations via these supply systems.

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440.2 Normative references

Delete the following normative reference:

IEC 60364-5-548

Insert the following new normative references:

IEC 60950-1, *Information technology equipment – Safety – Part 1: General requirements*

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

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

IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*

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

IEC 61558-2-1, *Safety of power transformers, power supply units and similar – Part 2: Particular requirements for separating transformers for general use*

IEC 61558-2-4, *Safety of power transformers, power supply units and similar – Part 2: Particular requirements for isolating transformers for general use*

IEC 61558-2-6, *Safety of power transformers, power supply units and similar – Part 2: Particular requirements for safety isolating transformers for general use*

IEC 61558-2-15, *Safety of power transformers, power supply units and similar – Part 2-15: Particular requirements for isolating transformers for the supply of medical locations*

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

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Clause 444

Replace the existing Clause 444 (with its subclauses and Figures 44L to 44P) by the following new Clause 444 (to Subclause 444.7.3.2):

444 Measures against electromagnetic influences

444.1 General

Clause 444 provides basic recommendations for the mitigation of electromagnetic disturbances. Electromagnetic Interference (EMI) may disturb or damage information technology systems or information technology equipment as well as equipment with electronic components or circuits. Currents due to lightning, switching operations, short-circuits and other electromagnetic phenomena may cause overvoltages and electromagnetic interference.

These effects are most severe

– where large metal loops exist; and

– where different electrical wiring systems are installed in common routes, e.g. for power supply and for signalling information technology equipment within a building.

The value of the induced voltage depends on the rate of rise (di/dt) of the interference current, and on the size of the loop.

Power cables carrying large currents with a high rate of rise of current (di/dt) (e.g. the starting current of lifts or currents controlled by rectifiers) can induce overvoltages in cables of information technology systems, which can influence or damage information technology equipment or similar electrical equipment.

In or near rooms for medical use, electric or magnetic fields associated with electrical installations can interfere with medical electrical equipment.

This clause provides information for architects of buildings and for designers and installers of electrical installations of buildings on some installation concepts that limit electromagnetic influences. Basic considerations are given here to mitigate such influences that may result in disturbance.

444.2 (void) NOTE This clause is reserved for future input.

444.3 Definitions

See IEC 60364-1 for basic definitions. For the purposes of this document, the following definitions apply:

444.3.1
bonding network
BN
set of interconnected conductive structures that provides an “electromagnetic shield” for electronic systems at frequencies from direct current (DC) to low radio frequency (RF)

[3.2.2 of ETS 300 253:1995]

NOTE The term “electromagnetic shield” denotes any structure used to divert, block or impede the passage of electromagnetic energy. In general, a BN does not need to be connected to earth but BN considered in this standard are connected to earth.

444.3.2
bonding ring conductor
BRC
an earthing bus conductor in the form of a closed ring

[3.1.3 of EN 50310:2000]

NOTE Normally the bonding ring conductor, as part of the bonding network, has multiple connections to the CBN that improves its performance.

444.3.3
common equipotential bonding system
common bonding network
CBN
equipotential bonding system providing both protective-equipotential-bonding and functional-equipotential-bonding

[IEV 195-02-25]

444.3.4
equipotential bonding
provision of electric connections between conductive parts, intended to achieve equi-potentiality

[IEV 195-01-10]

444.3.5
earth-electrode network
ground-electrode network (US)
part of an earthing arrangement comprising only the earth electrodes and their inter-connections

[IEV 195-02-21]

444.3.6
meshed bonding network
MESH-BN
bonding network in which all associated equipment frames, racks and cabinets and usually the DC power return conductor, are bonded together as well as at multiple points to the CBN and may have the form of a mesh

[3.2.2 of ETS 300 253:1995]

NOTE The MESH-BN augments the CBN.

444.3.7
by-pass equipotential bonding conductor/
parallel earthing conductor
PEC
earthing conductor connected in parallel with the screens of signal and/or data cables in order to limit the current flowing through the screens

444.4 Mitigation of Electromagnetic Interference (EMI)

Consideration shall be given by the designer and installer of the electrical installation to the measures described below for reducing the electric and magnetic influences on electrical equipment.

Only electrical equipment, which meets the requirements in the appropriate EMC standards or the EMC requirements of the relevant product standard shall be used.

444.4.1 Sources of EMI

Electrical equipment sensitive to electromagnetic influences should not be located close to potential sources of electromagnetic emission such as

- switching devices for inductive loads,
- electric motors,
- fluorescent lighting,
- welding machines,
- computers,
- rectifiers,
- choppers,
- frequency converters/regulators,
- lifts,
- transformers,
- switchgear,
- power distribution busbars.

444.4.2 Measures to reduce EMI

The following measures reduce electromagnetic interference.

a) For electrical equipment sensitive to electromagnetic influences, surge protection devices and/or filters are recommended to improve electromagnetic compatibility with regard to conducted electromagnetic phenomena.

b) Metal sheaths of cables should be bonded to the CBN.

c) Inductive loops should be avoided by selection of a common route for power, signal and data circuits wiring.

d) Power and signal cables should be kept separate and should, wherever practical, cross each other at right-angles (see 444.6.3).

e) Use of cables with concentric conductors to reduce currents induced into the protective conductor.

f) Use of symmetrical multicore cables (e.g. screened cables containing separate protective conductors) for the electrical connections between convertors and motors, which have frequency controlled motor-drives.

g) Use of signal and data cables according to the EMC requirements of the manufacturer's instructions.

h) Where a lightning protection system is installed,

   - power and signal cables shall be separated from the down conductors of lightning protection systems (LPS) by either a minimum distance or by use of screening. The minimum distance shall be determined by the designer of the LPS in accordance with IEC 62305-3;
   - metallic sheaths or shields of power and signal cables should be bonded in accordance with the requirements for lightning protection given in IEC 62305-3 and IEC 62305-4.

i) Where screened signal or data cables are used, care should be taken to limit the fault current from power systems flowing through the screens and cores of signal cables, or data cables, which are earthed. Additional conductors may be necessary, e.g. a by-pass equipotential bonding conductor for screen reinforcement; see Figure 44.R1.

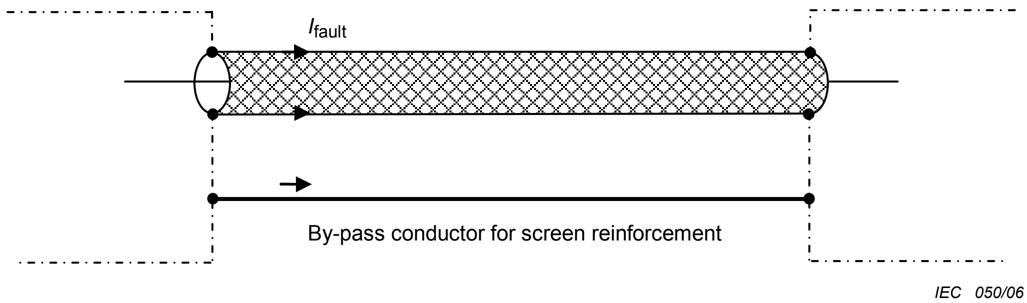


Figure 44.R1 – By-pass conductor for screen reinforcement to provide a common equipotential bonding system

NOTE The provision of a by-pass conductor in proximity to a signal, or data, cable sheath also reduces the area of the loop associated with equipment, which is only connected by a protective conductor to earth. This practice considerably reduces the EMC effects of Lightning Electromagnetic Pulse (LEMP).

j) Where screened signal cables or data cables are common to several buildings supplied from a TT-system, a by-pass equipotential bonding conductor should be used; see Figure 44.R2. The by-pass conductor shall have a minimum cross-sectional area of 16 mm^2 Cu or equivalent. The equivalent cross-sectional area shall be dimensioned in accordance with 544.1 of IEC 60364-5-54.

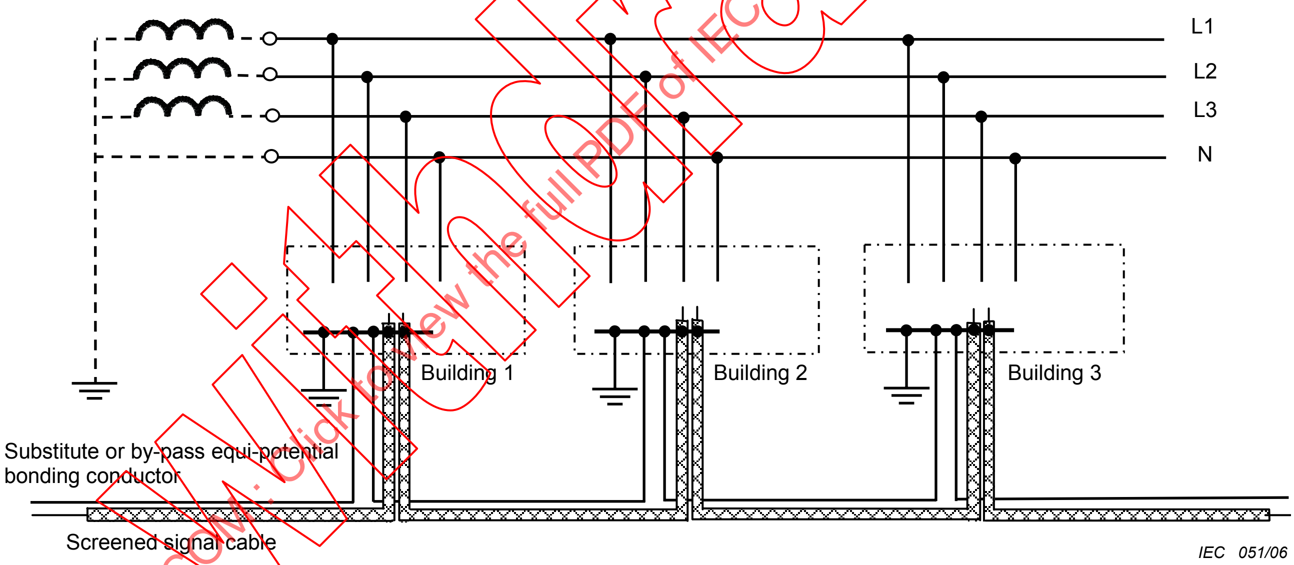


Figure 44.R2 – Example of a substitute or by-pass equipotential bonding conductor in a TT-system

NOTE 1 Where the earthed shield is used as a signal return path, a double-coaxial cable may be used.

