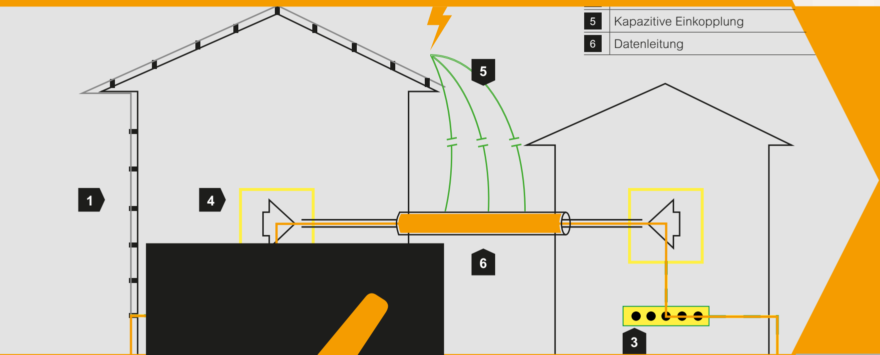

Lightning protection guide

To assist in the planning and design of lightning and surge protection systems

Building Connections

OBO BETTERMANN

Foreword

OBO Bettermann is one of the world's most experienced manufacturers of lightning and surge protection systems. For almost 100 years, OBO has been developing and producing standard-compliant lightning protection components. The rise of the modern computer began in the 1970s, with the invention of the electronic typewriter. OBO responded by launching its groundbreaking V-15 surge arrester. Countless new products over the years, such as the first connectable type 2 surge protection device with VDE test mark, or the first connectable type 1 lightning current arrester with carbon technology, laid the foundation for the uniquely comprehensive product range that we offer today.

OBO was the first manufacturer to publish a guide to lightning protection – way back in the 1950s. This original guide focused on external lightning protection and earthing systems. Since then, further information has been steadily added to the "planner sections" of the guide to include information on surge protection for everything from energy to data systems. The motto in the picture – BLITZSCHUTZ GIBT SICHERHEIT ("LIGHTNING PROTECTION PROVIDES SAFETY") – is as relevant today as it ever was, with external lightning protection still providing valuable passive fire protection in the event of a direct lightning strike.

Just like its predecessors, this edition of the lightning protection guide offers assistance in installing professional lightning protection systems in line with the very latest standards.

OBO's research and development activities received a boost in 1996 with the opening of a new BET research centre, home to one of the largest lightning surge current generators in Europe and numerous testing units. Today, lightning and surge protection components, lightning protection structures and surge protection devices are put through their paces there by highly qualified specialists in accordance with the relevant standards.

From our archives: a cartoon from 1958. The caption reads: "Lightning protection provides safety."

OBO supports and drives the development of national and international lightning protection standards of the series IEC 62305 (VDE 0185-305).

Through its membership of the VDB (Association of German Lightning Protection Companies) and the VDE Committee for Lightning Protection and Research, OBO is always up to date with the latest insights from the worlds of science and lightning protection practice.

Establishing partnerships with customers is a top priority for OBO, and OBO staff are available to support customers in all aspects of their projects, including products, installation and planning advice. Through its policy of continuous improvement, OBO creates fertile conditions for the development of new products and documents. This guide aims to provide practical assistance. We are always more than glad to incorporate suggested improvements.

We would like to wish all readers and lightning protection specialists the greatest possible satisfaction as they go about their important task of keeping people, buildings and equipment safe from lightning currents and electrical surges.

Andreas Bettermann

OBO Bettermann GmbH & Co.KG
www.obo.de

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Protected ④

The “Protected to the power of four” principle: only if protection is coordinated is it effective. Discover what our different systems do.

4 | Surge protection systems

Surge protection systems form a multi-stage barrier which no surge voltage can break through.

1 Air-termination and down-conductor systems

Interception systems reliably intercept direct lightning strikes carrying up to 200,000 A of energy and conduct them down into an earthing system through the arrester system.

3 Equipotential bonding systems

These form the interface between external and internal lightning protection. They ensure that dangerous potential differences do not come about in the building.

2 Earthing systems

When the derived lightning current reaches the earthing system, around 50% of the energy is discharged into the earth while the other half is distributed via the equipotential bonding.

1

Every year, lightning strikes and surge voltages put at risk – or cause harm to – people, animals and property. Damage to property is becoming an ever greater problem as the failure of electronic devices can cause financial loss in industry and inconvenience for individuals. Building regulations mean that it is a legal requirement today that buildings incorporate personal safety elements. The work of public agencies, such as the police, ambulance and fire services, is also particularly worthy of protection.

Whether a lightning protection system is needed in a given situation can be determined on the basis of the latest standards. Alternatively, the cost of damage to equipment can be compared with the cost of fitting a protection system that would prevent that damage from occurring. The latest standards also explain in technical terms how protective measures should be executed. Certain specialised components are required for installing a lightning protection system.

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"The protection of oneself from lightning strikes on a building is most reliably achieved through the installation of a lightning down-conductor, which carries the electrical matter from the thundercloud safely down into the earth without allowing it to touch even a single beam of the house."

Joseph Kraus' "Catechism of Lightning", 1814

1. General introduction

Lightning is a naturally occurring spark discharge or short-lived electric arc. Lightning discharges can take place from one cloud to another, or between a cloud and the ground. Lightning – one of the "electrometeors" – generally occurs during thunderstorms, where it is accompanied by thunder. Lightning involves an exchange of electric charges (electrons or gas ions), in other words the flow of electric currents. Depending on the polarity of the electrostatic charge, lightning can alternatively start from the ground.

90% of all lightning discharges between a cloud and the ground are negative, i.e. "negative cloud-to-ground strikes". Here, the lightning begins in an area of negative charge in the cloud and spreads to the positively charged ground.

However, the vast majority of discharges take place within clouds, or from one cloud to another.

NASA has measured the annual global frequency of lightning over the period 1995 to 2003. **(Figure 1.1)** The local values obtained by NASA can be used to determine the annual number of lightning strikes per km² even for countries that do not have their own information on numbers of lightning impulses. For risk assessments according to IEC 62305-2 it is recommended that these values are doubled.

The less common types of discharge are:

- *Negative ground-to-cloud lightning*
- *Positive cloud-to-ground lightning*
- *Positive ground-to-cloud lightning*

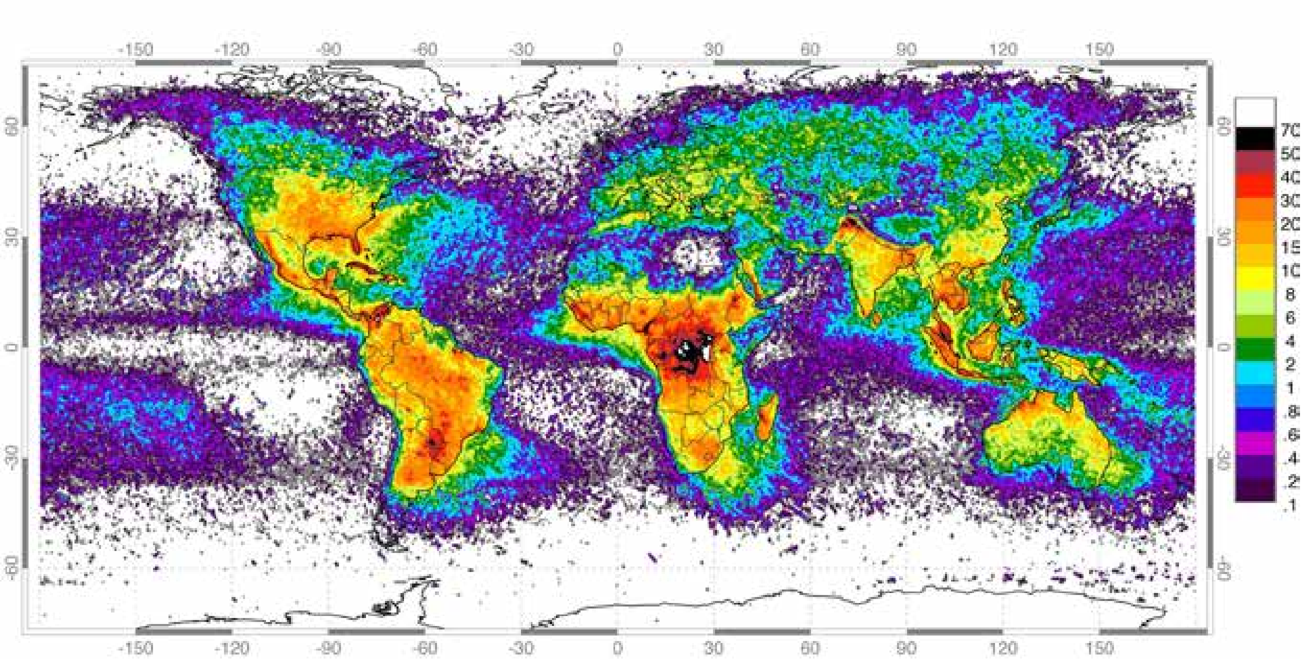


Figure 1.1: Annual number of lightning strikes per km² between 1995 and 2003 (www.nasa.gov)

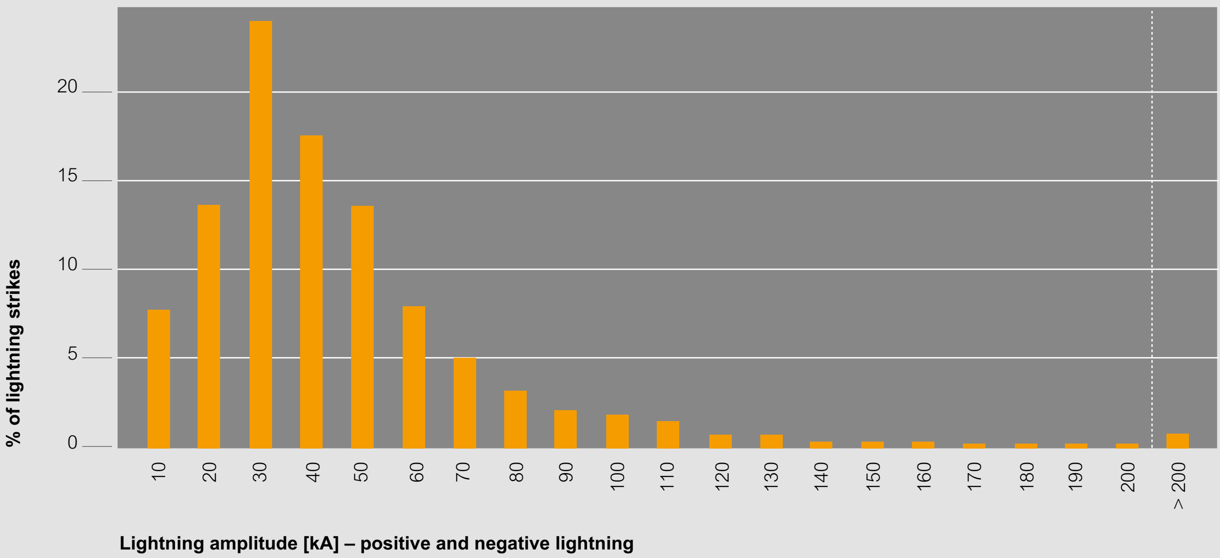


Figure 1.2: Frequency of lightning by amplitude

1.1 Lightning

Lightning and voltage surges endanger people and assets. Lightning strikes Germany around two million times a year, and that figure is rising. Discharges occur in both rural and densely populated areas, endangering people, buildings and technical equipment. Several hundred million euros of damage is done each year, especially as a result of electrical surges.

A lightning protection system consists of both external and internal lightning protection measures. It protects people from injury, structures from damage and electrical equipment from failure due to surge voltages.

Key data about lightning:

- 1,500,000,000 lightning strikes annually per year
- 2,000,000 lightning strikes in Germany per year
- 450,000 instances of surge voltage damage in Germany per year
- Surge voltage damage can occur over a radius of up to 2 km from the location of the lightning strike
- 80% of lightning strikes are of a magnitude between 30 and 40 kA

  (Figure 1.2)

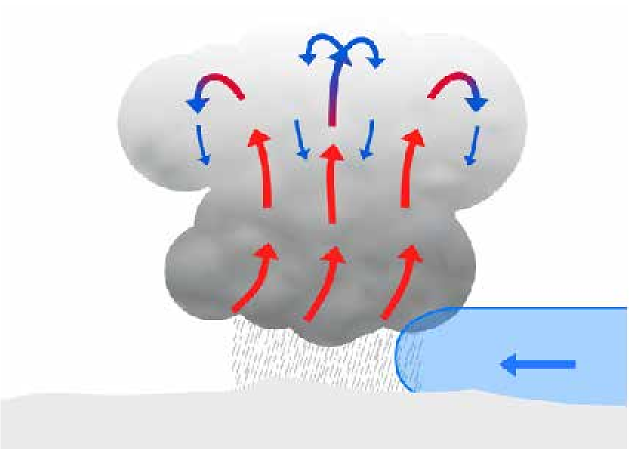


Figure 1.3: A cold front

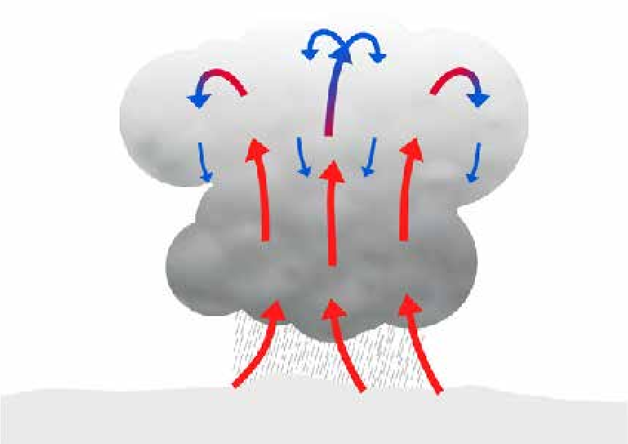


Figure 1.4: A heat thunderstorm

1.1.1 How lightning is formed

Storm fronts can occur when clouds expand to heights of up to 15,000 metres.

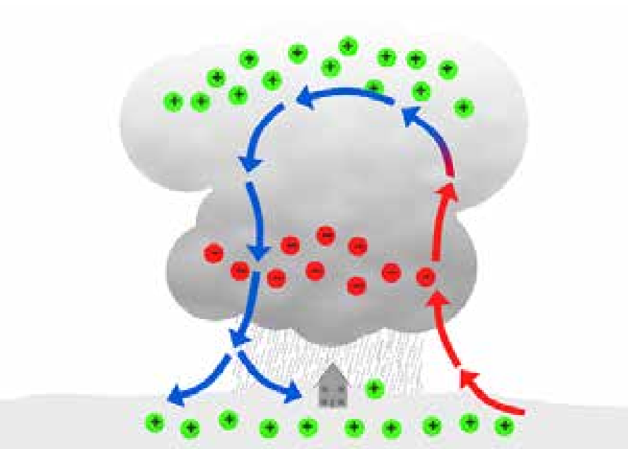


Figure 1.5: How lightning forms – negative and positive charges

1.1.1.1 Types of thunderstorm

Cold front thunderstorms **(Figure 1.3)** develop when humid warm air meets a front of cold air. Heat thunderstorms **(Figure 1.4)** are produced by a combination of intense solar radiation and moist, warm air rising rapidly to great heights.

1.1.1.2 Charge separation

When warm, damp air rises, the moisture in the air condenses and, at higher altitudes, ice crystals form. Strong upwinds of up to 100 km/h cause the light ice crystals to move to the upper area and the hail particles to the lower area. Impact and friction cause charge separation. **(Figure 1.5)**

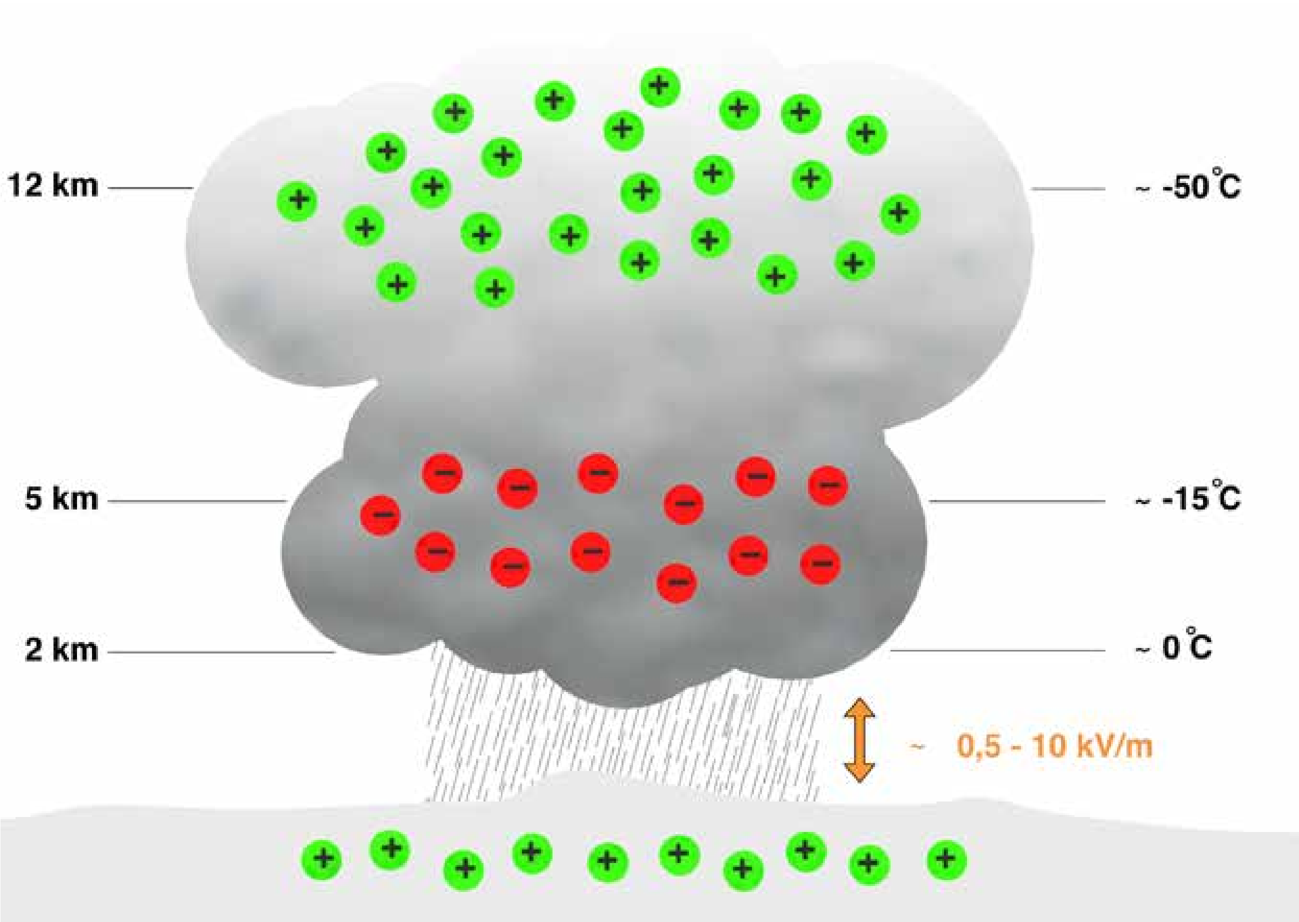


Figure 1.6: Charge distribution in a cloud

1.1.1.3 Charge dispersion

Studies have proved that the sleet falling down (area warmer than –15 °C) has a negative charge and the ice crystals being thrown upwards (area colder than –15 °C) have a positive charge. The light ice crystals are carried into the upper areas of the cloud by the upwind and the sleet falls to the central areas of the cloud. **(Figure 1.6)**

Typical charge distribution:

- Positive in the upper part, negative in the middle part, and weakly positive in the lower part.
- The area near the ground also has a positive charge.
- The field strength required to trigger lightning is dependent on the insulation ability of the air and is between 0.5 and 10 kV/m.

1.2 Risks posed by lightning discharges

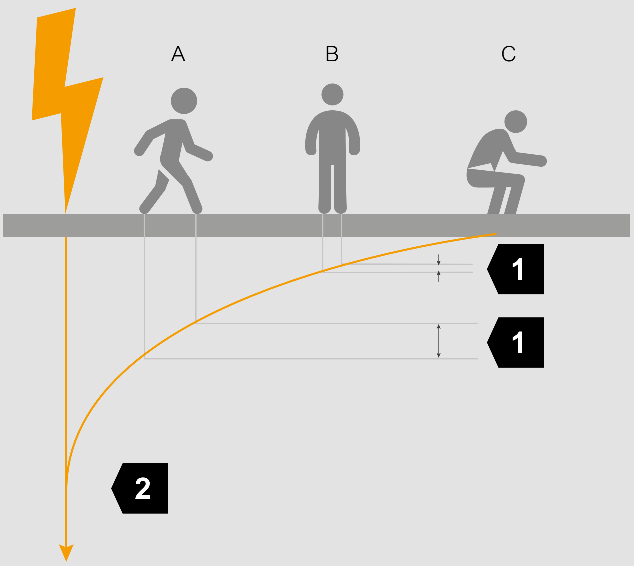
Our dependency on electrical and electronic equipment continues to increase, in both our professional and private lives. Data networks in companies or emergency facilities such as hospitals and fire stations are lifelines for an essential real time information exchange. Sensitive databases, e.g. in banks or media publishers, need reliable transmission paths.

It is not only lightning strikes that pose a latent threat to these systems. More and more frequently, today's electronic aids are damaged by surge voltages caused by remote lightning discharges or switching operations in large electrical systems. During thunderstorms too, high volumes of energy are instantaneously released. These voltage peaks can penetrate a building though all manner of conductive connections and cause enormous damage.

1.2.1 Risk to humans

When lightning hits buildings, trees, or even the ground itself, the lightning current enters the ground and a "potential funnel" forms. (Figure 1.7) The greater the distance from the point where the current enters the ground, the lower the electrical potential in the ground. The difference in potential produces a step voltage that puts people and animals at risk of electric shock. In buildings fitted with lightning protection systems, the lightning current causes a voltage drop at the earthing resistor. All metal components in and on the building must be connected with the equipotential bonding system to rule out the risk of high touch voltages.

On the ground near the building, step voltages pose a further risk. If a person touches the lightning protection system, they are at risk of harm due to the large touch voltage.



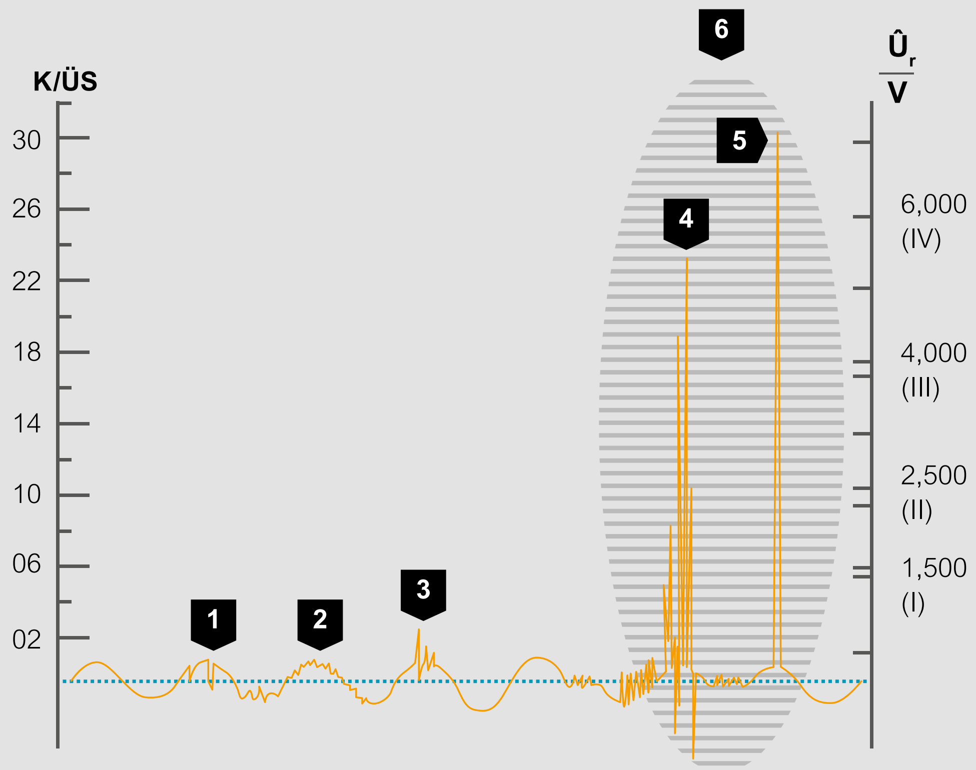
1	Step voltage U_S
2	Potential gradient area
A	Close to the point of strike/beside the down-conductor, the step voltage (1) is high.
B	The step voltage decreases with distance away from the point of lightning impact.
C	Out in the open, a crouching position provides protection against direct lightning impact.

