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SERIES K: PROTECTION AGAINST INTERFERENCE

**Protection of customer premises from
overvoltages**

Recommendation ITU-T K.66



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Protection of customer premises from overvoltages

Summary

Recommendation ITU-T K.66:

- provides recommendations for bonding and earthing of telecommunication equipment in residential and commercial customer premises;
- refers to Recommendation ITU-T K.21 (2008) for equipment resistibility requirements;
- recommends earthing and bonding requirements to coordinate with the resistibility requirements of Recommendation ITU-T K.21 (2008) and the safety requirements of IEC 60950-1 and IEC 62368;
- recommends the installation practices for bonding of all services and the installation of surge protective devices (SPDs);
- illustrates problems associated with earthing and bonding and provides solutions for these earthing and bonding problems. These include:
 - 1) methods to improve the earthing and bonding;
 - 2) methods of providing additional protection external to the equipment;
 - 3) special resistibility and safety requirements;
- recommends responsibilities for protection at customer premises;
- refers to IEC 62305-3 for protection against direct lightning.

This revision of ITU-T K.66 includes an update of the references and a revision of clause 6.3 to include more information on preventing equipment damage. Appendix IV, containing information on special resistibility requirements has been deleted; the reader is directed to Recommendation ITU-T K.44 (2008).

History

Edition	Recommendation	Approval	Study Group
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FOREWORD

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The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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Introduction

Overvoltage protection may be required for safety of persons and for protection of equipment. To provide this protection, it is necessary to bond metallic services and screens to the building earth and install SPDs at the building entry point on power and telecommunication conductors. This will reduce the risk of people using these services being injured during a.c. fault conditions and during lightning storms. These methods will also provide a level of protection for equipment connected to one or more of these services. The building owner may elect to install protection at the building entry point in areas deemed not at risk by the service operator to protect against injury or equipment damage.

The increasing use and interconnection of complex electronic telecommunication equipment, such as ISDN terminals, modems and computers, at customers' buildings requires special care for protecting against overvoltages and overcurrents. Such overvoltages and overcurrents include exposure of the serving telecommunications cable and power line to lightning, and the coupling of a.c. voltages onto the telecommunication cable due to faults on the external power system. Properly configured equipotential bonding within the building helps to achieve the necessary protection, while also helping to ensure the safety of those using terminal equipment.

[IEC 60950-1] assumes that the telecommunication network operator will install overvoltage protection at the network termination to prevent overvoltages from exceeding 1.5 kV for the majority of surges. The standard way to do this is to install primary protection in lightning-prone areas. Limiting the overvoltage to 1.5 kV for the majority of di/dt expected to occur, in the case of a direct strike to the premises or to one of the services, requires good earthing and bonding techniques.

This Recommendation includes how the responsibilities for protection are shared between the service provider and the customer. Generally, the overvoltage protection has been required for terminal equipment that has been traditionally under the network operator's responsibility. Due to liberalization in telecommunications, the customer may now own this type of equipment. Customer ownership is expected to extend to even more types of equipment in the future. It is reasonable that the electromagnetic environment in the customers' premises should be the major dimensioning factor for protection needs and not its ownership. The electromagnetic environment effect is, on one hand, dependent on the type and probability of the occurrence of the electromagnetic phenomena and, on the other hand, on the physical layout of the equipment installation. Effective protection requires that the service provider have access to an equipotential bonding bar (EBB) complying with [IEC 60364-1] and this Recommendation. As some of the practices required to achieve good earthing and bonding are beyond the control of the telecommunication network operator, this Recommendation allocates responsibility to other parties, e.g., the building owner/occupier. It is clear that the electrical installations of buildings are a part of the protection for safety and are the responsibility of the building owner.

Good earthing and bonding is usually easy to achieve in new buildings and is the main thrust of this Recommendation. For existing buildings, it may be difficult and expensive to upgrade the installation. In this case, alternative methods of protecting the installation (customer and equipment) are provided in Annex B.

Recommendation ITU-T K.66

Protection of customer premises from overvoltages

1 Scope

This Recommendation:

- provides practices for installing protection at residential and commercial customers' premises;
- is intended to comply with [IEC 60364-5-54] or national standardizing bodies on a.c. power installations;
- is intended for use with new installations as well as for expansion and upgrading of existing installations;
- is intended to encourage planning for electromagnetic compatibility and safety, which should include bonding and earthing arrangements that accommodate installation tests and diagnostics;
- is not intended to replace national regulations on bonding configurations and earthing.

For telecommunication equipment resistibility requirements, see [ITU-T K.21]. Permissible levels of electromagnetic emissions are covered by [CISPR 22], or by national regulations. Concerning the need for overvoltage protectors, see [ITU-T K.11], [ITU-T K.39], [ITU-T K.46], [ITU-T K.47] and [IEC 62305-2]. Concerning the need for a lightning protection system (LPS), see [IEC 62305-2] and national regulations.

This Recommendation is intended for customers' buildings, including residential and commercial installations.

This Recommendation is not mandatory but intends to promote 'best practice' protection methods by operators and regulators.

Areas subject to a.c. earth potential rise (EPR), e.g., substations, may require additional protection measures. See "Directives concerning the protection of telecommunication lines against harmful effects from electric power and electrified railway lines", Volumes VII and VIII (ITU handbook).

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- | | |
|--------------|---|
| [ITU-T K.11] | Recommendation ITU-T K.11 (2009), <i>Principles of protection against overvoltages and overcurrents</i> . |
| [ITU-T K.12] | Recommendation ITU-T K.12 (2010), <i>Characteristics of gas discharge tubes for the protection of telecommunication installations</i> . |
| [ITU-T K.21] | Recommendation ITU-T K.21 (2008), <i>Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents</i> . |
| [ITU-T K.27] | Recommendation ITU-T K.27 (1996), <i>Bonding configurations and earthing inside a telecommunication building</i> . |

- [ITU-T K.39] Recommendation ITU-T K.39 (1996), *Risk assessment of damages to telecommunication sites due to lightning discharges.*
- [ITU-T K.44] Recommendation ITU-T K.44 (2008), *Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation.*
- [ITU-T K.46] Recommendation ITU-T K.46 (2008), *Protection of telecommunication lines using metallic symmetric conductors against lightning-induced surges.*
- [ITU-T K.47] Recommendation ITU-T K.47 (2008), *Protection of telecommunication lines using metallic conductors against direct lightning discharges.*
- [ITU-T K.65] Recommendation ITU-T K.65 (2011), *Overvoltage and overcurrent requirements for termination modules with contacts for test ports or surge protective devices.*
- [ITU-T K.67] Recommendation ITU-T K.67 (2006), *Expected surges on telecommunications and signalling networks due to lightning.*
- [ITU-T K.72] Recommendation ITU-T K.72 (2008), *Protection of telecommunication lines using metallic conductors against lightning – Risk management.*
- [ITU-T K.75] Recommendation ITU-T K.75 (2008), *Classification of interface for application of standards on resistibility and safety of telecommunication equipment.*
- [CISPR 22] CISPR 22 ed.6.0 (2008), *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement.*
- [IEC 60050-604] IEC 60050-604 ed.1 (1987), *International Electrotechnical Vocabulary, Chapter 604: Generation, transmission and distribution of electricity – Operation.*
- [IEC 60050-826] IEC 60050-826 ed.2 (2004), *International Electrotechnical Vocabulary, Part 826: Electrical installations.*
- [IEC 60364-1] IEC 60364-1 ed.5.0 (2005-11), *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions.*
- [IEC 60364-4-44] IEC 60364-4-44 (2007-08), *Low-voltage electrical installations– Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances.*
- [IEC 60364-5-54] IEC 60364-5-54 ed.2.0 (2002-06), *Electrical installations of buildings – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors.*
- [IEC 60950-1] IEC 60950-1 ed.2.0 (2005-12), *Information technology equipment – Safety – Part 1: General requirements.*
- [IEC 61643-11] IEC 61643-11 ed.1 (2011-03), *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods.*
- [IEC 61643-12] IEC 61643-12 ed.2.0 (2008-11), *Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles.*
- [IEC 61643-21] IEC 61643-21 ed.1.1 (2009-04), *Low-voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signalling networks – Performance requirements and testing methods.*

[IEC 61643-22]	IEC 61643-22 ed.1 (2004-11), <i>Low-voltage surge protective devices – Part 22: Surge protective devices connected to telecommunications and signalling networks – Selection and application principles.</i>
[IEC 61643-311]	IEC 61643-311 ed.1 (2001-10), <i>Components for low-voltage surge protective devices – Part 311: Specification for gas discharge tubes (GDT).</i>
[IEC 62305-1]	IEC 62305-1 ed.2 (2010-12), <i>Protection against lightning – Part 1: General principles.</i>
[IEC 62305-2]	IEC 62305-2 ed.2 (2010-12), <i>Protection against lightning – Part 2: Risk management.</i>
[IEC 62305-3]	IEC 62305-3 ed.2 (2010-12), <i>Protection against lightning – Part 3: Physical damage to structures and life hazard.</i>
[IEC 62305-4]	IEC 62305-4 ed.2 (2010-12), <i>Protection against lightning – Part 4: Electrical and electronic systems within structures.</i>
[IEC/TR 62102]	IEC/TR 62102 ed.2 (2005-05), <i>Electrical Safety – Classification of interfaces for equipment to be connected to information and communications technology networks.</i>

3 Definitions

3.1 Terms defined elsewhere

In this Recommendation, earthing definitions already introduced by [IEC 60050-604] are used to maintain conformity. Definitions in [ITU-T K.27], related to bonding configurations and earthing, also apply.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 bonding terminal: A terminal provided to allow easy connection of bonding conductors at point of entry of services. The bonding terminal is connected to a main earth terminal (MET) or to an equipotential bonding bar (EBB).

3.2.2 equipment class I: Equipment where protection against electric shock is achieved by:

- 1) using basic insulation; and also
- 2) providing a means of connecting to the protective earthing conductor in the building wiring those conductive parts that are otherwise capable of assuming hazardous voltages if the basic insulation fails.

3.2.3 equipment class II: Equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation are provided, there being no reliance on either protective earthing or installation conditions.

3.2.4 functional earth: A functional earth (FE) is used for the purpose of allowing the intended signalling function of telecommunication equipment to be fulfilled. The signalling function may include signalling with earth return.

3.2.5 network boundary: This is the point of demarcation between the operator's network and the customer's (private) network.

3.2.6 network termination point: The physical point at the boundary of a network intended to accept the connection of a terminal equipment or to be interconnected to another network (see [IEC/TR 62102]).

3.2.7 network termination unit: Operator-owned equipment that forms the network boundary.

3.2.8 signalling network: A network with a dedicated purpose, not carrying public services to third parties and which is constructed as a telecommunication network.

4 Abbreviations

This Recommendation uses the following abbreviations:

AE	Auxiliary Equipment
CB	Circuit Breaker
CBN	Common Bonding Network
CDN	Coupling/Decoupling Network
CUE	Combined Utilities Enclosure
E	mains Earth conductor
EBB	Equipotential Bonding Bar
ELB	Earth Leakage Breaker
EMC	Electromagnetic Compatibility
EPR	Earth Potential Rise
FE	Functional Earth
GDT	Gas Discharge Tube
IT	Type of power distribution system
ITE	Information Technology Equipment
L	mains Line (phase) conductor
LPS	Lightning Protection System
MCCB	Moulded Case Circuit Breaker
MET	Main Earth Terminal
MSPD	Multiservice Surge Protective Device
N	mains Neutral conductor
NBP	Network Boundary Point
NT	Network Termination
NTBA	Network Termination, Basic Access
NTP	Network Termination Point
NTU	Network Termination Unit
P	Protector
PC	Personal Computer
PE	Protective Earth
PEN	Protective Earth Neutral
RCCB	Residual Current Circuit Breaker
RCD	Residual Current Device

S	Switching centre
SPD	Surge Protective Device
TCP	Termination Connection Point
TN-C	Type of power distribution system
TN-C-S	Type of power distribution system
TN-S	Type of power distribution system
TNV	Telecommunication Network Voltage
TT	Type of power distribution system
TTE	Telecommunication Terminal Equipment

5 Responsibility

This Recommendation suggests that responsibility for the various protection measures be allocated as shown in Table 5-1.

Table 5-1 – Responsibility

Protection	Responsibility
Installation of an LPS	<ul style="list-style-type: none"> • Building owner
Installation of an effective earthing and bonding system, including the required EBB	<ul style="list-style-type: none"> • Building owner
Manufacture of equipment with a minimum level of resistibility to the relevant standard (e.g., basic level of [ITU-T K.21] for telecommunication equipment)	<ul style="list-style-type: none"> • Manufacturer
Use of equipment with the required level of resistibility to the relevant standard	<ul style="list-style-type: none"> • Network equipment: Network operator • Customer equipment: Customer/Regulator
Installation of SPDs and bonding of metallic pipes and cable screens	<ul style="list-style-type: none"> • Services SPDs, screens and metallic pipes: Network operator/Service owner • Customer SPDs, screens and metallic pipes in private network: Customer

5.1 Building owner

The building owner is responsible for the overall safety of the installation. The building owner is also responsible for providing a bonding terminal, EBB or access to the MET, to enable the earthing of protective devices, services, screens and metallic pipes.

5.2 Manufacturer

Manufacturers are responsible for providing equipment, which complies with [ITU-T K.21].

5.3 Network operator

The network operator is responsible for supplying a safe service to the customer. This essentially means that the operator needs to install primary protection when the probability of the surge exceeding 1.5 kV has reached an unacceptable level. The primary protector is bonded to the bonding terminal provided by the building owner.

The installation of SPDs may be subject to requirements for safety and performance. The responsibility for these requirements is given in Figure 8.3-1.

5.4 Customer

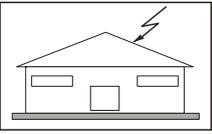
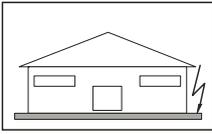
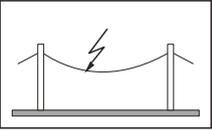
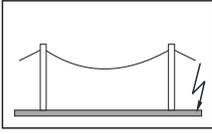
The customer is responsible for determining when to protect his equipment. The decision to install SPDs will depend on:

- importance of the service (e.g., hospitals, traffic control);
- the resistibility level of the equipment;
- serviceability of the equipment (equipment installed in difficult to reach places, e.g., high mountains);
- the cost of repair of the equipment;
- the electromagnetic environment at the particular site including:
 - a.c. power induction and a.c./d.c. EPR;
 - lightning (induction and EPR);
- the probability of damages.

6 Risk management

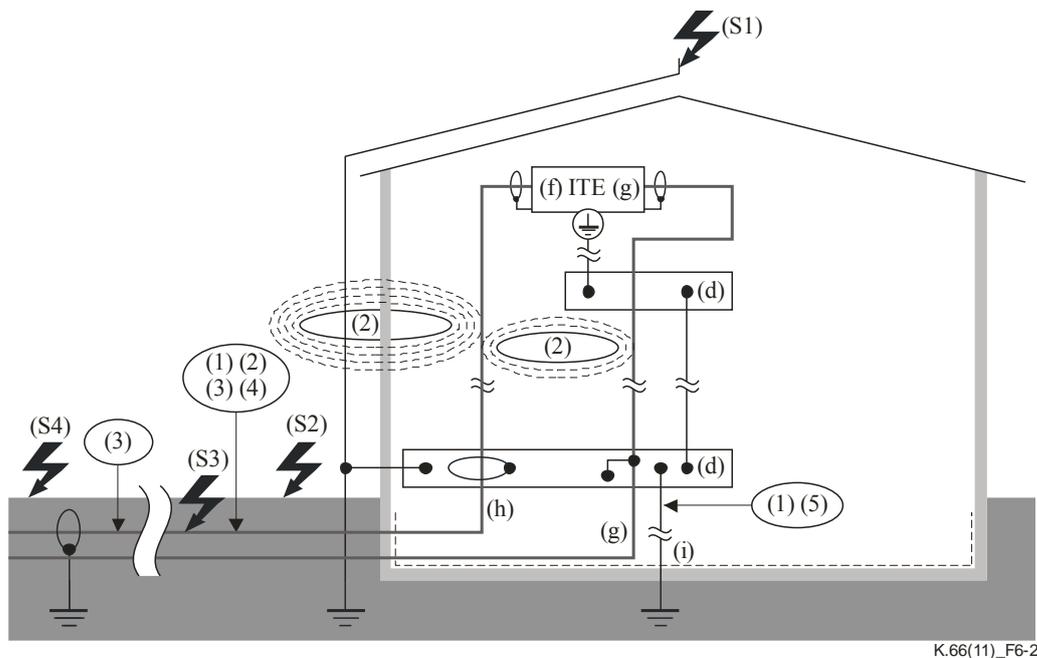
6.1 Sources of damage

The need to provide protection depends not only on the overvoltages and overcurrents coming from the telecom and power lines (due to conducted and induced lightning surges on the line), but also due to overvoltages and overcurrents coming from the structure (due to a direct lightning strike to the structure), as shown in Figures 6-1 and 6-2.

Point of strike	Examples	Point of strike	Examples
Structure		Ground near a structure	
Incoming line		Ground near a line	

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Figure 6-1 – Examples of direct and indirect lightning to the customer's building and services



- | | |
|---|--|
| (S1) Direct lightning strike to the structure | (g) Mains port or line |
| (S2) Near to the structure | (h) IT/telecommunication line or network |
| (S3) Direct lightning strike to the telecom or power line | (i) Earth electrode |
| (S4) Near to the telecom or power line | (1, 4, 5) Resistive |
| (d) EBB (equipotential bonding bar) | (2, 3) Induction |
| (f) Information technology/telecommunication port | |

Figure 6-2 – Coupling mechanism

6.2 Risk assessment

The risk of damage and injury should be determined taking into account the electromagnetic environment (lightning flash density, earth resistivity and the nature of the installation). Refer to [IEC 62305-2] for guidance on performing the risk assessment.

The tolerable risk of damage should be determined taking into account:

- the consequences of the loss of service for the customer and the network operator (downtime of the service, number of customers);
- the importance of the service (e.g., for hospitals, traffic control) and repair costs (high repair costs of inadequately protected equipment versus no repair costs of adequately protected equipment, probability).

The values of tolerable risk should be under the responsibility of the national body concerned. If the national body does not provide values, guidance is given in [IEC 62305-2].

If the risk of damage exceeds the level of tolerable risk, protective measures should be considered.

The need for an LPS should be assessed in accordance with [IEC 62305-2].

Guidance on when to install SPDs to protect customer-owned equipment is given in [ITU-T K.46] and [IEC 62305-2].

Determining when to protect network operator plant against lightning is in accordance with [ITU-T K.46], [ITU-T K.47], [ITU-T K.72] and [IEC 62305-2].

Protection of telecommunication equipment users within the building is normally only required when there is a significant risk of a direct strike to the customer's building or a direct strike to one of the building services near the building.

6.3 Risk reduction

Preventing damage to an installation or injury to persons may require one or more of the following:

- Use of equipment with a minimum level of resistibility and safety isolation.
- Ensure the correct classification of the equipment ports. Refer to [ITU-T K.75] for information on classifying equipment ports.
- Good installation practices. Minimize the cabling loop area where possible. Refer to [IEC 60364-4-44] for information on minimizing the loop area of cabling.
- Correct earthing and bonding. Bond all earths points to the main earth bar (MEB). This may be via added earth bars. Do not connect to a separate earth electrode which is not bonded to the MEB.

NOTE 1 – The above four requirements are good engineering practice and apply to all installations.

- Installation of SPDs and bonding of metallic pipes and cable screens using an effective earthing and bonding system as required by the risk assessment.
- Installation of an LPS to prevent direct strikes causing damage as required by the risk assessment.

NOTE 2 – Associated equipment containing ports with a low surge impedance to ground connected by short cables, e.g., printers using USB cables, may be susceptible to damage due to circulating earth currents.

As can be seen in the following clauses, the effectiveness of the protective measures depends not only on the installation of the selected protective devices (e.g., SPDs), but also on equipotential bonding within the customer's building.

This objective can be achieved by following the suggestions of this Recommendation and clearly defining the responsibility between the network operator and the customer; see clause 5.