NOTE 2 It is recalled that if the consent according to 413.1.2.1 (last paragraph) cannot be obtained, it is the responsibility of the owners or operators to avoid any danger due to the exclusion of those cables from the connection to the main equipotential bonding.

NOTE 3 The problems of earth differential voltages on large public telecommunication networks are the responsibility of the network operator, who may employ other methods.

NOTE 4 In the Netherlands, a by-pass equipotential bonding conductor, connecting the earthing sytems of several TT installations together, is permitted only if fault protection, in accordance with 413.1.4, remains effective in the case of failure of any single RCD.

k) Equipotential bonding connections should have an impedance as low as possible
   - by being as short as possible,
   - by having a cross-section shape that results in low inductive reactance and impedance per metre of route, e.g. a bonding braid with a width to thickness ratio of five to one.

l) Where an earthing busbar is intended (according to 444.5.8) to support the equipotential bonding system of a significant information technology installation in a building, it may be installed as a closed ring.

NOTE This measure is preferably applied in buildings of the telecommunications industry.

444.4.3 TN-system

To minimize electromagnetic influences, the following subclauses apply.

444.4.3.1 It is recommended that TN-C systems should not be maintained in existing buildings containing, or likely to contain, significant amounts of information technology equipment.

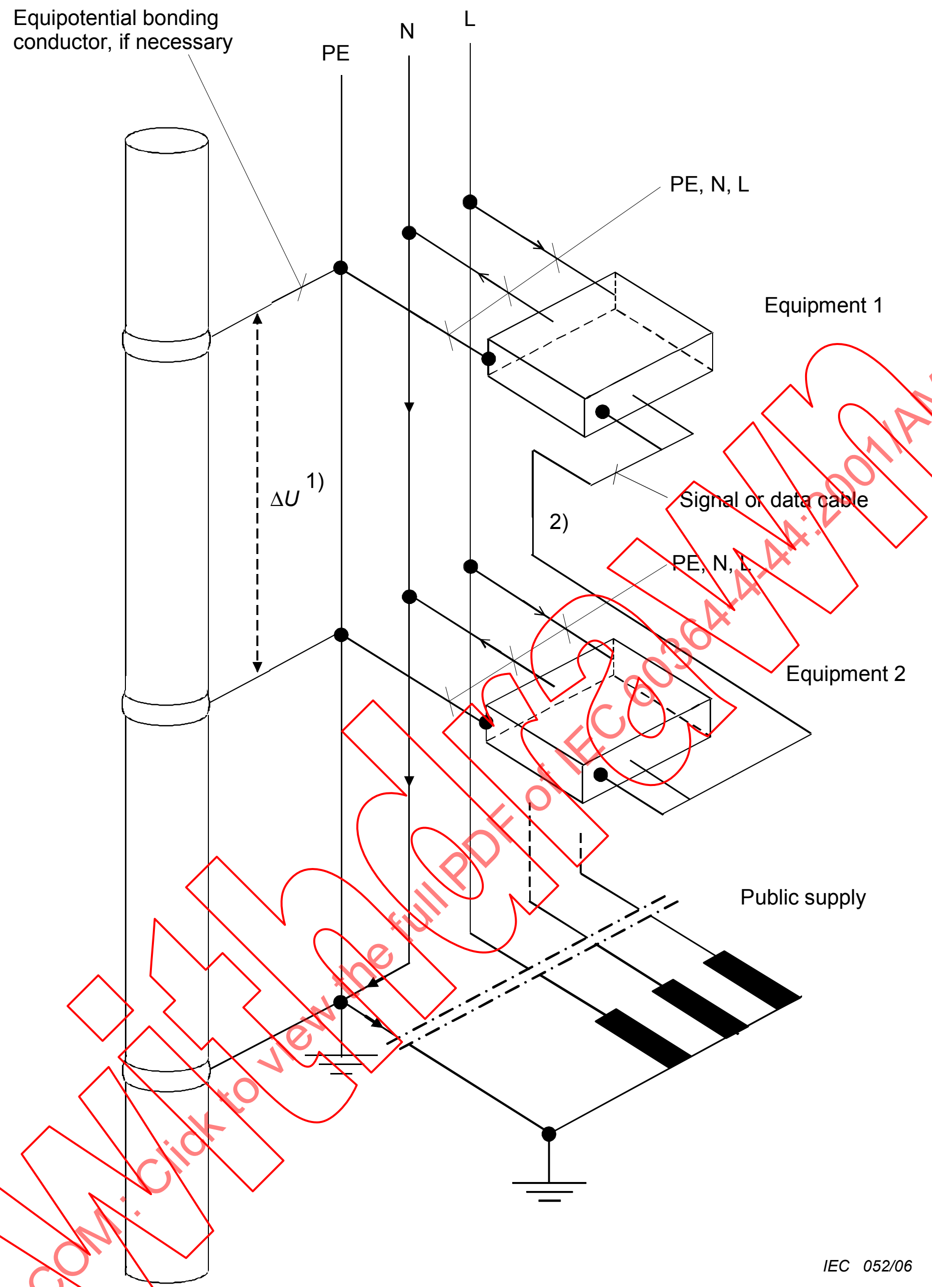
TN-C-systems shall not be used in newly constructed buildings containing, or likely to contain, significant amounts of information technology equipment.

NOTE Any TN-C installation is likely to have load or fault current diverted via equipotential bonding into metallic services and structures within a building.

444.4.3.2 In existing buildings supplied from public low-voltage networks and which contain, or are likely to contain, significant amounts of information technology equipment, a TN-S system should be installed downstream of the origin of the installation; see Figure 44.R3A.

In newly constructed buildings, TN-S systems shall be installed downstream of the origin of the installation; see Figure 44.R3A.

NOTE The effectiveness of a TN-S-system may be enhanced by use of a residual current monitoring device, RCM, complying with IEC 62020.

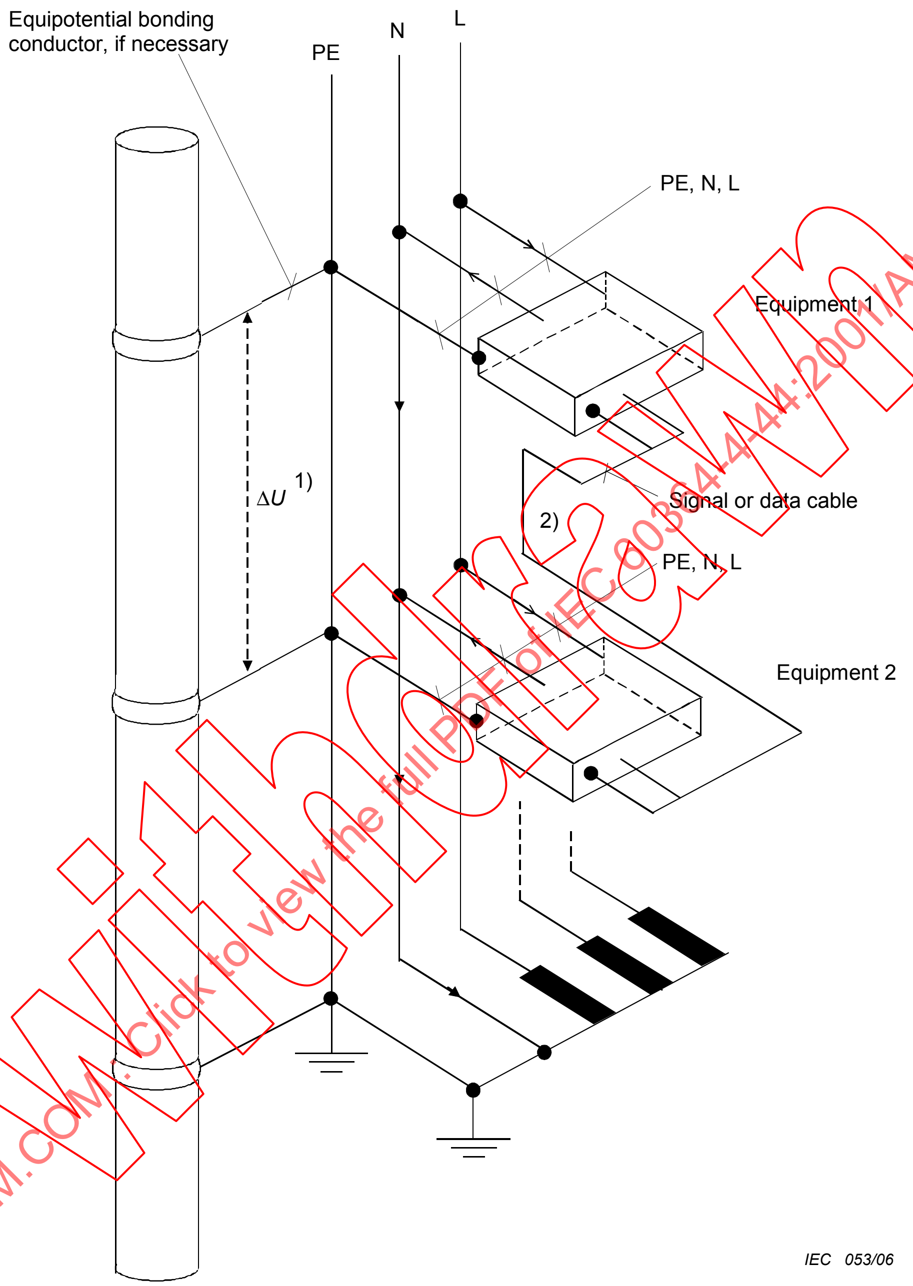


1) No voltage drop ΔU along the PE conductor under normal operation conditions

2) Loops of limited area formed by signal or data cables

Figure 44.R3A – Avoidance of neutral conductor currents in a bonded structure by using the TN-S system from the origin of the public supply up to and including the final circuit within a building