Figure 1.7: Step voltage and potential funnel formed when lightning strikes

1.2.2 Risk to buildings and equipment

Buildings and equipment are at risk not just from direct lightning strikes, but also from the surges that can occur up to two kilometres away from a lightning strike. Surges are several times (factor: K/ÜS) above the permissible mains voltage. If the voltage above resistance (Ûr/V) of an electrical system is exceeded, this will lead to malfunctions or even permanent destruction.

Weak and frequent permanent surges are triggered by high-frequency interference and line disruptions. In these cases the sources of interference must be removed or suitable line filters fitted. Suitable lightning and surge protection systems are needed to protect against energy-rich switching or lightning surges (see 4 and 5 in Figure 1.8) in buildings and equipment.



1	Voltage dips of various duration
2	Harmonics caused by slow and rapid voltage fluctuations
3	Transient surge voltages
4	Switching surges
5	Lightning surges
6	Range within which surge protection devices are used

Fig. 1.8: Types of surge voltage

1.2.2.1 Transient surges
Transient surges are voltage increases lasting for a matter of microseconds but whose magnitude is several times that of the mains voltage. Permanent surges caused by impermissible conditions in the mains network are not considered as transient surges.

Switching surges
Switching surges can arise from various sources, e.g. switching operations involving large inductive loads such as motors. As a rule, switching surges amount to twice to three times the operating voltage.

Induced surge voltages
Induced voltage peaks in building installations and energy or data line supply cables can also reach many times the nominal operating voltage and cause the immediate failure of the systems.

1.2.2.2 Lightning surges
The largest voltage peaks in the low-voltage consumer network are caused by lightning discharges. Lightning surges can sometimes reach 100 times the nominal voltage value and transport a high energy content. When a direct strike hits the external lightning protection system or a low-voltage open-wire line, this usually causes – without internal lightning and surge protection – damage to the insulation and total outage of the connected consumers.

1.2.2.3 Effects of surges
High-energy lightning currents often cause the instantaneous destruction of unprotected systems. In the case of small surges, on the other hand, failures often occur only after a time delay as they accelerate the aging process of the components in the affected devices, causing them insidious damage. A number of different protection measures are required. These depend on the exact cause and/or impact point of the lightning discharge.

1.3 Sources and causes of damage according to standards

For the purposes of the risk analysis according to IEC 62305-2 (DIN EN 62305-2), lightning strikes are assigned to one of four possible "sources of damage" (S1-S4). A lightning strike can lead to three possible "causes of damage" (D1-D3). The damage/loss is then categorised according to four different "types of damage" (L1-L4). **(Figure 1.10)**

Lightning surges can sometimes reach 100 times the nominal voltage value and transport a high energy content.

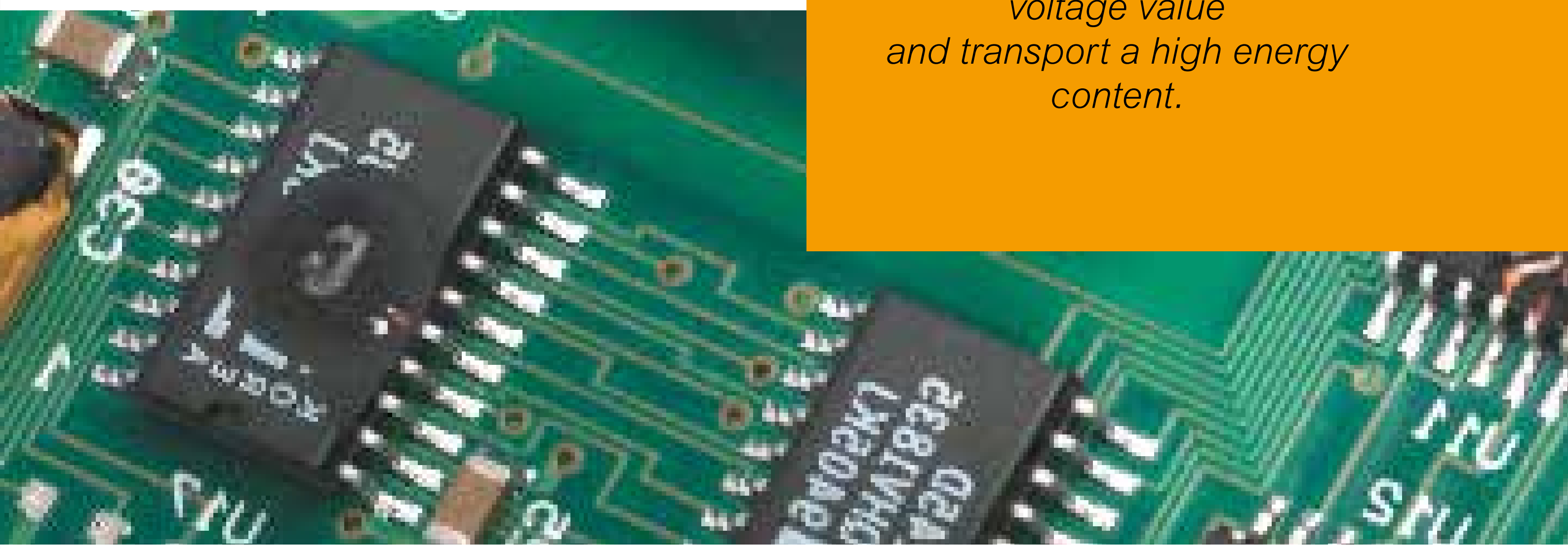


Figure 1.9: Circuit board destroyed by a surge

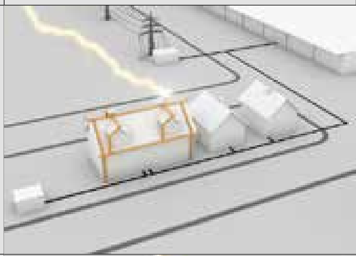
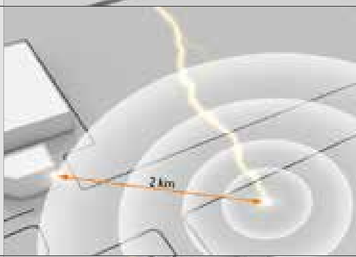
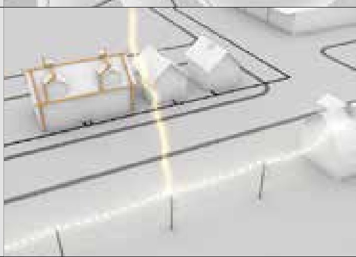
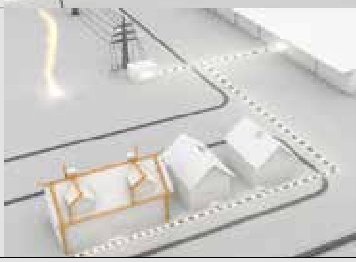
Point of strike	Example	Source of damage	Type of damage	Type of loss
Structure		S1	C1 C2 C3	D1, D4 D1, D2, D3, D4 D1, D2, D4
Ground near a structure		S2	C3	D1, D2, D4
Service connected to the structure		S3	C1 C2 C3	D1 D1, D2, D3, D4 D1, D2, D4
Ground near a service		S4	C3	D1, D2, D4

Figure 1.10: Risk analysis according to IEC 62305-2 (VDE 0185-305-2)

C1	Electric shock to life-beings due to touch and step voltages
C2	Fire, explosion and mechanical and chemical impact due to physical effects of lightning discharge
C3	Destruction of electrical or electronic systems by surge voltages
D1	Injury to or death of people
D2	Loss of services to the public
D3	Loss of irreplaceable cultural treasures
D4	Financial loss

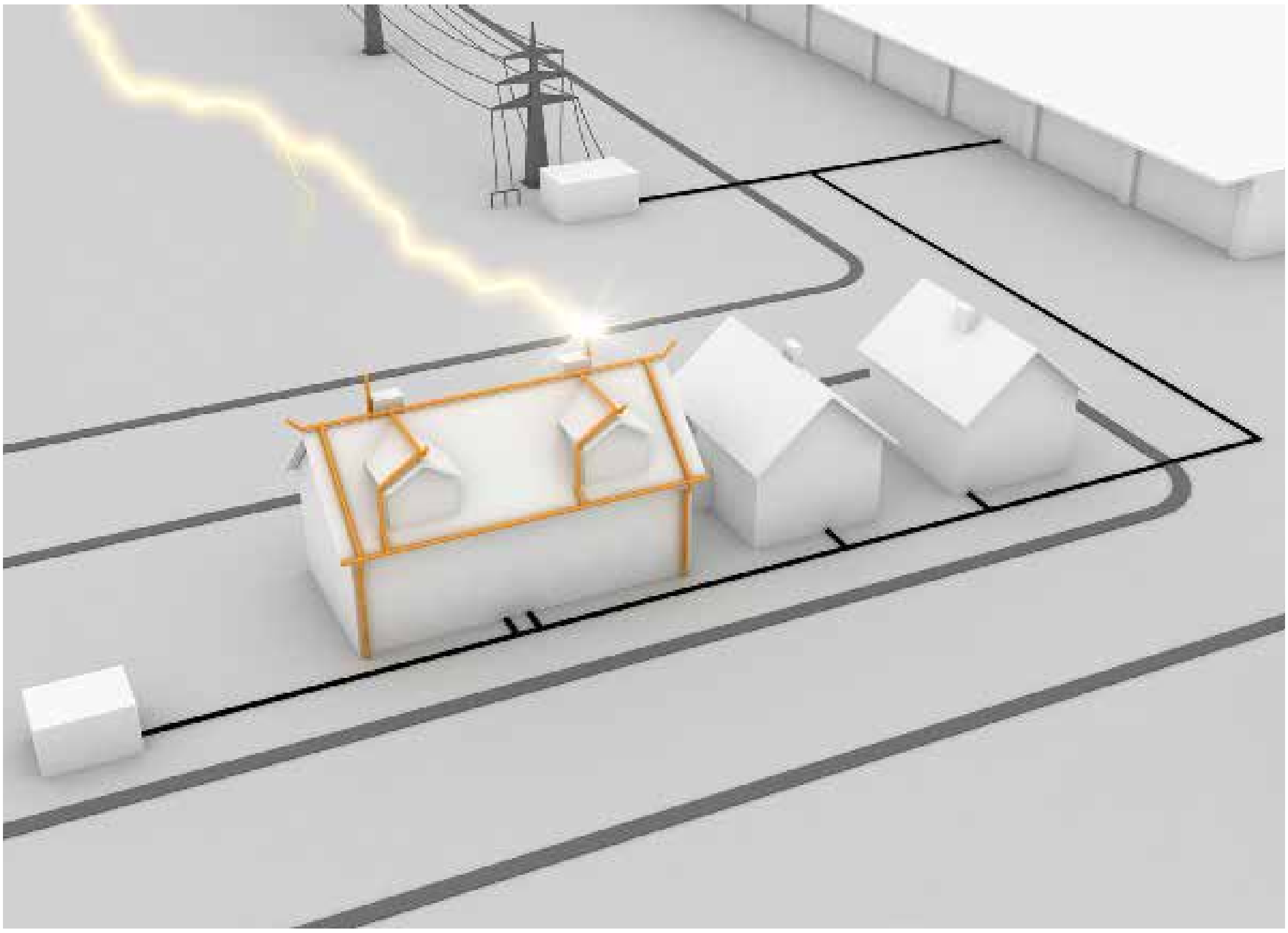


Figure 1.11: Danger: direct lightning strike

S1: Direct lightning strike into a building
If a lightning stroke hits the external lightning protection system or earthed roof structures capable of carrying lightning current (e.g. rooftop antennas), the lightning energy can be safely discharged to earth potential. But a lightning protection system alone is not enough: due to its impedance, the building's entire earthing system is raised to a high potential. This potential increase causes the lightning current to split over the building's earthing system and also over the power supply systems and data cables to the adjacent earthing systems (adjacent building, low-voltage transformer). A direct lightning strike poses a risk of loss of human beings, public services (telephone, fire brigade), cultural treasures (museums, theatres) and economic goods (property). The lightning protection system protects the building and people from direct lightning impulses and fire risk. **(Figure 1.11)**

If a lightning strike hits the external lightning protection system or earthed roof structures capable of carrying lightning current, the lightning energy can be safely discharged to earth potential.

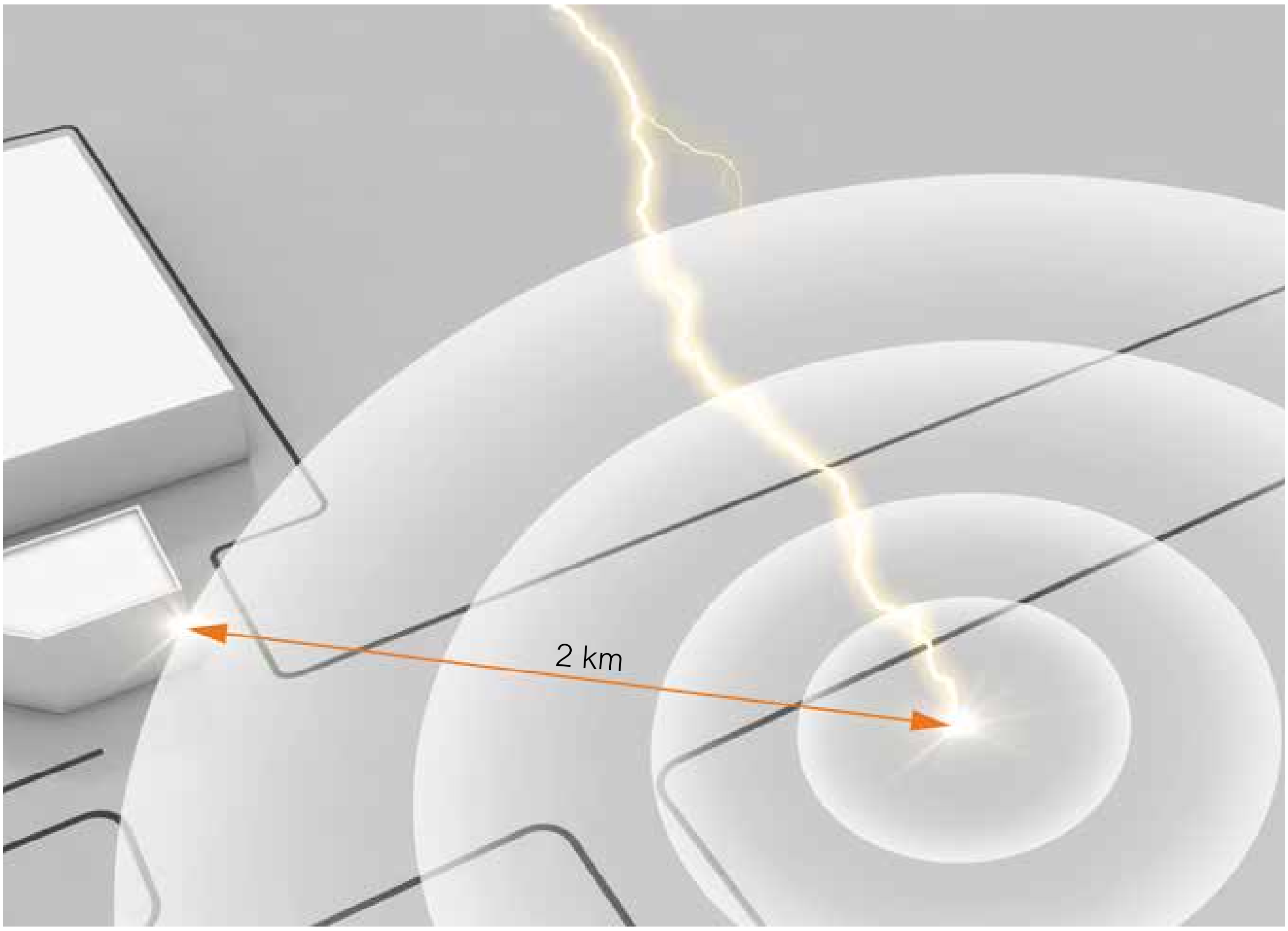


Figure 1.12: Danger: surge pulse due to inductive and galvanic coupling

S2: Lightning strike near a building and couplings over a radius of up to 2 km
A local lightning strike creates additional high magnetic fields, which in turn induce high voltage peaks in line systems. Inductive or galvanic couplings can cause damage within a radius of up to 2 km around the lightning impact point. Surge voltages interfere with or destroy electrical and electronic systems.

Lightning and surge protection devices protect against uncontrolled arcing (sparks) and the resulting fire risk. **(Figure 1.12)**

A local lightning strike creates additional high magnetic fields, which in turn induce high voltage peaks in line systems.

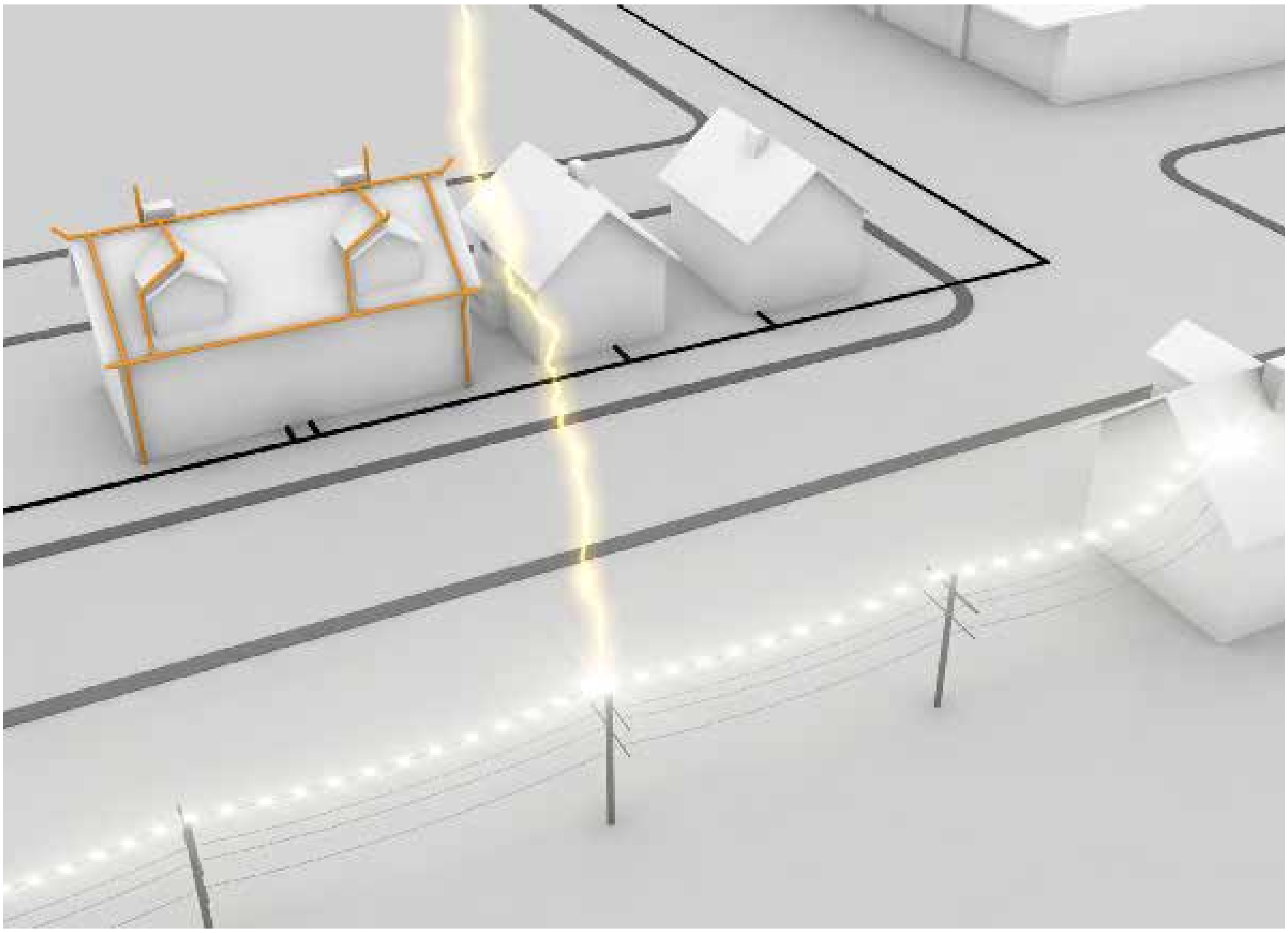


Figure 1.13: Danger: lightning impulse and partial lightning currents along wires

S3: Direct lightning strike into a supply line
A direct lightning strike into a low-voltage open wire line or data cable can couple high partial lightning currents in an adjacent building. Electrical equipment in buildings at the end of the low-voltage open-wire line are at particular risk of damage caused by surges.

The degree of risk depends on how the lines are laid. Distinctions are made between exposed and underground wires, and according to the way in which the shielding is connected to the equipotential bonding. Suitable lightning and surge protection devices are used to compensate the energy from the lightning pulse at the entry to the building. **(Figure 1.13)**

A direct lightning strike into a low-voltage open-wire line or data cable can couple powerful partial lightning currents into an adjacent building.

Fig. 1.14: Danger: galvanically coupled and line-carried surge voltage

S4: Direct lightning strike close to a supply line

The proximity of the lightning strike induces surge voltages in cables. Switching surges are additionally caused by switch-on and switch-off operations, by the switching of inductive and capacitive loads, and by the interruption of short circuit currents. Particularly when production plants, lighting systems or transformers are switched off, electrical equipment located in close proximity can be damaged. **(Figure 1.14)**

Switching surges and induced surge voltages in lines account for the majority of cases of damage.

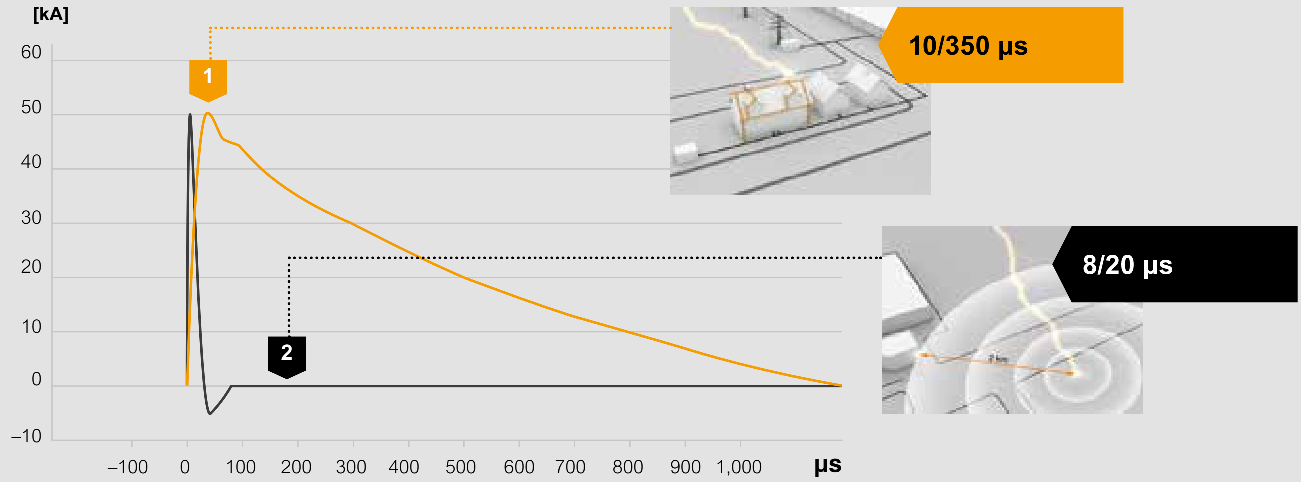


Figure 1.15: Types of pulse and their characteristics

1	Pulse shape 1: direct lightning strike, 10/350 µs simulated lightning pulse
2	Pulse shape 2: remote lightning strike or switching operation, 8/20 µs simulated current pulse (surge voltage)

1.4 Test currents and simulated surge voltages

High lightning currents can flow to the ground during a storm. If a building with external lightning protection receives a direct hit, a voltage drop occurs on the earthing resistor of the lightning protection equipotential bonding system, which represents a surge voltage against the distant environment.