7 Objectives for bonding configurations and earthing

The purpose of bonding configurations and earthing at a customer's premises is to:

- 1) promote safety by reducing the potential differences which could otherwise occur between the telecommunications system and earthed systems;
- 2) mitigate damage caused by lightning and other surges on the mains, telecommunications cables and other metallic services;
- 3) facilitate rapid de-energization of mains lines that accidentally contact telecommunication equipment or cable, thereby reducing hazard and damage;
- 4) provide paths to divert to earth the surge currents entering the premises on cable screens and conductors via SPDs.

To coordinate with the requirements of [IEC 60950-1], it is necessary to prevent the potential difference which can occur between the symmetric pair conductor and other metallic parts, within the premises, from exceeding 1.5 kV for the majority of di/dt expected to occur. Figures III.1 to III.4 show that this voltage is affected by the individual voltage drops occurring across bonding conductors.

The requirements for earthing and bonding given in this Recommendation will achieve the objective of preventing the voltage between the telecommunication conductor and the MET from exceeding 1.5 kV for the majority of di/dt expected to occur.

8 Protection requirements

8.1 Equipotential bonding

Equipment and persons in a building are exposed to externally-produced energy because conductive services such as telecommunication lines, power lines, antenna leads, waveguides, earthing conductors, and metallic pipes penetrate the shell of the building. The penetration of conducted energy is mitigated by interconnecting all with low-impedance bonding conductors to the MET, the mesh bonding network or CBN. This low impedance is achieved by keeping the length of bonding conductors short (< 1.5 m). The use of low impedance bonding conductors is particularly important when there is a significant risk of a direct lightning strike to the structure or to the line immediately adjacent to the building.

NOTE 1 – The limit value of 1.5 m for connecting conductors is based on an assumed voltage drop on such conductors, $\Delta U = 1 \text{ kV}$ per m length, for direct lightning strikes. See Note 2 of Annex D.1.1 of [IEC 62305-4].

This 1.5 m requirement may be relaxed where the probability of direct lightning strikes is low, see Table 8-1 for bonding conductor requirements.

Table 8-1 – Bonding conductor requirements

Mechanism	Maximum bond conductor length/resistance
Direct strikes	1.5 m
Induced surges	10 m
Power induction/power contact	1Ω (< 50 V a.c. @ 2 times 24 A a.c.)

Emphasis is on equipotential bonding of all metallic services to the MET to prevent high potential differences occurring between the mains power network and the other metallic services. The resistance to ground of the earthing network may be of importance, for direct strikes to the structure, for systems that interface to more than one external cable to reduce the magnitude of the current conducted into the unsurged cable.

It is recommended that all metallic services, e.g., a.c. mains power, telecommunication cables, gas pipes, water pipes, CATV and the earthing conductor enter the building at the same point to reduce bonding conducting lengths and to reduce EMI. In this case, the building owner shall provide a MET, located as close as possible to the expected entry point for the metallic services. Note, Electromagnetic coupling between unshielded power cables and telecommunications may have to be considered. [IEC 60364-4-44] may assist.

However, the metallic services often enter the building at different points. In this case, the building owner shall provide an earthed equipotential bonding bar (EBB) or bonding terminal (BT), located as close as possible to the entry point for each metallic service. Each EBB or BT shall be connected to an earthing system and all the EBBs shall be bonded together, for example by a ring conductor; see Figure 9.2-5. (A ring earth electrode can also achieve this bonding requirement, see Figure 9.2-4, however, bonding of the EBBs to a ring conductor is recommended due to the shorter bonding conductor lengths.)

NOTE 2 – The MET or the EBBs may be a designated connection provided for the purpose, or other connections may be used, e.g., metallic waterpipe or a conductor to the earthing system. Note that national safety regulations may prohibit the use of the metallic waterpipe as the MET.

In order to minimize surge currents and voltages in the building, the shields of all cables entering the building should be directly bonded to the MET or the EBB. SPDs may be used for galvanic isolation, if necessary for corrosion considerations.

In some installations, it may not be possible to install short bond wires. In this case, there are a number of options:

- request the building owner to provide an EBB;
- install the shortest bond wires possible and use additional SPDs, e.g., CPUs, see clause 10, to achieve bonding at the equipment. These additional SPDs shall be coordinated with the upstream SPDs.

NOTE 3 – While the voltage drop along a long bond wire, due to the current that is conducted through the SPD and the bond wire, may cause a breakdown of the equipment insulation and damage the equipment, the energy of the bond wire voltage drop is quite small. This is because the duration of the surge, generated by $L * \frac{di}{dt}$, is only a few microseconds. This statement only applies

to a high impedance loop. For a low impedance loop, e.g., with an SPD at the equipment, the current waveshape in the loop approaches the waveshape of the inducing current. It is easy to clamp this surge at the equipment but the SPD needs to be appropriately rated. [ITU-T K.67] contains information on waveshapes. It should be noted that the large voltage developed across the long bond wire may cause a flashover to a nearby earthed object. This possibility should be considered when choosing the location of the SPDs and the routing of the bond wire;

- or use equipment with a higher resistibility and higher voltage insulation barriers.

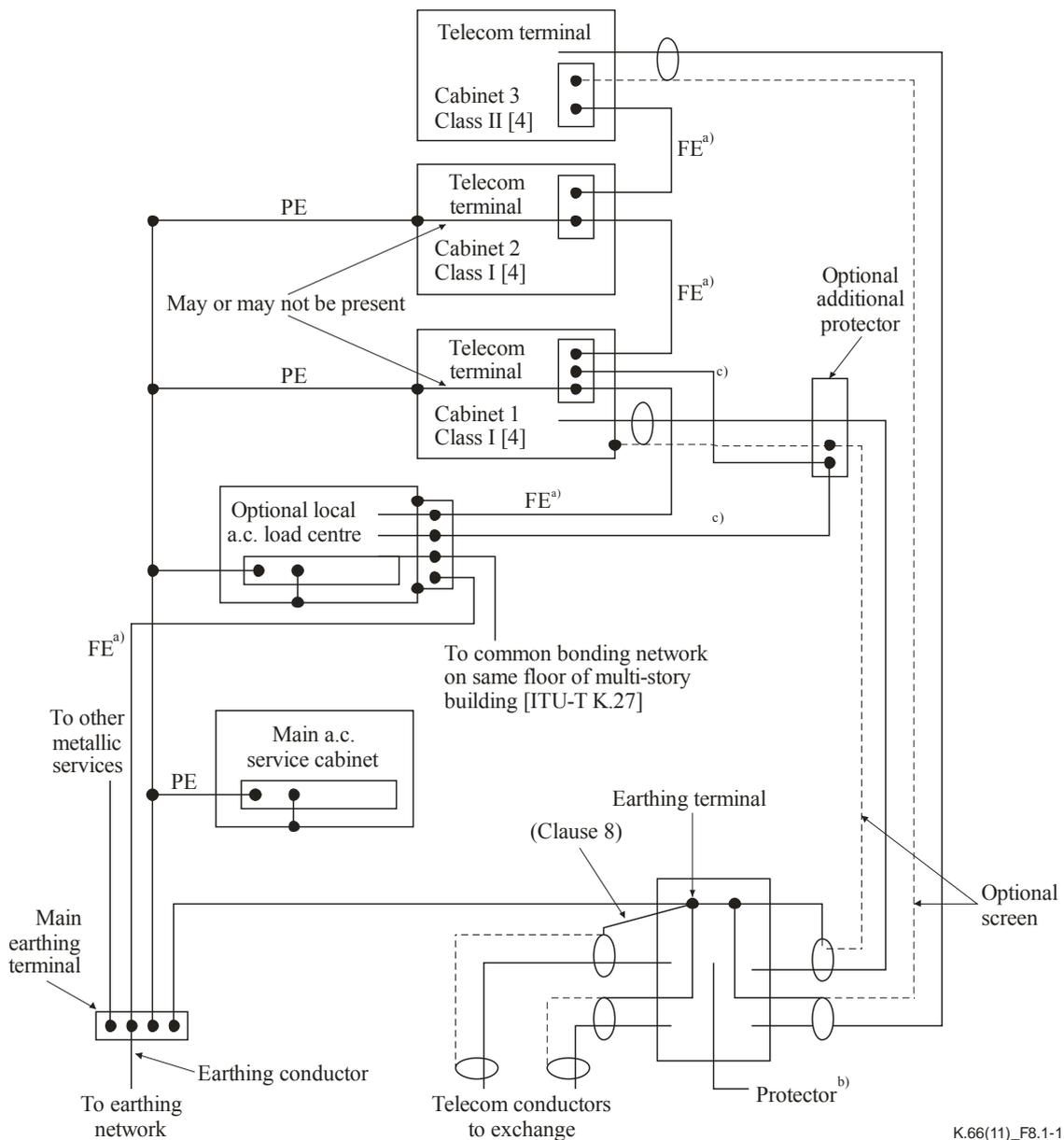
To protect the building against direct lightning strikes, an LPS may need to be installed and bonded to the MET. This LPS should be installed in accordance with [IEC 62305-3]. Particular attention may need to be given to antennas installed above roof level.

There are situations where equipment damage or customer injury may occur which are beyond the control of the network operator (overvoltage protection has been correctly installed) and some examples of these are:

- Equipment without an earth connection is installed in a building with a non-metallic floor. Under direct strike conditions, the earth potential rise at the location of the equipment can be different to that of the location of the MET, resulting in a discharge to the equipment. The solution to prevent this is to install a ring earth, see Figure 9.2-4, which creates an equipotential environment in the house.
- Equipment is installed in a building with a conductive floor or walls not bonded to the MET. Under direct strike conditions, the earth potential rise at the location of the equipment can be different to that of the location of the MET resulting in a discharge to the equipment. The solution to prevent this is to install a bond between the metallic parts and the MET.

The FE conductor is used for the purpose of allowing the intended signalling function of telecommunication equipment to be fulfilled. This signalling function may include signalling with earth return. Note, the signalling function may be compromised in a combined FE and PE conductor if it is designed to the rules imposed on it by safety requirements.

Figure 8.1-1 provides an example of a bonding configuration and earthing inside a customer's building.



K.66(11)_F8.1-1

- a) Optional for equipment using earth return signalling.
- b) If required (see [ITU-T K.11]).
- c) Alternative routings.

Figure 8.1-1 – Example of a bonding configuration and earthing inside a customer building

8.2 a.c. power distribution and SPDs

The a.c. power installation in a customer's building should be one of the types described in [IEC 60364-1]. EMC performance of telecommunication equipment is eased if the a.c. power installation inside a customer's building is of type TN-S as described by [IEC 60364-5-54]. This power configuration requires that there is no PEN conductor within the building.

If power is served to the customer's building by an IT or TT distribution network, the PE conductor inside the building is connected to the MET or EBB, but the neutral conductor is not.

NOTE – If an IT or TT distribution network is equipped with a separation transformer dedicated to that building (e.g., to mitigate interference), or equivalent, it would allow the procedures of a TN-S installation to be followed.

It is recognized that installations within a building with a TN-C section are in widespread use in some countries; however, bonding configurations and earthing for such an installation are a subject for further study. Although the measures to be used with TN-C and TN-C-S installations are still under study, several administrations have reported acceptable results using the mitigation measures described in Appendix II.

If SPDs, often Class I Tests SPDs ([IEC 61643-11] and [IEC 61643-12]) (primary protectors), are installed on the power mains conductors, they should be located as close as practicable to the location at which the lines enter the premises. The SPD should be connected to the mains conductors as shown in the appropriate figures in Annex A. The SPD should be located where the leads for connection to the mains conductors, including the neutral conductor, where applicable, are as short as possible. Lead lengths that are less than 0.5 m are recommended.

8.3 Telecommunication lines and SPDs

If SPDs, often GDTs, (primary protectors) are installed on the telecommunication lines, they should be located as close as practicable to the location at which the lines enter the premises. By also locating these primary protectors near the entrance of the power mains, the length of the earthing conductor from the protector to the MET can be kept < 1.5 metres. The low impedance of a short earthing conductor helps to reduce surge voltage differences between the telecommunication lines and the protective conductor of the power system.

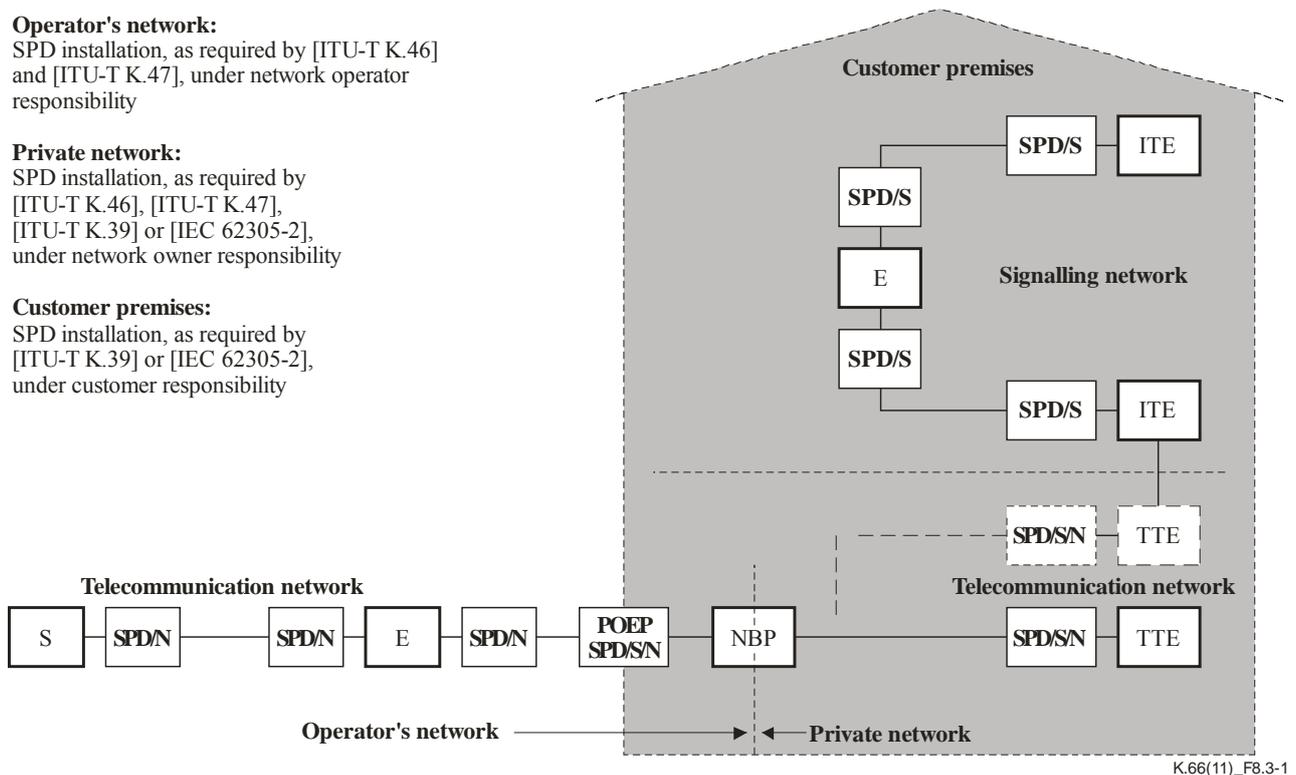
NOTE – It is recognized that, in some countries, the earthing terminal of the telecommunication line primary protectors is connected only to a separate earth electrode. This is not compatible with protecting the equipment and it may even result in a fire in the premises or, injury or death of a person using telecommunication equipment in the premises.

Additional SPDs, e.g., MSPD, are sometimes installed at the location of the telecommunication terminal equipment in order to limit surges caused by coupling within the building. The common terminal of these protectors should be connected to the protective conductor near the protected equipment. These SPDs must also be coordinated with the upstream SPDs. See clause 1.4.5 of [ITU-T K.11] regarding the use of secondary protectors, and clause 10.

Operator's network:
SPD installation, as required by [ITU-T K.46] and [ITU-T K.47], under network operator responsibility

Private network:
SPD installation, as required by [ITU-T K.46], [ITU-T K.47], [ITU-T K.39] or [IEC 62305-2], under network owner responsibility

Customer premises:
SPD installation, as required by [ITU-T K.39] or [IEC 62305-2], under customer responsibility



K.66(11)_F8.3-1

- SPD/N SPD requirements/restrictions given by network operator/authority
- SPD/S SPD requirements/restrictions may be given by equipment manufacturer
- SPD/S/N SPD requirements/restrictions may be given by equipment manufacturer and network operator/authority

Figure 8.3-1 – Responsibility for selection of SPDs

Figure 8.3-1 shows primary protection installed at the point of entry. The operator decision to install protection should be based on a risk assessment. It is important to note that the location of the point of entry protection may be different to the location of the NBP which will be determined by the local regulator. Depending on the country, the NBP may be at one or more of the following locations, e.g., the NTU, the MDF or the first telecommunication outlet. In small residential dwellings, the network operator would normally install the primary protector outside the building for safety and access reasons. In larger buildings, it will probably be installed in an MDF inside the building.

8.4 Selection of SPDs for installation at the point of entry

The effective protection level (U_{eff}) of these SPDs shall be coordinated with the resistibility (U_i) of the equipment to be protected:

$$U_{eff} < U_i$$

When an SPD is connected to the electrical and electronic system, inductive voltage drop ΔU on the connecting conductors will add to the protection level U_p of the SPD. Therefore, the resulting effective protection level is:

$$U_{eff} = U_i + \Delta U \text{ for SPD clamping type;}$$

$$U_{eff} = \max(U_p \text{ or } \Delta U) \text{ for SPD switching type.}$$

8.4.1 a.c. power distribution

[IEC 62305-4] provides information for the design and installation of a lightning protection system within structures and requirements for protection measures on power lines. To achieve optimum protection effectiveness, it is a guideline for the cooperation between the designer/operator of the different electrical systems and the designer of the protection measures.

The specifications and application requirements for power line SPDs are given in [IEC 61643-11] and [IEC 61643-12].

8.4.2 Telecommunication lines

GDTs, [ITU-T K.12], or high energy SPDs, [IEC 61643-311], should be installed at the location where the lines enter the premises, when required, to protect against direct lightning strikes.

If the telecommunication cable is protected against direct strikes, referring to [ITU-T K.47], any GDT chosen from [ITU-T K.12] should have an adequate current rating. If the cable is not protected against direct strikes, it may be necessary to choose a GDT with a higher current rating from [ITU-T K.12] or [IEC 61643-311].

9 Installation of SPDs (primary protectors)

To prevent high current surges entering the structure due to strikes to services it is important to install the primary protection at the point where the services enter the building.

9.1 Installation methods for SPDs (primary protection) for different power distribution systems

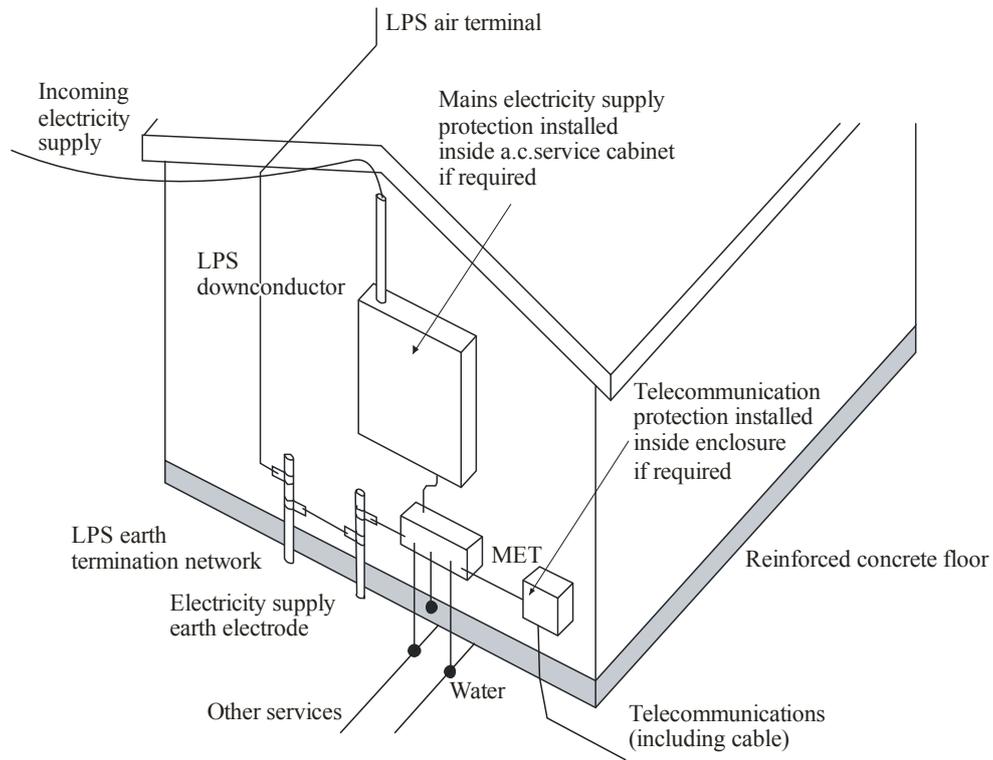
The methods for installing SPDs, for the different power distribution systems described in Annex V of [IEC 60950-1], are described in Annex A.