444.4.3.3 In existing buildings where the complete low-voltage installation including the transformer is operated only by the user and which contain, or are likely to contain, significant amounts of information technology equipment, TN-S systems should be installed; see Figure 44.R3B.



1) No voltage drop ΔU along the PE conductor under normal operation conditions

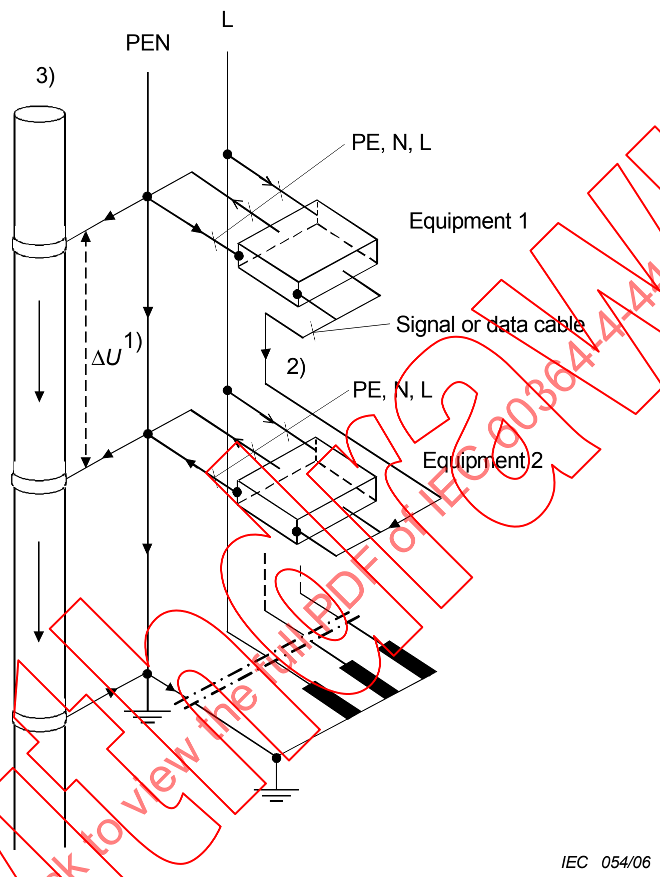
2) Loops of limited area formed by signal or data cables

Figure 44.R3B – Avoidance of neutral conductor currents in a bonded structure by using a TN-S system downstream of a consumer's private supply transformer

444.4.3.4 Where an existing installation is a TN-C-S system (see Figure 44.R4), signal and data cable loops should be avoided by

– changing all TN-C parts of the installation shown in Figure 44.R4 into TN-S, as shown in Figure 44.R3A, or

– where this change is not possible, by avoiding signal and data cable interconnections between different parts of the TN-S installation.



1) Voltage drop ΔU along PEN in normal operation

2) Loop of limited area formed from signal or data cables

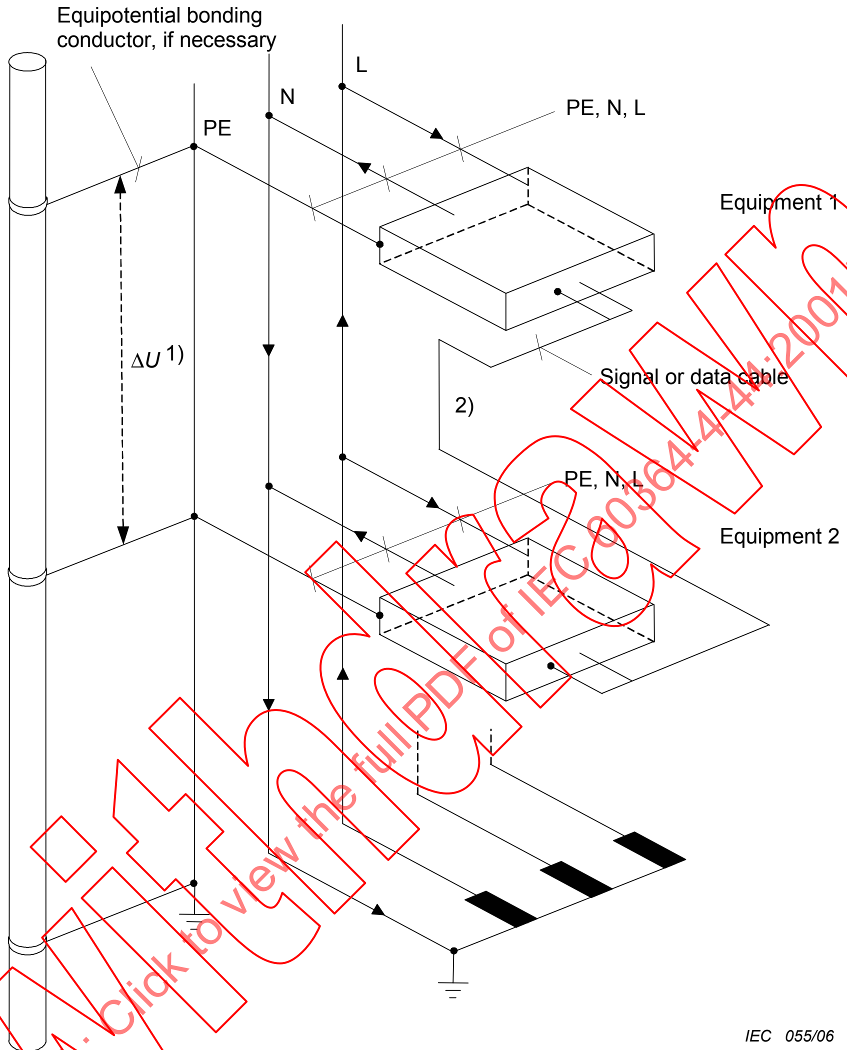
3) Extraneous-conductive-part

NOTE In a TN-C-S system, the current, which in a TN-S system would flow only through the neutral conductor, flows also through the screens or reference conductors of signal cables, exposed-conductive-parts, and extraneous- conductive-parts such as structural metalwork.

Figure 44.R4 – TN-C-S system within an existing building installation

444.4.4 TT system

In a TT system, such as that shown in Figure 44.R5, consideration should be given to overvoltages which may exist between live parts and exposed-conductive-parts when the exposed-conductive-parts of different buildings are connected to different earth electrodes.