Example:
- Lightning current (i): 100 kA
- Earthing resistance (R): 1 Ω
- Voltage drop (u): R x i = 1 Ω x 100 kA = 100,000 V

Conclusion:
The voltage between the earthing resistor and the remotely earthed network increases by 100 kV.

This rise in potential poses a threat to the electrical systems (e.g. voltage supply, telephone systems, cable TV, control cables, etc.) that are routed into the building. Suitable test currents for testing different lightning and surge protectors have been defined in national and international standards. **(Figure 1.15)**

Direct lightning strike: Pulse shape 1
Lightning currents that can occur during a direct lightning strike can be imitated with the surge current of waveform 10/350 µs. The lightning test current imitates both the fast rise and the high energy content of natural lightning. Type 1 lightning current arresters and external lightning protection components are tested using this pulse.

Remote lightning strikes or switching operations: Pulse shape 2
The surges created by remote lightning strikes and switching operations are imitated with test impulse 8/20 µs. The energy content of this impulse is significantly lower than the lightning test current of surge current wave 10/350 µs. Surge arresters of type 2 and type 3 are impacted with this test impulse.

The area under the current-time curve for surge currents indicates the amount of charge. The charge of the lightning test current of waveform 10/350 roughly corresponds to 20 times the charge of a surge current of waveform 8/20 with the same amplitude.

1. Legislation	Examples: German Constitution, regional building regulations for public buildings and meeting places
2. Ordinances	Example: Technical Rules for Industrial Safety (TRBS) of the German Federal Institute for Occupational Safety and Health
3. Specifications	Example: Accident prevention regulations
4. Technical rules	Example: IEC 62305 (VDE 0185-305)
5. Contracts	Example: Insurers' guidelines, e.g. VDS 0185

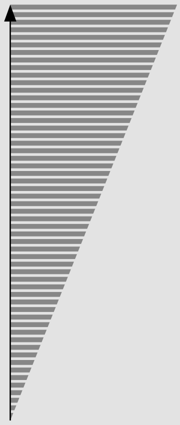


Figure 1.16: List of applicable documents shown in order of increasing legal force

1.5 Legal regulations defining what lightning protection is required

What lightning protection is required depends on five factors (Figure 1.16):

1. Legislation

The most important tasks of the legal system are to protect human life and basic social assets (cultural treasures, security of energy supplies, etc.). Lightning protection is demanded by, for example, the German regional building regulations for public buildings and meeting places.

2. Ordinances

An ordinance is passed not by national parliaments but by national executive bodies, e.g. the Technical Rules for Industrial Safety (TRBS) published by the German Federal Institute for Occupational Safety and Health. For example, lightning protection is referred to in part 3 of TRBS 2152 as a means of preventing the ignition of dangerous explosive atmospheres.

3. Specifications

Under specifications such as the German “accident prevention regulations”, all companies are required to adhere to certain occupational safety and health requirements in the workplace.

The individual owner or operator is responsible for the safety of their own plant.
It is in their interest to keep their plant in operation, so they should check what the cost of failure would be.

4. Technical rules

Standards and technical rules present methods and technical solutions to ensure adherence to the safety standards specified in the legislation. The most important standard for lightning protection is IEC 62305 (VDE 0185-305). IEC 60364-4-44 (VDE 0100-443) describes a risk analysis for determining what surge protection devices are required.

5. Contracts

Insurance companies have drawn up guidelines on the basis of damage and accidents that have been observed in the past. Objects for which lightning and surge protection measures are obligatory are listed in, e.g. VDS 2010. A relevant excerpt from VDS 2010 can be found in Table 4 on page 28.

1.5.1 Lightning and surge protection standards

When planning and executing a lightning protection system, it is necessary to observe all relevant national annexes and take account of any special circumstances or applications and the safety stipulations in the relevant country-specific supplements.

A lightning and surge protection system consists of several systems, each tailored to each of the others. (Fig. 1.17) At its most basic, a lightning and surge protection system consists of one internal and one external lightning protection system. These, in turn, can be categorised as follows:

- Interception systems
- Down-conductor system
- Earthing systems
- Area shielding
- Separation distance
- Lightning protection equipotential bonding

These systems must be carefully selected for the application at hand, and used in a coordinated way. Installation of the systems takes place according to various application and product standards (Tables 1.1 and 1.2 on page 24). The supplements to the international IEC guidelines and harmonised European versions of the various country-specific translations often contain additional informative information specific to the country in question.

Product standards

To ensure that the components can withstand the loads to which they are likely to be exposed in application, they must be checked against the respective product standard for external and internal lightning protection.

Comprehensive lightning protection can only be achieved through a coordinated approach.

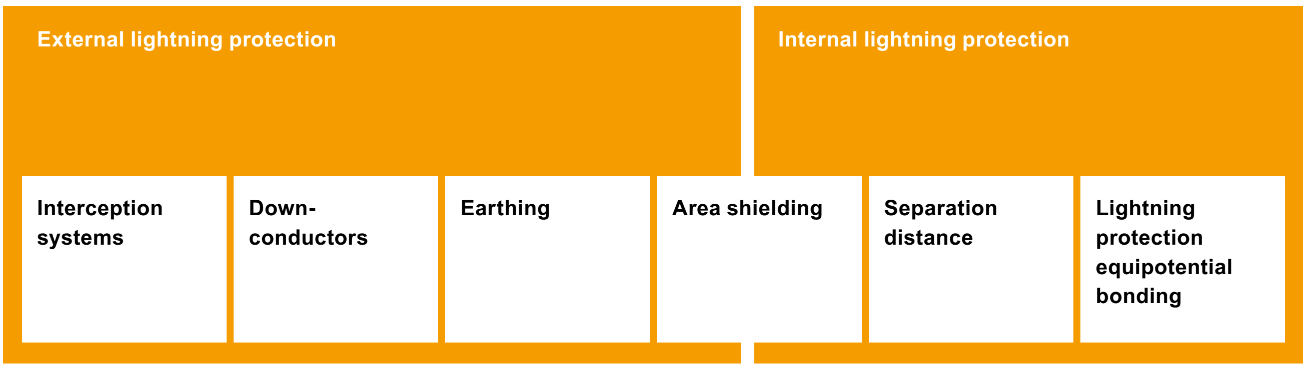


Figure 1.17: External and internal lightning protection systems

Standard	German supplement	Contents
IEC 62305-1 (VDE 0185-305-1)		Protection against lightning – Part 1: General principles
IEC 62305-2 (VDE 0185-305-2)		Protection against lightning – Part 2: Risk management
	1	Lightning risk in Germany
	2	Calculation aids for estimating the risk of damage for buildings
	3	Additional information on use of EN 62305-2
IEC 62305-3 (VDE 0185-305-3)		Protection against lightning – Part 3: Protection of structures and people
	1	Additional information on use of EN 62305-3
	2	Additional information for building structures
	3	Additional information for the testing and servicing of lightning protection systems
	4	Use of metal roofs in lightning protection systems
	5	Lightning and surge protection in PV power supply systems
IEC 62305-4 (VDE 0185-305-4)		Protection against lightning – Part 4: Electrical and electronic systems within structures
	1	Distribution of the lightning current
IEC 0675-6-11 (VDE 0675-6-11)		Low-voltage surge protection devices – Part 11: Surge protection devices connected to low-voltage power systems
IEC 60364-5-53 (VDE 0100-534)		Low-voltage electrical installations – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control – Clause 534: Devices for protection against surge voltages
IEC 60364-4-44 (VDE 0100-443)		Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances – Clause 443: Protection against surge voltages of atmospheric origin or due to switching
IEC 60364-7-712 (VDE 0100-712)		Requirements for operational premises, special rooms and systems – Solar photovoltaic (PV) power supply systems

Table 1.1: Key lightning protection standards and specifications

Product standards	Contents
IEC 62561-1 (VDE 0185-561-1)	Lightning protection system components – Requirements for connection components
IEC 62561-2 (VDE 0185-561-2)	Lightning protection system components – Requirements for conductors and earth electrodes
IEC 62561-3 (VDE 0185-561-3)	Lightning protection system components – Requirements for isolating spark gaps
IEC 62561-4 (VDE 0185-561-4)	Lightning protection system components – Requirements for conductor fasteners
IEC 62561-5 (VDE 0185-561-5)	Lightning protection system components – Requirements for earth electrode inspection housings and earth electrode seals
IEC 62561-6 (VDE 0185-561-6)	Lightning protection system components – Requirements for lightning strike counters
IEC 62561-7 (VDE 0185-561-7)	Lightning protection system components – Requirements for earthing enhancing compounds
IEC 61643-11 (VDE 0675-6-11)	Surge protective devices connected to low-voltage power systems – Requirements and test methods
IEC 61643-21 (VDE 0845-3-1)	Surge protective devices connected to telecommunications and signalling networks

Table 1.2: Lightning protection and surge protection components

1.5.2 Hierarchy of standards: international/European/national

When the European standardisation committee (CEN) and the European committee for electrotechnical standardisation (CENELEC) adopt an international standard (IEC) as a European standard (EN), all member states must adopt this standard as a national standard without any changes (e.g. a VDE standard in Germany).

1.5.3 Latest German national lightning protection standards

VDE 0185-305-1 … -4: 2011-10 has replaced VDE 0185-305-1...-4: 2006-11. The coexistence phase ended on 2 January 2014. **(Figure 1.18)**

Worldwide	**IEC** **International Standard**	**IEC 62305-1... -4**	**2011-01**
Europe	**CENELEC** **European Standard**	**EN 62305-1... -4**	**2011-02** **2012-03 (Part 2)**
Germany	**VDE** **German National Standard**	**VDE 0185-305-1... -4**	**2011-10** **2013-02 (Part 2)**

VDE 0185-305-1 General principles (2011-10)	**VDE 0185-305-2** Risk management (2013-02)	**VDE 0185-305-3** Protection of buildings and humans (2011-10)	**VDE 0185-305-4** Electrical and electronic systems within structures (2011-10)
	+	+	+
	Supplement 1, 2 Suppl. 1+2: 2013-2 Suppl. 3: 2013-12	**Supplement 1, 2, 3** (2012-10) Suppl. 4: 2007-11 Suppl. 5: 2014-02	**Supplement 1** (2012-10)

Figure 1.18: Hierarchy of lightning protection standards (international/European/national) and current German lightning protection standards: Standardisation and regulations

1.5.4 Responsibility of the erection engineer

"The overall responsibility for electrical safety is in the hands of the commissioner."

The erection of a lightning protection system often requires major intervention in the electrical infrastructure of a building. This is reflected in the wide range of standards and regulations to be complied with. The person erecting the system is liable for correct fulfilment for 30 years, and the requirements of the insurance company come on top of that.

The specialist company installing an electrical system is required by law to hand it over in perfect condition. According to the low-voltage connection ordinance (NAV), the electrician listed in the energy supplier's installer list may only connect tested and correct systems to the public power grid.

Please observe the appropriate local and statutory requirements. Depending on the system type, the following standards must be complied with:

- Low-voltage electrical installations
  - IEC 60364-4-41 (VDE 0100-410)
  - IEC 60364-4-44 (VDE 0100-443)
  - IEC 60364-4-534 (VDE 0100-534)
- Tests (commissioning test) and documentation
  - IEC 60364-6 (VDE 0100-600)
  - EN 50110-1 (VDE 0105-100)
- Requirements for solar PV power supply systems
  - IEC 60634-7-712 (VDE 0100-712)
  - IEC 62446 (VDE 0126-23)

1.5.5 Responsibility of the operator

The system operator is obliged to give the system the proper maintenance, checking and repairs. These regular recurring checks of the electrical system components may only be carried out by an electrical technician.

"People and animals must be protected against injury and property must be protected against damage from surge voltages resulting from atmospheric impacts or switching surges."

IEC 60364-1 (VDE 0100-100)

Figure 1.19: Building damage due to a direct lightning strike

1.6 Financial implications of lightning and surge voltage damage

Financial loss can only be considered in isolation in cases where no legal or insurance requirements relating to personal safety apply. **(Figure 1.19)**

Substantial losses result from the destruction of electrical devices, notably:
- Computers and servers
- Telephone systems
- Fire alarm systems
- Monitoring systems
- Lift, garage door and roller shutter drives
- Consumer electronics
- Kitchen appliances

Further costs can also be incurred due to outages and consequential damage in relation to:
- Loss of data
- Production outages
- Loss of contactability (Internet, telephone, fax)
- Defective heating systems
- Costs due to faults and false alarms in fire and burglar alarm systems

Financial losses are on the rise
Current statistics and estimates of insurance companies show: Damage levels caused by surges – excluding consequential or outage costs – long since reached drastic levels due to the growing dependency on electronic "aids". It's no surprise, then, that property insurers are checking more and more claims and stipulating the use of devices to protect against surges. Information on protection measures can be found in, for example, the German Directive VDS 2010.

Year	Number of lightning and surge voltage damage	Paid damages for lightning and surge voltage damage
1999	490,000	€310 million
2006	550,000	€340 million
2007	520,000	€330 million
2008	480,000	€350 million
2009	490,000	€340 million
2010	330,000	€220 million
2011	440,000	€330 million
2012	410,000	€330 million
2013	340,000	€240 million
2014[1]	410,000	€340 million

Table 1.3: Number of instances of damage from lightning and surge voltages and amounts paid out by home and contents insurance companies; source: GDV · Extrapolation based on industry and risk statistics; numbers rounded to the nearest 10,000 or €10 million. [1] Provisional

1.7 Lightning protection risk analysis and categorisation by lightning protection class

The risk of lightning strikes can be determined by carrying out a risk analysis according to IEC 62305-2 (VDE 0185-305-2). The local risk is determined by multiplying the frequency of lightning strikes with the likelihood of damage and a factor to cover the likely loss/extent of damage.

The building's lightning protection class is determined on the basis of the risk of lightning strike and the damage that can be expected. In Germany, the standard DIN EN 62305-2 includes three national supplements containing additional information on risk management – for example, Supplement 2 (Calculation aids for estimating the risk of damage for structures), which offers assistance with the often complicated process of assessing the risk of damage.

Alternatively, the lightning protection class can be determined on the basis of statistical data, e.g. claim statistics from property insurance companies. Efficiency in lightning protection class I is the highest at 98%, and in lightning protection class IV the lowest at 81% or 79%. **(Figure 1.20)**

The cost and time involved in erecting a lightning protection system (e.g. necessary protective angle and spacings of meshes and arresters) is more involved for lightning protection class I systems than for lightning protection class IV systems.

Lightning protection level (LPL)	Protection class (LPS = class of lightning protection system)
I	I
II	II
III	III
IV	IV

Table 1.4: LPL vs. LPS

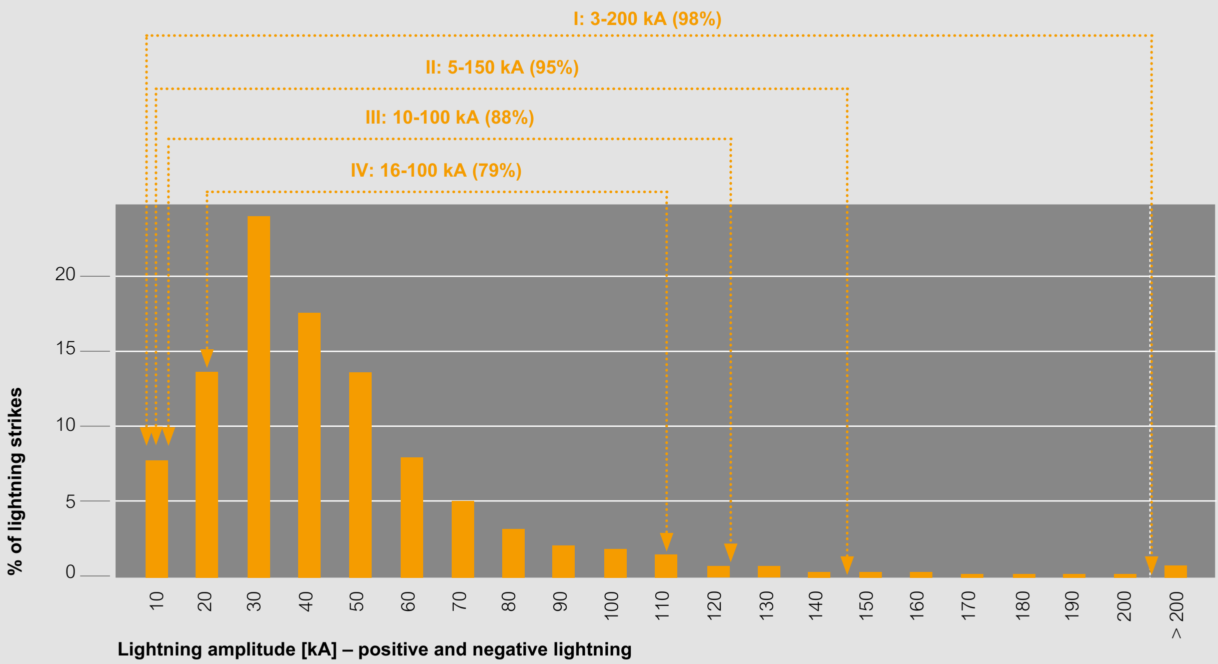


Figure 1.20: Lightning current parameters according to the risk level (LPL) in accordance with DIN VDE 0185-305-1

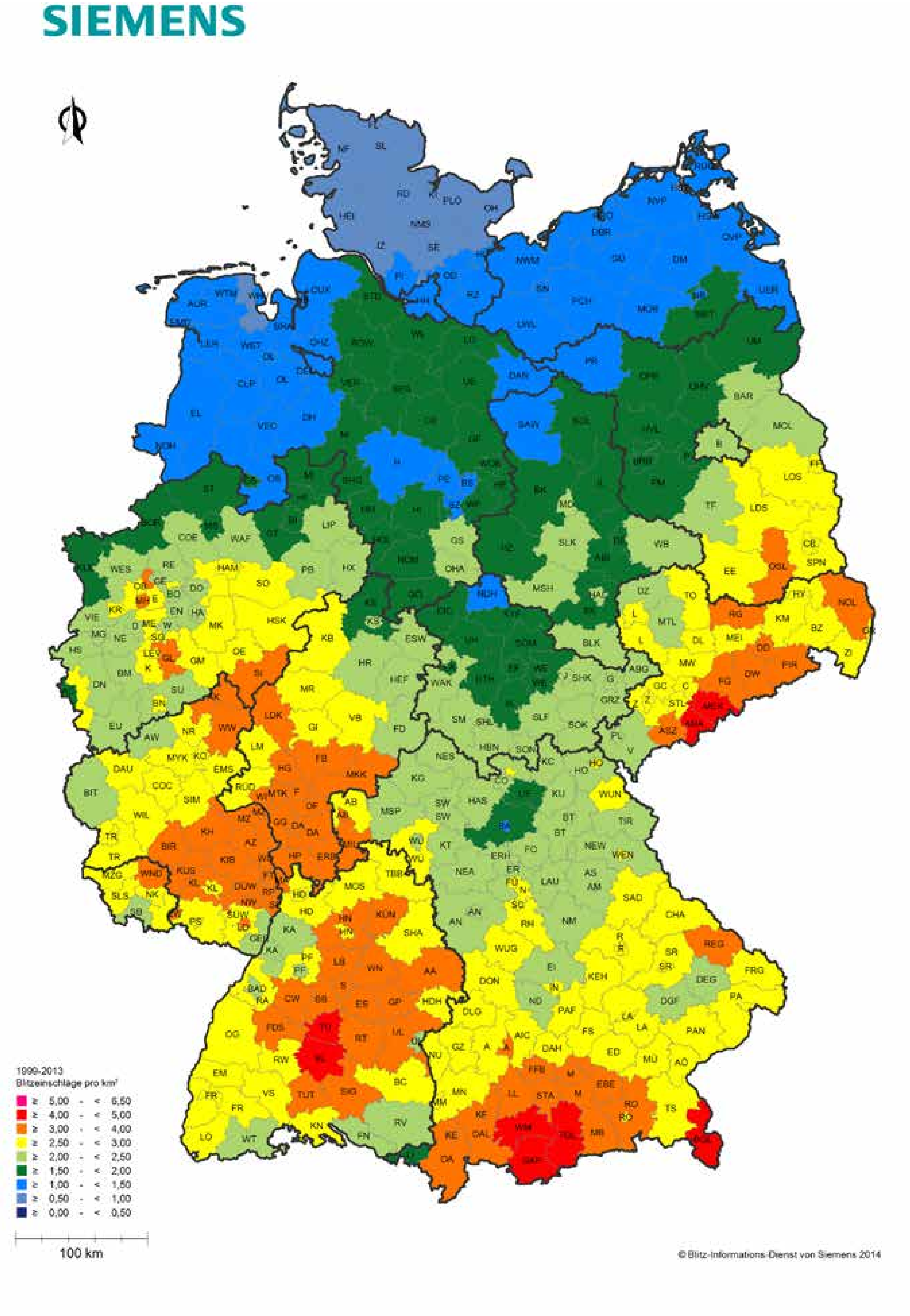
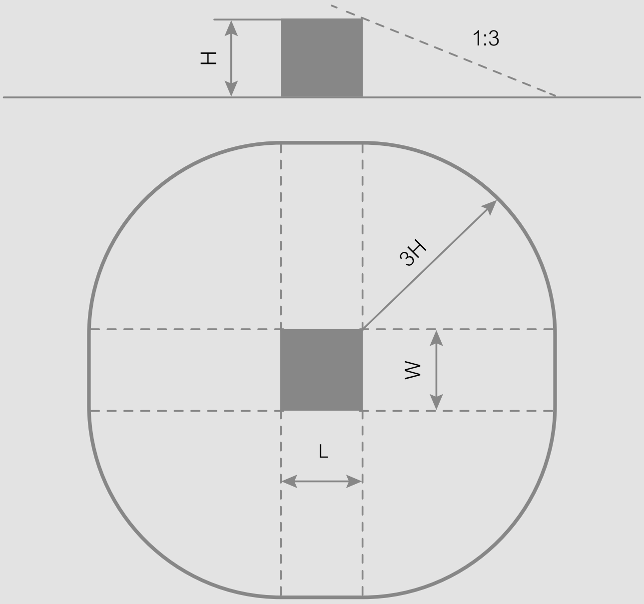


Figure 1.21: Frequency of lightning in Germany. Source: www.siemens.com



H	Height of the building structure
W	Width of the building structure
L	Length of the building structure

Figure 1.22: Equivalent interception area for direct lightning strikes

The effectiveness of a lightning protection system is indicated by assigning it a lightning protection class between I and IV:

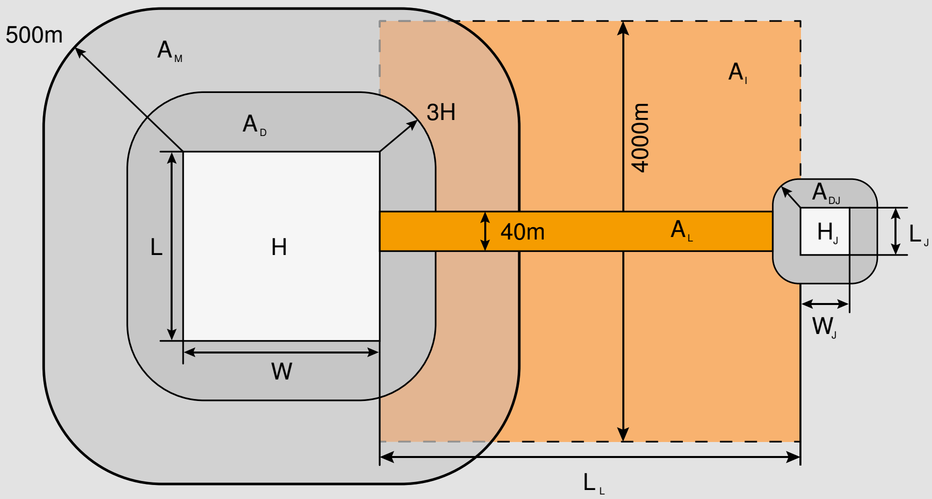
- Lightning protection class I = greatest need for protection, e.g. hospitals
- Lightning protection class II = substantial need for protection, explosive areas
- Lightning protection class III = limited need for protection, residential buildings
- Lightning protection class IV = smallest need for protection (not used in Germany)

1.7.1 Frequency of lightning strikes by region

A large number of countries maintain statistics on the frequency of lightning strikes in that country. Thanks to the BLIDS lightning location system, region-specific data is available for Germany, Austria and Switzerland. Further data can be found in national supplement 1 to the German standard DIN EN 62305-2. The standard recommends doubling these values. **(Figure 1.21)**

1.7.2 Equivalent interception area

The risk analysis considers as areas at risk from lightning not just the real area of the building but also the equivalent interception area. **(Figure 1.22)** Direct and nearby lightning strikes lead to the coupling of electric current into building structures. The equivalent interception area is a circle with a radius three times the building's height, centred on the building's base. Damage can also be caused by lightning striking supply lines leading into the building, or lightning striking close to these lines.