9.2 Examples of installation methods to achieve the requirements of short bond wires

There are a number of ways to install SPDs (primary protection) to achieve the requirements of short bonding conductors as shown in Figure I.1. Five examples are provided below. The first example involves the co-location of services and the use of an MET, see clause 9.2.1. The second example/co-location involves the use of a combined utilities enclosure, see clause 9.2.2. The third example uses a reinforced concrete slab as a common bonding network (CBN), see clause 9.2.3. The fourth example involves the use of a buried ring conductor, see clause 9.2.4. The fifth example involves the use of an unburied ring conductor, see clause 9.2.5. If no suitable method can be found to achieve the required short bonding conductors or equivalent equipotential bonding, multiservice surge protective device (MSPDs) may be required, see clause 10.

9.2.1 Co-location of services near the MET

In this method, all services must be co-located next to a MET. Short bonding conductors connect all metallic services and SPDs, where required, to the MET, see Figure 9.2-1.



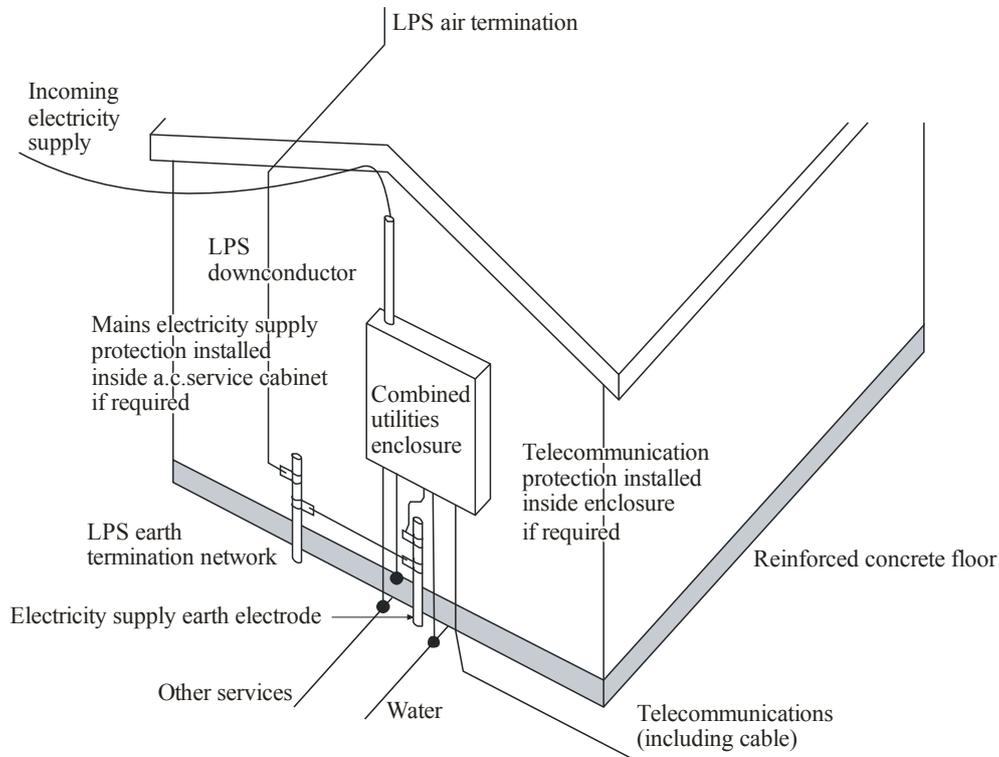
K.66(11)_F9.2-1

NOTE – In some countries, the MET may be inside the a.c. service cabinet.

Figure 9.2-1 – Co-location of services next to an MET

9.2.2 Combined utility enclosures

A combined utilities enclosure (CUE) can be used to house the primary protectors and to achieve short bond wires. It also has the advantage that all metallic services can enter at the same point and be bonded together. This is the best method to protect all services in a customer premises. An example of an installation with a combined utilities enclosure is shown in Figure 9.2-2.



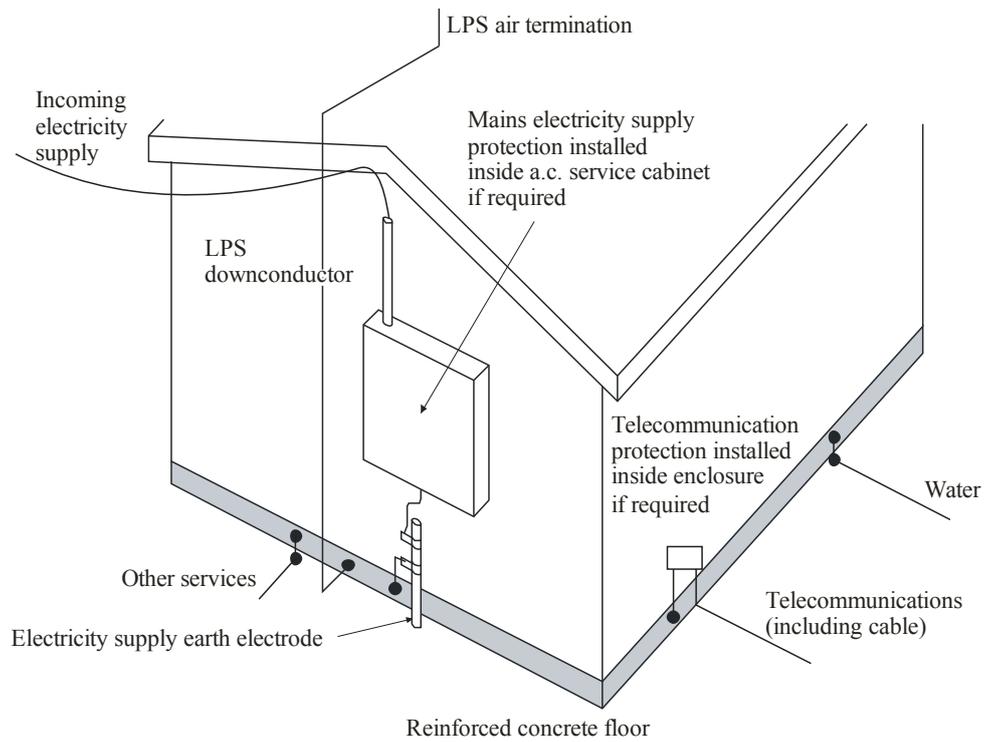
K.66(11)_F9.2-2

NOTE – The MET in this example is inside the combined utilities enclosure.

Figure 9.2-2 – Combined utilities enclosure

9.2.3 Common bonding network

A building with a properly bonded reinforced concrete floor effectively provides a common bonding network (CBN). In this case, bonding can be achieved by bonding the various services and surge protective devices (SPDs) directly to the CBN. This connection must be made by connecting directly to the reinforcing mesh by a suitable method. The mesh must be electrically continuous between the points of attachment. See Figure 9.2-3, which is an example showing a building with a reinforced concrete floor. In a new building, the reinforcing sheets should be tied together with wire or welded to form an electrically continuous mesh. In an existing building, an attempt should be made to measure the resistance from one side of the slab to the other. If continuity of the slab is in doubt, e.g., the measurement was made with the soil wet, a ring earth should be installed and bonded to the slab at every rod electrode.



K.66(11)_F9.2-3

Figure 9.2-3 – Common bonding network (CBN)

9.2.4 Ring earth electrode

A ring earth electrode, if not already provided for the LPS, should be provided by installing a bare conductor below ground, see Figure 9.2-4. Additional earth electrodes should be installed at each bonding point to the ring earth, if required by the dimensions of the LPS earthing system.

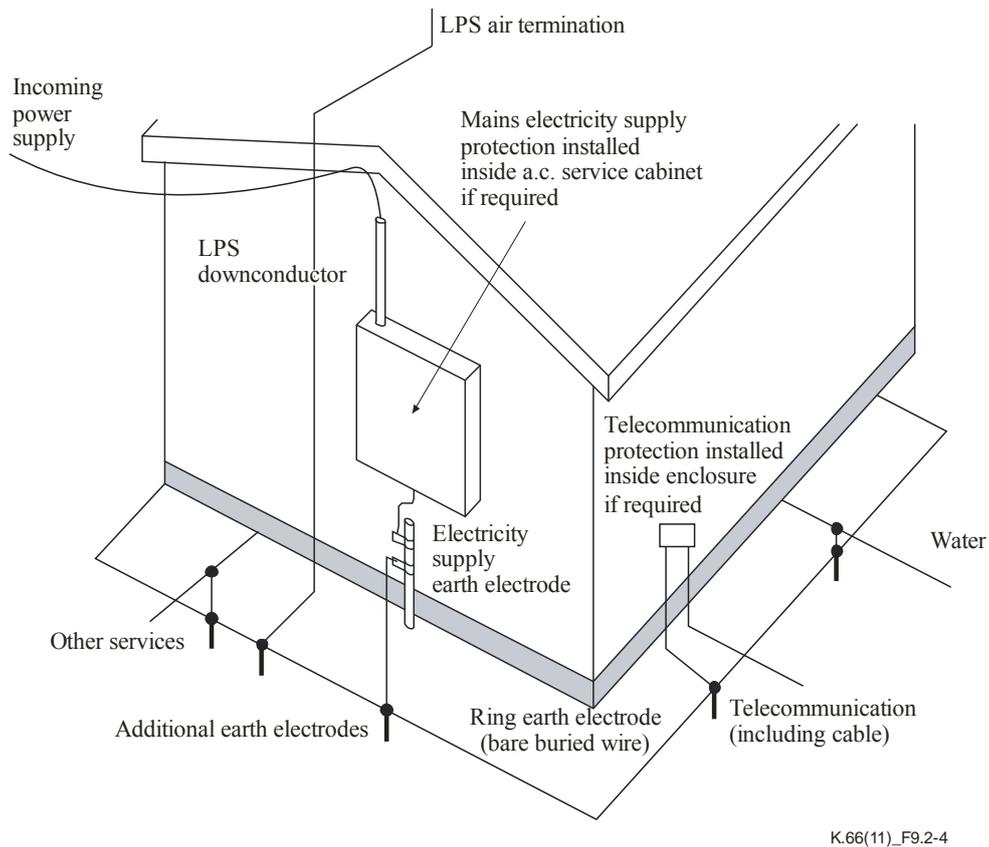


Figure 9.2-4 – Ring earth electrode

9.2.5 Ring conductor

A ring conductor shall be provided by installing a conductor above ground connecting all of the EBBs. Each EBB is connected to an earth electrode, see Figure 9.2-5.

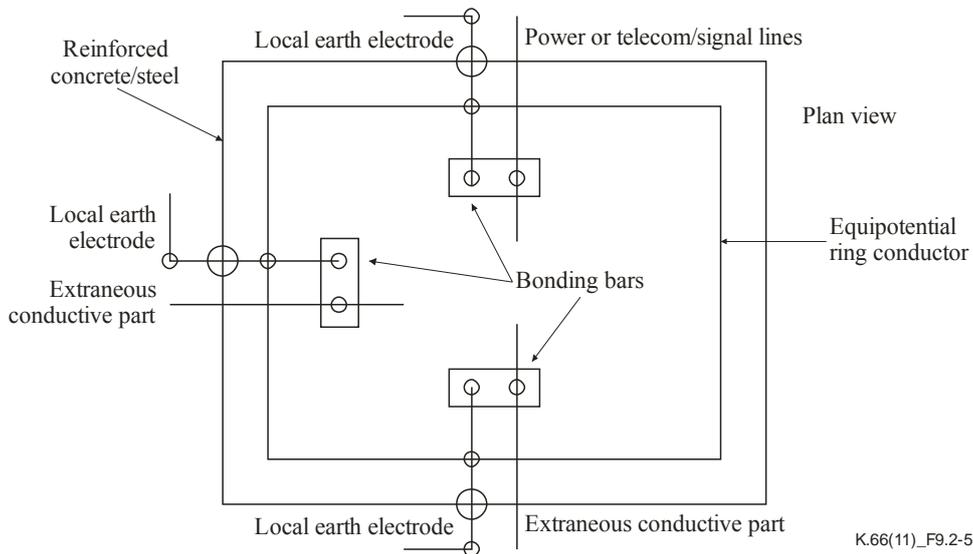


Figure 9.2-5 – Equipotential bonding of incoming metallic services entering at several points: Use of internal ring conductor

9.3 Location of the telecommunication SPD

Normally the telecommunication SPD would be installed on the operator side of the network boundary. The network boundary is the demarcation point between the operator's network and customer cabling and may be inside or outside the customer's building, depending on National requirements. The operator installed SPD needs to be in a secure location to prevent non-operator personnel from removing the SPD and causing a safety hazard (risk of lightning injury to users of telecommunication equipment in the customer's building). The customer would install an SPD on the customer side of the network boundary.

9.4 Safety issues

If a primary protector is installed inside the premises, there is a risk of a fire occurring, due to overheated telecommunication wiring, SPD or SPD housing, if a direct lightning strike occurs to the telecommunication service cable/line or there is a contact between the telecommunication service cable/line and a power conductor. This risk can be greatly reduced by applying both of the following mitigation techniques:

- doubling the cross sectional area of the internal conductors compared with the external wiring conductors or installing a fusible conductor between the external wiring and the SPD. Note, this fusible conductor has to be able to break the current caused by a power conductor contact. Typically, this will require a non-sheathed cable (to allow the plasma to escape) at least 600 mm long. This section of fusible conductor should be suitably located to ensure that it is unlikely to create a fire hazard;
- using fire resistant SPD housings and/or using a thermal shorting link, see [ITU-T K.65]

NOTE – One operator's experience indicates that installations with 10 or more working cable pairs are not at risk.

10 Multiservice surge protective devices

Where it is not possible to use any of the methods described in clause 9.2, or additional protection is required, multiservice surge protective devices (MSPDs) may be used. MSPDs contain the SPDs for all ports and achieve the requirement for short bond wires. They are installed near the equipment and hence also protect against overvoltages occurring in internal wiring. MSPDs shall be coordinated with the primary protector.

The indiscriminate use of MSPDs may allow damage to occur to the equipment being protected and associated equipment.

To ensure maximum protection for interconnected equipment, there are two methods:

- Use of a single MSPD.
- Use of multiple MSPDs.

10.1 Single MSPD

This method is suitable for protection of a single piece of equipment and for protecting interconnected equipment in close proximity. In this case, only ports connected to external cables require protection.

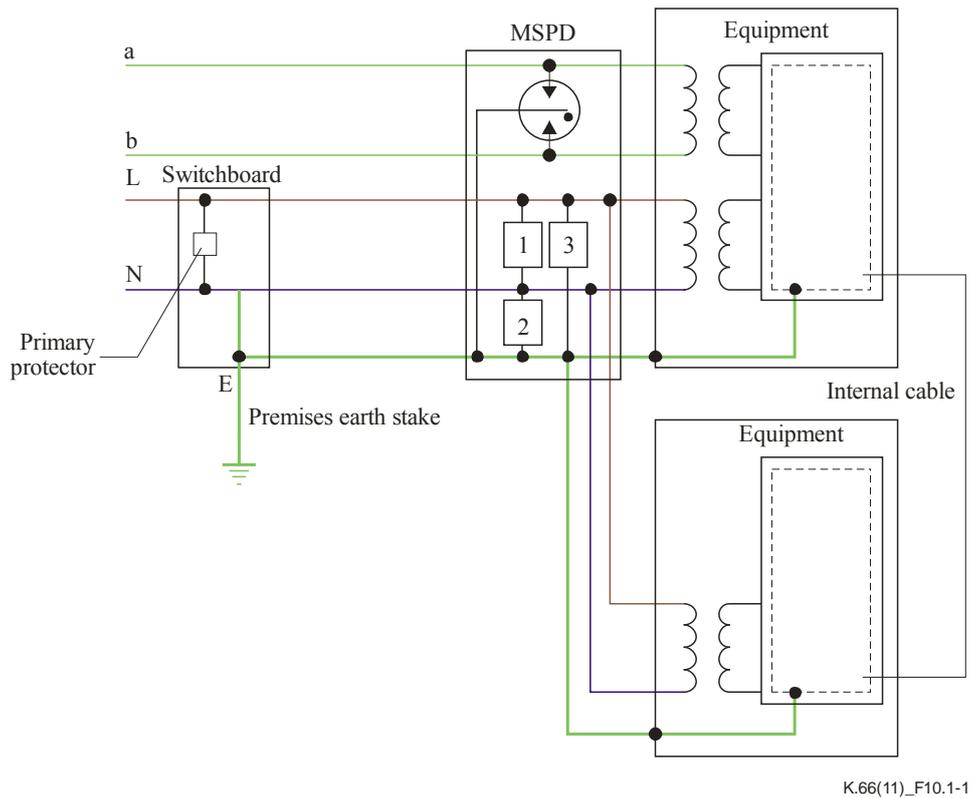
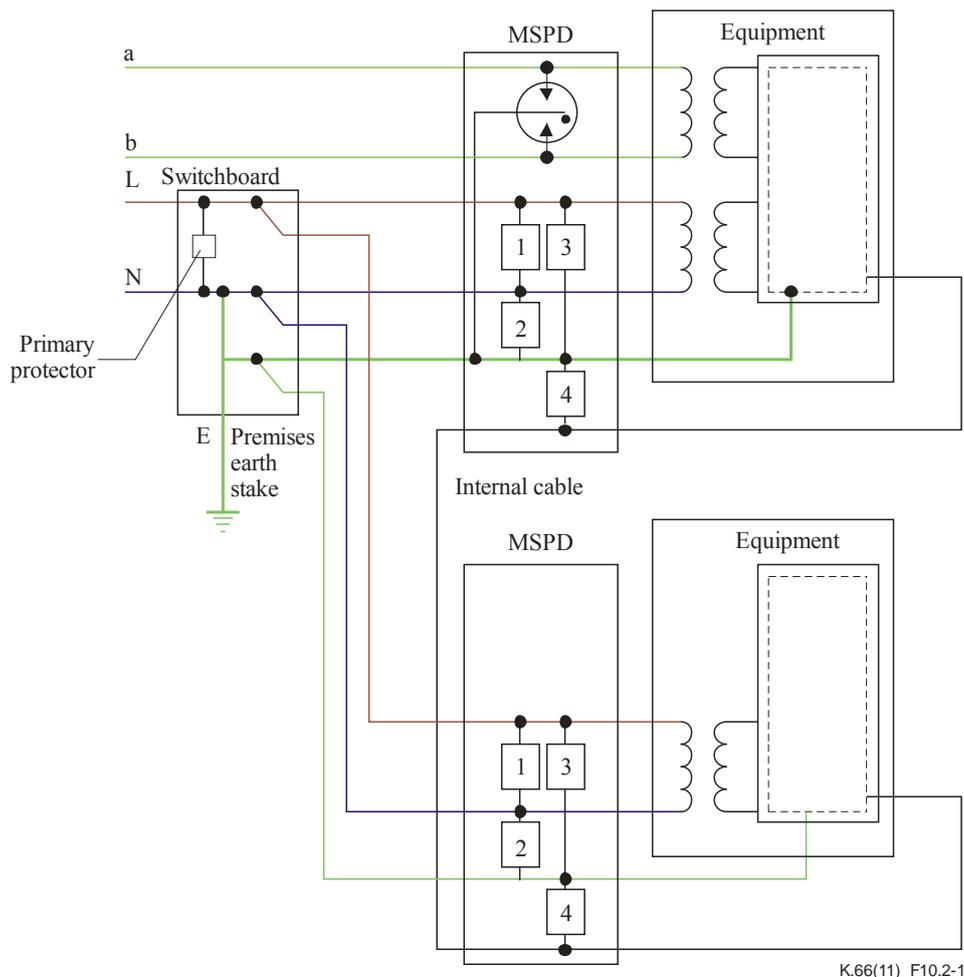


Figure 10.1-1 – Equipment protected by the same MSPD

10.2 Multiple MSPDs

This method needs to be used when the interconnected equipment is spaced too far apart, e.g., the power cord of one piece of equipment will not reach the MSPD, or there are insufficient outlets on the MSPD. In this case all ports require protection. Note, the need for internal cable ports to be routed via the MSPD is under study.