1) Voltage drop ΔU along PEN in normal operation

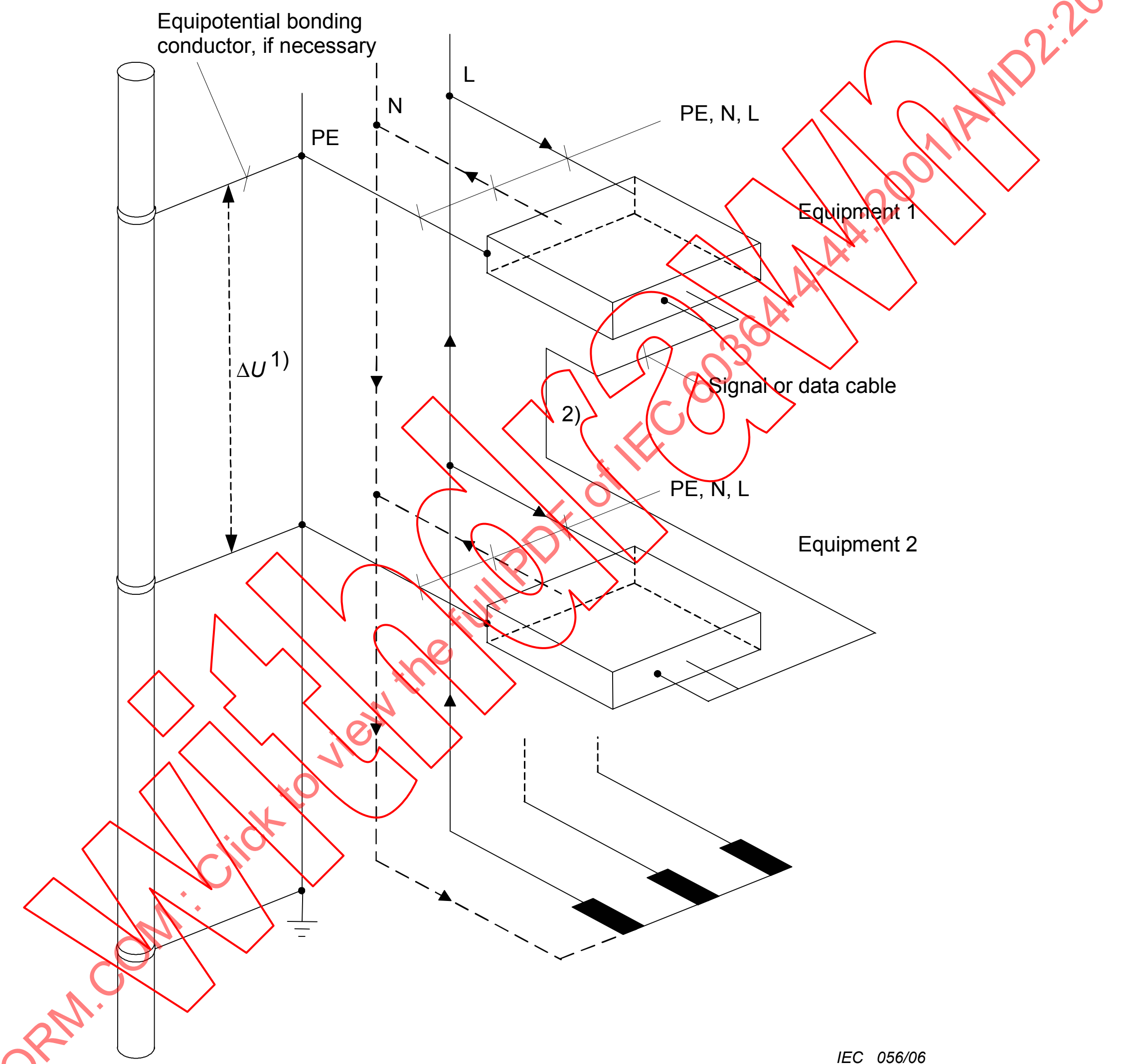
2) Loop of limited area formed from signal or data cables

Figure 44.R5 – TT system within a building installation

444.4.5 IT system

In a three-phase IT system (see Figure 44.R6), the voltage between a healthy line-conductor and an exposed-conductive-part can rise to the level of the line-to-line voltage when there is a single insulation fault between a line conductor and an exposed-conductive-part; this condition should be considered.

NOTE Electronic equipment directly supplied between line conductor and neutral should be designed to withstand such a voltage between line conductor and exposed-conductive-parts; see corresponding requirement from IEC 60950-1 for information technology equipment.



1) Voltage drop ΔU along PEN in normal operation

2) Loop of limited area formed from signal or data cables

Figure 44.R6 – IT system within a building installation

444.4.6 Multiple-source supply

For multiple-source power supplies, the provisions in 444.4.6.1 and 444.4.6.2 shall be applied.

NOTE Where multiple earthing of the star points of the sources of supplies is applied, neutral conductor currents may flow back to the relevant star point, not only via the neutral conductor, but also via the protective conductor as shown in Figure 44.R7A. For this reason the sum of the partial currents flowing in the installation is no longer zero and a magnetic stray field is created, similar to that of a single conductor cable.

In the case of single conductor cables, which carry AC current, a circular electromagnetic field is generated around the core conductor that may interfere with electronic equipment. Harmonic currents produce similar electromagnetic fields but they attenuate more rapidly than those produced by fundamental currents.

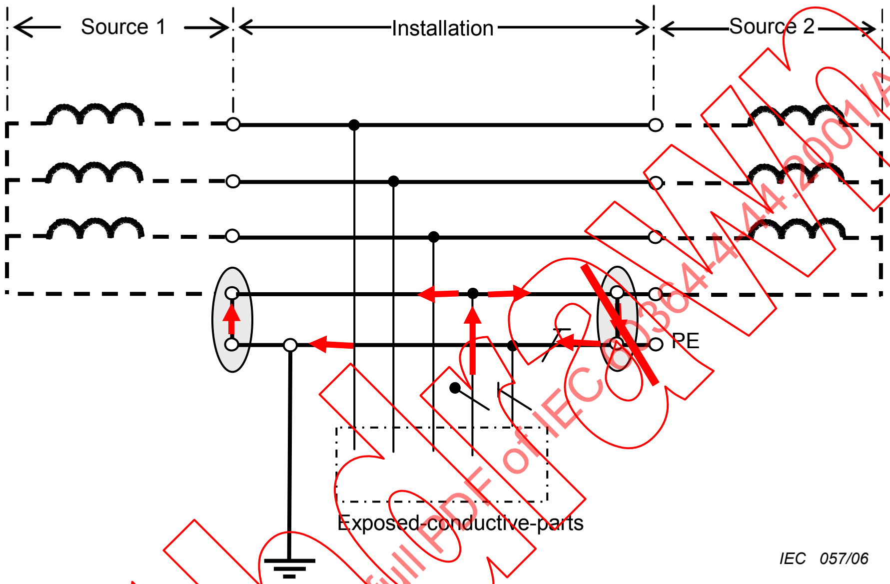
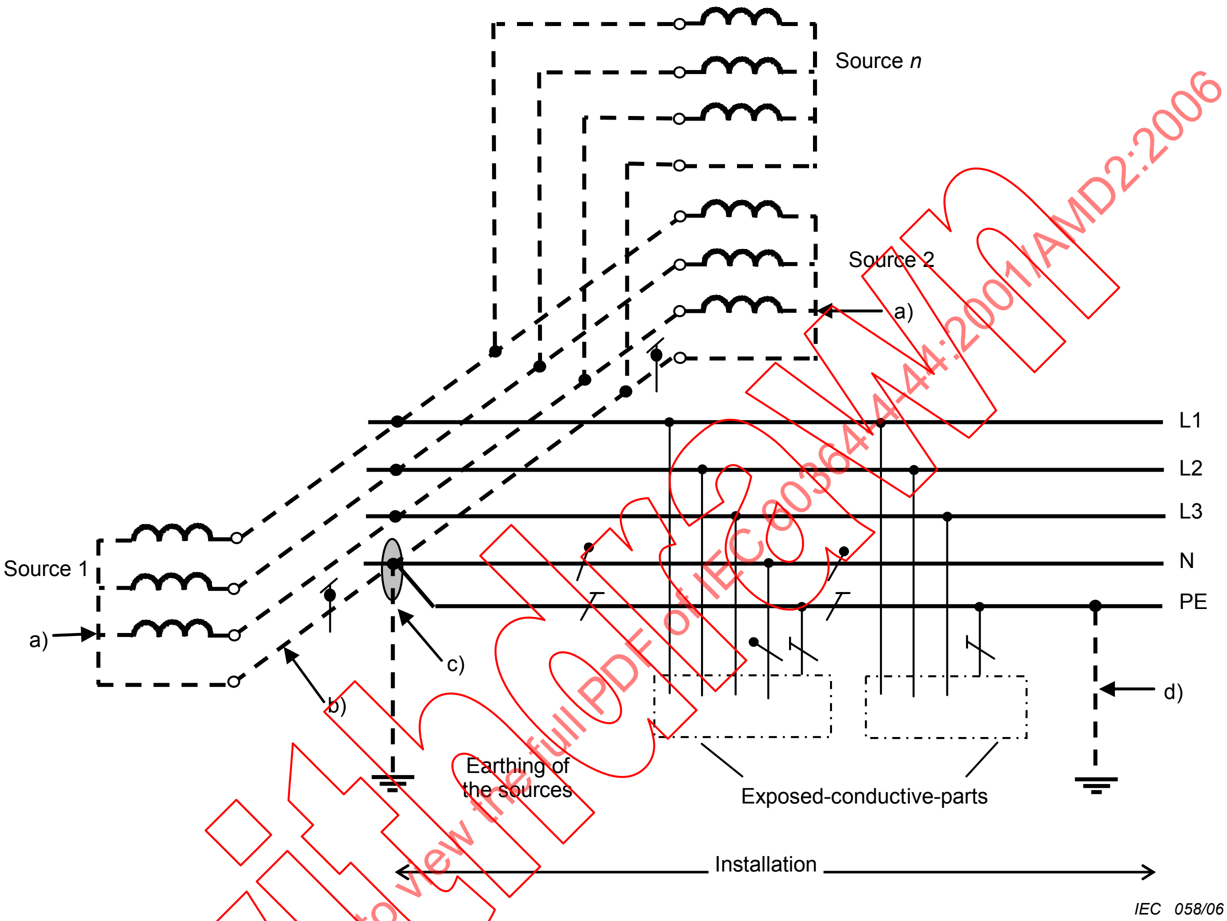


Figure 44.R7A – TN multiple-source power supply with a non-suitable multiple connection between PEN and earth

444.4.6.1 TN multiple source power supplies

In the case of TN multiple-source power supplies to an installation, the star points of the different sources shall, for EMC reasons, be interconnected by an insulated conductor that is connected to earth centrally at one and the same point; see Figure 44.R7B.



a) No direct connection from either transformer neutral points or generator star points to earth is permitted.

b) The conductor interconnecting either the neutral points of transformers, or the star-points of generators, shall be insulated. This conductor functions as a PEN conductor and it may be marked as such; however, it shall not be connected to current-using-equipment and a warning notice to that effect shall be attached to it, or placed adjacent to it.