L	Length of the building structure
W	Width of the building structure
H	Height of the building structure
A_D	Equivalent interception area of the building structure
A_M	Equivalent interception area of couplings due to electro-magnetic effect (building)
A_L	Equivalent interception area of supply lines
A_I	Equivalent interception area of couplings due to electro-magnetic effect (line)

Figure 1.23: Equivalent interception area for indirect lightning strikes

The equivalent interception area for indirect lightning strikes is a circle with a radius of 500 m around the base of the building and an area extending 2,000 m either side of the supply line. **(Figure 1.23)**

1.7.3 Estimation of the damage risk

The damage risk is assessed using the lightning threat data and the possible damage. The greater the risk of a lightning strike and the likely damage, the more effective must be the design of the lightning protection system.

Lightning threat types:

- Frequency of lightning strikes by region
- Equivalent interception area

Possible damage:

- Injury to or death of people
- Unacceptable failure of services
- Loss of irreplaceable cultural treasures
- Economic loss

Application	Lightning protection class according to IEC 62305 (VDE 0185-305)
Computer centres, military applications, nuclear power stations	I
Ex zones in industry and the chemicals sector	II
Photovoltaic systems > 10 kW	III
Museums, schools, hotels with more than 60 beds	III
Hospitals, churches, storage facilities, meeting places accommodating more than 100/200 people	III
Administrative buildings, sales points, offices and bank buildings of over 2,000 m²	III
Residential buildings with more than 20 apartments, multi-storey buildings over 22 m high	III
Photovoltaics (< 10 kW)	III

Table 1.5: Excerpt from Directive VdS 2010: lightning protection classes I to IV

1.7.4 Empirical lightning protection classification of buildings

One way of determining the necessary lightning protection classes is through the use of statistical data. In Germany, the German Insurance Federation publishes Directive VdS 2010 (risk-oriented lightning and surge protection) which offers help in classifying buildings in this way. **(Table 1.5)**

1.7.5 Cost-effectiveness calculation for lightning protection systems

In buildings where no danger is posed to humans, the need for lightning protection measures can be assessed according to purely economic criteria.
On the one hand, it is necessary to consider the likelihood of a lightning strike and the cost of the damage that this would cause. On the other hand, this needs to be compared with the cost of a lightning protection system, and the reduction in damage that would be achieved by installing it.

1.7.5.1 Costs without lightning protection system

In a building where no lightning protection measures have been taken, the annual costs are determined by multiplying the probability of a lightning strike with the damage that a lightning strike is likely to do to the property. **(Figure 1.24)**

1.7.5.2 Costs with lightning protection system

In a building where lightning protection measures have been taken, the likelihood of damage occurring is smaller. The annual costs are determined by multiplying the (now lower) probability of a lightning strike with the likely damage that a lightning strike would cause at the property, and the annual costs of the lightning protection system.

1.7.5.3 Comparing the costs of lightning damage in buildings with and without a lightning protection system

The cost-effectiveness of lightning protection measures is assessed by comparing the annual costs for an unprotected building with the annual costs for a protected building. **(Figure 1.24)**

Note

A precise calculation involving numerous other parameters must be carried out in the form of a risk analysis in accordance with IEC 62305-2 (VDE 0185-305-2).

Cost-effectiveness without lightning protection system

Cost-effectiveness with lightning protection system

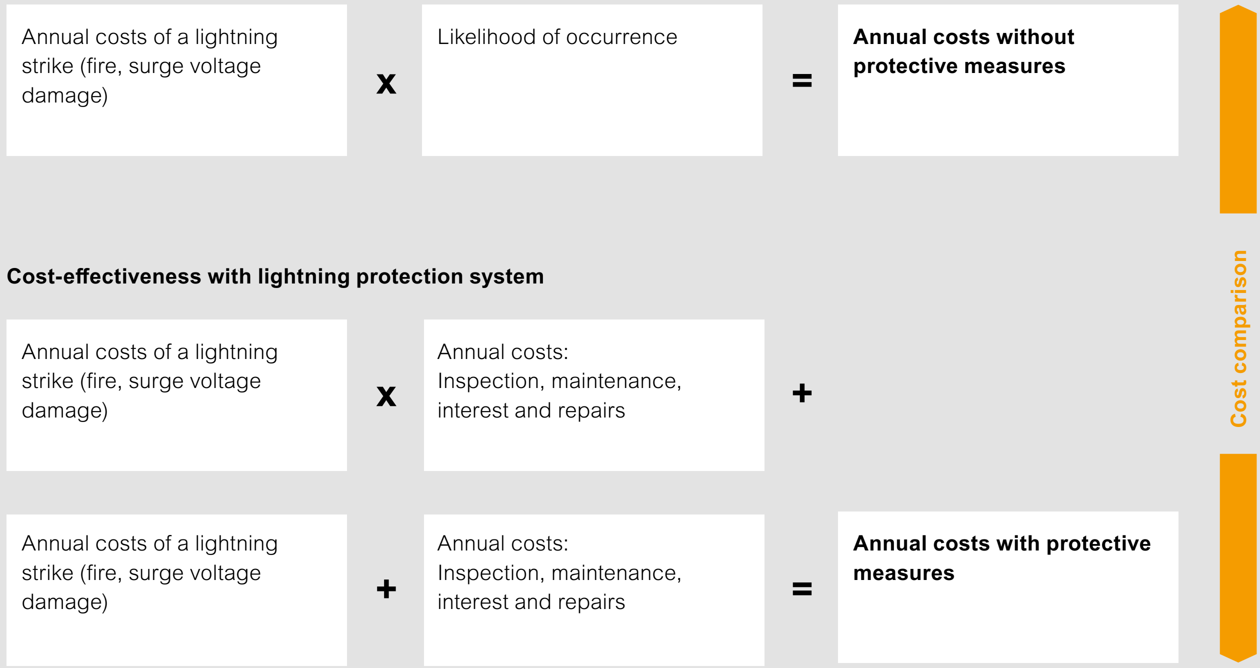


Figure 1.24: Risk management

Example (lightning damage in building without lightning protection system)

- Value of building with contents: €500,000
- Lightning strikes per year: ≤ 1.6 per km^2 (doubled: ≤ 3.2 per km^2)
- Building size: 10 m long, 20 m wide, 10 m high
- Interception area: 4,827 m^2

Likelihood of a lightning strike

- 3.2 / 1,000,000 m^2 x 4,827 m^2 = 0.015 (= every 66 years) / theoretical value

Annual damage in an unprotected building

- €500,000 x 0.01 (total loss) = €5,000 per year

Example (lightning damage in building with lightning protection system)

- Value of building with contents: €500,000
- Lightning strikes per year: ≤ 1.6 per km^2 (doubled: ≤ 3.2 per km2)
- Building size: 10 m long, 20 m wide, 10 m high
- Interception area: 4,827 m^2

Likelihood of a lightning strike

- Lightning protection class 3 = 88% protective impact = Residual risk 12% (0.12)
- Probability of risk occurrence: 3.2 x 12% / 1,000,000 m^2 x 4,827 m^2 = 0.002 (= every 500 years) Annual damage in protected building (not including costs of lightning protection system)
- €500,000 x 0.0018 = €900 per year

Calculation of the annual costs for the lightning protection system

- Costs of lightning protection system: €10,000
- Costs/depreciable life (20 years): €500/year
- Annual interest incurred due to investment (5%): €500
- Annual maintenance costs for lightning protection system (5%): €500
- Total annual cost of lightning protection system: €1,500

Annual costs with protective measures (including costs of lightning protection system)

- Annual damage: €900 per year
- Total annual cost of lightning protection system: €1,500
- Total costs: €2,400 per year

Example

Through suitable lightning protection measures, annual costs can be reduced by €3,100.

Figure 1.25: BET test generator

Figure 1.26: BET SO_2 testing system

1.8 Laboratory testing of lightning and surge protection components

In the BET testing centre, lightning and surge protection components, lightning protection structures and surge protection devices are put through their paces by highly qualified specialists in accordance with the relevant standards. In addition, the impact of events involving lightning is scientifically investigated. **(Figure 1.25)**

The BET possesses a test generator for lightning current tests of up to 200 kA and a hybrid generator for surge current tests of up to 20 kV.
Tasks performed include developmental tests of new developments and modifications to OBO surge protection devices according to the testing standard IEC 61643-11 (VDE 0675-6-11). The tests for lightning protection components are carried out according to IEC 62561-1 (DIN EN 62561-1) and those for spark gaps according to IEC 62561-3 (DIN EN 62561-3).

The hybrid generator is used for testing data cable protection devices in accordance with IEC 61643-21 (VDE 0845-3-1) (Surge protective devices connected to telecommunications and signalling networks).

The following standard-compliant tests can be carried out:

- Lightning protection components to EN 62561-1
- Spark gaps to EN 62561-3
- Lightning current meters to EN 62561-6
- Surge protection devices to EN 61643-11
- Data cable protection devices to EN 61643-21
- Environmental testing to EN ISO 9227 (neutral continuous salt spray testing)
- Environmental testing to EN 60068-2-52 (cyclical salt spray testing) **(Figure 1.26)**
- Environmental testing to EN ISO 6988 (SO_2 toxic gas testing)
- Protection rating to EN 60592
- Tensile strength to EN 10002-1

However, customer-specific requirements and tests not covered by standards can be tested up to the following parameters:

- Lightning current pulses (10/350) up to 200 kA, 100 As and 10 MA²s
- Surge current pulses (8/20) up to 200 kA 8/20
- Combined surges (1.2/50) up to 20 kV
- Combined surges (10/700) up to 10 kV
- Follow current system 255 V, 50 Hz, up to 3 kA
- Insulation measurement up to 5 kV AC, 50 Hz and up to 6 kV DC
- Conductivity measurements up to 63 A, 50 Hz
- Tensile and compression strengths up to 100 kN

Components of a lightning and surge protection system

All lightning and surge protection systems are made up of the following elements: (Figure 1.27)

1. Interception and down-conductor systems
Interception and arresting systems reliably arrest direct lightning strikes with energy of up to 200,000 A and conduct them safely into the earthing system.

2. Earthing systems
Earthing systems discharge approx. 50% of the arrested lightning current into the ground; the other half is distributed via the equipotential bonding.

3. Equipotential bonding systems
Equipotential bonding systems form the interface between external and internal lightning protection. They ensure that dangerous potential differences do not come about in the building.

4. Surge protection systems
Surge protection systems form a multi-stage barrier which no surge voltage can break through.

OBO offers all components required for comprehensive lightning and surge voltage protection systems. Standard-compliant, tested components from OBO offer protection and safety of the highest order not just for homes but also for industrial plants and potentially explosive areas.

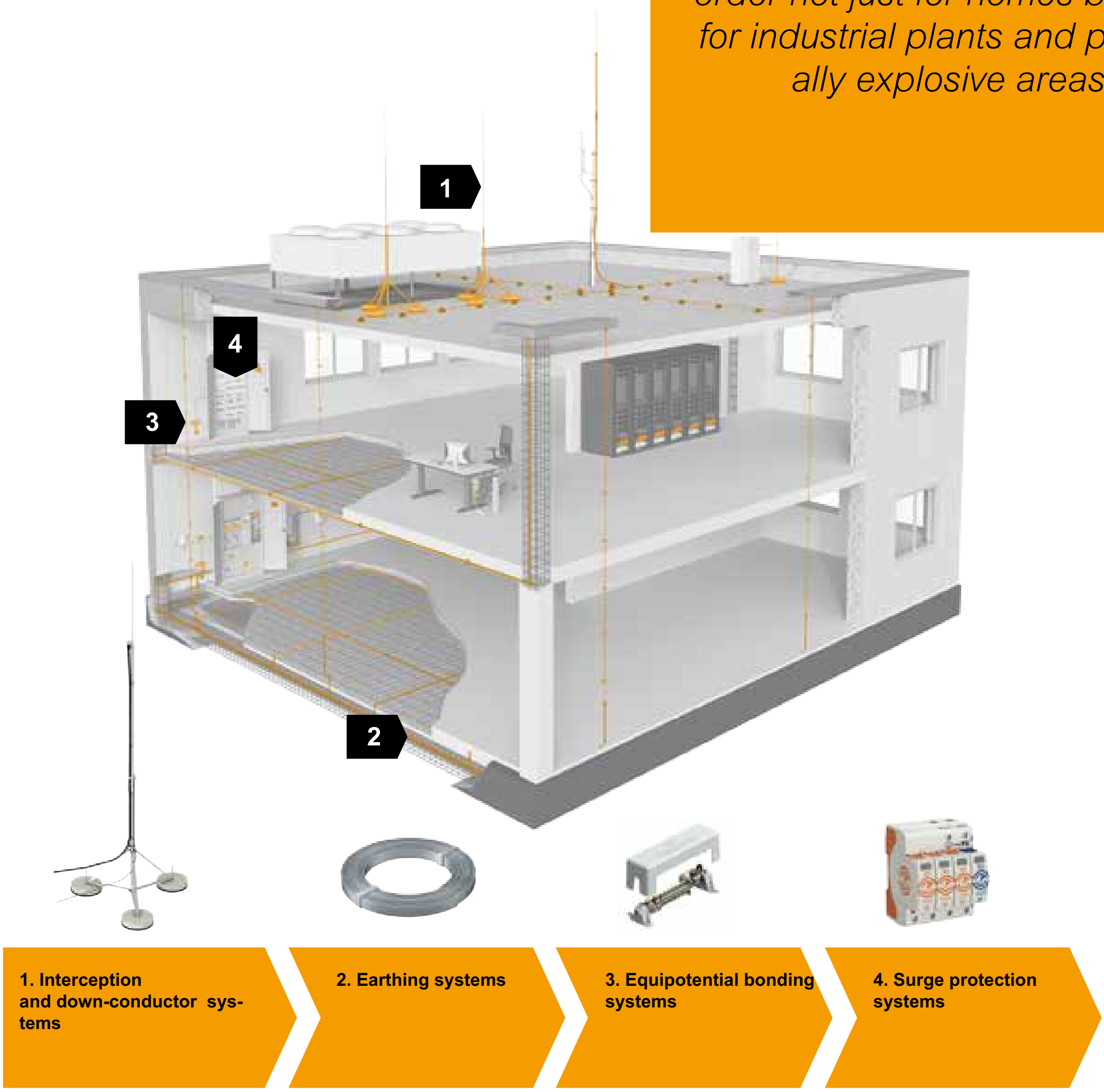


Figure 1.27: Components of a lightning and surge protection system

2

The lightning current must be intercepted and arrested by the lightning protection system. In case of a direct strike, the lightning protection system protects the building against fire. The interception systems provide an optimal impact point and are connected via the down-conductors with the earthing system. For lightning currents this creates a conductive path into the ground. The air-termination systems form protective spaces, the necessary size of which can be determined using, for example, the “rolling sphere method”.

Alongside the air-termination system and the down-conductors, the earthing system is another integral part of the external lightning protection system. The lightning current needs to be safely routed into the earthing system without any sparking or arcing into other metallic structures. The equipotential bonding system creates the connection into the building.

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2. The external lightning protection system

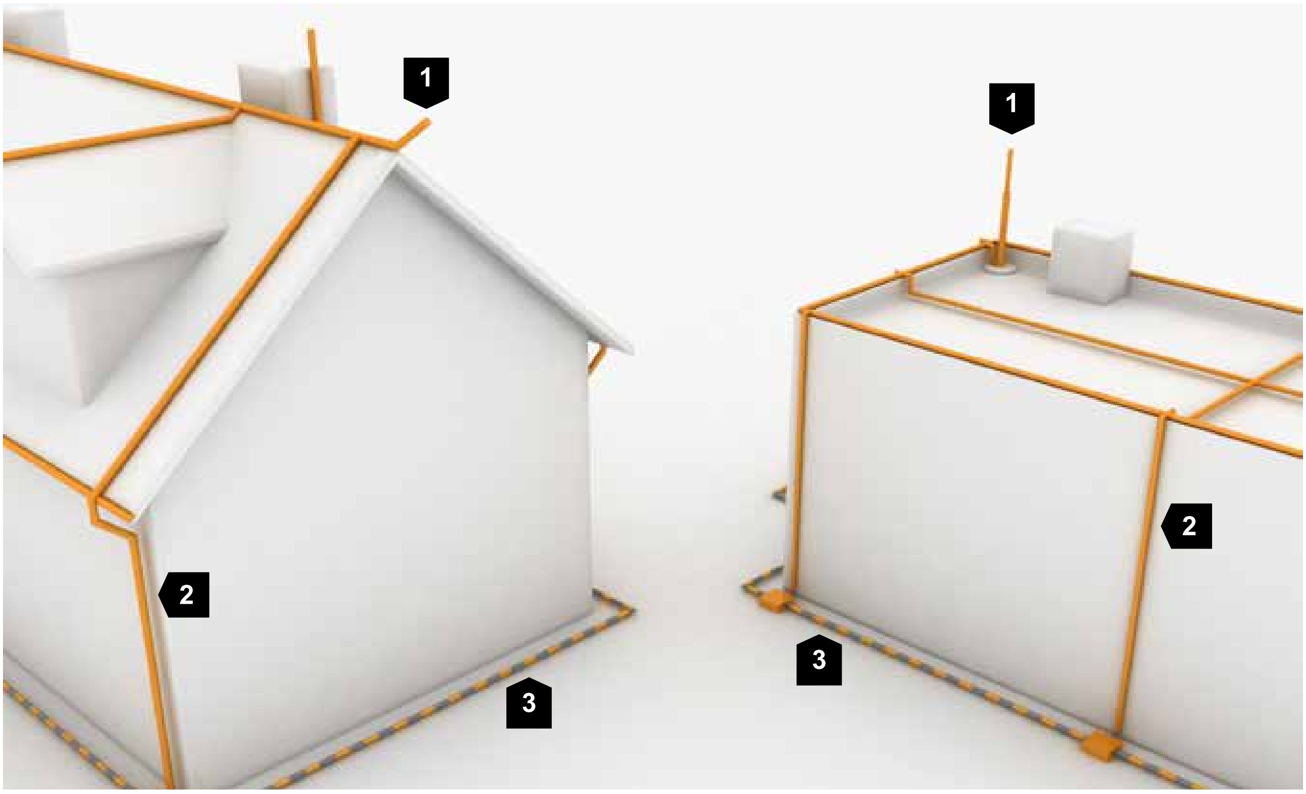
The external lightning protection system consists of interception systems, arresters and the earthing system. With these components it is able to perform the functions required of it, namely intercepting direct lightning strikes, discharging the lightning current to earth and distributing it in the ground. **(Figure 2.1)**

2.1 Air-termination systems

Air termination systems are the part of the lightning protection system that protect the building structure from direct lightning strikes.

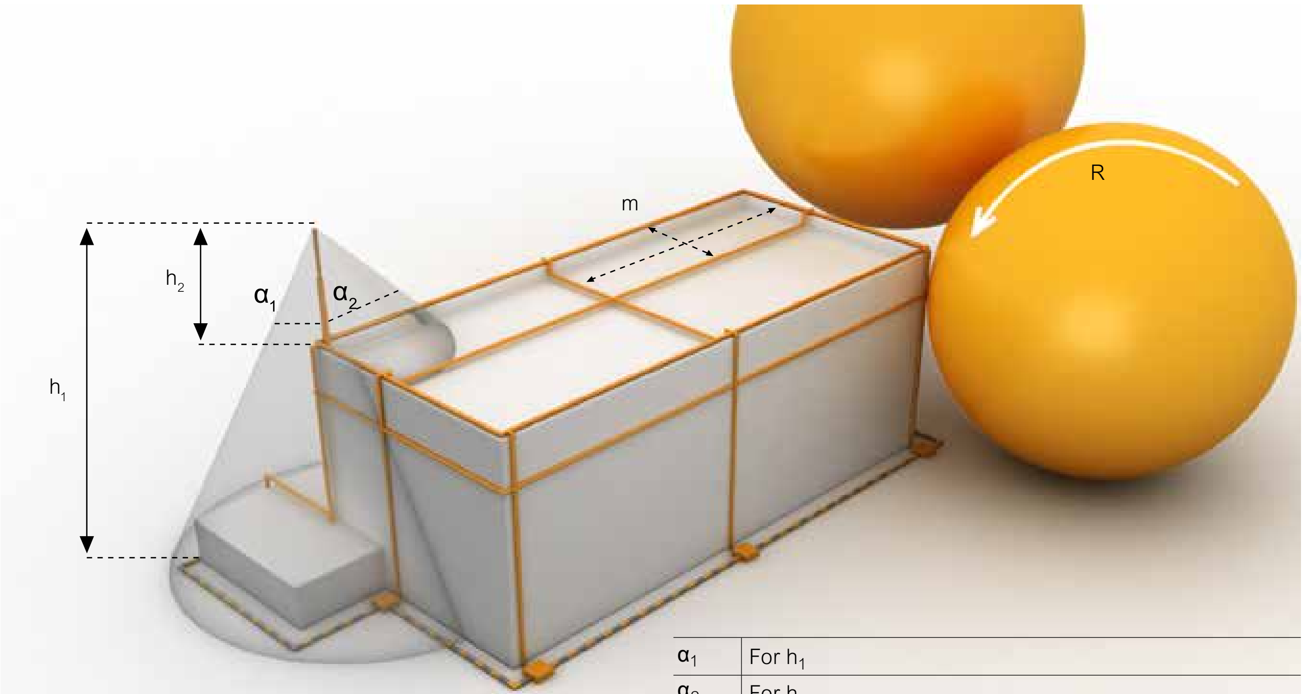
Interception systems can be comprised of any combination of the following components:

- Interception rods (including free-standing masts) **(Figure 2.2)**
- Tensioned cables
- Meshed conductors



1	Air-termination system
2	Down-conductor
3	Earthing system

Figure 2.1: Components of an external lightning protection system



α_1	For h_1
α_2	For h_2
h_1	Building height + air-termination rod
h_2	air-termination rod height
α_{1+2}	Protective angle
R	Radius
m	Mesh width

Figure 2.2: Designing a lightning protection system using the protective angle, mesh and rolling sphere methods

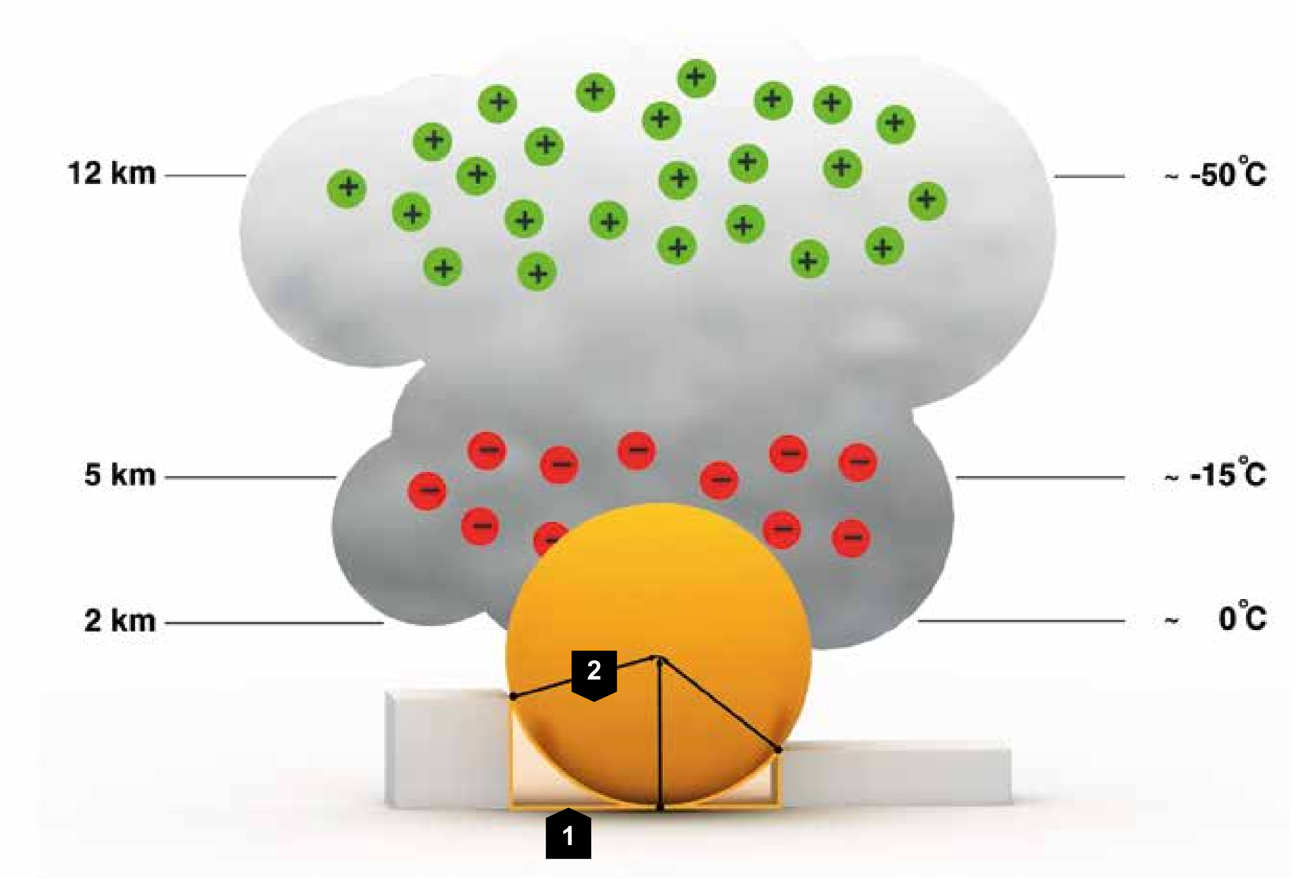
The rolling sphere method is the only one of the methods for planning interception systems that is derived from the electrogeometric lightning model and founded on physical principles.