K.66(11)_F10.2-1

NOTE – SPDs 1, 2 and 3 need to be suitable for use on the mains.
 SPD 4 will need to be suitable to protect the equipment's internal port.

Figure 10.2-1 – Equipment protected by multiple MSPDs

11 Implementation

The earthing and bonding methods proposed in clauses 9.2.1 to 9.2.5 are easy to implement in a new building. Therefore, in new installations, where practical, the recommendations in these clauses should be followed.

In existing installations, it may be very difficult to modify the installation to comply with these clauses. It is therefore felt that in old installations an upgrade to comply with these clauses should only be considered when a major wiring upgrade is being undertaken or there are exceptional safety issues that require an upgrade. In cases that do not warrant an upgrade, customer safety and equipment protection can be achieved by the use of long bond wires and using additional SPDs, see clause 8.1.

12 Large installations

Large installations of telecommunication equipment may require special care to avoid damage or upset from electromagnetic sources. Such installations should make use of the bonding configurations and earthing techniques of [ITU-T K.27].

Some installations at customers' premises may consist of several buildings, with the telecommunications cable from the public network entering the first building then continuing to the other buildings. In that case, the telecommunications equipment of each building should be earthed and protected as in the previous case for an individual building.

Annex A

Installation methods for different power systems

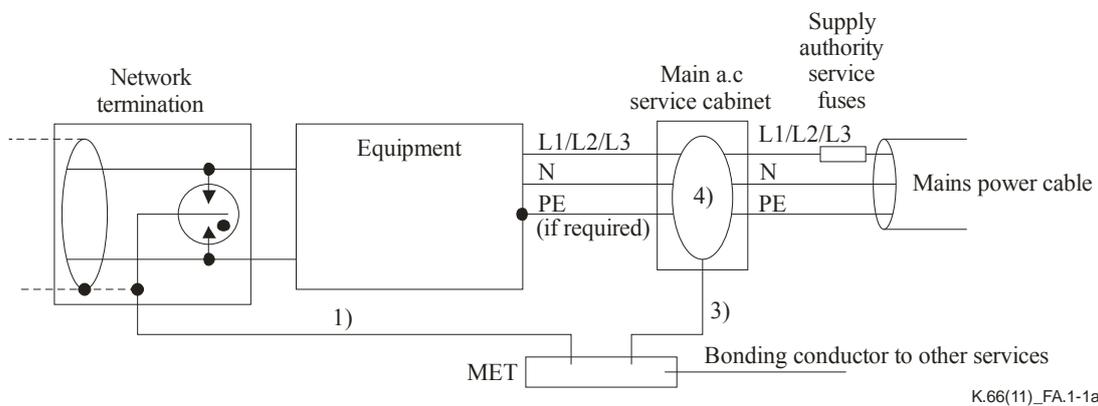
(This annex forms an integral part of this Recommendation.)

A.1 Installation method for TN-S power distribution systems

In a TN-S power distribution system there is a direct connection of one pole to earth, the equipment is earthed, generally to the neutral, and a separate protective conductor is used throughout the system.

A.1.1 Installation method for a TN-S power distribution system with separate neutral and protective conductors (MET installed outside the main a.c. service cabinet)

See Figure V.1 of [IEC 60950-1].

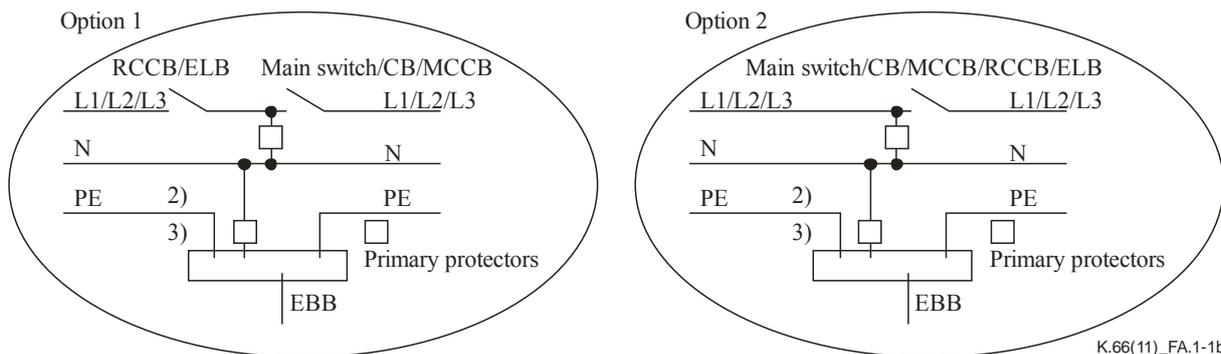


NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

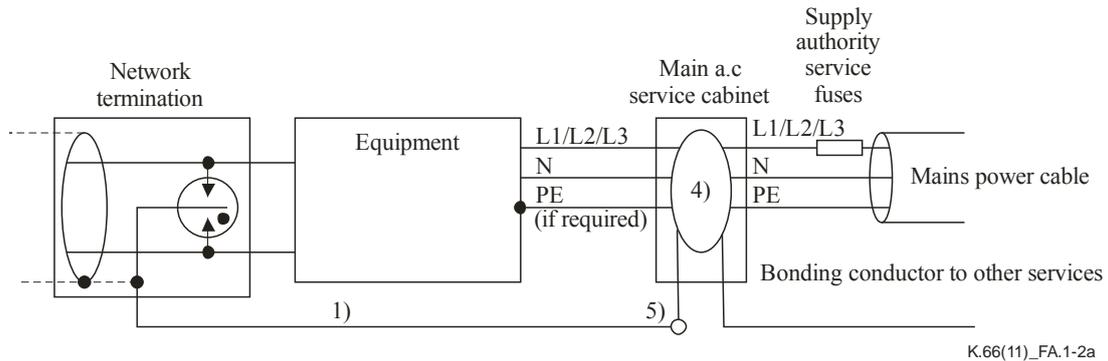


NOTE 5 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.1-1 – TN-S installation with separate neutral and protective conductors (MET installed outside the main a.c. service cabinet)

A.1.2 Installation method for a TN-S power distribution system with separate neutral and protective conductors (MET installed inside the main a.c. service cabinet)

See Figure V.1 of [IEC 60950-1].



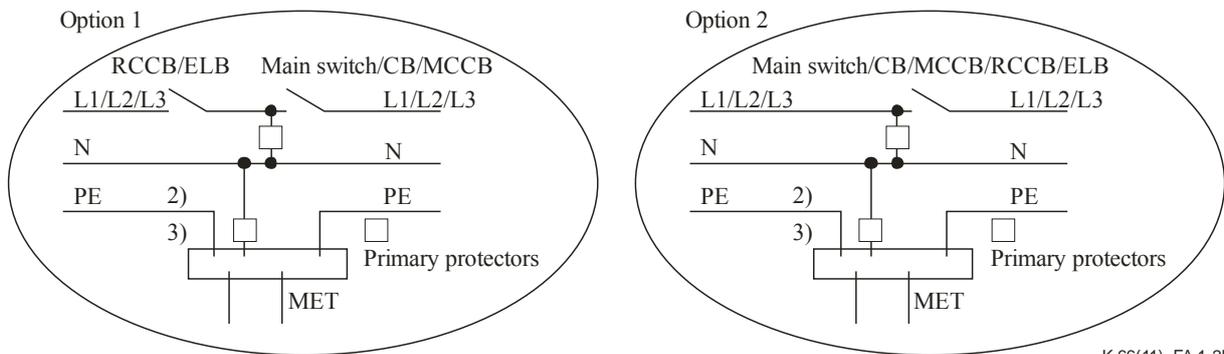
NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

NOTE 5 – A bonding bar or terminal may be required by some administrations.

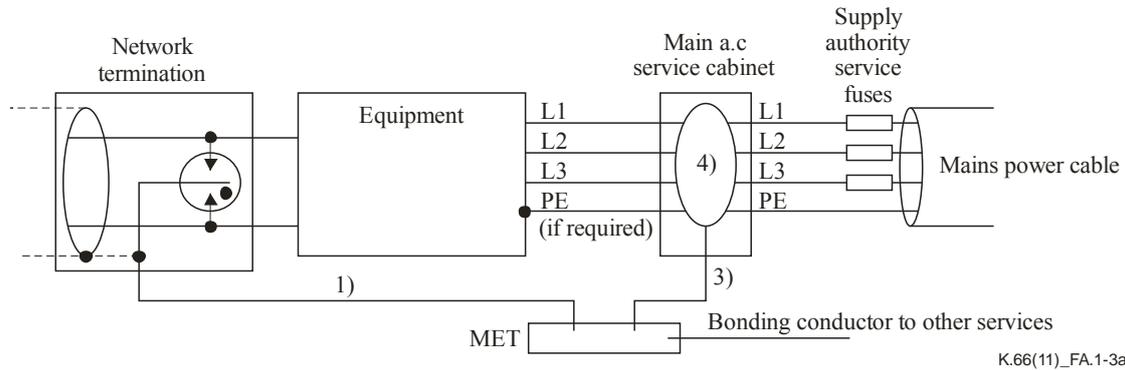


NOTE 6 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.1-2 – TN-S installation with separate neutral and protective conductors (MET installed inside the main a.c. service cabinet)

A.1.3 Installation method for a TN-S power distribution system with earthed line conductor (MET installed outside the main a.c. service cabinet)

See Figure V.1 of [IEC 60950-1].

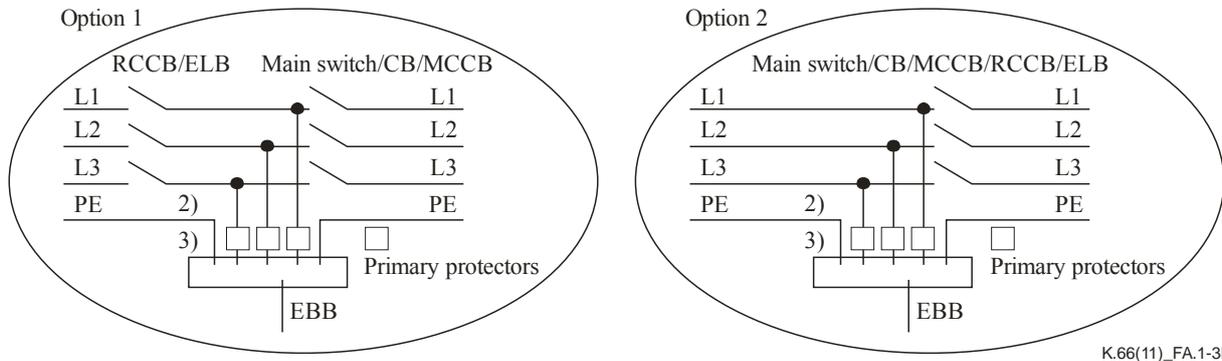


NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

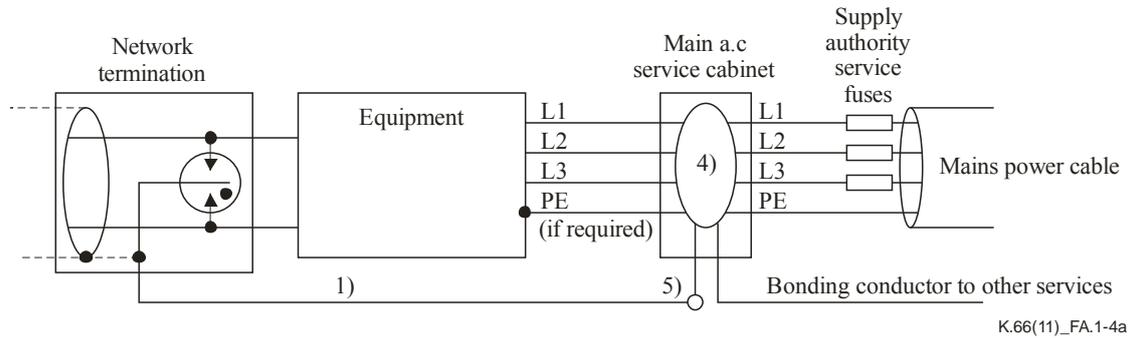


NOTE 5 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.1-3 – TN-S installation with earthed line conductor (MET installed outside the main a.c. service cabinet)

A.1.4 Installation method for a TN-S power distribution system with earthed line conductor (MET installed inside the main a.c. service cabinet)

See Figure V.1 of [IEC 60950-1].



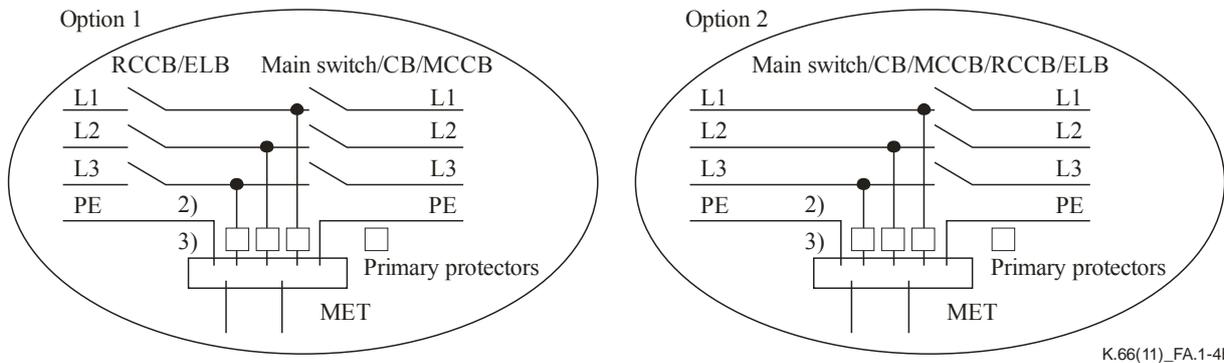
NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

NOTE 5 – A bonding bar or terminal may be required by some administrations.



NOTE 6 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

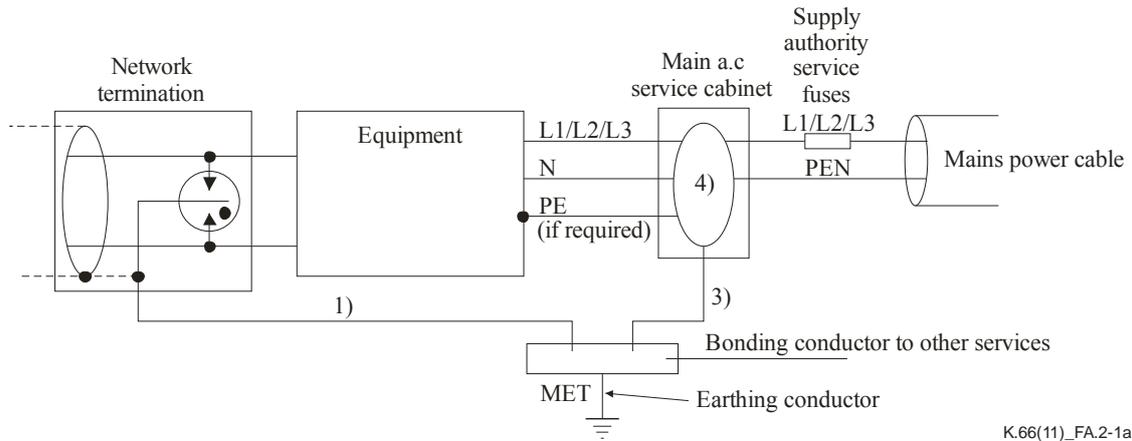
Figure A.1-4 – TN-S installation with earthed line conductor (MET installed inside the main a.c. service cabinet)

A.2 Installation method for TN-C-S power distribution systems

Type of power distribution system where there is a direct connection of one pole to earth, the equipment is earthed, generally to the neutral, and the neutral and protective functions are combined in a single conductor (PEN conductor) in part of the system.

A.2.1 Installation method for a TN-C-S power distribution system, with earth neutral link, (MET installed outside the main a.c. service cabinet)

See Figure V.2 of [IEC 60950-1].



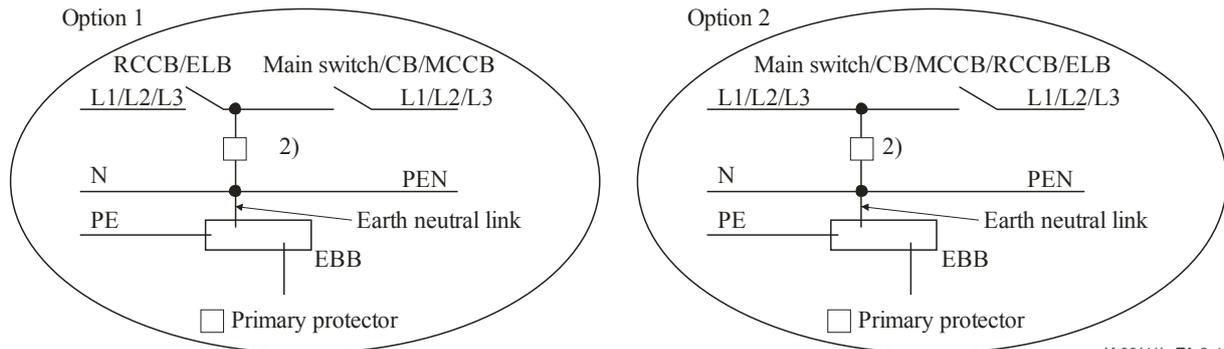
K.66(11)_FA.2-1a

NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.



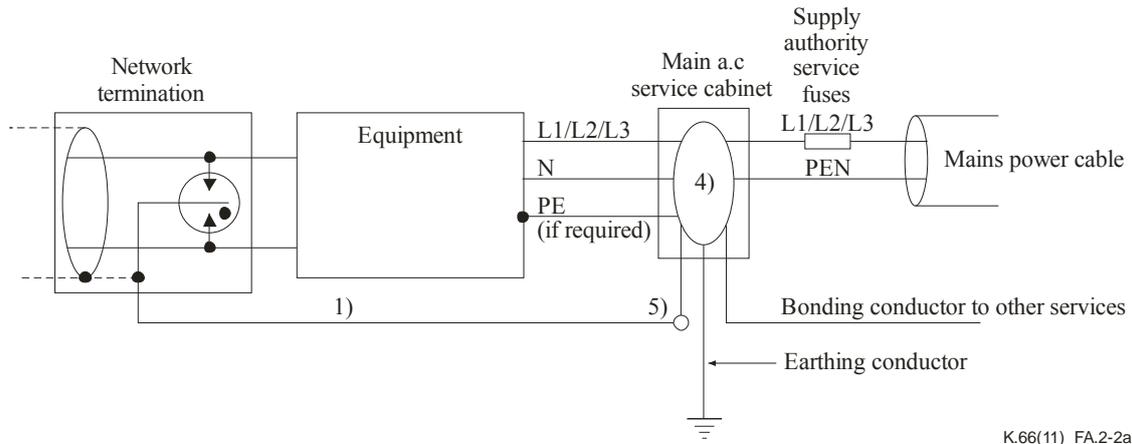
K.66(11)_FA.2-1b

NOTE 5 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.2-1 – TN-C-S with earth neutral link (MET installed outside the main a.c. service cabinet)

A.2.2 Installation method for a TN-C-S power distribution system, with earth neutral link, (MET installed inside the main a.c. service cabinet)

See Figure V.2 of [IEC 60950-1].