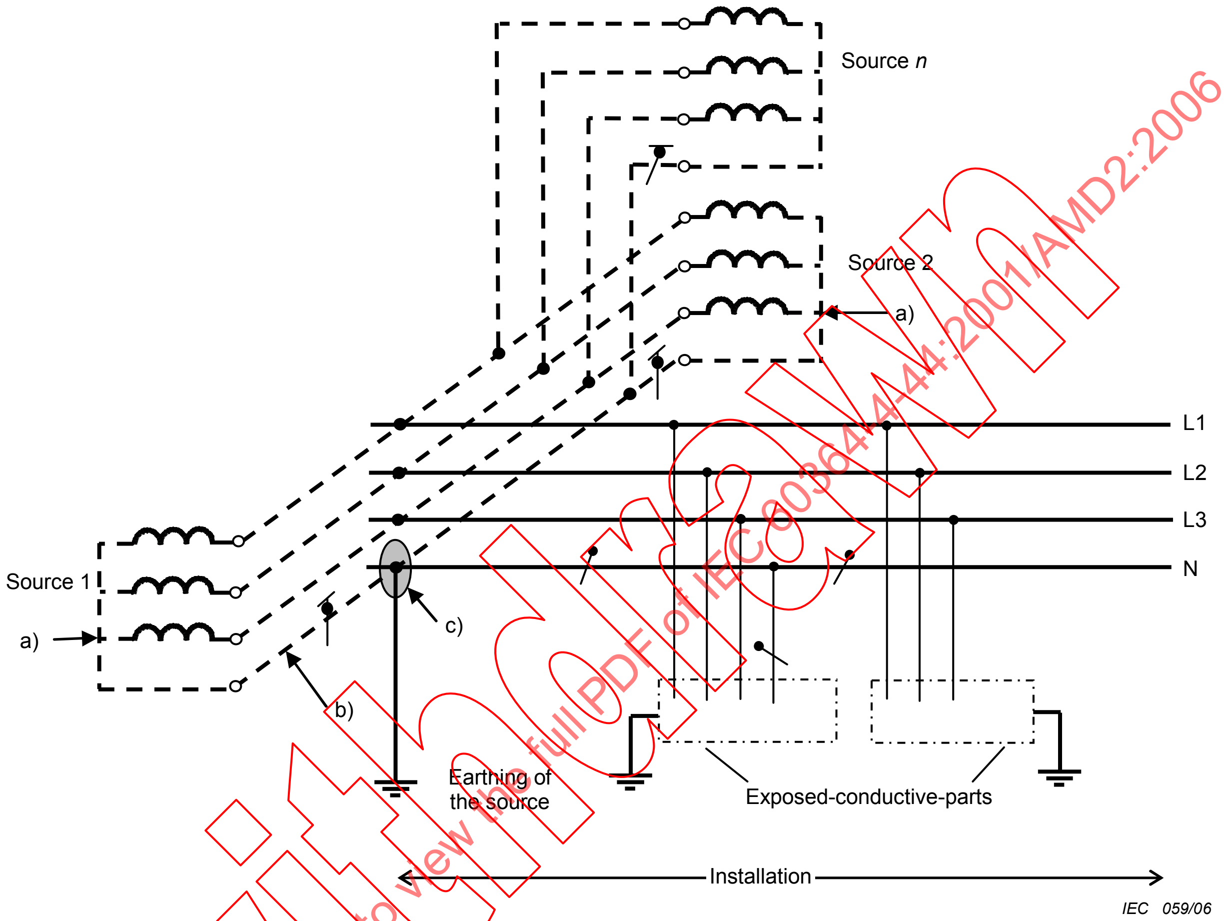
c) Only one connection between the interconnected neutral points of the sources and the PE shall be provided. This connection shall be located inside the main switchgear assembly.

d) Additional earthing of the PE in the installation may be provided.

Figure 44.R7B – TN multiple source power supplies to an installation with connection to earth of the star points at one and the same point

444.4.6.2 TT multiple-source power supplies

In the case of TT multiple-source power supplies to an installation, it is recommended that the star points of the different sources are, for EMC reasons, interconnected and connected to earth centrally at only one point; see Figure 44.R8.



a) No direct connection from either the transformer neutral points or the generator star points to earth is permitted.

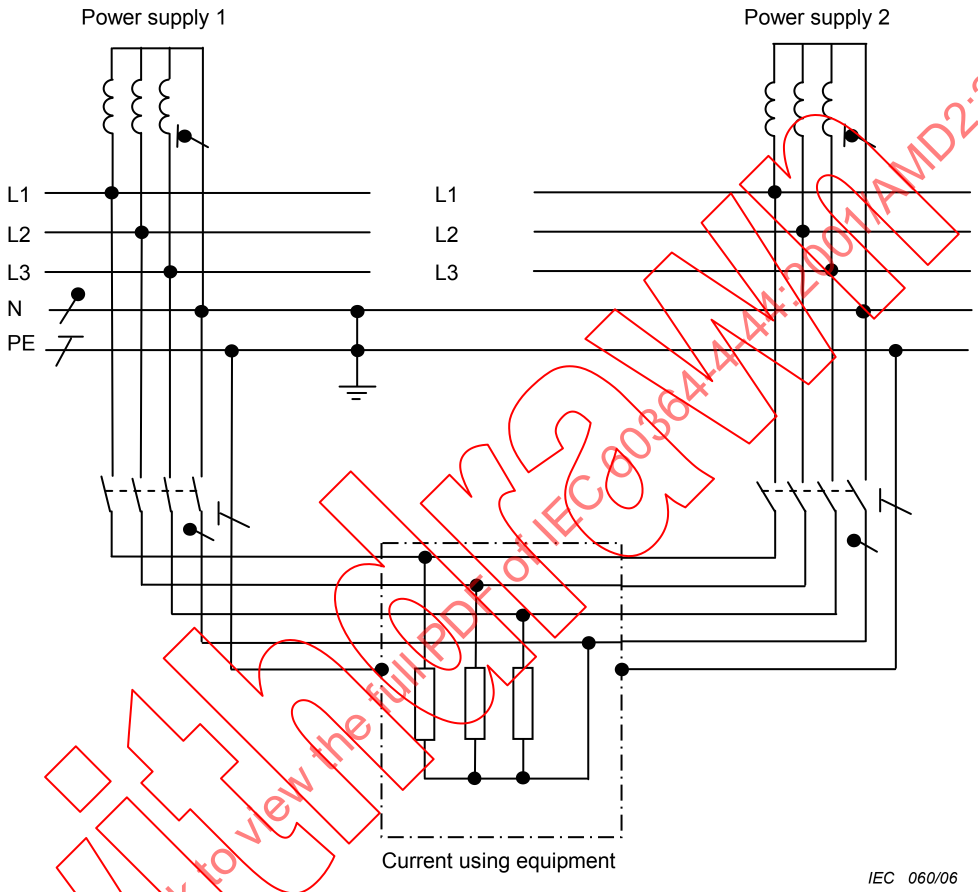
b) The conductor interconnecting either the neutral points of transformers, or generator star points, shall be insulated. This conductor functions as a PEN conductor and it may be marked as such; however, it shall not be connected to current-using-equipment and a warning notice to that effect shall be attached to it, or placed adjacent to it.

c) Only one connection between the interconnected neutral points of the sources and the PE shall be provided. This connection shall be located inside the main switchgear assembly.

Figure 44.R8 – TT multiple-source power supplies to an installation with connection to earth of the star points at one and the same point

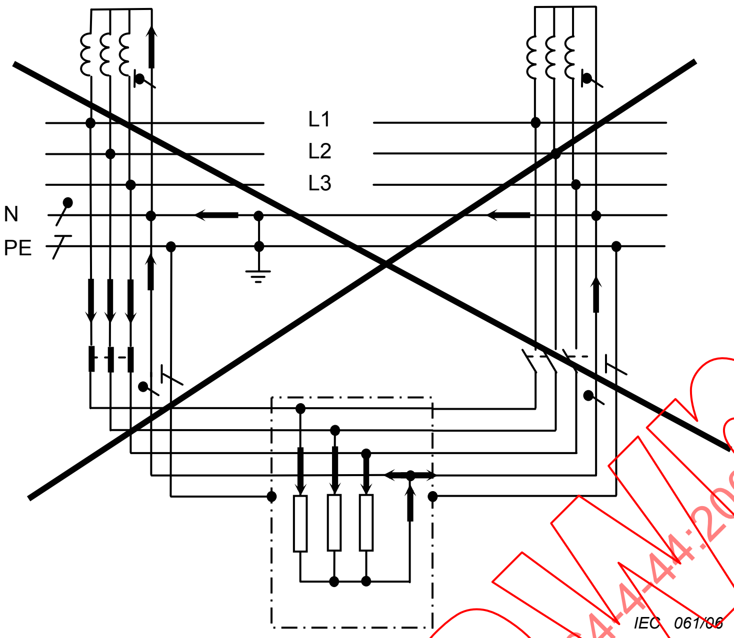
444.4.7 Transfer of supply

In TN systems the transfer from one supply to an alternative supply shall be by means of a switching device, which switches the line conductors and the neutral, if any; see Figures 44.R9A, 44.R9B and 44.R9C.