This is therefore, the method that should be used where the protective angle or grid method throw up uncertainties.

2.1.1 Planning methods for air-termination systems

Following a practical assessment of the building, one or a combination of the following planning methods is selected:

- Rolling sphere method (particularly suitable for complex systems)
- Protective angle method (for simple planning tasks, e.g. for interception rods)
- Mesh method (for simple planning tasks, e.g. for flat roofs) **(Figure 2.2)**



1	Protected area
2	Area exposed to strike

Figure 2.3: Electrogeometric lightning model/rolling sphere method

2.1.1.1 Rolling sphere method (Figure 2.3)

Charge separation causes a potential difference between the clouds and the ground, producing a downward leader with the head of a downward leader. Upward leaders are launched towards the head of the stepped leader from various points such as trees, houses and antennas. At the point whose interception discharge is first reached by the tip of the downwards leader, a strike occurs. It is therefore necessary to protect all points on the surface of a ball with the radius of the striking distance and with the tip of the stepped leader as its centre, against direct lightning strike. This ball will be referred to here as the "rolling sphere". The radius of the rolling sphere depends on the lightning protection class of the buildings that are to be protected. **(Figure 2.4)**

The rolling sphere rolls over the building; everywhere where it makes contact is a possible impact point for the lightning.

Risk level (LPL = lightning protection level)	Radius of rolling sphere
I	20 m
II	30 m
III	45 m
IV	60 m

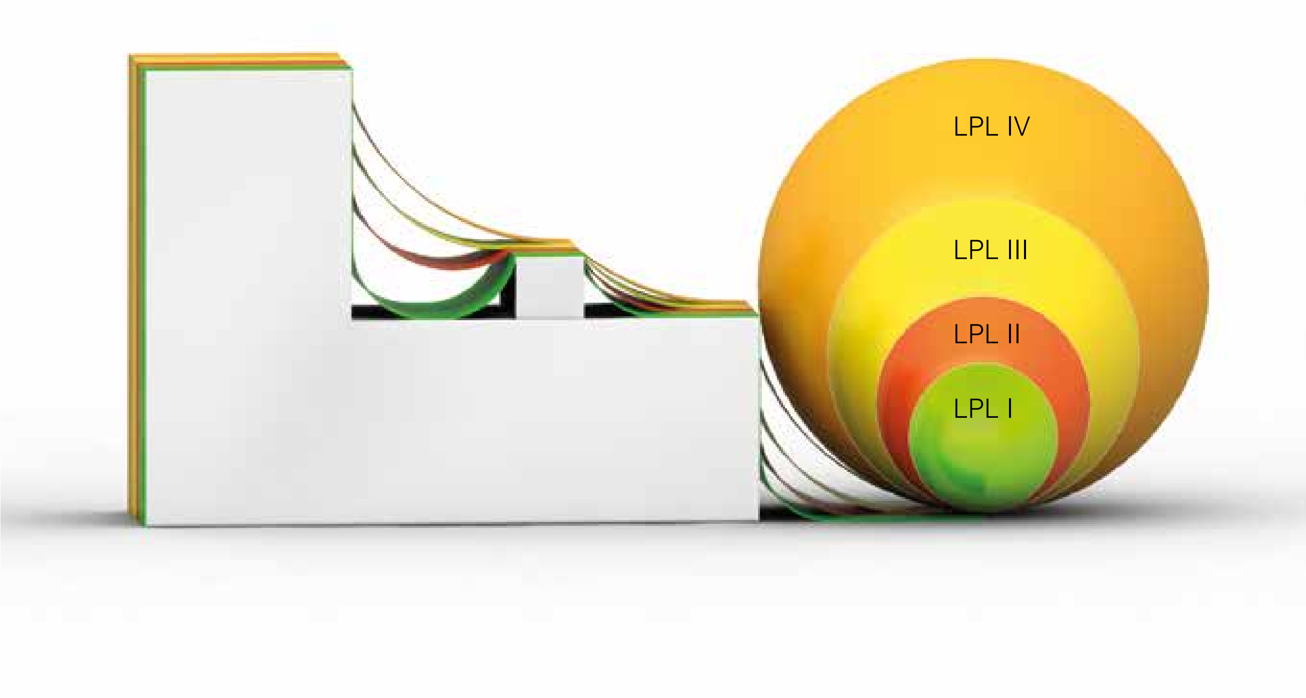


Figure 2.4: Radius of rolling sphere for different lightning protection classes

Modern CAD programs can reproduce in 3D the rolling sphere rolling over the entire installation that is to be protected. For example, in buildings of lightning protection class I, the ball touches surfaces and points that in buildings of lightning protection class II (or III or IV) would still be in the protected area. **(Fig. 2.5)** The rolling sphere method allows the installation to be divided into different external lightning protection zones (LPZs) or "lightning protection levels" (LPLs):

LPZ 0A

Hazards from direct lightning strikes and the entire electromagnetic field of the lightning.

LPZ 0B

Protected against direct lightning strikes, but at risk from the entire electric field of the lightning.

Note

Side strikes can occur on any building structures higher than the radius of the rolling sphere. However, the probability of a side strike is negligible on structures with a height (h) of < 60 m.

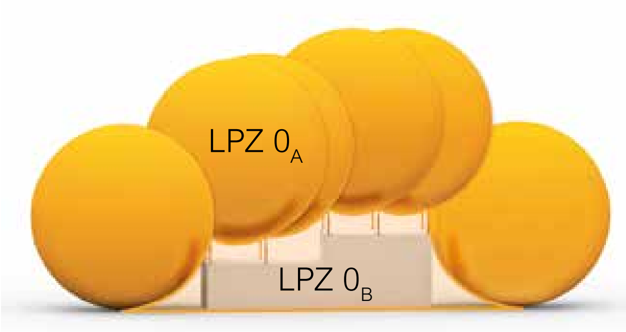


Figure 2.5: Rolling sphere method and the resulting lightning protection zones (LPZs)

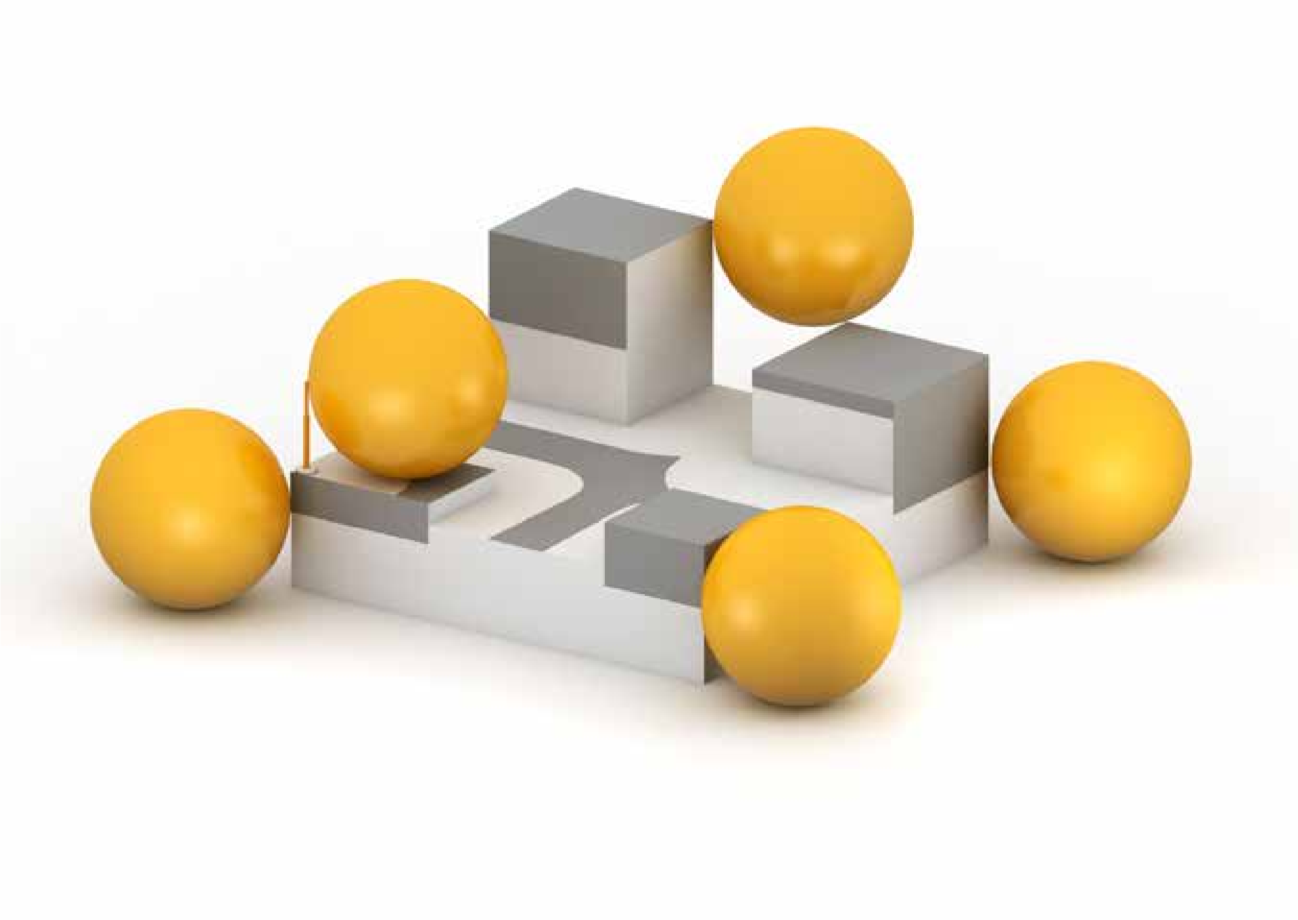
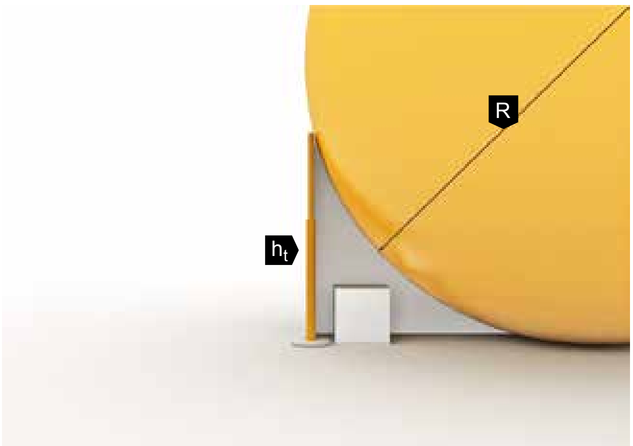


Figure 2.6: Rolling sphere method (dark grey areas are areas at risk of strike)

The building that is to be protected must be fitted with interception systems in such a way that a sphere with a radius determined on the basis of the lightning protection class **(see Figure 2.6)** cannot touch the building. Air-termination systems are required in the dark grey areas.

The rolling sphere method can be used to determine the required lengths of interception rods and the distances between them. **(Figures 2.7 and 2.8)** The interception rods must be arranged in such a way that all parts of the structure to be protected are located in the protection area of the interception system.



h_t	Air-termination rod
R	Rolling sphere radius

Figure 2.7: Protection area of an interception rod determined using the rolling sphere method

Protecting roof structures using multiple interception rods

If you use several interception rods to protect an object, you must take into consideration the penetration depth between them. For a brief overview see Table 2.1, or to calculate the penetration depth use the following formula:

$$p = r - \sqrt{r^2 - \left(\frac{d}{2}\right)^2}$$

Formula for calculating the penetration depth

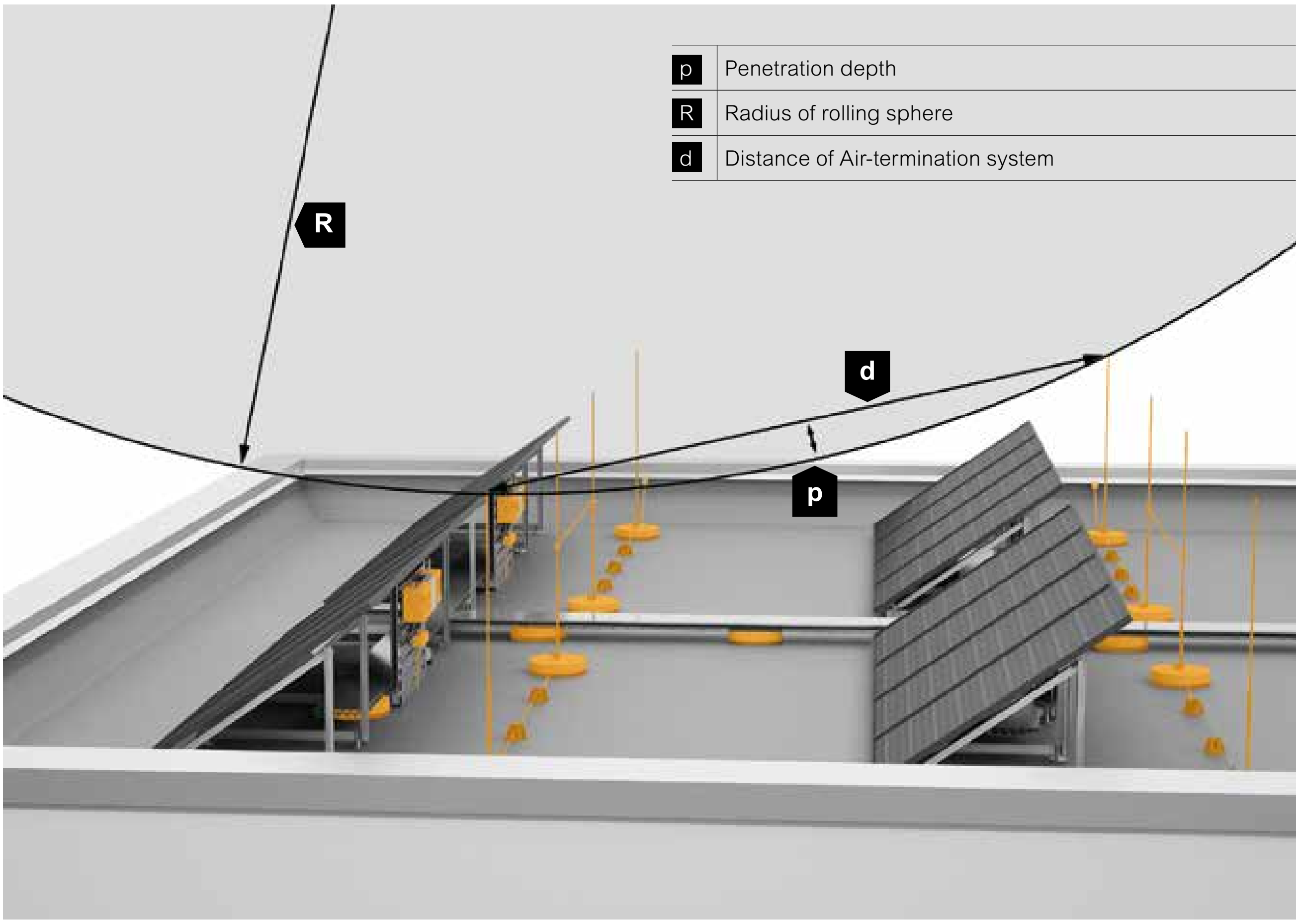


Figure 2.8: Penetration (p) of the rolling sphere between the interception rods

Distance of interception system (d) in m	Penetration depth, lightning protection class I, rolling sphere: r = 20 m	Penetration depth, lightning protection class II, rolling sphere: r = 30 m	Penetration depth, lightning protection class III, rolling sphere: r = 45 m	Penetration depth, lightning protection class IV, rolling sphere: r = 60 m
2	0.03	0.02	0.01	0.01
3	0.06	0.04	0.03	0.02
4	0.10	0.07	0.04	0.04
5	0.16	0.10	0.07	0.05
10	0.64	0.42	0.28	0.21
15	1.46	0.96	0.63	0.47
20	2.68	1.72	1.13	0.84

Table 2.1: Penetration depth (p) according to the lightning protection class according to IEC 62305 (VDE 0185-305)

α	Protective angle
s	Separation distance

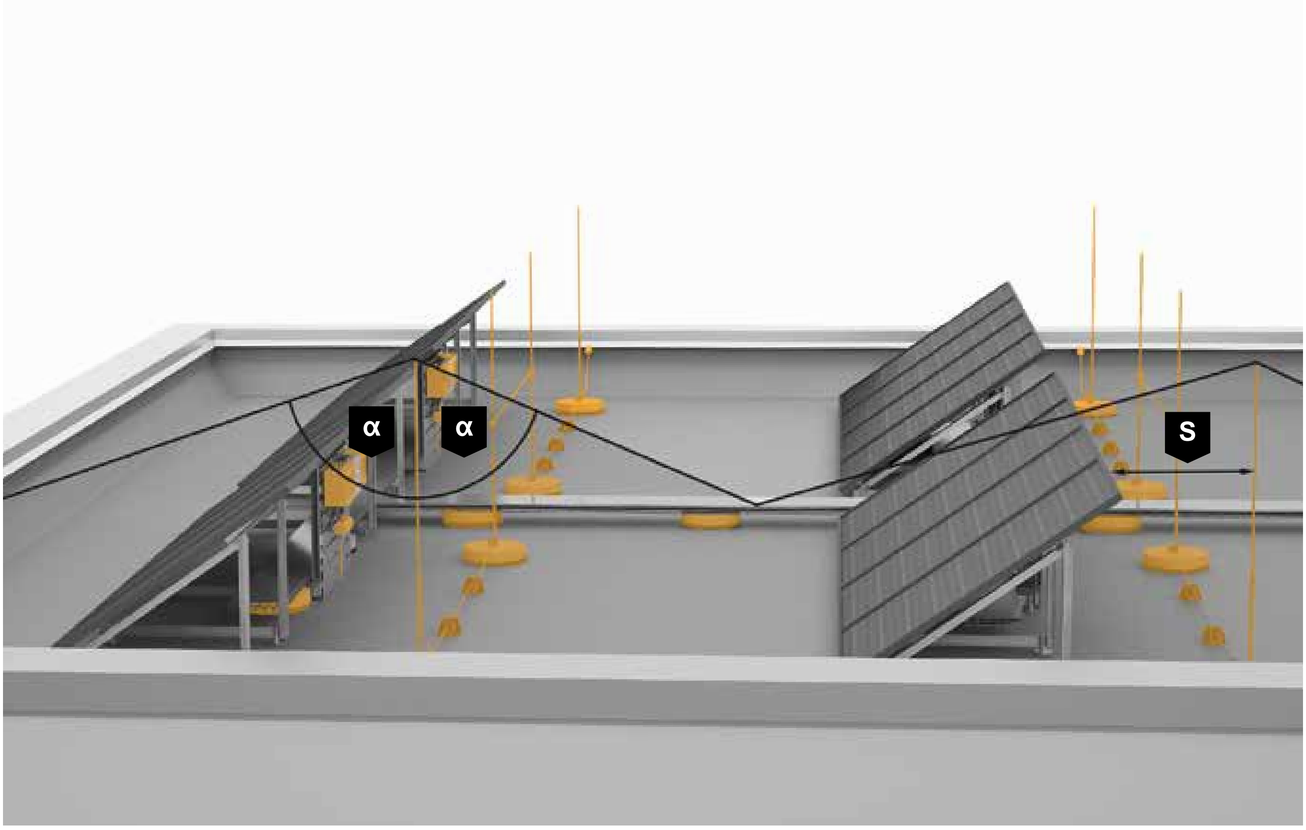


Figure 2.9: Protective angle and separation distance of air-termination rods in a photovoltaic system

2.1.1.2 Protective angle method (Figure 2.9)
Using the protective angle method is only advisable in simple or small buildings and for individual sections of buildings.

This method should therefore only be used where the building is already protected with air-termination rods whose positions were determined using the rolling sphere or grid method. The protective angle method is well suited to determining the positions of interception rods providing merely additional protection for a small number of protruding building parts or structures.

All roof structures must be protected with interception rods. Here it is necessary to observe the relevant separation distance ("s") between earthed roof structures and metal systems.

If the roof structure has a conductive continuation into the building (e.g. with a stainless steel pipe with a connection to the ventilation or air-conditioning system), then the air-termination rod must be erected at a separation distance of s from the object to be protected. This distance safely prevents arcing of the lightning current and dangerous spark creation.

The use of the protective angle method is only advisable in simple or small buildings and sections of buildings.