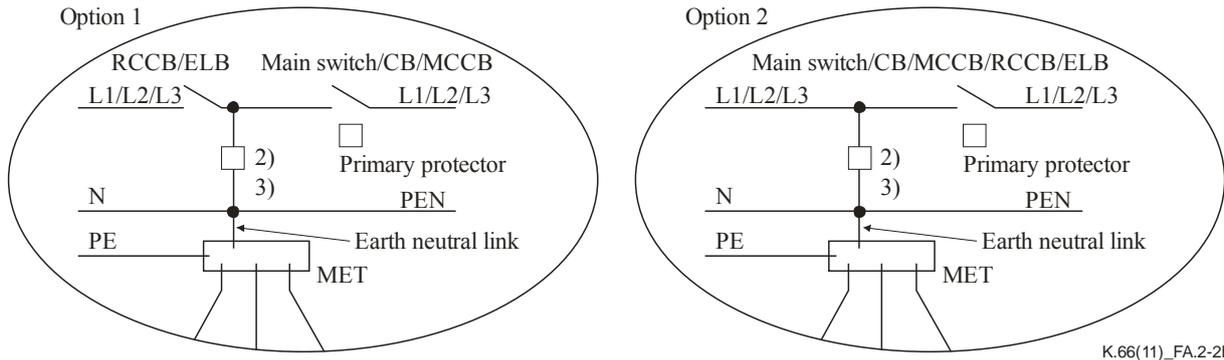
NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

NOTE 5 – A bonding bar or terminal may be required by some administrations.

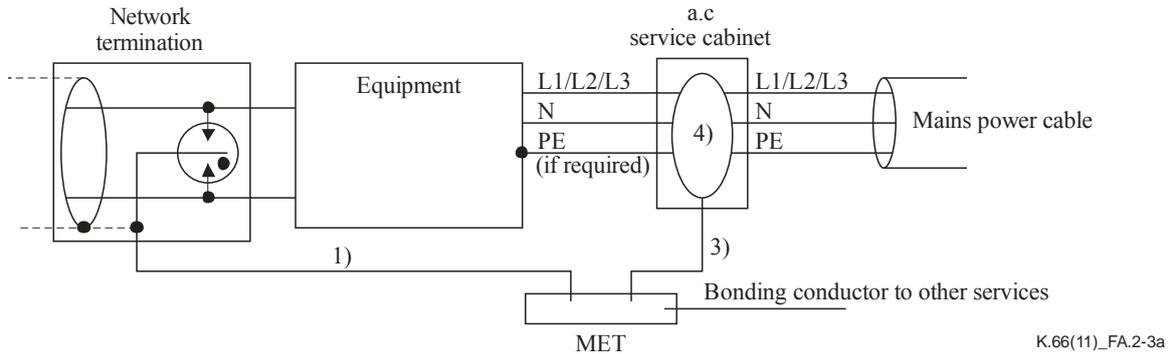


NOTE 6 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.2-2 – TN-C-S installation with earth neutral link (MET installed inside the main a.c. service cabinet)

A.2.3 Installation method for a TN-C-S power distribution system, without earth neutral link, (MET installed outside the a.c. service cabinet)

See Figure V.2 of [IEC 60950-1].

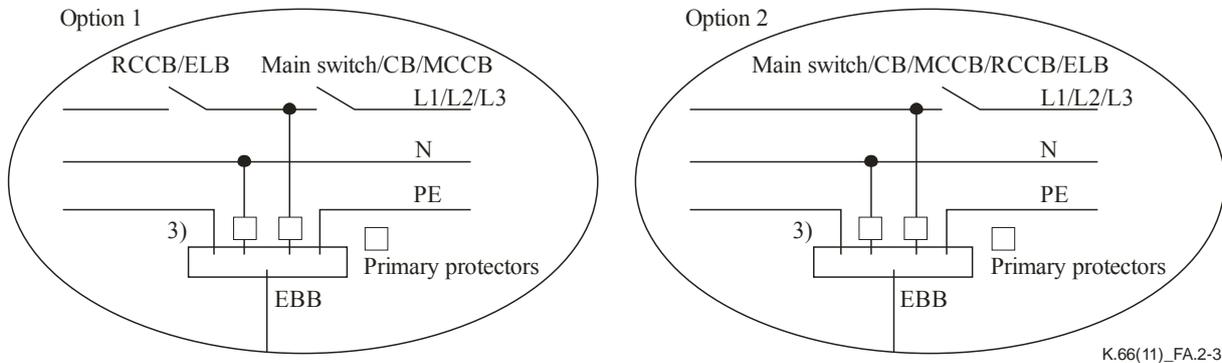


NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

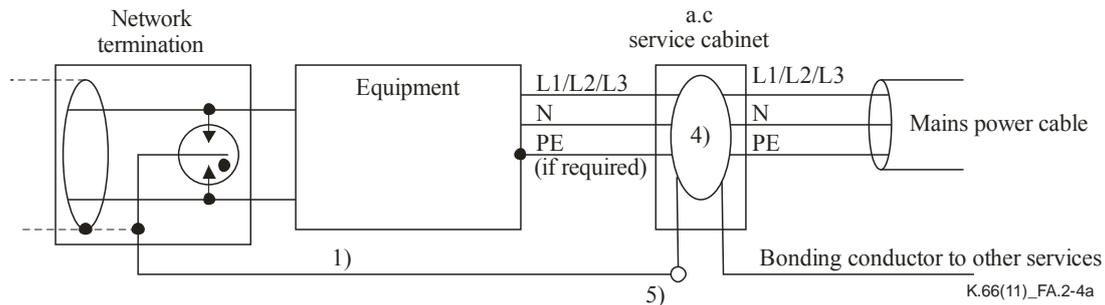


NOTE 5 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.2-3 – TN-C-S installation without earth neutral link (MET installed outside the a.c. service cabinet)

A.2.4 Installation method for a TN-C-S power distribution system, without earth neutral link, (MET installed inside the a.c. service cabinet)

See Figure V.2 of [IEC 60950-1].



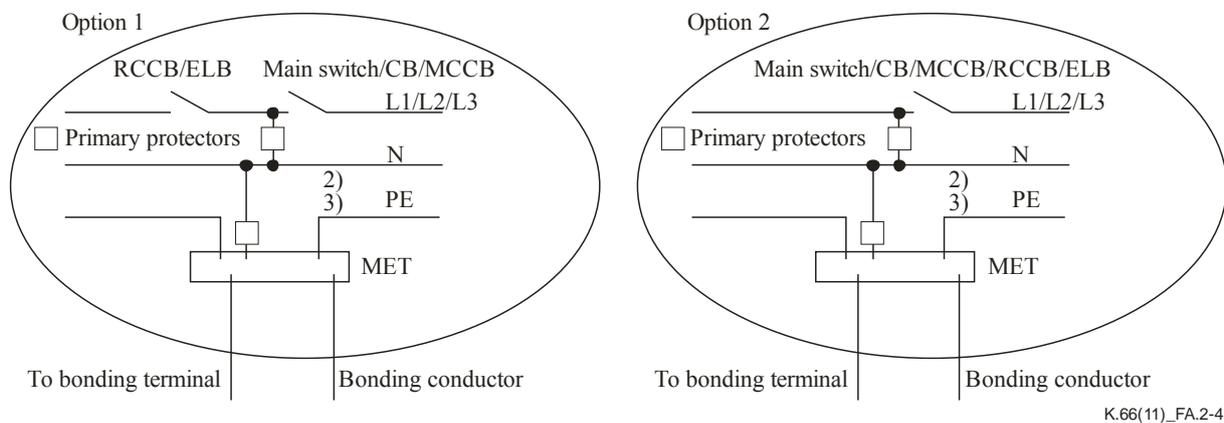
NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

NOTE 5 – A bonding bar or terminal may be required by some administrations.



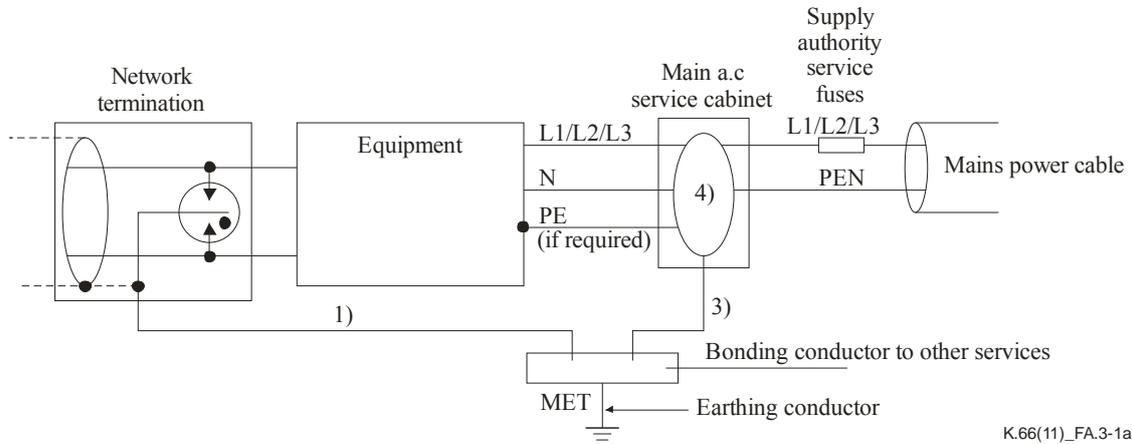
NOTE 6 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.2-4 – TN-C-S installation without earth neutral link (MET installed inside the a.c. service cabinet)

A.3 Installation method for TN-C power distribution systems

A.3.1 Installation method for a three-phase 4-wire TN-C power distribution system, (MET installed outside the main a.c. service cabinet)

See Figure V.3 of [IEC 60950-1].

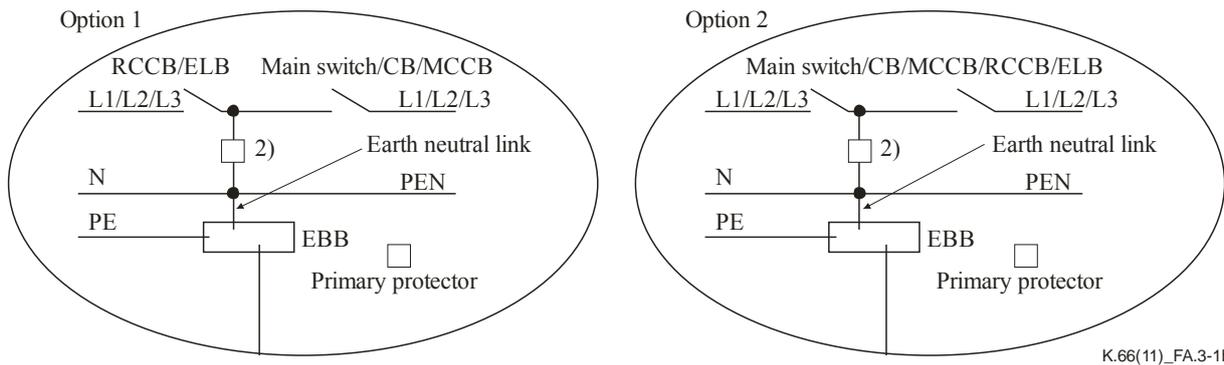


NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

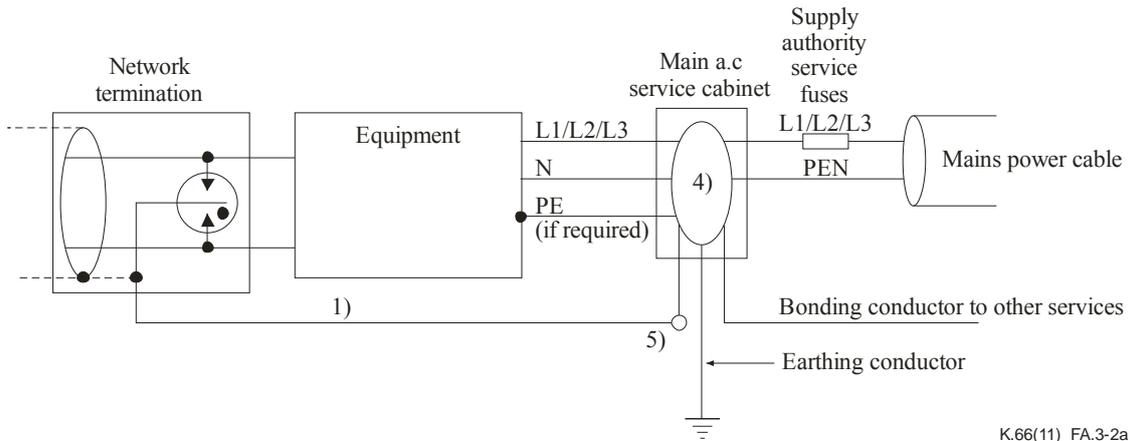


NOTE 5 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.3-1 – TN-C installation with earth neutral link (MET installed outside the main a.c. service cabinet)

A.3.2 Installation method for a three-phase 4-wire TN-C power distribution system, (MET installed inside the main a.c. service cabinet)

See Figure V.3 of [IEC 60950-1].



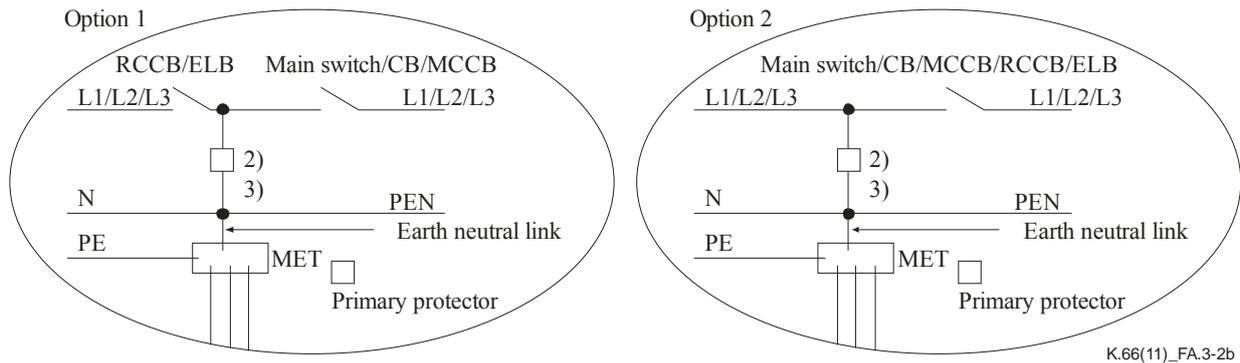
NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

NOTE 5 – A bonding bar or terminal may be required by some administrations.

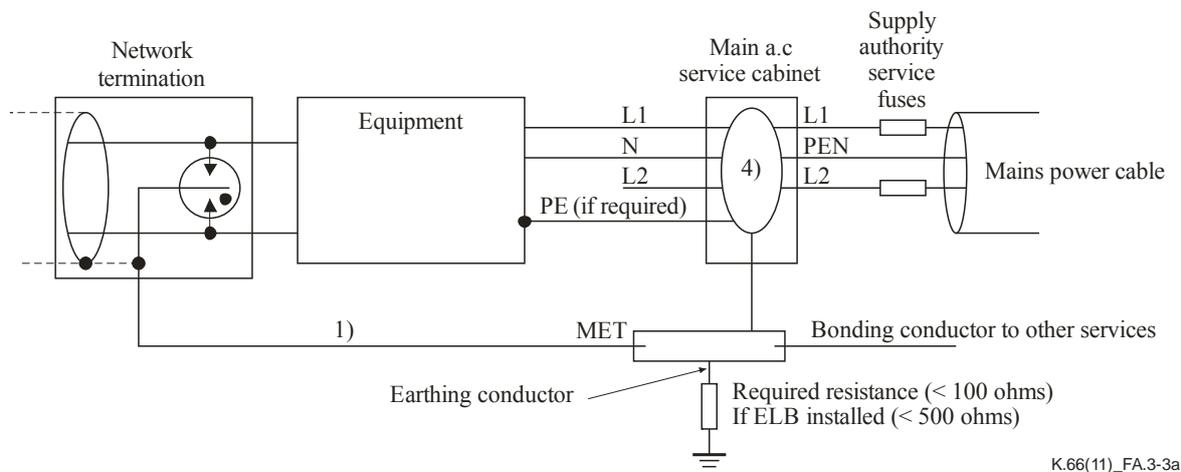


NOTE 6 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

**Figure A.3-2 – TN-C installation with earth neutral link
(MET installed inside the main a.c. service cabinet)**

A.3.3 Installation method for a single-phase three-wire TN-C power distribution system, (MET installed outside the main a.c. service cabinet)

See Figure V.4 of [IEC 60950-1].



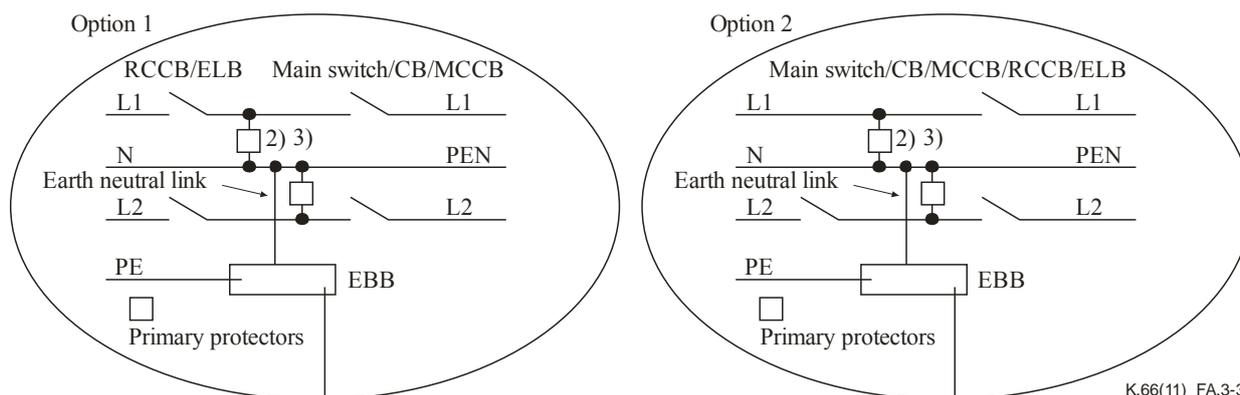
K.66(11)_FA.3-3a

NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.



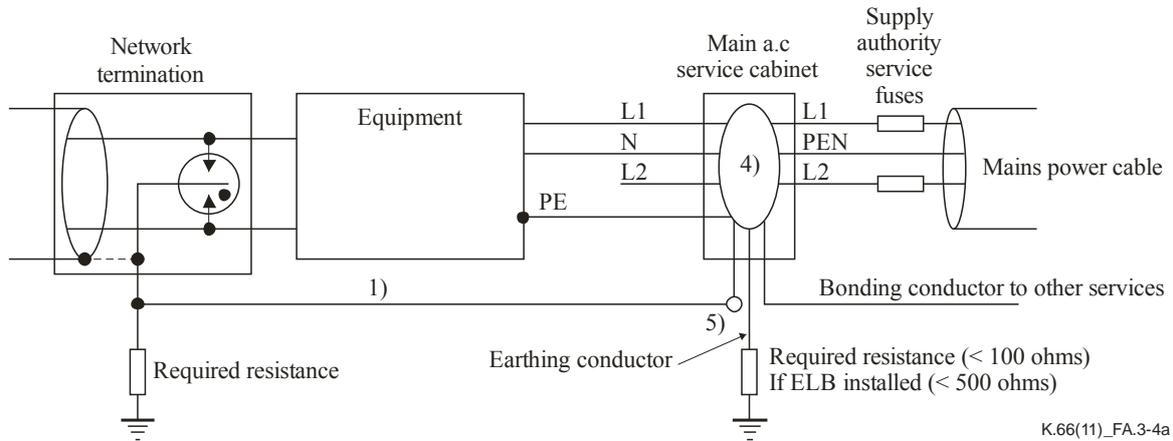
K.66(11)_FA.3-3b

NOTE 5 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.3-3 – Single-phase three-wire TN-C PEN power distribution system (MET installed outside the main a.c. service cabinet)

A.3.4 Installation method for a single-phase three-wire TN-C power distribution system, (MET installed inside the main a.c. service cabinet)

See Figure V.4 of [IEC 60950-1].