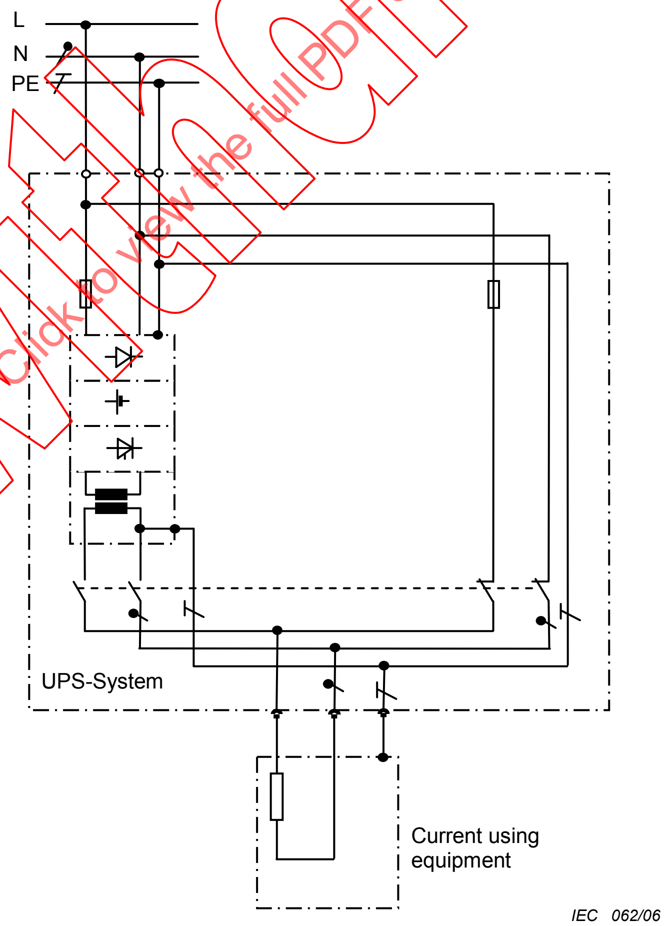
NOTE This method prevents electromagnetic fields due to stray currents in the main supply system of an installation. The sum of the currents within one cable must be zero. It ensures that the neutral current flows only in the neutral conductor of the circuit, which is switched on. The 3rd harmonic (150 Hz) current of the line conductors will be added with the same phase angle to the neutral conductor current.

Figure 44.R9A – Three-phase alternative power supply with a 4-pole switch



NOTE A three-phase alternative power supply with an unsuitable 3-pole switch will cause unwanted circulating currents, that will generate electromagnetic fields.

Figure 44.R9B – Neutral current flow in a three-phase alternative power supply with an unsuitable 3-pole switch



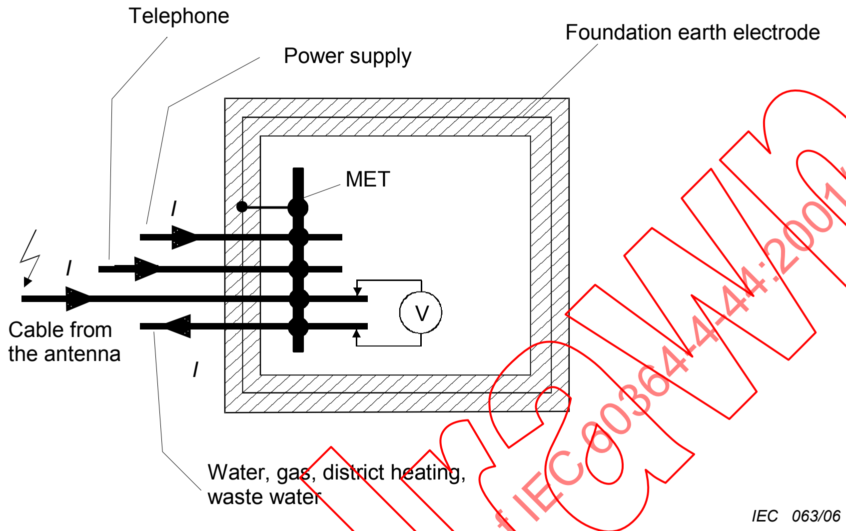
NOTE The earth connection to the secondary circuit of a UPS is not mandatory. If the connection is omitted, the supply in the UPS-mode will be in the form of an IT system and, in by-pass mode, it will be the same as the low-voltage supply system.

Figure 44.R9C – Single-phase alternative power supply with 2-pole switch

444.4.8 Services entering a building

Metal pipes (e.g. for water, gas or district heating) and incoming power and signal cables should preferably enter the building at the same place. Metal pipes and the metal armouring of cables shall be bonded to the main earthing terminal by means of conductors having low impedance; see Figure 44.R10.

NOTE Interconnection is only permitted with the consent of the operator of the external service.



MET Main earthing terminal
I Induction current

NOTE A common entry point is preferred, $U \cong 0$ V.

Figure 44.R10 – Armoured cables and metal pipes entering the buildings (examples)

For EMC reasons, closed building voids housing parts of the electrical installation should be exclusively reserved for electrical and electronic equipment (such as monitoring, control or protection devices, connecting devices, etc.) and access shall be provided for their maintenance.

444.4.9 Separate buildings

Where different buildings have separate equipotential bonding systems, metal-free fibre optic cables or other non-conducting systems may be used for signal and data transmission, e.g. microwave signal transformer for isolation in accordance with IEC 61558-2-1, 2-4, 2-6, 2-15 and IEC 60950-1.

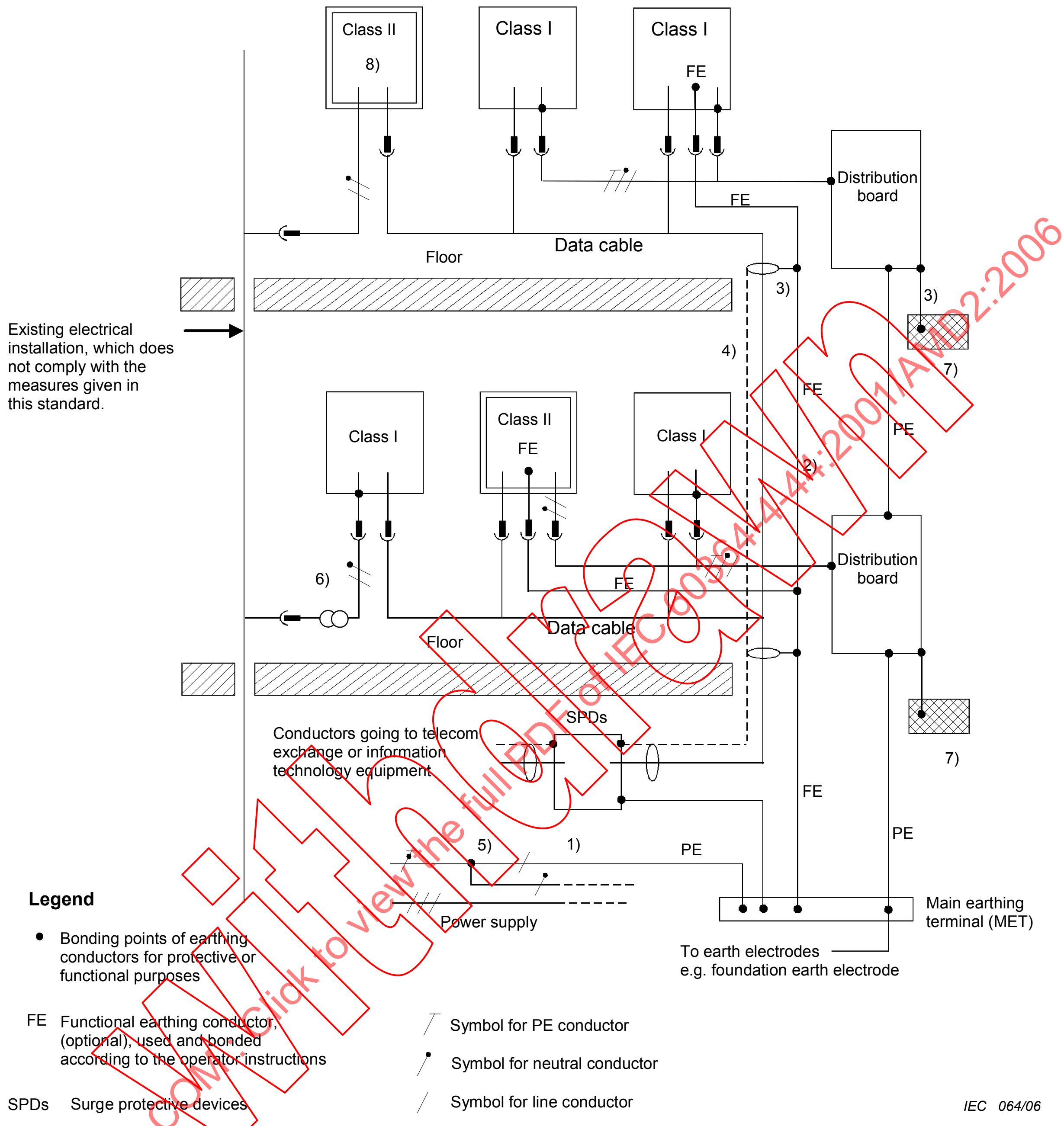
NOTE 1 The problem of earth differential voltages on large public telecommunication networks is the responsibility of the network operator, who may employ other methods.

NOTE 2 In case of non-conducting data-transmission systems, the use of a by-pass conductor is not necessary.

444.4.10 Inside buildings

Where there are problems in existing building installations due to electromagnetic influences, the following measures may improve the situation; see Figure 44.R11:

1) use of metal free fibre optic links for signal and data circuits, see 444.4.9;
2) use of Class II equipment;
3) use of double winding transformers in compliance with IEC 61558-2-1 or IEC 61558-2-4 or IEC 61558-2-6 or IEC 61558-2-15. The secondary circuit should preferably be connected as a TN-S system but an IT-system may be used where required for specific applications.