α	Protective angle
1	LPZ 0_A: Danger posed by direct lightning strikes
2	LPZ 0_B: Protected from direct lightning strikes but at risk
3	h_1: Air-termination rod height

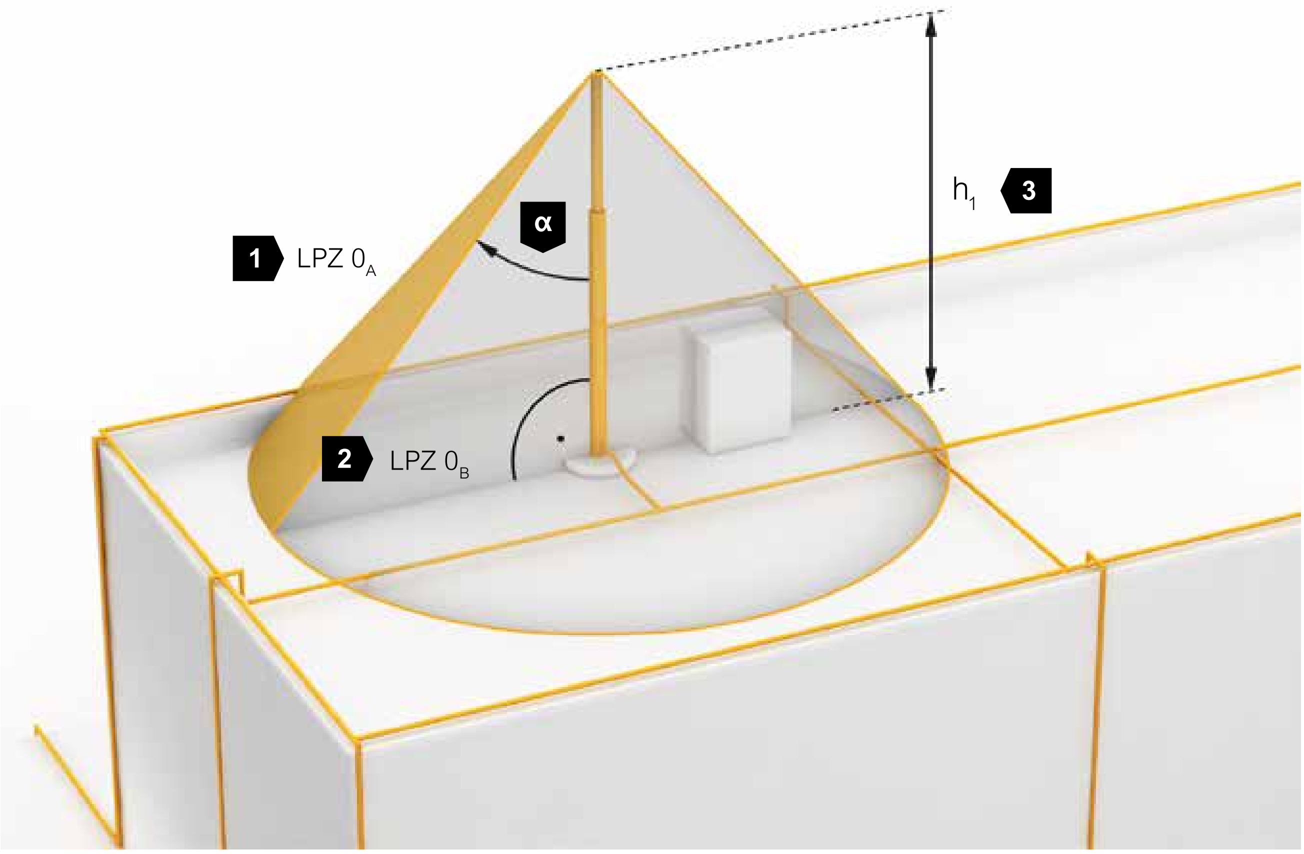


Fig. 2.10: Protected area of an air-termination rod calculated with the simplified protective angle method.

The protective angle (α) for interception rods varies according to lightning protection class. You can find the protective angle (α) in the table for the most common interception rods of up to 2 m in length. (Table 2.2)

The structure to be protected (e.g. building part or device) must be fitted with one or several interception rods in such a way that the structure fits fully underneath a cone sheath formed by the tips of the interception rods and whose top angle is taken from the table (see diagram on p. 70). The areas bordered by the horizontal plane (roof surface) and the areas enclosed by the cone sheath can be considered protected areas.
(Figure 2.10)

Lightning protection class	Protective angle α for air-termination rods up to 2 m in length
I	70°
II	72°
III	76°
IV	79°

Table 2.2: Protective angle based on lightning protection class according to IEC 62305-3 (VDE 0185-305-3) for air-termination rods up to 2 m in length

l	Building length
m	Mesh width

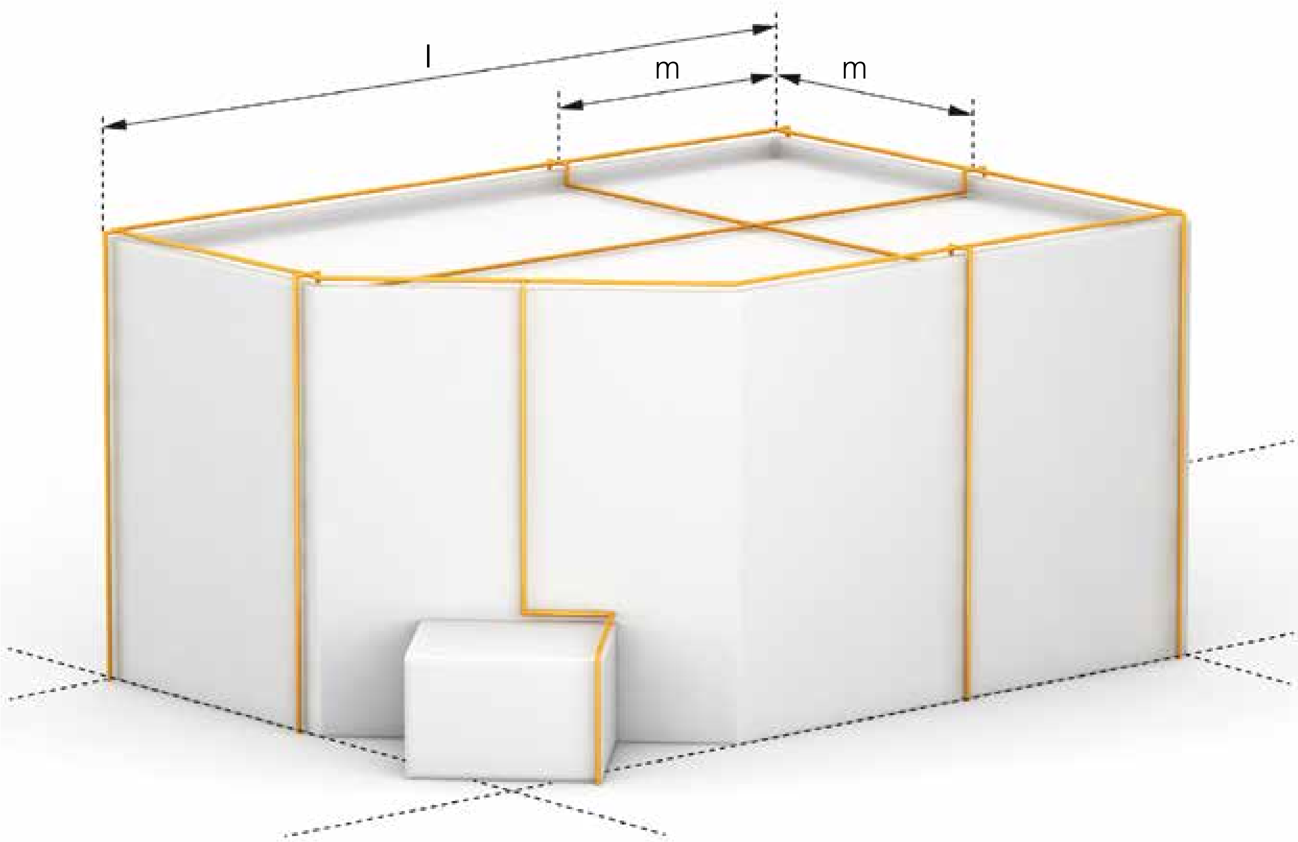


Figure 2.11: Grid system on a flat roof

2.1.1.3 Mesh method (Figure 2.11)

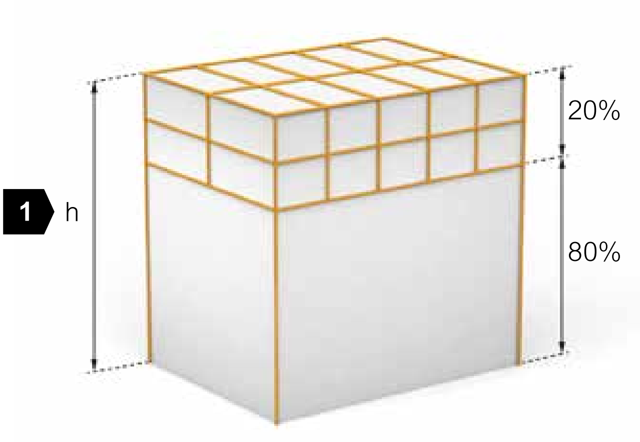
Installing the loops

A number of different loop sizes are suitable for the particular lightning protection class of the building. The building in our example has building lightning protection class III. A loop size of 15 m x 15 m must therefore not be exceeded. If, as in our example, the overall length l is greater than the recommended size indicated in Table 2.3, an expansion piece must also be integrated for temperature-controlled length changes.

The grid method is used exclusively on the basis of the lightning protection class.

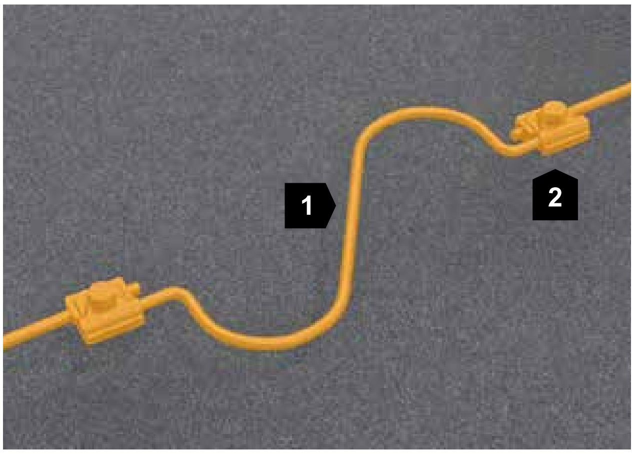
Class	Mesh width
I	5 x 5 m
II	10 x 10 m
III	15 x 15 m
IV	20 x 20 m

Table 2.3: Grid widths for different lightning protection classes



1	Building height (h) > 60 m

Fig. 2.12: Grid method and protection against lateral impact



1	Expansion piece
2	Terminal

Figure 2.13: Lightning protection grid with expansion piece

Protection against lateral impact
From a building height of 60 m and the risk of serious damage (e.g. with electrical or electronic devices) it is advisable to install a ring circuit to protect against lateral impact.

The ring is installed at 80% of the building's overall height, the loop size depends – as it does in the case of roof installation – on the lightning protection class, e.g. lightning protection class corresponds to a loop size of 15 x 15 m. **(Figure 2.12)**

2.1.2 Changes in length due to temperature
At higher temperatures, e.g. in summer, the length of the interception systems and arresters changes. These temperature-related changes in length must be taken to into account during installation. Expansion pieces **(Figure 2.13)** must allow a flexible response to changes in length, either through their shape (e.g. S shape), or because they are flexible lines. For practical purposes, the expansion piece spacings listed in **Table 2.4** have proved to be effective.

Material	Expansion piece spacing in m
Steel	15
Stainless steel	10
Copper	10
Aluminium	10

Table 2.4: Expansion pieces to compensate changes in length due to temperature

2.1.3 External lightning protection for roof structures

Roof structures must be incorporated into the external lightning protection system according to IEC 62305-3 (VDE 0185-305) if they exceed the dimensions stated in Table 2.5.

Roof structures	Dimensions
Metal	0.3 m above roof level 1.0 m² total area 2.0 m length of the structure
Non-metal	0.5 m above the interception system

Table 2.5: Incorporation of roof structures

Smoke and heat exhaust (SHE) roof light domes must be protected from direct lightning strikes.

Surge protection devices protect the electrical drives of these devices from damage due to inductive coupling.

Figure 2.14: Natural components (here: metal of roof parapet) for air-termnation systems, IEC 62305-3 (VDE 0185-305-3)

2.1.4 Use of natural components

If there are conductive elements on the roof, it can make sense to use these as natural interception systems. **(Figure 2.14)**

Examples of natural components for air-termination systems according to IEC 62305-3 (VDE 0185-305-3) can include:

- Panelling with metal plate (e.g. parapet)
- Metallic components (e.g. supports, through connected reinforcement)
- Metal parts (e.g. rain gutters, ornamentation, railings)
- Metallic pipes and tanks

Electrical continuity between the various parts must be permanently guaranteed (e.g. through hard soldering, welding, crushing, beading, screwing or riveting). What is essential is that there is no conductive connection into the building interior. In this case the lightning protection class is irrelevant to the selection of a natural interception system.

Characteristic data that apply irrespective of the protection class:

- Minimum thickness of metal plates or pipes on air-termination systems
- Materials and their conditions of use
- Materials, shape and minimum dimensions of interception systems, arresters and earthers
- Minimum dimensions of connection cables

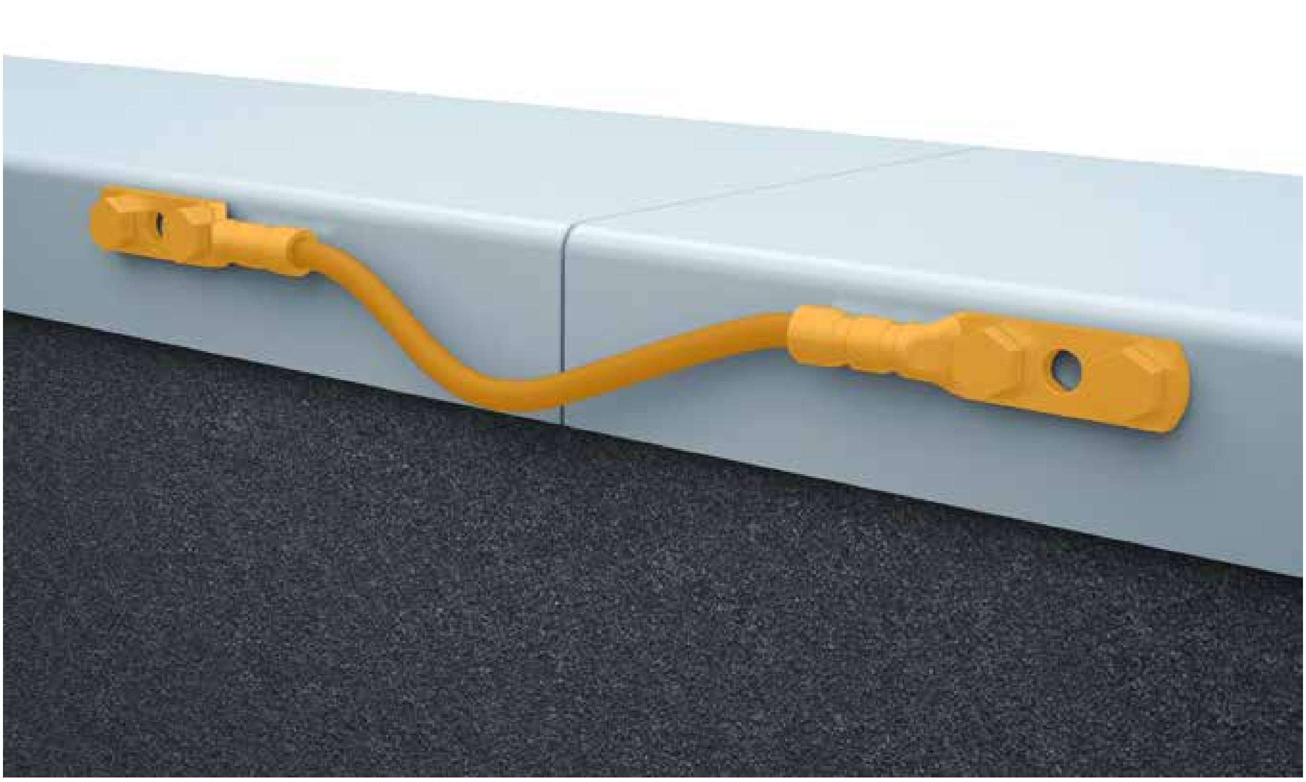


Figure 2.15: Possible method for connecting metal on roof parapet by bridging with a flexible cable

Various bridging and connecting components are available for connecting metal roof elements (e.g. parapets) in such a way that they can conduct lightning current. **(Figure 2.15)** Depending on the product, these can be fitted to the roof element in a standard-compliant way. The application standard offers a variety of options in this regard. **(Figure 2.16)**

Metal covers to protect the exterior wall can be used as a natural component of the interception system, if melting at the impact point of the lightning strike is accepted.
(Table 2.6)

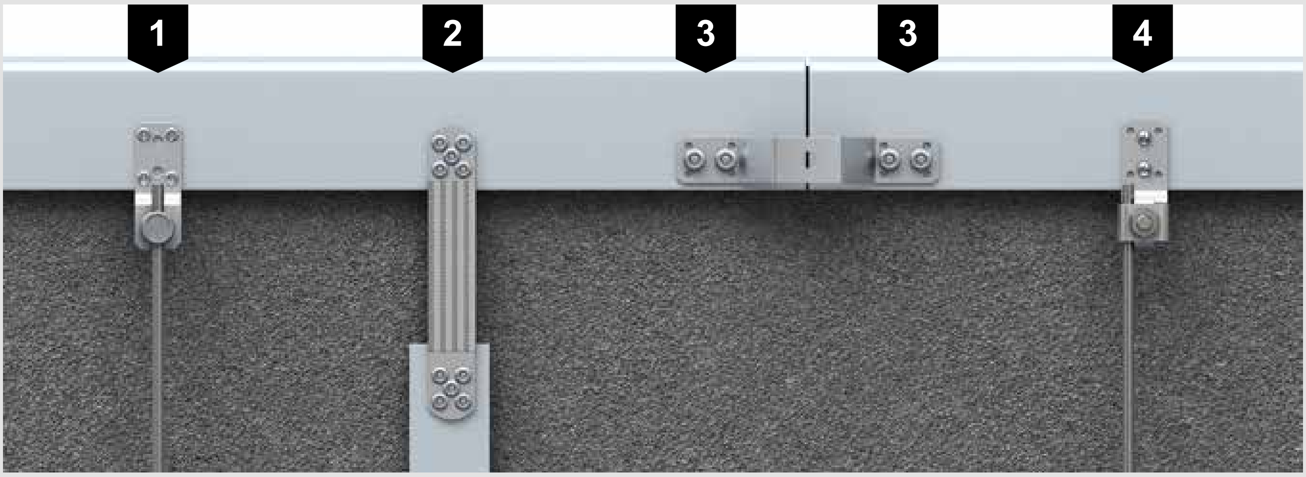


Figure 2.16: Screw connection on metal cover of roof parapet, source IEC 62305-3 (VDE 0185-305-3), Supplement 1:2012-10

1	4 blank rivets of 5 mm diameter
2	5 blank rivets of 3.5 mm diameter
3	2 blank rivets of 6 mm diameter
4	2 metal self-tapping screws of 6.3 mm diameter, made of rust-proof steel, e.g. material number 1.4301

Material	Thickness t mm (prevents penetration, overheating and inflammation)	Thickness t mm (if prevention of penetration, overheating and inflammation are not important)
Lead	-	2.0
Steel (rustproof/galvanised)	4	0.5
Titanium	4	0.5
Copper	5	0.5
Aluminium	7	0.65
Zinc	-	0.7

Table 2.6: Minimum thickness of metal plates or pipes on interception systems in accordance with IEC 62305-3 (VDE 0185-305-3), protection class (LPS): I to IV

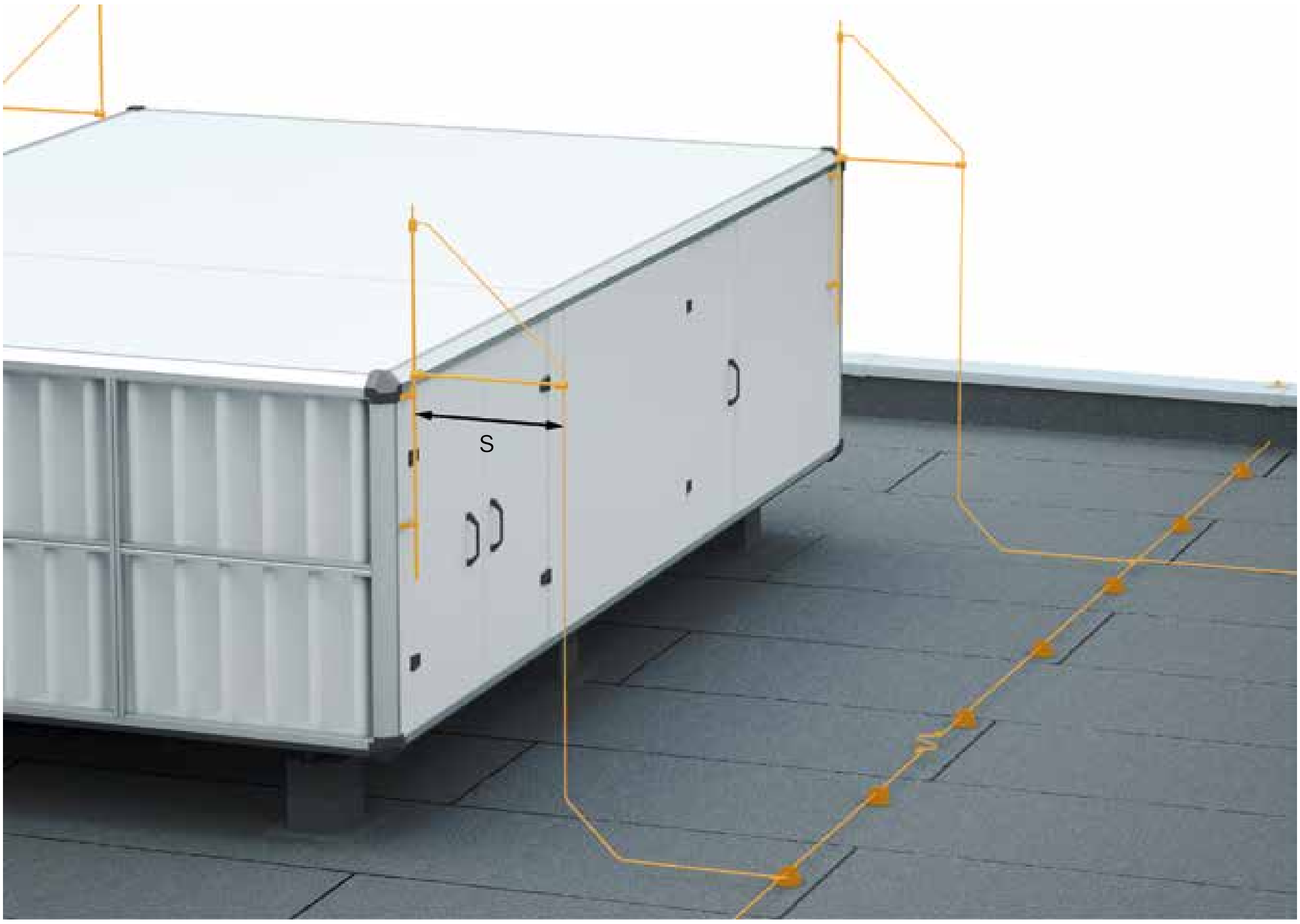


Figure 2.17: Correctly maintained separation distance (s) between arrester systems and roof structures

2.1.5 Separation distance (s)

All metallic parts of a building and electrically powered equipment and their supply cables must be integrated into the lightning protection system. This measure is required to avoid dangerous sparking between both air-termination system and down-conductor and also the metallic building parts and electrical equipment. **(Figure 2.17)**

What is the separation distance?

If there is an adequate distance between the conductor passing from the lightning current and the metallic building parts, the risk of sparking is practically non-existent. This distance is described as the separation distance (s).

Components with direct connection to lightning protection system

A separation distance does not have to be observed in buildings with cross-connected, reinforced walls and roofs or with cross-connected metal facades and metal roofs. Metallic components with no conductive connection into the building to be protected and whose distance to the conductor of the external lightning protection system is less than one metre, must be connected directly to the lightning protection system. These include, although are not limited to, metallic railings, doors, pipes (with non-flammable and/or explosive contents), facade elements, etc.

Figure 2.18: Lightning down-conductor at a downpipe

Figure 2.19: Direct connection of PV mounting frames to the lightning protection down-conductor system

Application example 1: Lightning protection
(Figure 2.18)

Situation
Metallic structures such as mounting frames **(Figure 2.19)**, grilles, windows, doors, pipes (with non-flammable and or explosive contents) or facade elements with no conductive connection into the building.

Solution
Connect the lightning protection system with the metallic components.