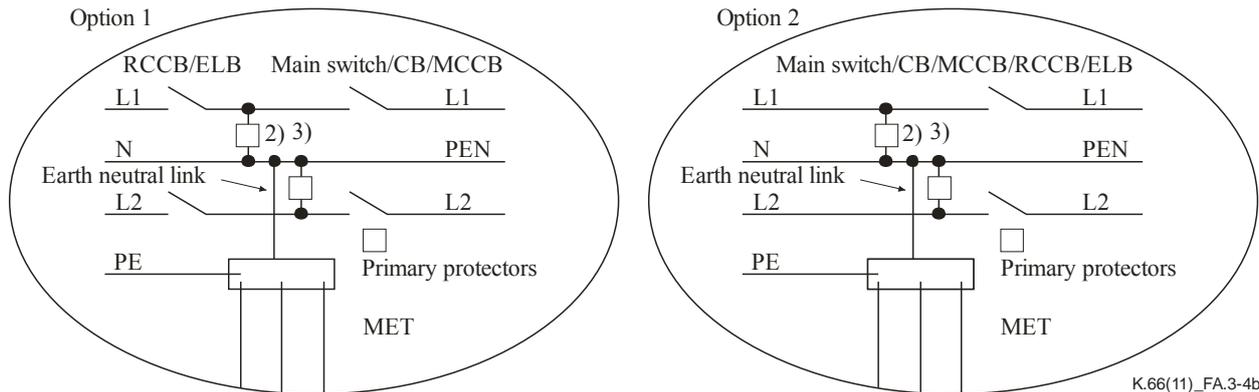
NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

NOTE 5 – A bonding bar or terminal may be required by some administrations.



NOTE 6 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

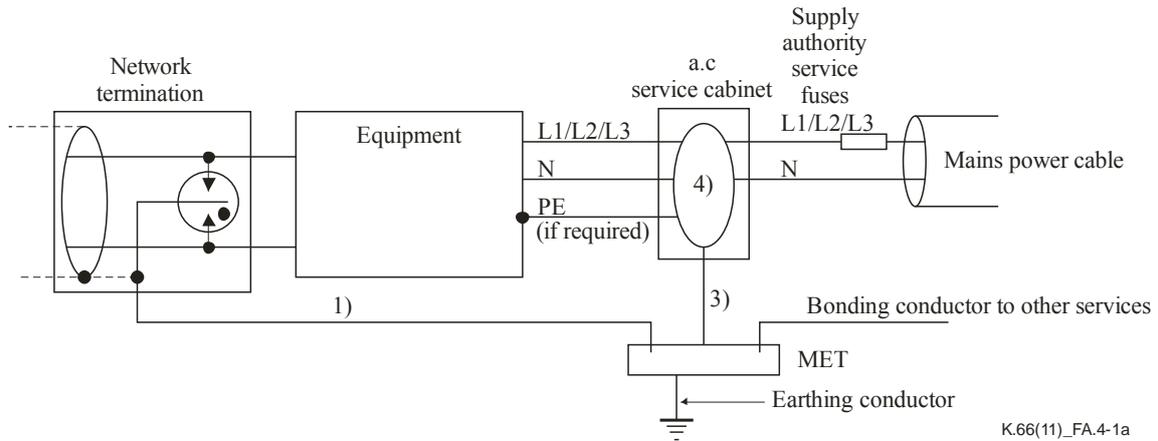
Figure A.3-4 – Single-phase three-wire TN-C PEN power distribution system (MET installed inside the main a.c. service cabinet)

A.4 Installation method for TT power distribution systems

TT power distribution systems have one point directly earthed, the parts of the equipment required to be earthed being connected at the users premises to earth electrodes that are electrically independent of the earth electrodes of the power distribution system.

A.4.1 Installation method for a three-line and neutral TT power distribution system, (MET outside the main a.c. service cabinet)

See Figure V.5 of [IEC 60950-1].

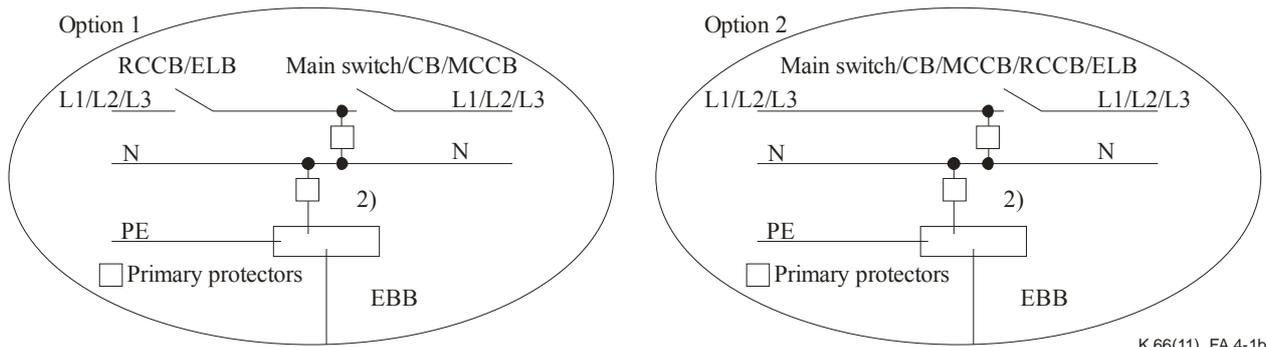


NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

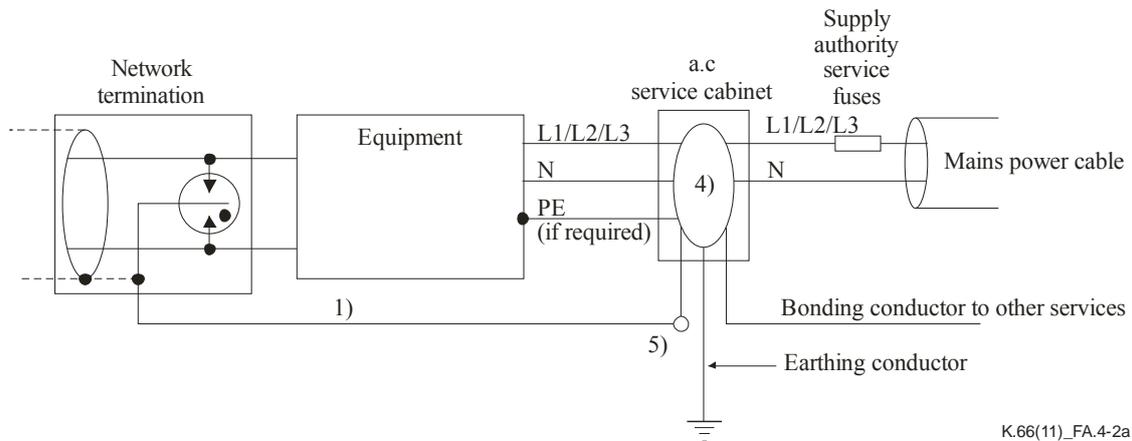


NOTE 5 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.4-1 – Three-line and neutral TT power distribution system (MET outside the main a.c. service cabinet)

A.4.2 Installation method for a three-line and neutral TT power distribution system, (MET inside the main a.c. service cabinet)

See Figure V.5 of [IEC 60950-1].



K.66(11)_FA.4-2a

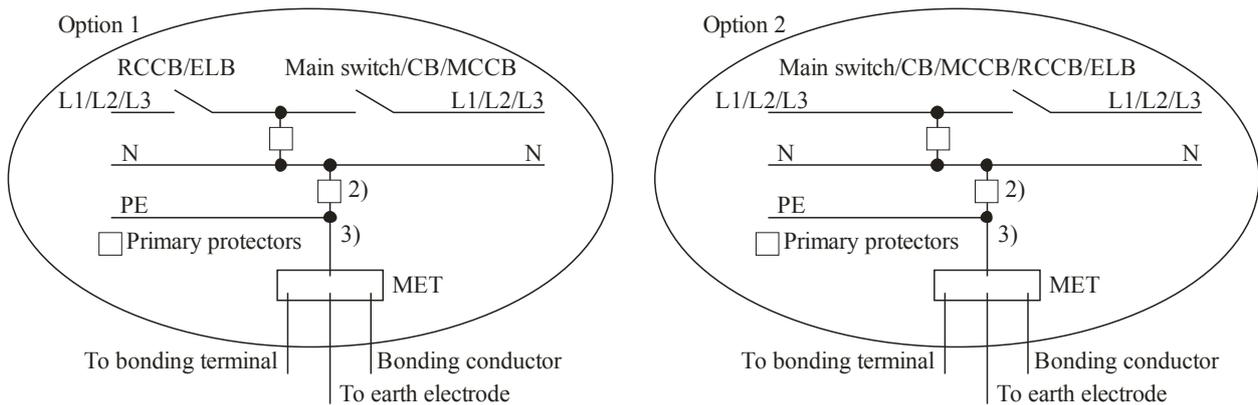
NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

NOTE 5 – A bonding bar or terminal may be required by some administrations.



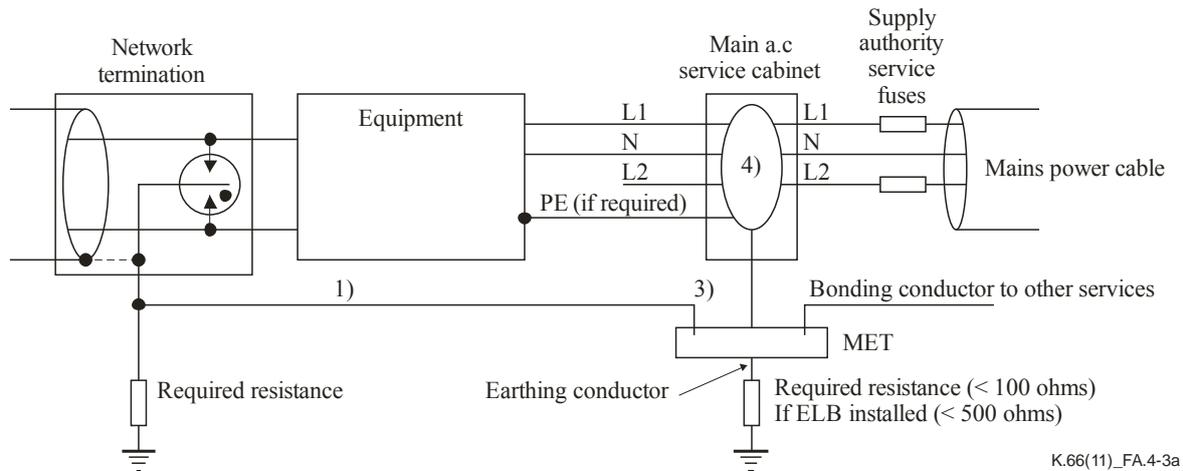
K.66(11)_FA.4-2b

NOTE 6 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.4-2 – Three-line and neutral TT power distribution system (MET inside the main a.c. service cabinet)

A.4.3 Installation method for a single-phase 3-wire TT power distribution system, (MET outside the main a.c. service cabinet)

NOTE – This power distribution method is not covered in [IEC 60950-1].



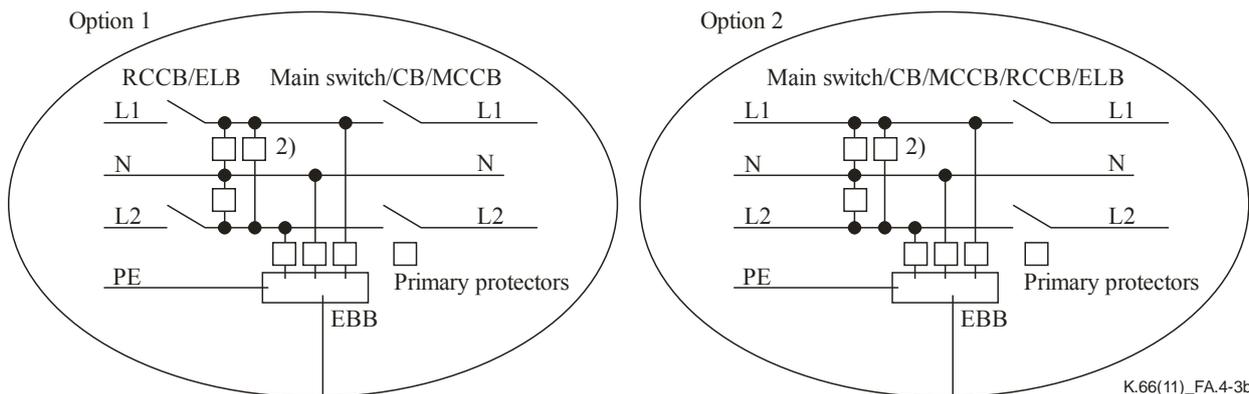
K.66(11)_FA.4-3a

NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.



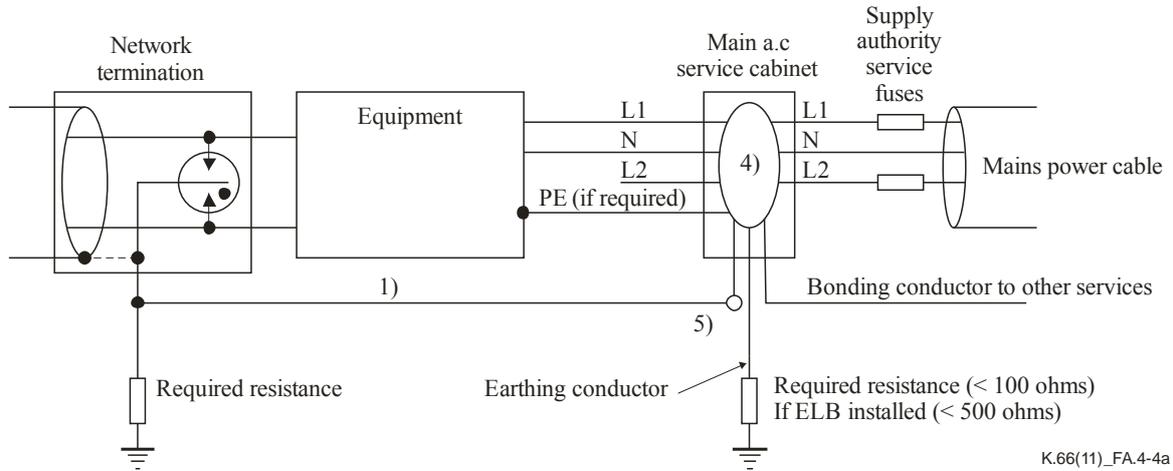
K.66(11)_FA.4-3b

NOTE 5 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.4-3 – Single-phase 3-wire TT power distribution system (MET outside the main a.c. service cabinet)

A.4.4 Installation method for a single-phase three-wire TT power distribution system, (MET inside the main a.c. service cabinet)

NOTE – This power distribution method is not covered in [IEC 60950-1].



K.66(11)_FA.4-4a

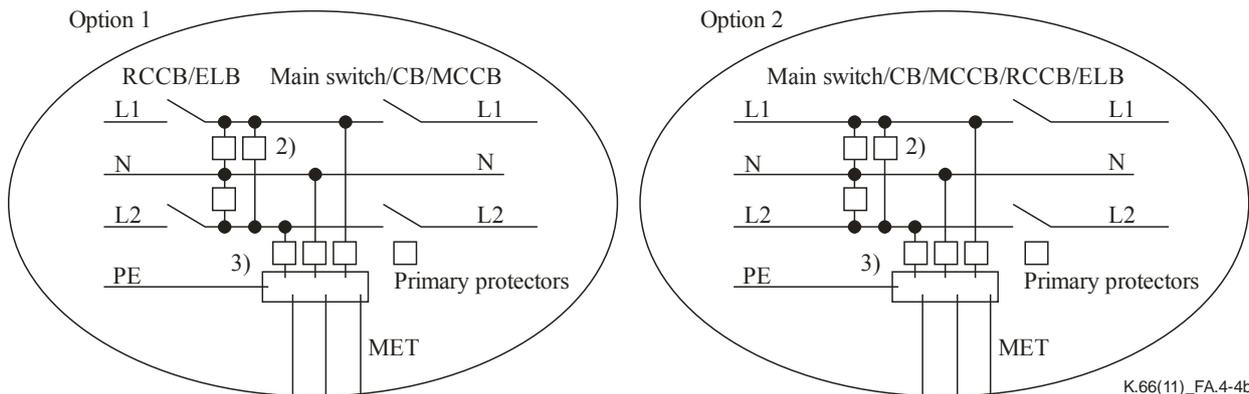
NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

NOTE 5 – A bonding bar or terminal may be required by some administrations.



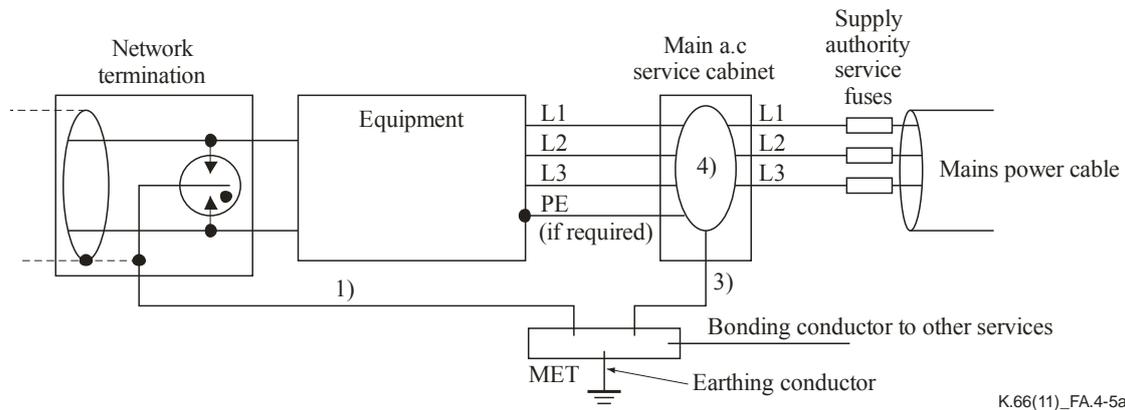
K.66(11)_FA.4-4b

NOTE 6 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.4-4 – Single-phase 3-wire TT power distribution system (MET inside the main a.c. service cabinet)

A.4.5 Installation method for a three-line (without neutral) TT power distribution system, (MET outside the main a.c. service cabinet)

See Figure V.6 of [IEC 60950-1].



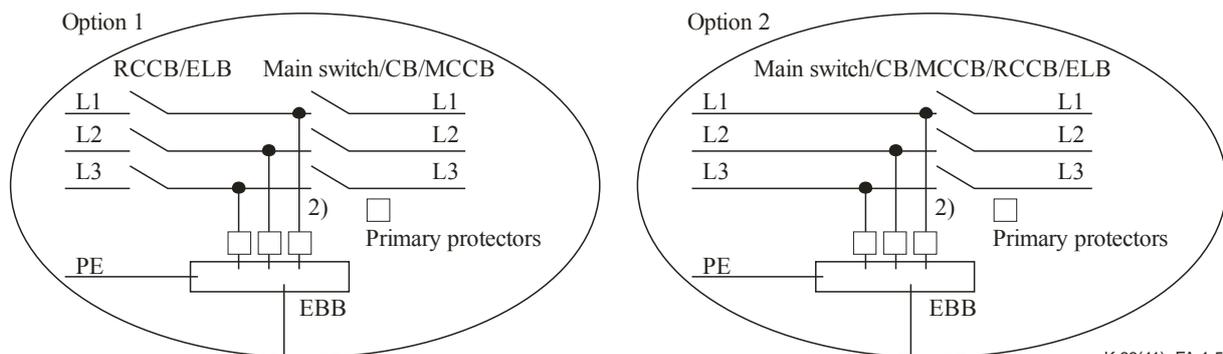
K.66(11)_FA.4-5a

NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.