Reference	Description of the illustrated measures	Subclause
1)	Cables and metal pipes enter the building at the same place	444.4.8
2)	Common route with adequate separations and avoidance of loops	444.4.2
3)	Bonding leads as short as possible, and use of earthed conductor parallel to a cable	IEC 61000-2-5 444.4.2
4)	Signal cables screened and/or conductors twisted pairs	444.4.12
5)	Avoidance of TN-C beyond the incoming supply point	444.4.3
6)	Use of transformers with separate windings	444.4.10
7)	Local horizontal bonding system	444.5.4
8)	Use of class II equipment	444.4.10

Figure 44.R11 – Illustration of measures in an existing building

444.4.11 Protective devices

Protective devices with appropriate functionality for avoiding unwanted tripping due to high levels of transient currents should be selected, e.g. time delays and filters.

444.4.12 Signal cables

Shielded cables and/or twisted pair cables should be used for signal cables.

444.5 Earthing and equipotential bonding

444.5.1 Interconnection of earth electrodes

For several buildings, the concept of dedicated and independent earth electrodes connected to an equipotential conductor network may not be adequate where electronic equipment is used for communication and data exchange between the different buildings for the following reasons:

– a coupling exists between these different earth electrodes and leads to an uncontrolled increase of voltage to equipment;

– interconnected equipment may have different earth references;

– a risk of electric shock exists, specifically in case of overvoltages of atmospheric origin.

Therefore, all protective and functional earthing conductors should be connected to one single main earthing terminal.

Moreover, all earth electrodes associated with a building i.e. protective, functional and lightning protection, shall be interconnected; see Figure 44.R12.

In the case of several buildings, where interconnection of the earth electrodes is not possible or practical, it is recommended that galvanic separation of communication networks is applied, for instance by the use of fibre optic links; see also 444.4.10.

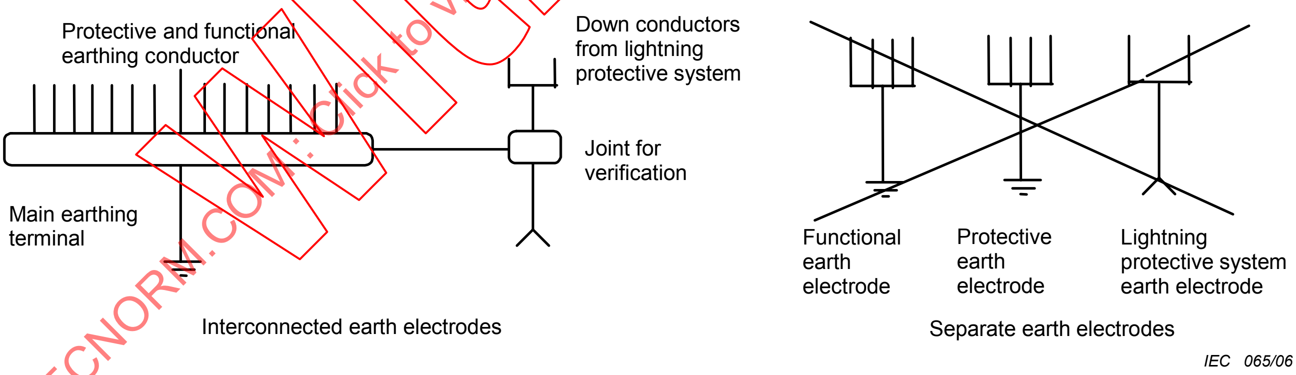


Figure 44.R12 – Interconnected earth electrodes

Protective and functional bonding conductors shall be connected individually to the main earthing terminal in such a way that if one conductor becomes disconnected the connections of all the other conductors remain secured.

444.5.2 Interconnection of incoming networks and earthing arrangements

Exposed-conductive-parts of information technology and electronic equipment within a building are interconnected via protective conductors.

For dwellings where normally a limited amount of electronic equipment is in use, a protective conductor network in the form of a star network may be acceptable; see Figure 44.R13.

For commercial and industrial buildings and similar buildings containing multiple electronic applications, a common equipotential bonding system is useful in order to comply with the EMC requirements of different types of equipment; see Figure 44.R15.

444.5.3 Different structures for the network of equipotential conductors and earthing conductors

The four basic structures described in the following subclauses may be used, depending on the importance and vulnerability of equipment.

444.5.3.1 Protective conductors connected to a bonding-ring conductor

An equipotential bonding network in the form of a bonding ring conductor, BRC, is shown in Figure 44.R16 on the top-floor of the structure. The BRC should preferably be made of copper, bare or insulated, and installed in such a manner that it remains accessible everywhere, e.g. by using a cable-tray, metallic conduit (see IEC 61386 series), surface mounted method of installation or cable trunking. All protective and functional earthing conductors may be connected to the BRC.

444.5.3.2 Protective conductors in a star network

This type of network is applicable to small installations associated with dwellings, small commercial buildings, etc., and from a general point of view to equipment, that is not interconnected by signal cables; see Figure 44.R13.

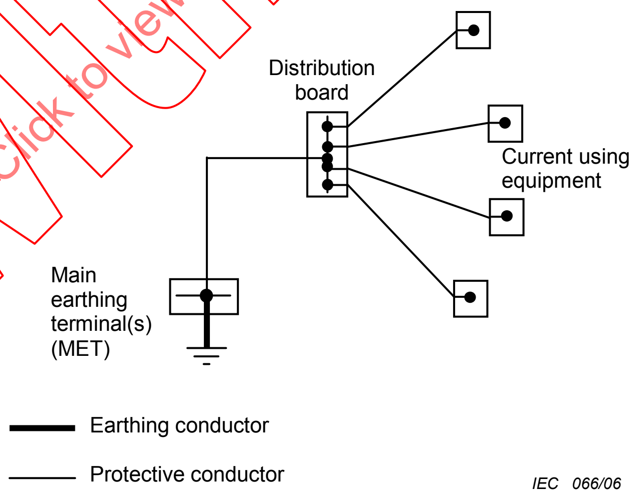


Figure 44.R13 – Examples of protective conductors in star network

444.5.3.3 Multiple meshed bonding star network

This type of network is applicable to small installations with different small groups of interconnected communicating equipment. It enables the local dispersion of currents caused by electromagnetic interference; see Figure 44.R14.

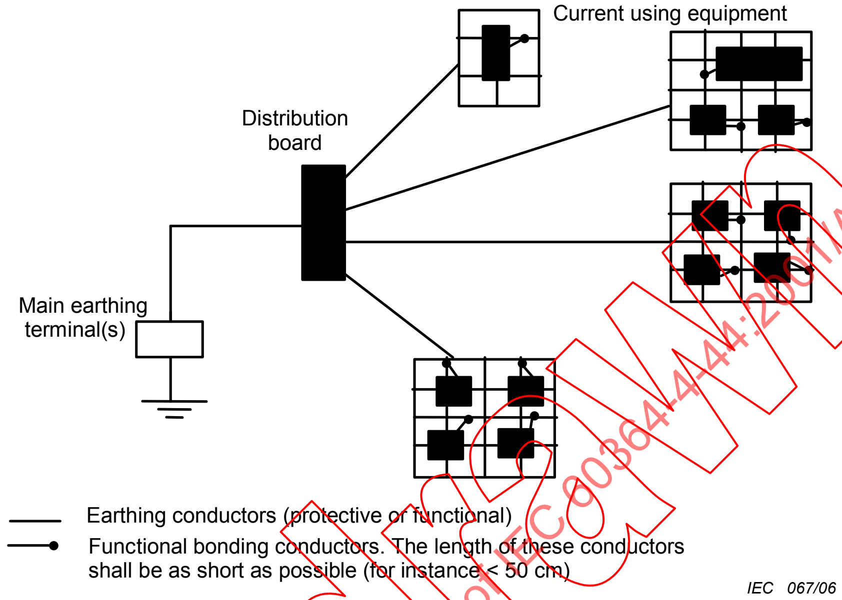


Figure 44.R14 – Example of multiple meshed bonding star network

444.5.3.4 Common meshed bonding star network

This type of network is applicable to installations with high density of communicating equipment corresponding to critical applications; see Figure 44.R15.

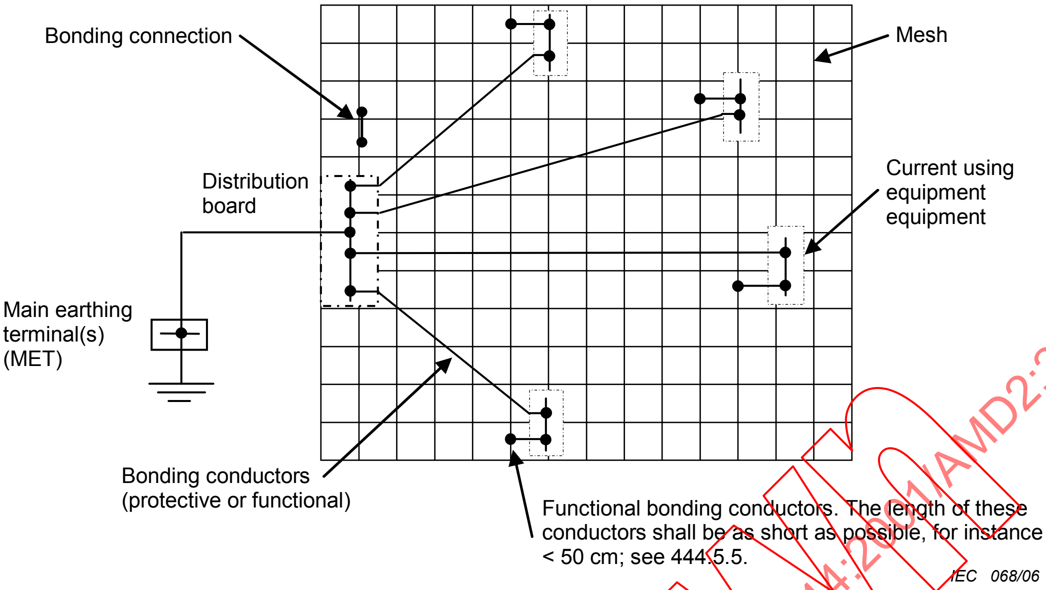
A meshed equipotential bonding network is enhanced by the existing metallic structures of the building. It is supplemented by conductors forming the square mesh.