Cables leading into the building can carry partial lightning currents.

A lightning protection equipotential bonding system must be implemented at the point of entry into the building.

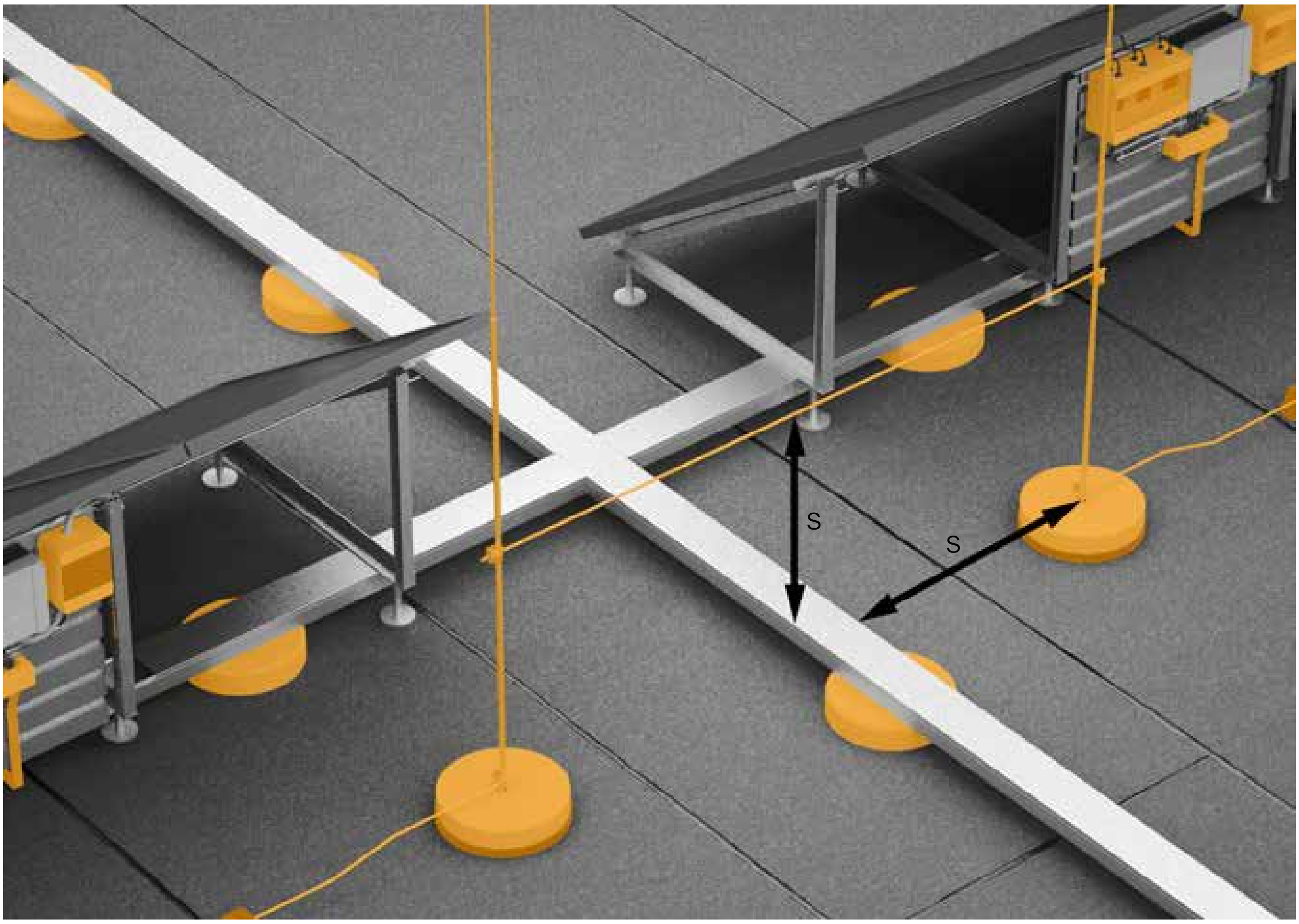


Figure 2.20: Isolated lightning protection with correctly maintained separation distance (s)

Application example 2: roof structures (Figure 2.20)

Situation
Air-conditioning systems, photovoltaic systems, electrical sensors/actuators or metallic vent pipes with conductive connection into the building.

Solution
Isolation through the use of a separation distance (s)

Note
Risk of inductively coupled surges must be considered.

$$s = k_i \frac{k_c}{k_m} L(m)$$

k_i	is dependent on the selected protection class of the lightning protection system
k_c	is dependent on the (partial) lightning current that flows into the down-conductors
k_m	is dependent on the material of the electrical insulation
L(m)	is the vertical distance from the point at which the separation distance (s) is to be determined up to the closest point of the equipotential bonding

Formula for calculating the separation distance

Procedure for calculating the separation distance according to VDE 0185-305 (DIN EN 62305-3)

1st step **Calculate the value of the coefficient k_i**	• Protection class I: k_i = 0.08 • Protection class II: k_i = 0.06 • Protection classes III and IV: k_i = 0.04
2nd step **Calculate the value of the coefficient k_c (simplified system)**	• 1 down-conductor (only in the case of an isolated lightning protection system): k_c = 1 • 2 down-conductor: k_c = 0.66 • 3 down-conductor or more: k_c = 0.44 The values apply to all type B electrodes and to those type A electrodes in which the earth resistance of the neighbouring earth electrodes does not differ by more than a factor of 2. If the earth resistance of individual electrodes deviates by more than a factor of 2, k_c = 1 should be assumed.
3rd step **Calculate the value of the coefficient k_m**	• Material air: k_m = 1 • Material concrete, brickwork: k_m = 0.5 • OBO GRP insulating rods: k_m = 0.7 If several insulating materials are used, in practice the lowest value for k_m is used.
4th step **Calculate the value L**	L is the vertical distance from the point at which the separation distance (s) is to be calculated up to the closest point of the equipotential bonding.

Table 2.7: Calculating the separation distance according to IEC 62305-3 (VDE 0185-305)

Example: building structure

Initial situation:

- Lightning protection class III
- Building with more than four arresters
- Material: concrete, brickwork
- Height/point at which the separation distance should be calculated: 10 m

Value determined:

- k_i = 0.04
- k_c = 0.44
- k_m = 0.5
- L = 10 m

Calculation of separation distance:

$s = k_i \times k_c / k_m \times L = 0.04 \times 0.44/0.5 \times 10\ m = 0.35\ m$

The wind load describes how wind will affect the buildings and installations.
It must be taken into account during planning.

2.1.6 Wind load

For decades, wind load has been an important consideration for OBO Bettermann in relation to external lightning protection. Today's calculation models and interception rod systems are the result of numerous studies and years of R&D experience.

The previous German standards in this area – DIN 1055:2005 Part 4: Wind loads and Part 5: Snow and ice loads, and DIN 4131: Steel antenna mounts – dealt with all load assumptions for mounts in Germany.

The eurocodes (EC) are the result of European standardisation in the construction field. EC 0 to EC 9 cover the documents in the series DIN EN 1990 to 1999. These are supplemented by the various national annexes (NA). The NAs contain provisions that go beyond the eurocode rules, i.e. the provisions that were previously part of the national standards.

Following the publication of the national annexes to the ECs, the old standards became invalid, following appropriate coexistence phases. **(Table 2.8)**

Old standard	New standard
DIN 1055:2005-03 Part 4: Wind loads	Eurocode 1: DIN EN 1991-1-4:2010-12: Parts 1-4: General effects; wind loads + DIN EN 1991-1-4/NA: 2010-12
DIN 1055:2005-03 Part 5: Snow and ice loads	DIN EN 1991-1-3: 2010-12 -; Parts 1-3: General effects; snow loads + DIN EN 1991-1-3/NA: 2010-12
DIN V 4131:2008-09 Steel antenna mounts	Eurocode 3: DIN EN 1993-3-1: 2010-12: Parts 3-1: Towers, masts and chimneys – towers and masts + DIN EN 1993-3-1/NA: 2010-12

Table 2.8: Example: German national standards for the calculation of wind load

1st step: determining the wind zone
The second factor that needs to be known when determining the wind load is the wind load zone in which the object is located. **(Table 2.9/Figure 2.21)**

The standards contain no statements regarding the following aspects:
- Framework masts and towers with non-parallel main legs
- Guyed masts and chimneys
- Cable-stayed and suspension bridges
- Torsional vibrations.

Zone	Wind speed in m/s	Speed pressure in kN/m²
1	22.5	0.32
2	25.0	0.39
3	27.5	0.47
4	30.0	0.56

Table 2.9: Basic speeds and speed pressures

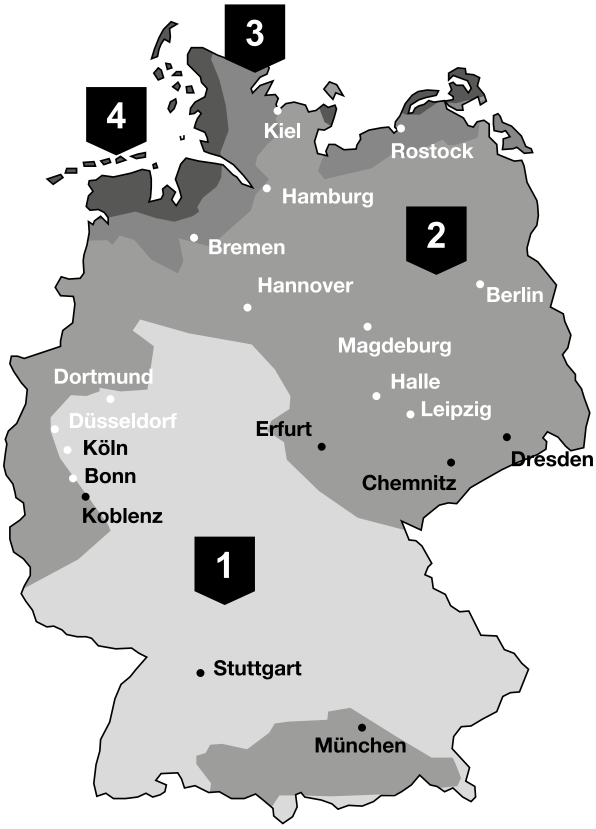


Figure 2.21: Wind zones in Germany as per DIN EN 1991-1-4 NA

2nd step: determining the terrain category (TC)
Terrain-specific loads and dynamic pressures are an important element in calculating wind loads.
(Table 2.10)

Terrain category (TC)	Definition
Terrain category I	Open sea; lakes with at least 5 km of open water in the wind direction; even, flat land without obstacles
Terrain category II	Terrain with hedges, individual farmsteads, buildings or trees, e.g. agricultural area
Terrain category III	Suburbs, industrial or commercial areas; forests
Terrain category IV	Urban areas in which at least 15% of the area is built up with buildings whose average height is higher than 15 m

Table 2.10: Terrain categories according to DIN EN 1991-1-4

3rd step: determining the maximum gust speed

The tilt and slip resistance of air-termination rods must always be determined on a project-by-project basis. The reference height is the building height plus 2/3 of the length of the interception rod. The maximum gust speed at the project location must be determined.

Figure 2.22: Air-termination rod

Gust speed in wind zone I				
Reference height in metres	**TC I in km/h**	**TC II in km/h**	**TC III in km/h**	**TC IV in km/h**
0	112	105	100	93
5	122	108	100	93
10	136	124	103	93
16	136	124	111	93
20	139	128	115	98
30	145	134	122	106
40	149	139	128	112
70	157	148	139	126
100	162	155	147	135

Table 2.11: Gust speeds, wind zone I

Gust speed in wind zone II				
Reference height in metres	**TC I in km/h**	**TC II in km/h**	**TC III in km/h**	**TC IV in km/h**
0	124	117	111	104
5	136	120	111	104
10	145	131	114	104
16	152	138	123	104
20	155	142	127	109
30	161	149	136	118
40	165	154	142	125
70	174	165	155	139
100	180	172	163	150

Table 2.13: Gust speeds, wind zone II

Gust speed in wind zone III				
Reference height in metres	**TC I in km/h**	**TC II in km/h**	**TC III in km/h**	**TC IV in km/h**
0	137	129	122	114
5	149	132	122	114
10	159	144	126	114
16	167	152	135	114
20	170	156	140	119
30	177	164	149	129
40	182	170	156	137
70	192	181	170	153
100	198	189	180	165

Table 2.12: Gust speeds, wind zone III

Gust speed in wind zone IV				
Reference height in metres	**TC I in km/h**	**TC II in km/h**	**TC III in km/h**	**TC IV in km/h**
0	149	140	133	124
5	163	144	133	124
10	174	157	137	124
16	182	166	148	125
20	186	170	153	130
30	193	179	163	141
40	198	185	170	150
70	209	198	185	167
100	216	206	196	180

Table 2.14: Gust speeds, wind zone IV

4th step: determining what concrete blocks are required

Based on the maximum gust speed, the number and size (10 or 16 kg) of concrete blocks required can be determined for the air-termination rod used. The value in the tables must lie above the maximum gust speed for the location.

An example

The maximum gust speed at the location is 142 km/h.

A tapered pipe interception rod of type 101 VL2500 and height 2.5 m is used.

Because the value in Table 2.15 must be higher than the maximum gust speed at the location (i.e. in this case more than 142 km/h), the next possible value is 164. Three concrete blocks, each of weight 16 kg, must therefore be used.

Number of concrete blocks for tapered pipe air-termination rods

Interception rod height in m	1.5	2	2.5	3	3.5	4	**Concrete blocks required**
Type	101 VL1500	101 VL2000	101 VL2500	101 VL3000	101 VL3500	101 VL4000	
Item no.	5401 98 0	5401 98 3	5401 98 6	5401 98 9	5401 99 3	5401 99 5	
Wind speed km/h	117	-	-	-	-	-	**1 x 10 kg**
	164	120	95	-	-	-	**2 x 10 kg**
	165	122	96	-	-	-	**1 x 16 kg**
	-	170	135	111	95	-	**2 x 16 kg**
	-	208	164	136	116	102	**3 x 16 kg**

Number of concrete blocks for air-termination rod, one end rounded

Interception rod height in m	1	1.5	2	2.5	3	**Concrete blocks required**
Type	101 ALU-1000	101 ALU-1500	101 ALU-2000	101 ALU-2500	101 ALU-3000	
Item no.	5401 77 1	5401 80 1	5401 83 6	5401 85 2	5401 87 9	
Wind speed km/h	97	-	-	-	-	**1 x 10 kg**
	196	133	103	-	-	**1 x 16 kg**
	-	186	143	117	100	**2 x 16 kg**
	-	-	173	142	121	**3 x 16 kg**

Number of concrete blocks for air-termination rod, one end rounded with connection strap

Interception rod height in m	1	1.5	**Concrete blocks required**
Type	101 A-L 100	101 A-L 150	
Item no.	5401 80 8	5401 85 9	
Wind speed km/h	100	-	**1 x 10 kg**
	192	129	**1 x 16 kg**
	-	177	**2 x 16 kg**
	-	214	**3 x 16 kg**

Table 2.15: Number of OBO concrete blocks required

Wind loads and the isFang rod

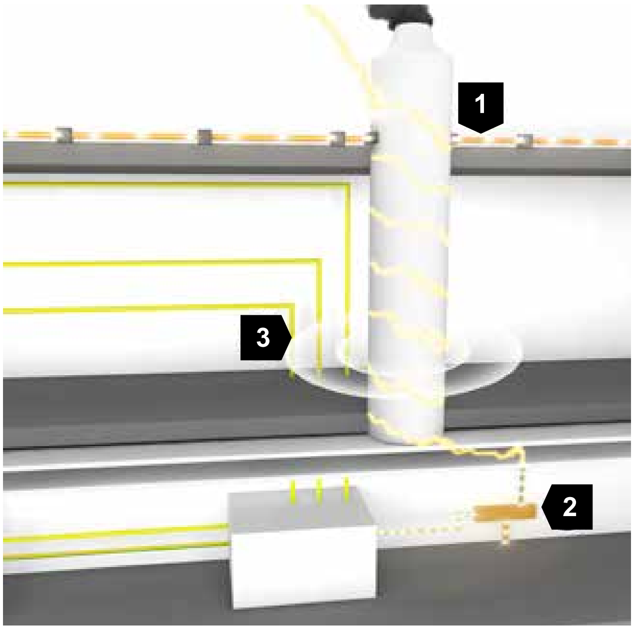
Table 2.16 shows the influence of wind zone, reference height and terrain category on the aluminium isFang rod (item no. 5402 88 0) with tripod (item no. 5408 96 7).

In wind zone 1, with a reference height of up to 10 m, and at up to 800 m above sea level, for example, the number of concrete blocks can be reduced to just 6 (2 concrete blocks per bracket).

Number of concrete blocks for isFang rods

Wind zone	1			2		
Reference height in metres	**10**	**40**	**75**	**10**	**40**	**75**
Terrain category I	12	15	-	15	-	-
Terrain category II	9	15	15	12	-	-
Terrain category III	9	12	15	9	15	-
Terrain category IV	6	9	12	9	12	15

Table 2.16: Required number of OBO 16 kg concrete blocks in accordance with N 1991-1-4 and EN 1991-3-1



1	Lightning strike. The lightning current enters the building via metallic components
2	The equipotential bonding rail conducts the lightning current into the earthing system
3	Surge voltage in power and data cable due to electromagnetic coupling

Figure 2.23: Danger due to non-isolated system

Figure 2.24: Isolated system with GRP holders

Figure 2.22: Insulated lightning protection with isFang

2.1.7 Types of air-termination systems

Air-termination systems can be either isolated or non-isolated systems; the two types can be used in combination. Non-isolated systems **(Figure 2.23)** are fitted directly to the object that is to be protected and the arresters are routed along the surface of the installation.

Isolated systems **(Figure 2.24)** prevent direct strikes into the object/installation that is to be protected. This can be achieved with interception rods and masts, but also by fixing the components with insulating GRP (fibre-glass-reinforced plastic) holders to the building/installation to be protected. In both cases it must be ensured that the separation distance (s) is adhered to. If this is not possible, the insulated, high-voltage-resistant isCon cable can be used to achieve an isolated interception system within a non-isolated system.

2.1.7.1 Insulated, high-voltage-resistant air-termination systems

The OBO isFang modular interception rod system can offer a fast and freely terminable solution for insulated interception rods of up to 10 m high for the largest possible protection angle.

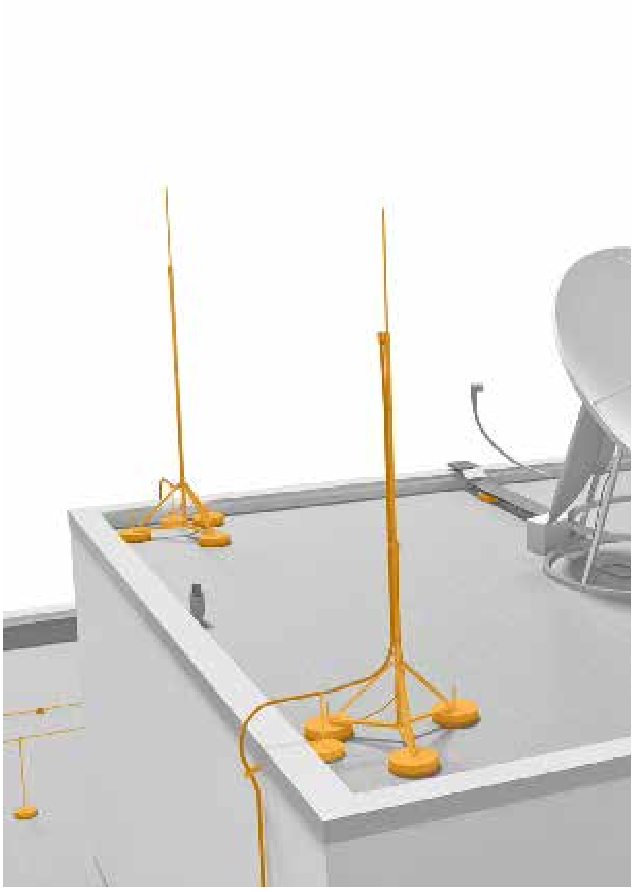


Figure 2.26: Interception masts with external isCon® cable

Figure 2.27: Interception rod with internal isCon® cable

2.1.7.1.1 Insulated air-termination masts with external isCon® conductor (Figure 2.26)

The insulated interception rods protect electrical and metallic roof structures, taking the calculated separation distance (s) according to IEC 62305-3 (VDE 0185-305-3) into account. An insulated section of 1.5 metres made of fibre-glass-reinforced plastic (GRP) ensures sufficient distance to all roof structures. Even complex building structures can be protected by the comprehensive system accessories.

2.1.7.1.2 Insulated interception rods with Internal isCon® cable (Figure 2.27)

The three-part aluminium and GRP interception rod with its insulated structure allows the isCon® cable (black and light grey) to be routed inside the interception rod. Combining a perfect appearance with perfect functionality, it offers the following advantages:

- Tidy appearance through internal isCon® cable
- 4 variants: 4 m to 10 m height
- Including connection element and potential connection in the rod
- For free-standing installation, can be combined with isFang interception rod stand with side exit

Visually attractive and functionally adapted insulated interception rod for flexible, simple and quick installation. The interior isCon® conductor means that the interception rod requires only a minimum wall attachment area and can thus also be installed at high and windy points. **(Figure 2.27)**

Table 2.17 shows the required number of OBO 16 kg concrete blocks based on the maximum permissible gust speed and interception rod height. These values should be compared with those in Tables 2.11-2.14. If the value is smaller, then the number of concrete blocks should be adjusted accordingly.

The insulated air termination rod should be connected to a reference potential using ≥ 6 mm² Cu or an equal conductivity. Lightning current must not flow through the reference potential and it must be in the protective angle of the lightning protection system. This means that the potential connection can me made via metallic and earthed roof structures, generally earthed parts of the building structure and via the protective conductor of the low-voltage system.

Number of concrete blocks for insulated VA and Al air termination rods

Interception rod height in m	4	6	4	6	**Concrete blocks required**
Material	VA	VA	Al	Al	
Item no.	5408 94 2	5408 94 6	5408 94 3	5408 94 7	
Item no. of appropriate interception rod stand	5408 96 8	5408 96 9	5408 96 6	5408 96 7	
Wind speed km/h	120	94	120	92	**3 x 16 kg**
	161	122	163	122	**6 x 16 kg**
	194	145	197	147	**9 x 16 kg**
	222	165	227	168	**12 x 16 kg**
	246	182	252	187	**15 x 16 kg**

Number of concrete blocks for insulated interception rods with exit

Interception rod height in m	4	6	8	10	**Concrete blocks required**
Item no.	5408 93 8	5408 94 0	5408 88 8	5408 89 0	
Item no. of appropriate interception rod stand	5408 93 0	5408 93 2	5408 90 2	5408 90 2	
Wind speed km/h	110	85	93	82	**3 x 16 kg**
	148	111	116	102	**6 x 16 kg**
	178	132	134	119	**9 x 16 kg**
	204	151	151	133	**12 x 16 kg**
	227	167	166	146	**15 x 16 kg**

2.17: Concrete blocks for insulated interception rods

Fig. 2.28: Insulated interception system with separation distance (s)

Fig. 2.29: Aluminium air-termination rod

2.1.7.2 Isolated air-termination systems

With the OBO isolated lightning protection, you can erect isolated interception systems safely, economically and in accordance with standards. The complex contours of metallic and electrical units protruding above the roof make particular demands of lightning protection and compliance with the separation distance. **(Figure 2.28)**

2.1.7.2.1 Aluminium interception rods

Our three-part aluminium interception rods from 4 m to 8 m in length complement our conventional interception system consisting of interception rod and weight, which is used up to a height of 4 m. Various brackets for mounting on walls, pipes and corner pipes, as well as two tripod stands with different spreading widths, are available to fasten the various interception rods. The number of FangFix blocks required may vary according to the wind load zone. **(Table 2.19)**

Number of concrete blocks for isFang air-termination rod with VA tripod

Interception rod height in m	4	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	**Concrete blocks required**
Interception rod item no.	5402 86 4	5402 86 6	5402 86 8	5402 87 0	5402 87 2	5402 87 4	5402 87 6	5402 87 8	5402 88 0	
Appropriate interception rod stand Item no.	5408 96 8	5408 96 8	5408 96 8	5408 96 8	5408 96 9	5408 96 9	5408 96 9	5408 96 9	5408 96 9	
Wind speed km/h	143	124	110	99	104	96	89	83	78	**3 x 16 kg**
	193	168	148	133	138	127	117	109	102	**6 x 16 kg**
	232	202	178	159	165	151	139	129	121	**9 x 16 kg**
	266	231	203	182	188	172	159	147	138	**12 x 16 kg**
	296	257	226	202	208	191	176	163	152	**15 x 16 kg**

Table 2.18: Number of OBO concrete blocks required

Number of concrete blocks for isFang rod with Al tripod

Interception rod height in m		4	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	**Concrete blocks required**
Interception rod item no.		5402 864	5402 86 6	5402 86 8	5402 87 0	5402 87 2	5402 87 4	5402 87 6	5402 87 8	5402 88 0	
Appropriate interception rod stand Item no.		5408 96 6	5408 96 6	5408 96 6	5408 96 6	5408 96 7	5408 96 7	5408 96 7	5408 96 7	5408 96 7	
Wind speed km/h		140	122	108	97	101	93	86	80	76	**3 x 16 kg**
		191	166	146	131	136	124	115	107	100	**6 x 16 kg**
		230	200	176	158	163	149	138	128	120	**9 x 16 kg**
		264	229	202	181	186	170	157	146	136	**12 x 16 kg**
		295	255	225	201	206	189	174	162	151	**15 x 16 kg**

Table 2.19: Number of OBO concrete blocks required

2.1.7.2.2 Tele rod systems up to 19.5 m in height

They reach more than 19 metres high – the rod of the irod system by OBO. The flexible system protects extremely sensitive biogas plants as reliably as free-standing PV systems or installations in potentially explosive areas against direct lightning strikes.