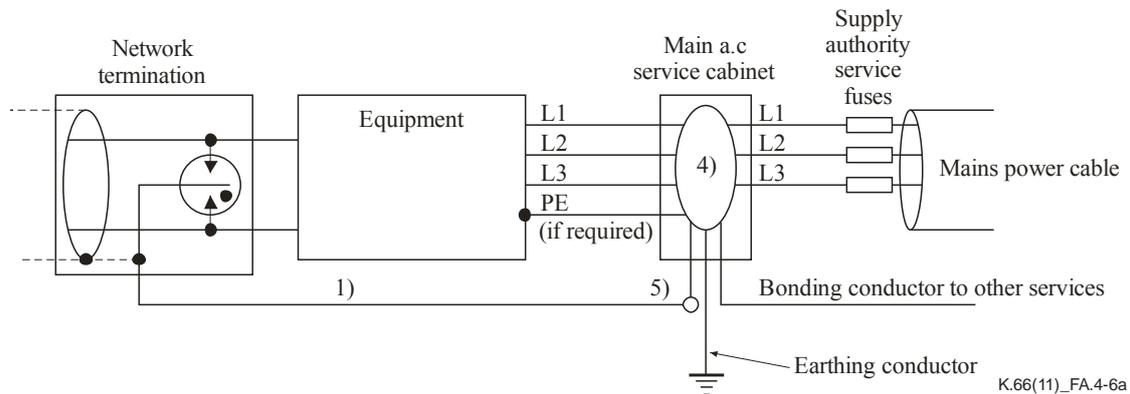
K.66(11)_FA.4-5b

NOTE 5 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.4-5 – Three-line (without neutral) TT power distribution system (MET outside the main a.c. service cabinet)

A.4.6 Installation method for a three-line (without neutral) TT power distribution system, (MET inside the main a.c. service cabinet)

See Figure V.6 of [IEC 60950-1].



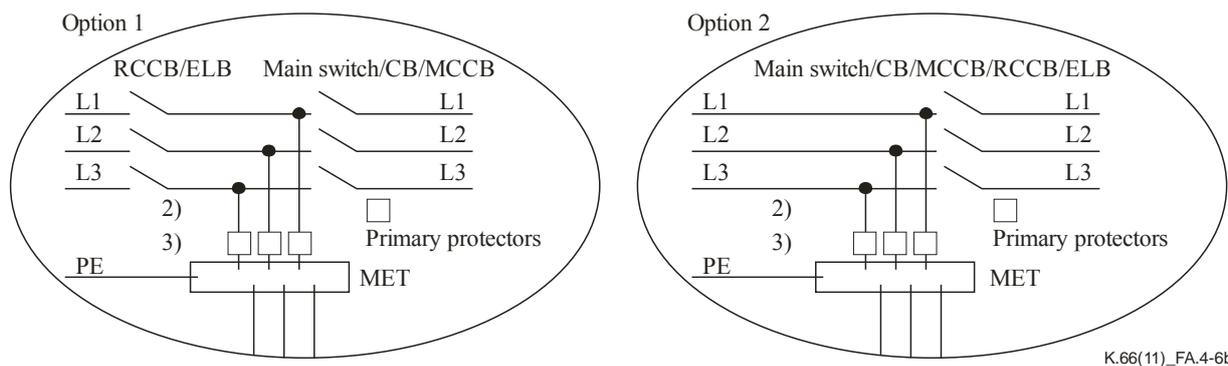
NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

NOTE 5 – A bonding bar or terminal may be required by some administrations.



NOTE 6 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

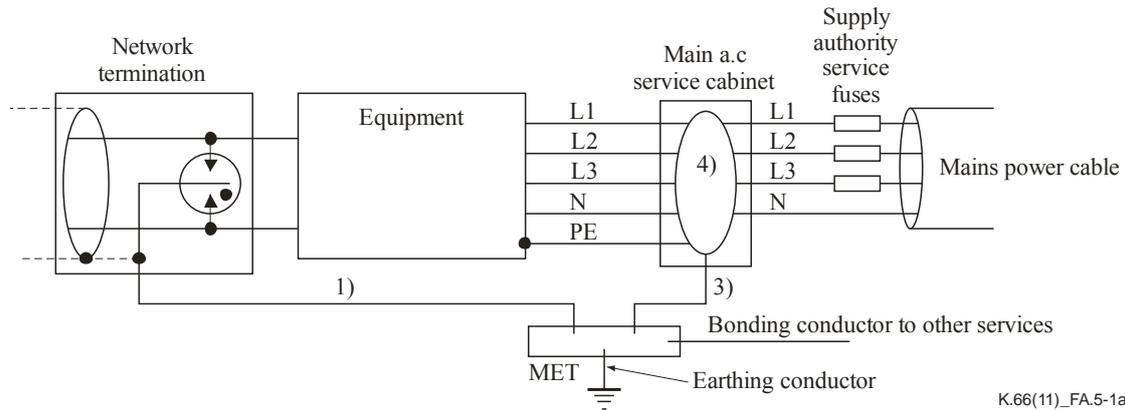
Figure A.4-6 – Three-line (without neutral) TT power distribution system (MET inside the main a.c. service cabinet)

A.5 Installation method for IT power distribution systems

IT power systems are isolated from earth, except that one point may be connected to earth through an impedance or a voltage limiter. The parts of the equipment to be earthed are connected to earth electrodes at the user's premises.

A.5.1 Installation method for a three-line (and neutral) IT power distribution system, (MET outside the main a.c. service cabinet)

See Figure V.7 of [IEC 60950-1].

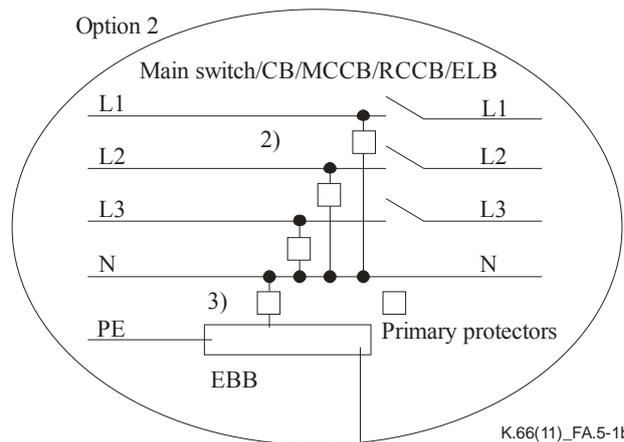
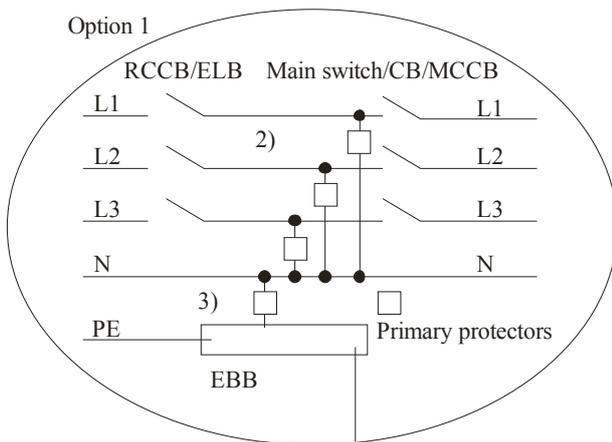


NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

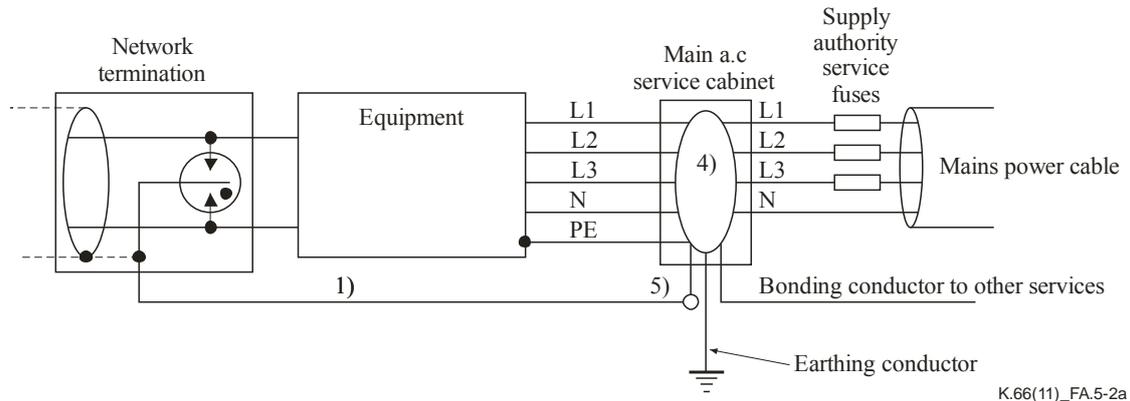


NOTE 5 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.5-1 – IT three-line (and neutral) power distribution system (MET outside the main a.c. service cabinet)

A.5.2 Installation method for a three-line (and neutral) IT power distribution system, (MET inside the main a.c. service cabinet)

See Figure V.7 of [IEC 60950-1].



K.66(11)_FA.5-2a

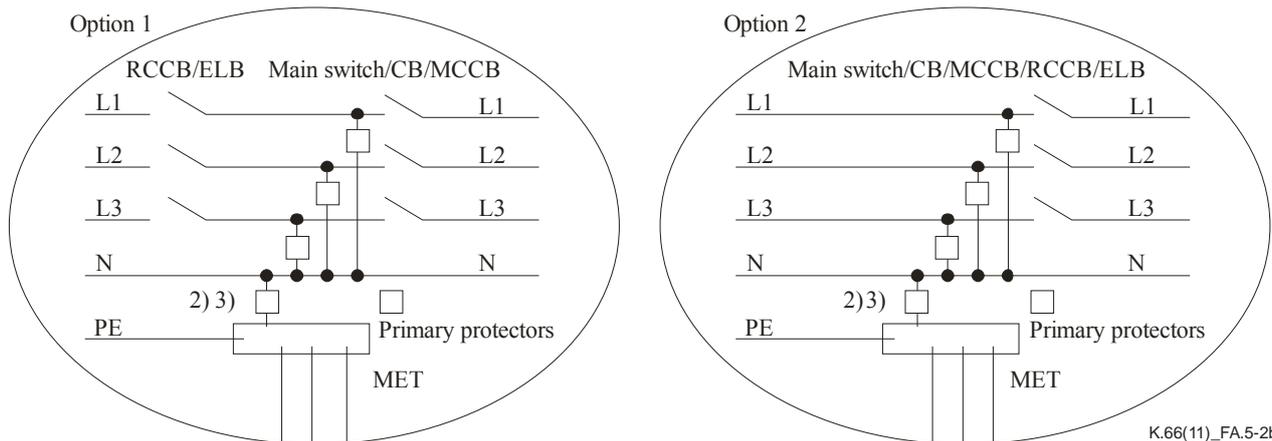
NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

NOTE 5 – A bonding bar or terminal may be required by some administrations.



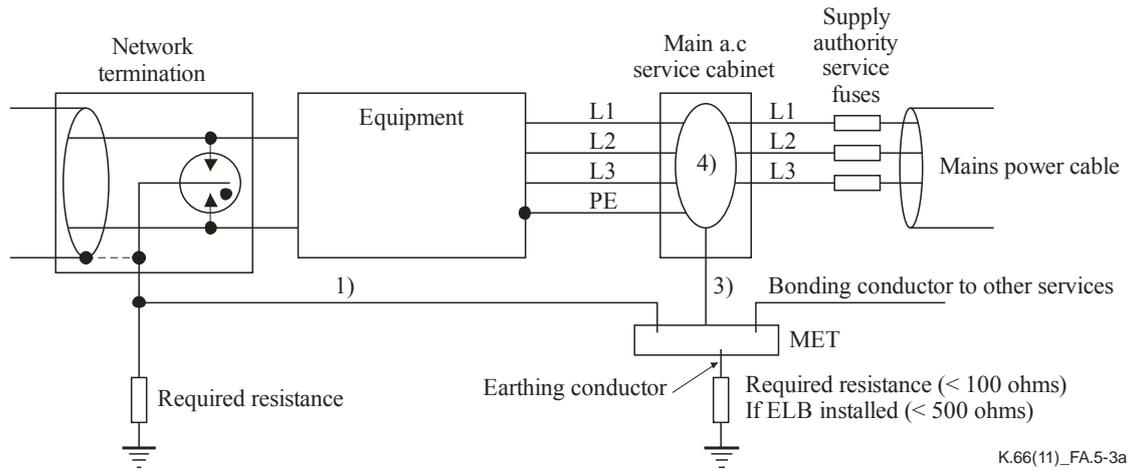
K.66(11)_FA.5-2b

NOTE 6 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.5-2 – IT three-line (and neutral) power distribution system (MET inside the main a.c. service cabinet)

A.5.3 Installation method for a three-line (without neutral) IT power distribution system, (MET outside the main a.c. service cabinet)

See Figure V.8 of [IEC 60950-1].

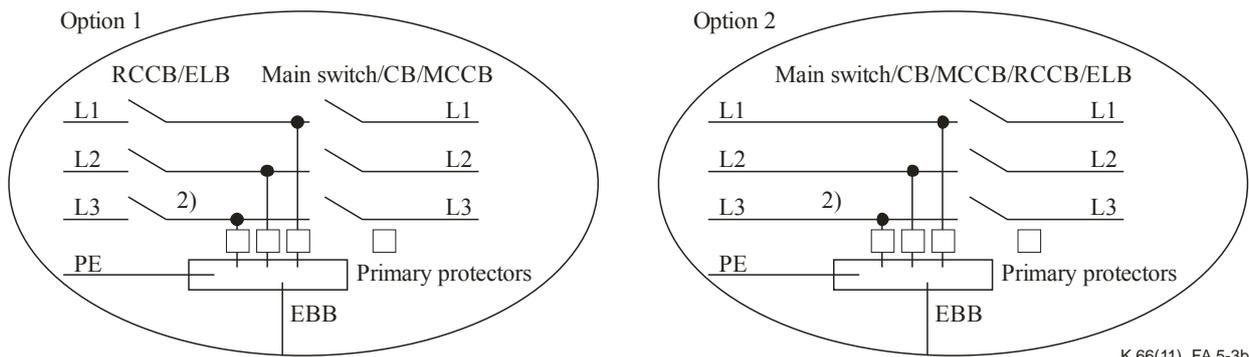


NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

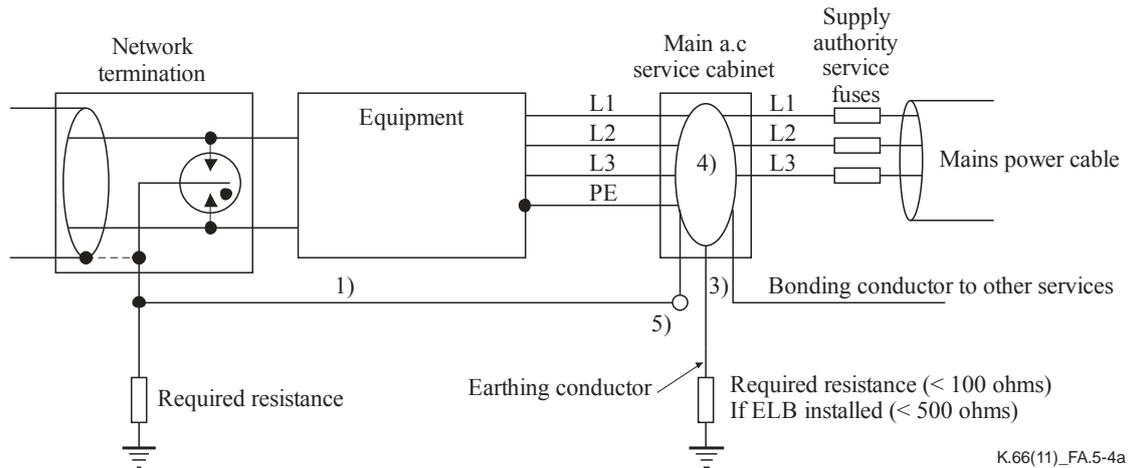


NOTE 5 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.5-3 – IT three-line (without neutral) power distribution system (MET outside the main a.c. service cabinet)

A.5.4 Installation method for a three-line (without neutral) IT power distribution system, (MET inside the main a.c. service cabinet)

See Figure V.8 of [IEC 60950-1].



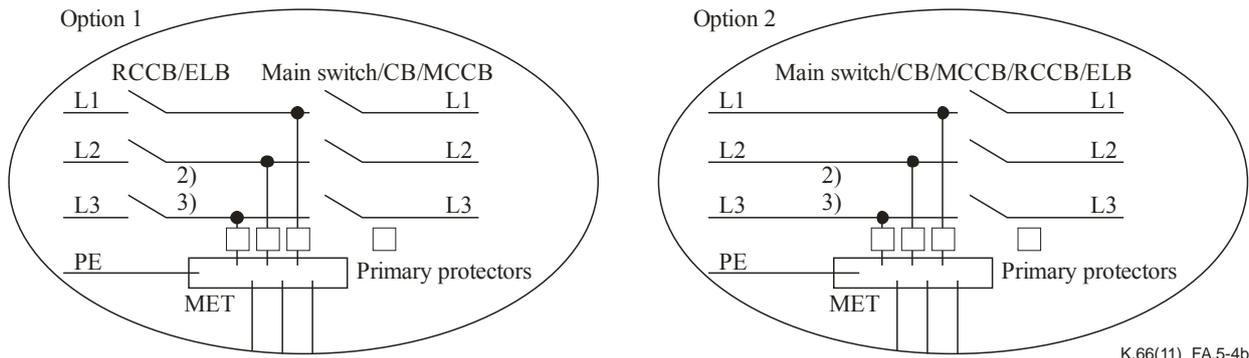
NOTE 1 – Total length of bonding wire to MET should be as short as possible (< 1.5 m if there is a significant risk of a direct lightning strike).

NOTE 2 – Total length of SPD connecting wires should be as short as possible (< 0.5 m).

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) should be as short as possible (< 1.5 m).

NOTE 4 – See options below for installing SPDs.

NOTE 5 – A bonding bar or terminal may be required by some administrations.



NOTE 6 – The SPD may be installed before the ELB (option 1) or after the ELB (option 2). If option 2 is used, nuisance tripping of the circuit breaker may occur, particularly if it contains an RCD.

Figure A.5-4 – IT three-line (without neutral) power distribution system (MET inside the main a.c. service cabinet)

Annex B

Solutions for earthing and bonding problems

(This annex forms an integral part of this Recommendation.)

There are three methods which can be used to solve earthing and bonding problems as described below:

B.1 Methods to improve earthing and bonding

Where the services are not co-located, there are ways to achieve short bonding conductors as explained in clauses 9.2.1 to 9.2.5.

B.2 Methods of providing additional protection external to the equipment

When it is decided that protection external to the equipment is required, CPUs may be used to provide this protection. The use of CPUs is explained in clause 10. Refer to clause 8.1 for information relating to issues with long bond wires.

B.3 Special resistibility and safety requirements

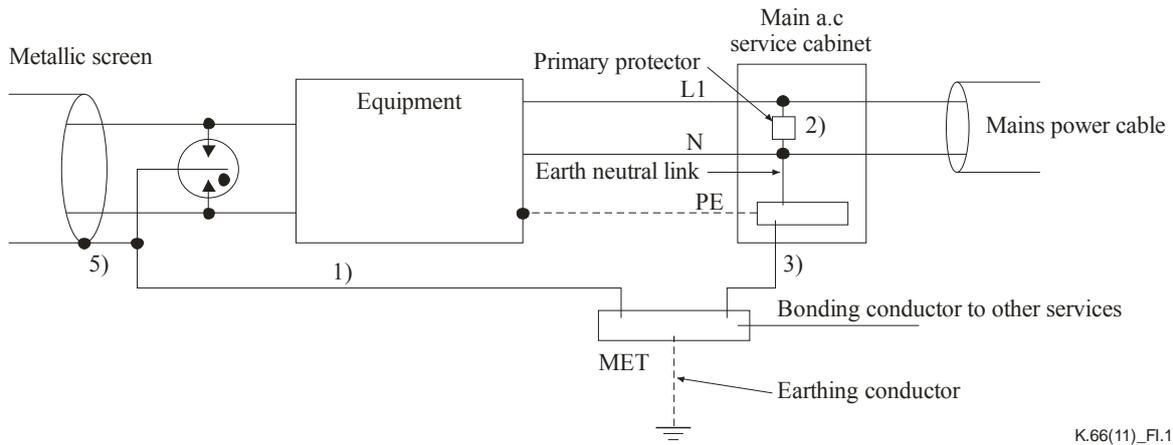
The third alternative is to specify special resistibility and safety requirements, see clause II.6 of [ITU-T K.44].

Appendix I

Earthing and bonding scenarios

(This appendix does not form an integral part of this Recommendation.)