The mesh-size depends on the selected level of protection against lightning, on the immunity level of equipment part of the installation and on frequencies used for data transmission.

Mesh-size shall be adapted to the dimensions of the installation to be protected, but shall not exceed 2 m × 2 m in areas where equipment sensitive to electromagnetic interferences is installed.

It is suitable for protection of private automatic branch exchange equipment (PABX) and centralized data processing systems.

In some cases, parts of this network may be meshed more closely in order to meet specific requirements.



The area covered by a mesh shall have overall dimensions; the mesh-size refers to the dimensions of square spaces enclosed by the conductors forming the mesh.

Figure 44.R15 – Example of a common meshed bonding star network

444.5.4 Equipotential bonding networks in buildings with several floors

For buildings with several floors, it is recommended that, on each floor, an equipotential bonding system be installed; see Figure 44.R16 for examples of bonding networks in common use; each floor is a type of network. The bonding systems of the different floors should be interconnected, at least twice, by conductors.

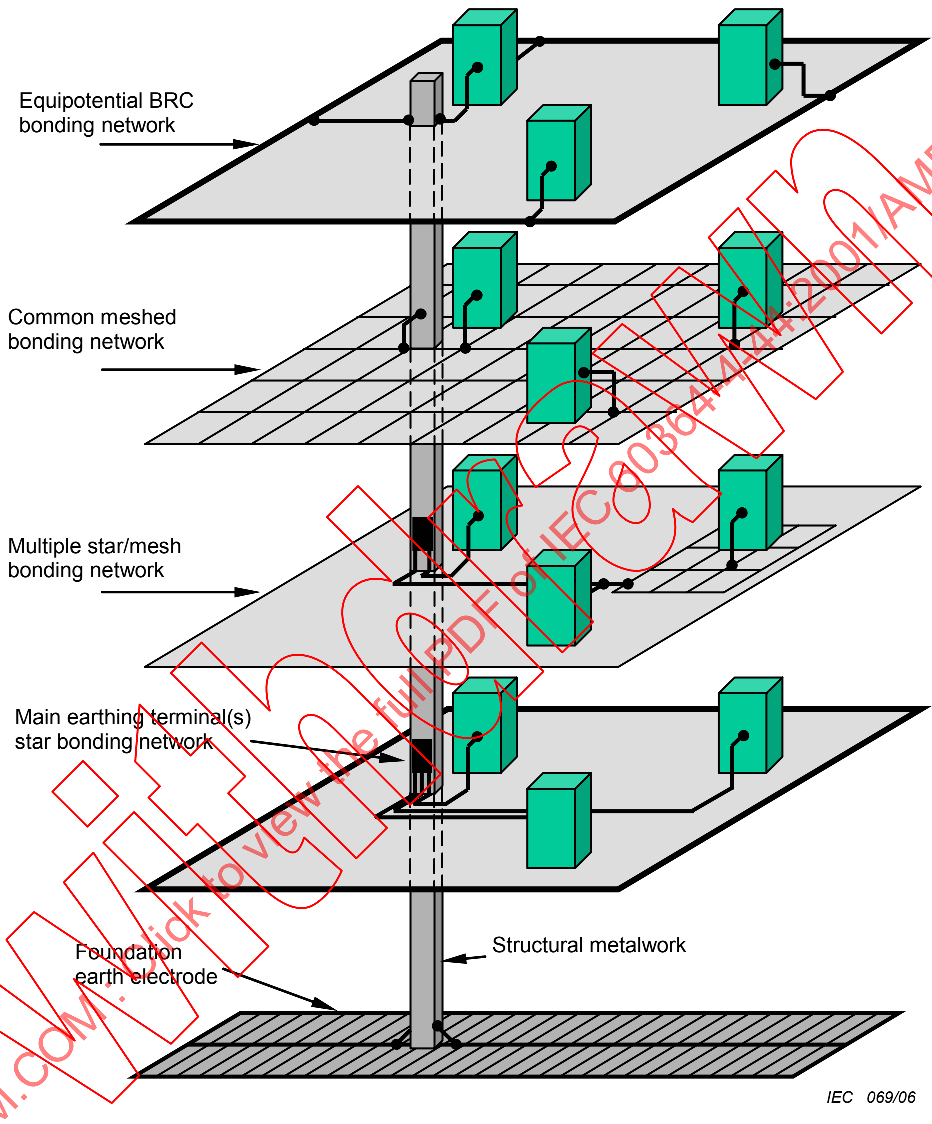


Figure 44.R16 – Example of equipotential bonding networks in structures without lightning protection systems

444.5.5 Functional earthing conductor

Some electronic equipment requires a reference voltage at about earth potential in order to function correctly; this reference voltage is provided by the functional earthing conductor.

Conductors for functional earthing may be metallic strips, flat braids and cables with circular cross section.

For equipment operating at high frequencies, metallic strips or flat braids are preferred and the connections shall be kept as short as possible.

No colour is specified for functional earthing conductors. However, the colours green-and-yellow specified for earthing conductors shall not be used. It is recommended that the same colour is used throughout the whole installation to mark functional earthing conductors at each end.

For equipment operating at low frequencies, cross sectional areas as indicated in 554.1.1 of IEC 60364-5-54 are considered satisfactory, independent of the conductor shape, see 444.4.2 b) and k).

444.5.6 Commercial or industrial buildings containing significant amounts of information technology equipment

The following additional specifications are intended to reduce the influences of electromagnetic disturbances on the information technology equipment operation.

In severe electromagnetic environments, it is recommended that the common meshed bonding star network described in 444.5.3.3 be adopted.

444.5.6.1 Sizing and installation of bonding ring network conductors

Equipotential bonding designed as a bonding ring network shall have the following minimum dimensions:

- flat copper cross-section: 30 mm × 2 mm
- round copper diameter: 8 mm

Bare conductors shall be protected against corrosion at their supports and on their passage through walls.

444.5.6.2 Parts to be connected to the equipotential bonding network

The following parts shall also be connected to the equipotential bonding network:

- conductive screens, conductive sheaths or armouring of data transmission cables or of information technology equipment;
- earthing conductors of antenna systems;
- earthing conductors of the earthed pole of DC supply for information technology equipment;
- functional earthing conductors.

444.5.7 Earthing arrangements and equipotential bonding of information technology installations for functional purposes

444.5.7.1 Earthing busbar

Where an earthing busbar is required for functional purposes, the main earthing terminal (MET) of the building may be extended by using an earthing busbar. This enables information technology installations to be connected to the main earthing terminal by the shortest practical route from any point in the building. Where the earthing busbar is erected to support the equipotential bonding network of a significant amount of information technology equipment in a building, it may be installed as a bonding ring network; see Figure 44.R16.

NOTE 1 The earthing busbar may be bare or insulated.

NOTE 2 The earthing busbar should preferably be installed so that it is accessible throughout its length, e.g. on the surface of trunking. To prevent corrosion, it may be necessary to protect bare conductors at supports and where they pass throughout walls.

444.5.7.2 Cross-sectional area of the earthing busbar

The effectiveness of the earthing busbar depends on the routing and the impedance of the conductor employed. For installations connected to a supply having a capacity of 200 A per phase or more, the cross-sectional area of the earthing busbar shall be not less than 50 mm^2 copper and shall be dimensioned in accordance with 444.4.2 k).

NOTE This statement is valid for frequencies up to 10 MHz.

Where the earthing busbar is used as part of a DC return current path, its cross-sectional area shall be dimensioned according to the expected DC return currents. The maximum DC voltage drop along each earthing busbar, dedicated as DC distribution return conductor, shall be designed to be less than 1 V.

444.6 Segregation of circuits

444.6.1 General

Information technology cables and power supply cables, which share the same cable management system or the same route, shall be installed according to the requirements of the following subclauses.

Verification of electrical safety, in accordance with IEC 60364-6-61 and/or 528.1 of IEC 60364-5-52, and electrical separation are required; see Clause 413 of IEC 60364-4-41 and/or 444.7.2. Electrical safety and electromagnetic compatibility require different clearances in some cases. Electrical safety always has the higher priority.

Exposed conductive parts of wiring systems, e.g. sheaths, fittings and barriers, shall be protected by requirements for fault protection; see clause 413 of IEC 60364-4-41.

444.6.2 Design guidelines

The minimum separation between power cables and information technology cables to avoid disturbance is related to many factors such as the

a) immunity level of equipment connected to the information technology cabling system to different electromagnetic disturbances (transients, lightning pulses, bursts, ring wave, continuous waves, etc.);
b) connection of equipment to earthing systems;
c) local electromagnetic environment (simultaneous appearance of disturbances, e.g. harmonics plus bursts plus continuous wave);
d) electromagnetic frequency spectrum;