There are many types of earthing and bonding practices used and these different practices can require additional protection to avoid damage to equipment complying with the resistibility requirements of [ITU-T K.21]. Five different earthing and bonding practices have been identified for customer premises installations and these are shown in Figures I.1 to I.5. Only practice 1, shown in Figure I.1, will protect the equipment without the use of additional protection from overvoltage surges entering via external cables. Note, even with Figure I.1, that additional protection may be required at the equipment against surge induced into long intra building wiring.



K.66(11)_Fl.1

NOTE 1 – Total length of bonding wire to MET < 1.5 m.

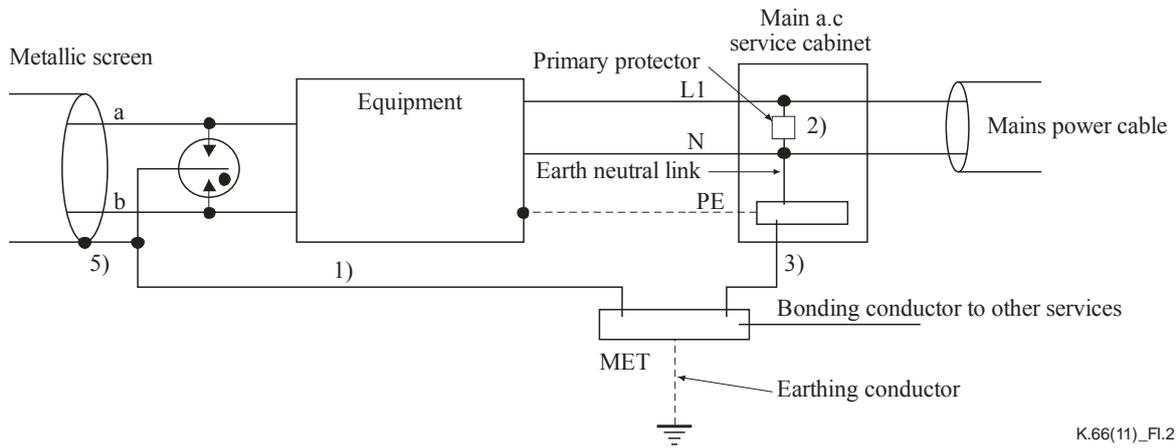
NOTE 2 – Total length of connecting wires < 0.5 m.

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) < 1.5 m.

NOTE 4 – An earth electrode is not required at the customer's premises in all power systems, it may be supplied in the distribution network.

NOTE 5 – The telecommunication cable may not always have a shield or be earthed.

Figure I.1 – Practice 1 – Common earth bar with short bond wires



K.66(11)_Fl.2

NOTE 1 – Total length of bonding wire to MET > 1.5 m.

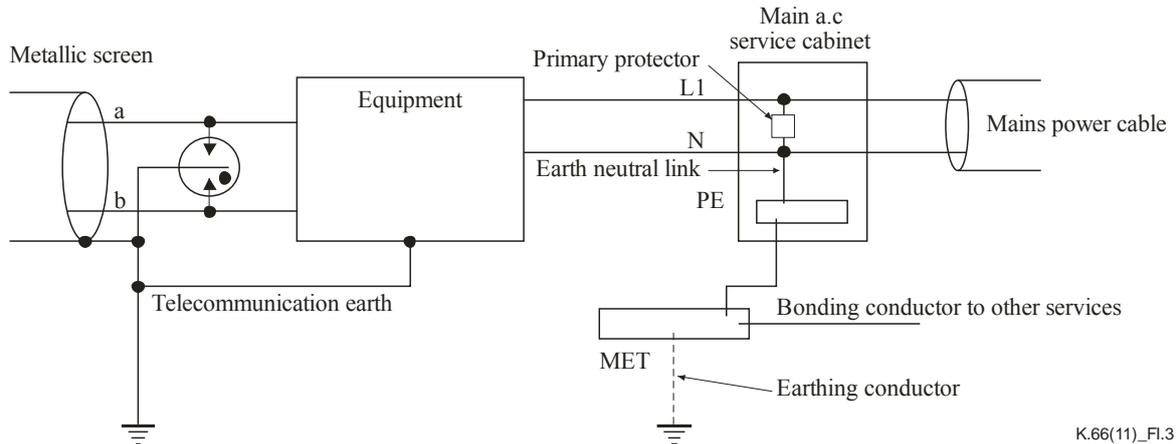
NOTE 2 – Total length of connecting wires > 0.5 m.

NOTE 3 – Total length of bonding and connecting wires (SPD to MET) > 1.5 m.

NOTE 4 – An earth electrode is not required at the customer's premises in all power systems, it may be supplied in the distribution network.

NOTE 5 – The telecommunication cable may not always have a shield or be earthed.

Figure I.2 – Practice 2 – Common earth bar with long bond wires

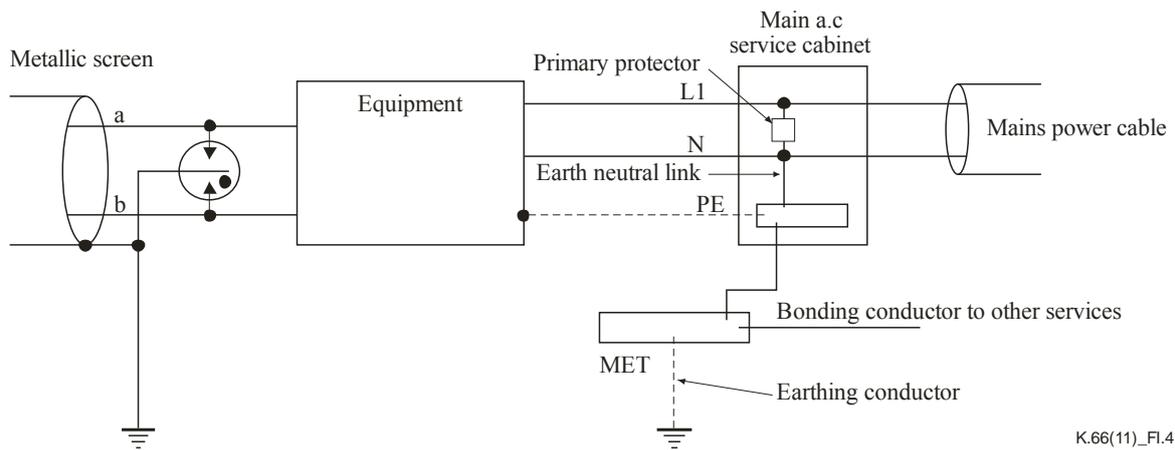


K.66(11)_Fl.3

NOTE 1 – An earth electrode is not required at the customer's premises in all power systems, it may be supplied in the distribution network.

NOTE 2 – The telecommunication cable may not always have a shield or be earthed.

Figure I.3 – Practice 3 – Separate telecommunication and mains earths, equipment connected to the telecommunication earth

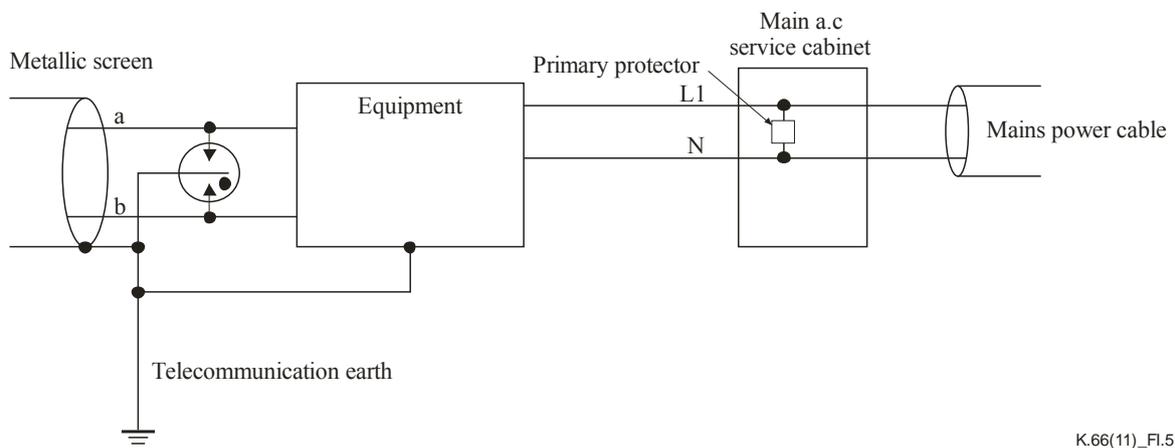


K.66(11)_Fl.4

NOTE 1 – An earth electrode is not required at the customer's premises in all power systems, it may be supplied in the distribution network.

NOTE 2 – The telecommunication cable may not always have a shield or be earthed.

Figure I.4 – Practice 4 – Separate telecommunication and mains earths, equipment connected to the mains earth



K.66(11)_Fl.5

NOTE – The telecommunication cable may not always have a shield or be earthed.

Figure I.5 – Practice 5 – Mains not referenced to local earth

In the cases shown in Figures I.2 to I.5, a 50-A surge from the telecommunication line discharging to ground via a 300-Ω earth electrode will cause a 15-kV earth potential rise of the telecommunication equipment with respect to the power network. Figures I.6 to I.7 show the difference in equipment protection when the installation has a common bonding terminal with short conductors and when it does not.

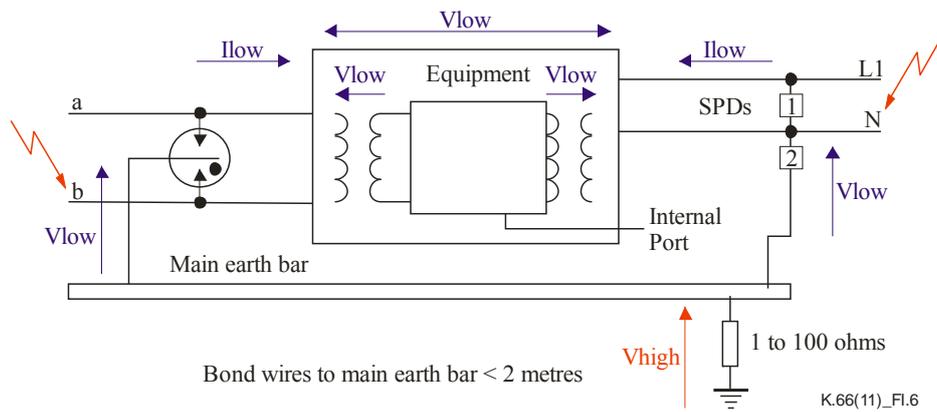


Figure I.6 – Installation has recommended earthing and bonding; equipment protected

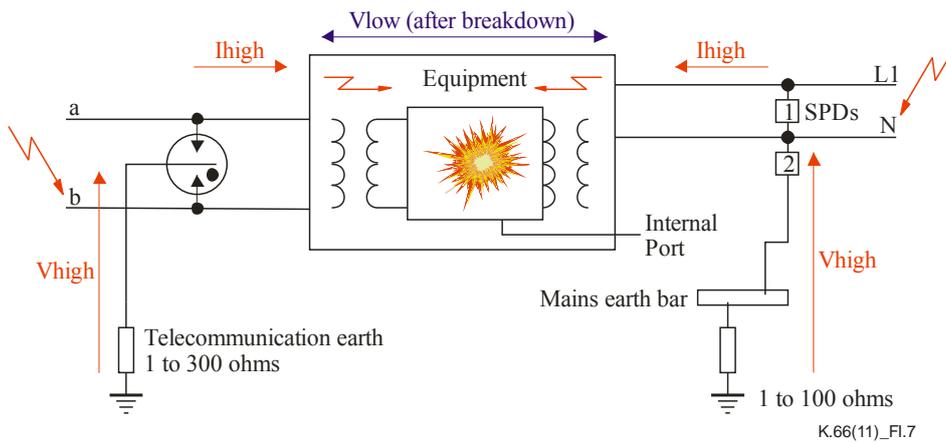


Figure I.7 – Installation has poor earthing and bonding; equipment damaged

The equipment overvoltage resistibility requirements in [ITU-T K.21] are based on the installation type shown in Figure I.1. If the equipment will be installed using the installation types shown in Figures I.2 to I.5, additional protection may be required. Information on additional protection and the correct method of installation is given in clauses 9, 10, and 11 and Annexes A and B.

Appendix II

Examples of mitigation measures for different power installations

(This appendix does not form an integral part of this Recommendation.)

II.1 TN-C and TN-C-S types

Where existing installations inside a building are of the TN-C or TN-C-S type, the following mitigation measures (either one alone or in combination) may be applied:

- 1) metal-free fibre optic cables for signal links interconnecting Class I equipment;
- 2) Class II equipment (double insulation, no PE conductor)¹;
- 3) local separation transformers to supply telecommunications Class I equipment¹;
- 4) suitable cable routing in order to minimize the enclosed area of common loops formed by the mains and signal cables;
- 5) additional screening².

II.2 TT and IT types

Where existing installations inside a building are of the TT or IT type, the following mitigation measures (either one alone or in combination) may be applied:

- 1) SPD bonding between the neutral/line conductor and the local safety earth;
- 2) use of external protection devices;
- 3) higher than normal resistibility and safety requirements for the equipment, see Table II.6-1 of [ITU-T K.44].

In addition to one or more of the above, one or more of the following mitigation methods may also be required.

- 1) metal-free fibre optic cables for signal links interconnecting Class I equipment;
- 2) Class II equipment (double insulation, no PE conductor)¹;
- 3) local separation transformers to supply telecommunications Class I equipment¹;
- 4) suitable cable routing in order to minimize the enclosed area of common loops formed by the mains and signal cables;
- 5) additional screening².

¹ In order to prevent low frequency interference currents through the equipment and its connected signal cables. These currents may be caused either by large loops or by the lack of a sufficiently low impedance CBN. If Class II equipment is not available, a separation transformer serves the same purpose.

² Additional screening (e.g., interconnected metal duct) also provides a lower impedance CBN.

Appendix III

Surge current paths and resulting potential differences

(This appendix does not form an integral part of this Recommendation.)

Figures III.1 to III.4 show how lightning surge currents through the various bonding conductors cause potential differences between the customer, the equipment, electrical equipment and the structure.

Figure III.1 shows the effect when lightning strikes an aerial (overhead) mains line conductor.

Figure III.2 shows the effect when lightning strikes a telecommunication cable or overhead telecommunication line.

Figure III.3 shows the effect when lightning strikes the premises.

Figure III.4 shows the effect when lightning strikes the structure.

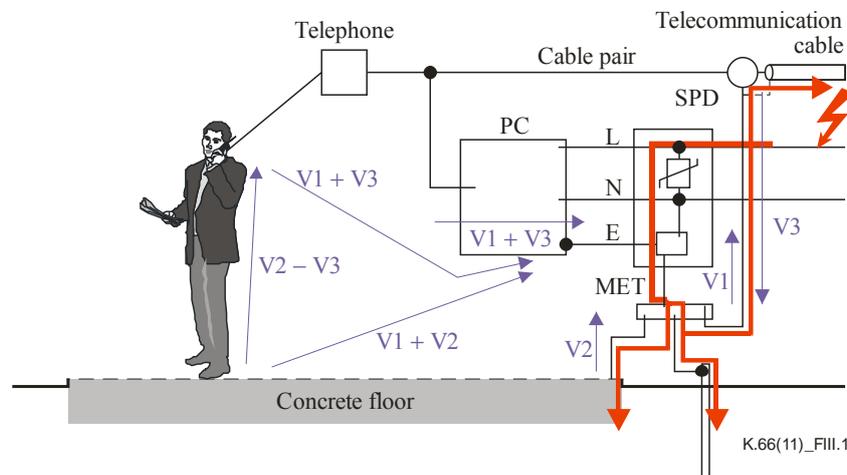


Figure III.1 – Lightning strike to phase conductor of the power line

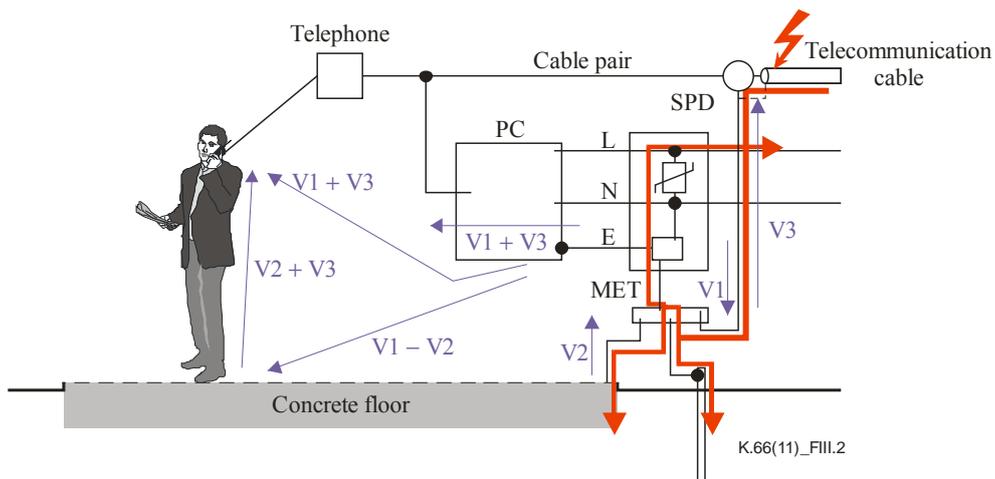


Figure III.2 – Lightning strike to the telecommunication cable

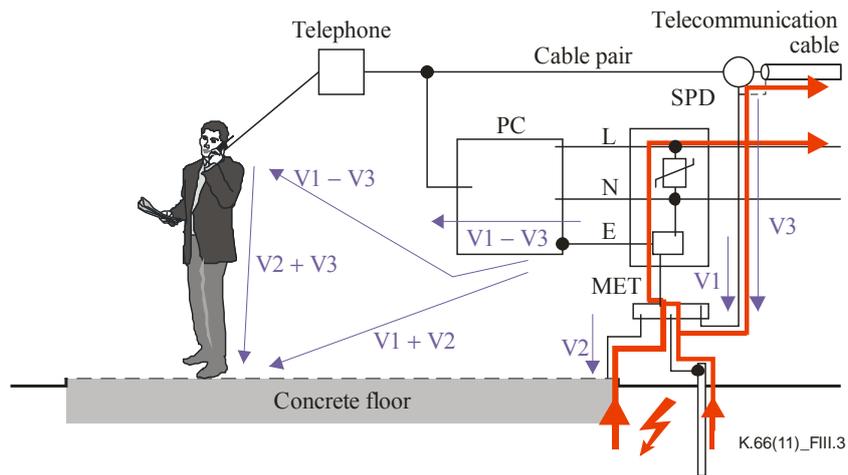


Figure III.3 – Lightning strike to ground resulting in EPR

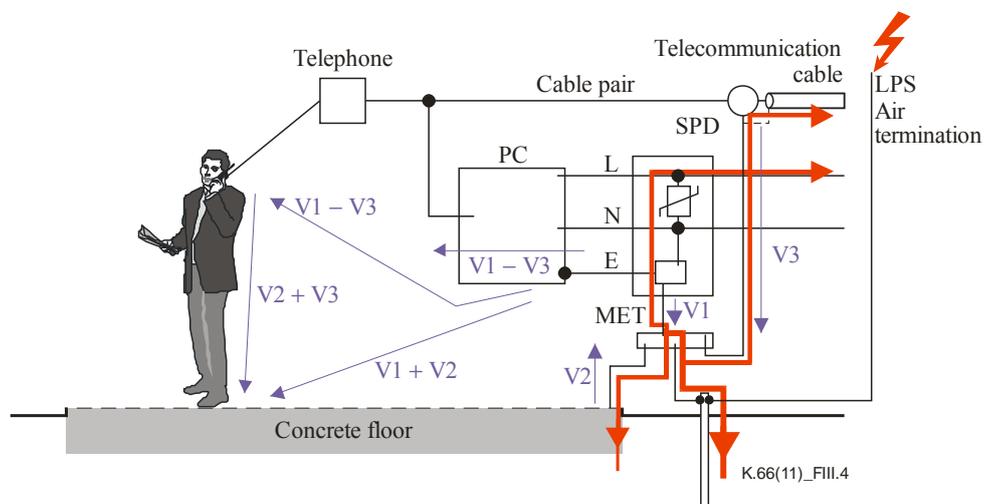


Figure III.4 – Lightning strike to structure

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