The benefit of irod: There is no need for shovel or digger to move the earth and no concrete foundation needs to be poured. Solid concrete blocks, each weighing 16 kg, give both the interception rods and the stands sufficient support. During installation, it is very easy to align the systems using the threaded rods. Thanks to these features, irod is ideally suited for the installation in already existing systems. **(Figure 2.30)**

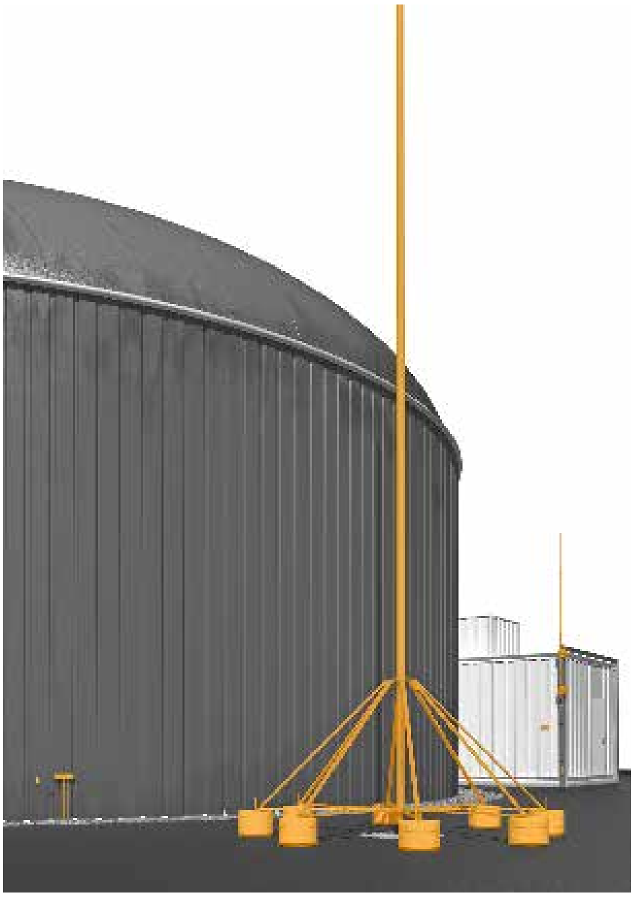


Figure 2.30: Tele rods at biogas plant

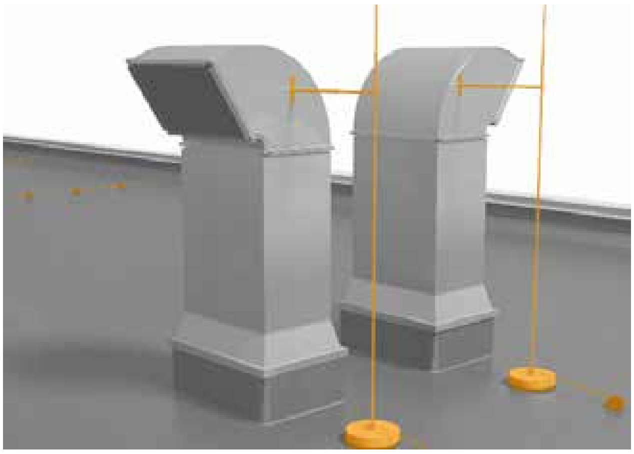


Figure 2.31: Interception rod with adjustable insulating beam

2.1.7.2.3 Systems with fibre-glass reinforced holders

The core of the system is an insulating, fibre-glass-reinforced plastic rod, which creates the separation distance safely and prevents uncontrolled arcing and dangerous spark creation. This means that no partial lightning currents can enter the building. **(Figure 2.31)**

Two material thicknesses for different applications

The insulated lightning protection system consists of GRP rods with a diameter of 16 or 20 mm. Their properties are presented in **Table 2.20**.

Particularly simple mounting through preterminated sets

Besides the modular products, we can offer you pre-installed sets for standard installation requirements:

- Set with two fastening plates
- Set with wall connection brackets
- Set for fastening on folds
- Set for fastening on pipes

16 mm GRP rods	20 mm GRP rods
0.75–1.5 and 3 m length	3 and 6 m length
UV-stable	UV-stable
Light grey	Light grey
Material factor km: 0.7	Material factor (k_m): 0.7
Load torque: > 400 mm^3	Load torque: > 750 mm^3
Support load: 54 N (1.5 m)	Support load: 105 N (1.5 m)

Table 2.20: Properties of the insulated GRP rods

When calculating the separation distance for GRP rods, the

material factor k_m = (0.7) must be taken into account

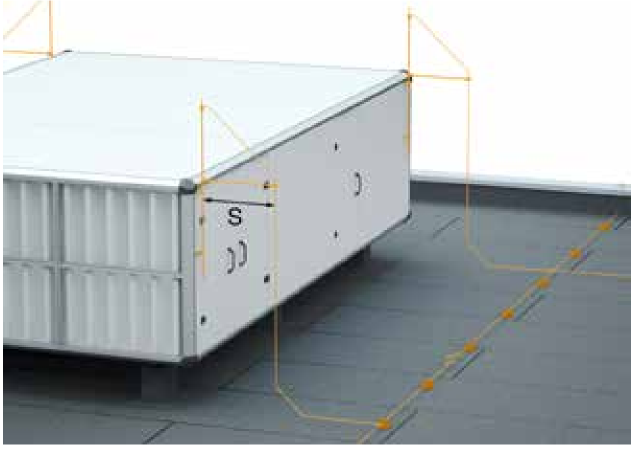


Figure 2.32: Example: air-termination system with Iso-combination set for triangular fastening

Figure 2.34: Example: air-termination system with Iso-combination set for fold fastening

Figure 2.33: Example: air-termination system with Iso-combination set for V fastening

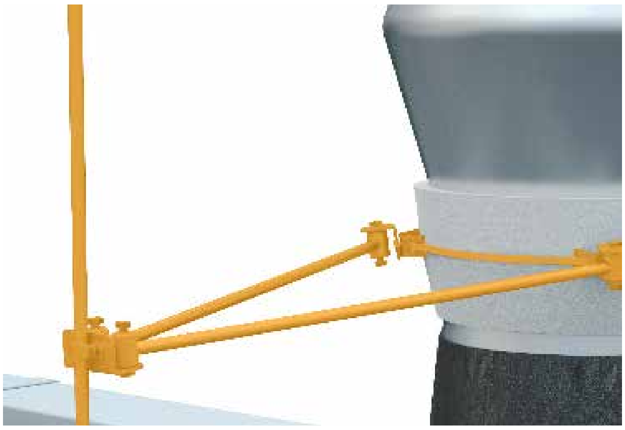


Figure 2.35: Example: air-termination system with Iso-combination set for pipe V fastening

Triangular fastening (Figure 2.32)
Iso-combination set (type 101 3-ES-16, item no.: 5408 97 6) for triangular connection for the erection of an insulated termination system at a safe separation distance (s).

V fastening (Figure 2.33)
Iso-combination set (type 101 VS-16, item no.: 5408 97 8) for wall fastening for the erection of an insulated air-termination system at a safe separation distance (s) of up to 750 mm. For mounting on walls and roof structures with two fastening plates. To accept interception rods and round cables of 8, 16 and 20 mm diameter.

Fold fastening (Figure 2.34)
Iso-combination set (type 101 FS-16, item no.: 5408 98 0) for fold fastening for the erection of an insulated air-termination system at a safe separation distance (s). For mounting on the fold of supports and roof structures with folding clamps with a folding thickness of up to 20 mm. To accept interception rods and round cables of 8, 16 and 20 mm diameter.

Pipe V fastening (Figure 2.35)
Iso-combination set (type 101 RVS-16, item no.: 5408 98 2) for pipe V fastening for the erection of an insulated air-termination system at a safe separation distance (s). For mounting on pipes with two pipe clamps. To accept interception rods and round cables of 8, 16 and 20 mm diameter.

2.1.7.3 Installation principle, building with flat roof (Figure 2.36)

In buildings with flat roofs, the grid solar is generally used. Roof structures such as PV systems, air-conditioning units, roof dome lights and ventilators are protected with additional interception rods.

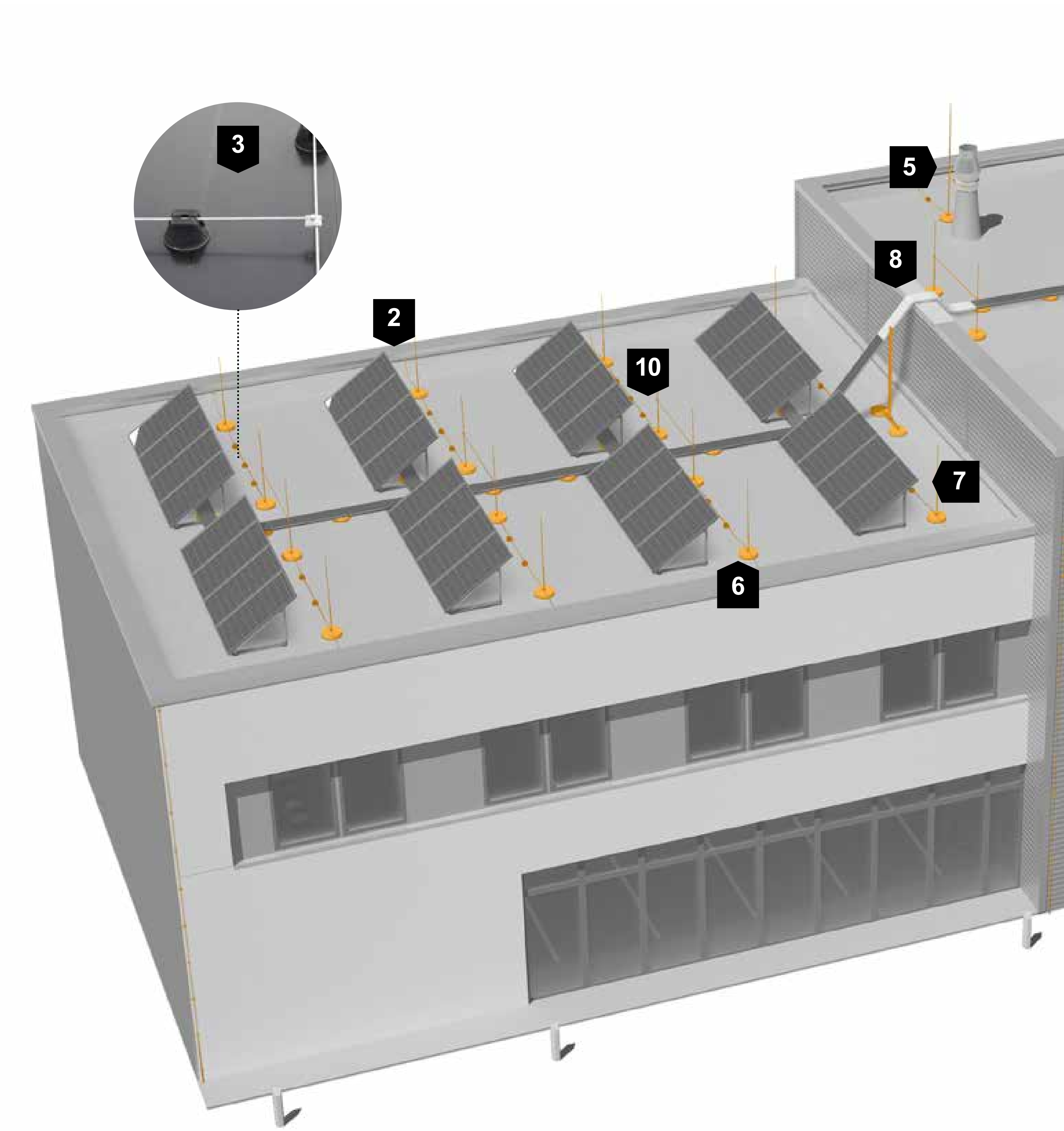
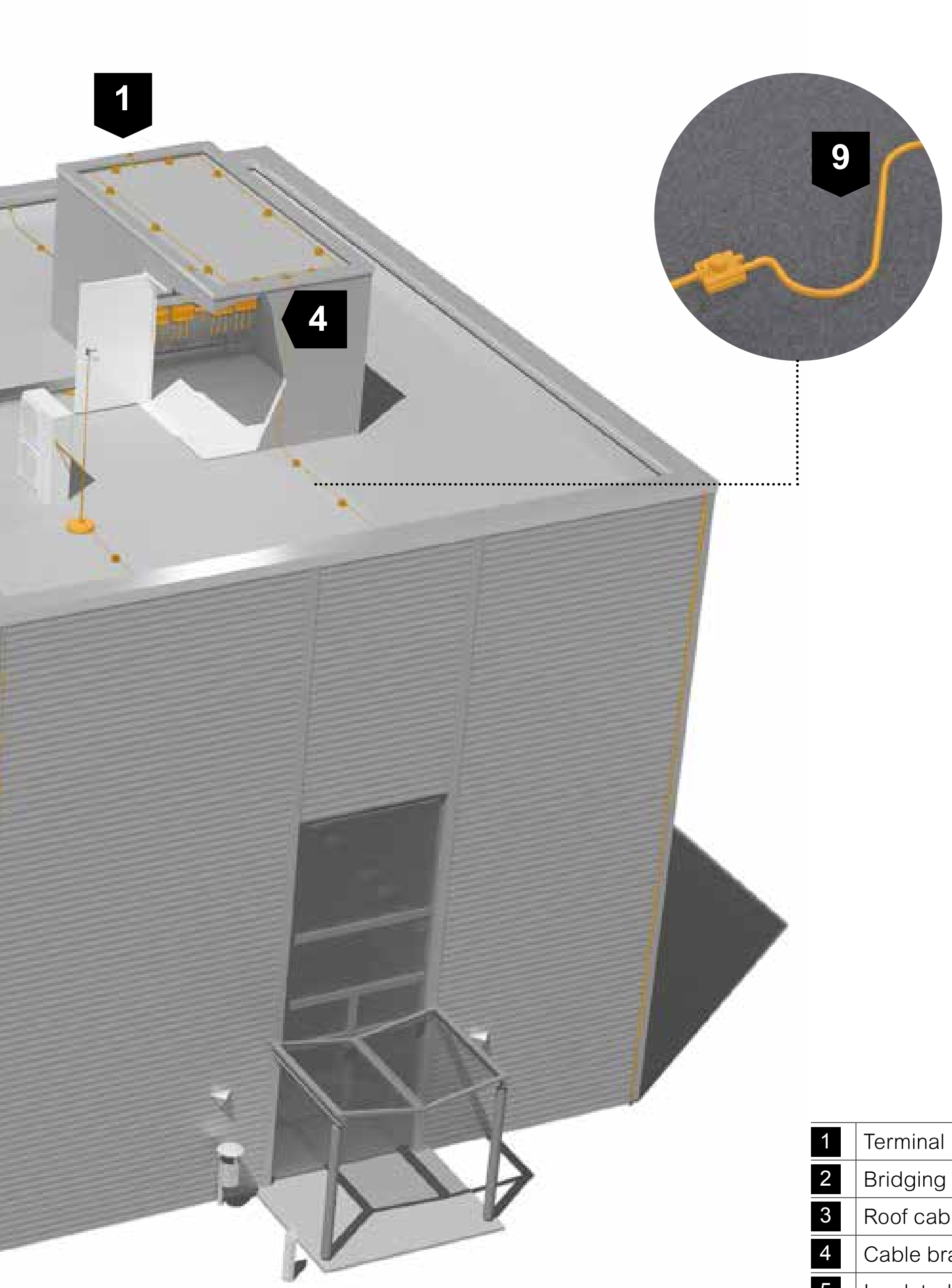


Figure 2.36: Example building with flat roof and lightning protection system

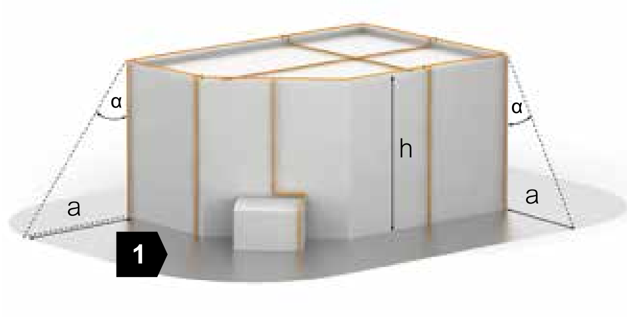


1	Terminal block
2	Bridging component
3	Roof cable holder
4	Cable bracket
5	Insulated spacer
6	Air-termination system stand
7	Air-termination rod
8	Fire protection bandage over insulated parapet cover
9	Expansion piece
10	Vario quick connector

1st step: Installing the air-termination system

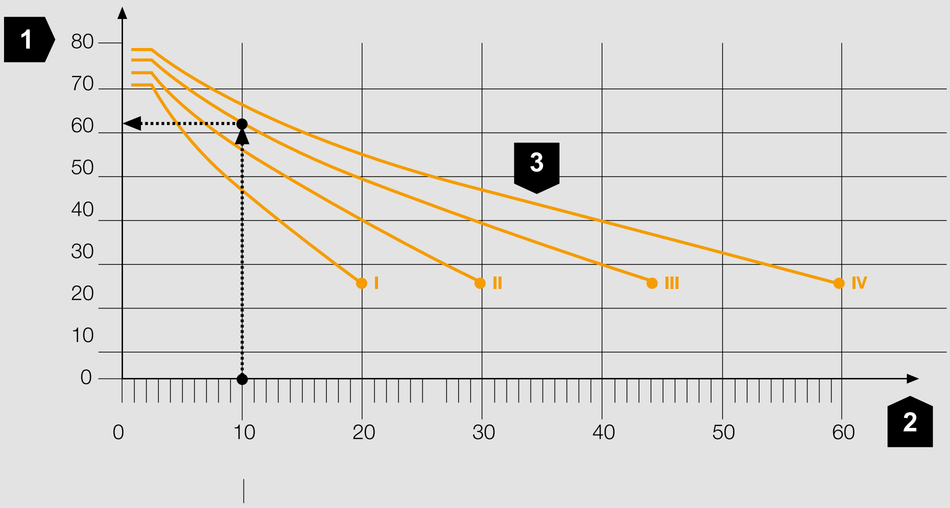
(Figure 2.37)

First, a conductor is installed at all primary impact points such as ridges, crests or edges. The protected area is determined as follows:
Transfer the height of the building to the diagram and read off the protective angle. In our example, this angle is 62° with protection class III and a building height up to 10 m. Transfer the protective angle to the building. All building parts within this angle are protected.



1	Protected area
α	Protective angle
a	Distance to furthest point of protected area
h	Height of the building

Figure 2.37: Installing the interception system



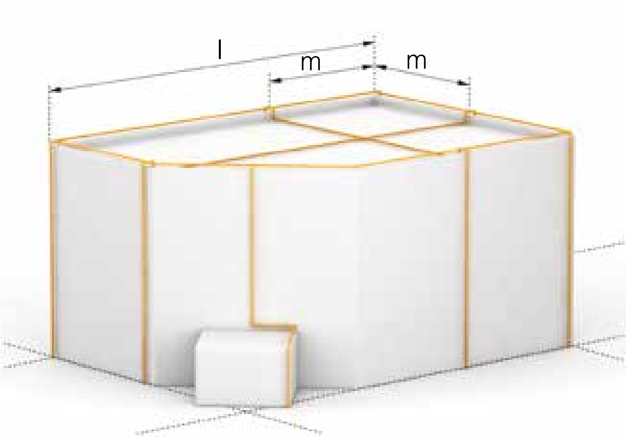
1	Lightning protective angle α
2	Ridge height h in m
3	Fire protection classes I, II, III, IV

Figure 2.38: Diagram to assist in determining the protective angle in accordance with VDE 0185-305 (IEC 62305)

2nd step: Determining the protective angle

Example:

The height of the building (in this case: 10 m) is entered onto the horizontal axis on the diagram **(Figure 2.38)** (see dot on axis 2 in graph). Then proceed vertically until you meet the curve for your lightning protection class (in this case: III). You can now read the protective angle (α) off the vertical axis ("1"). In our example, the angle is 62°. Transfer the protective angle to the building. All building parts within this angle are protected **(see Figure 2.37).**



l	Length
m	Mesh width

Figure 2.39: Mesh width on a flat roof

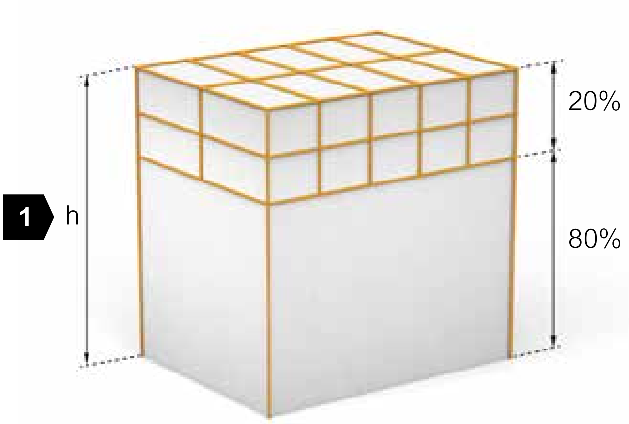
Lightning protection class	Grid width
I	5 x 5 m
II	10 x 10 m
III	15 x 15 m
IV	20 x 20 m

Table 2.21: Mesh width for different lightning protection classes

3rd step: Installing the mesh

(Figure 2.39)

A number of different mesh sizes are suitable for the particular lightning protection class of the building. The building in our example has building lightning protection class III. A mesh size of 15 m x 15 m must therefore not be exceeded. If, as in our example, the overall length l is greater than the cable lengths specified in **Table 2.3 on page 47**, an expansion piece must also be integrated for temperature-controlled length changes.



1	Building height (h) > 60 m

Figure 2.40: Mesh method

4th step: Protection against lateral impact

(Figure 2.40)

From a building height of 60 m and the risk of serious damage (e.g. with electrical or electronic devices) it is advisable to install a ring circuit to protect against lateral impact. The ring is installed in the top 20% of the building's height; the mesh size depends – as it does in the case of roof installation – on the lightning protection class, e.g. lightning protection class III corresponds to a loop size of 15 x 15 m.

The round conductors of the mesh are installed 1 m apart with roof conductor holders.

Where the material thickness and connections are sufficient, the metal of roof parapets is used as an air-termination and mesh system.

2.1.7.4 Installation principle for a building with a pitched/gabled roof (Figure 2.41)

The exposed points, e.g. the ridge, chimneys and any roof structures, must be protected with air-termination systems.

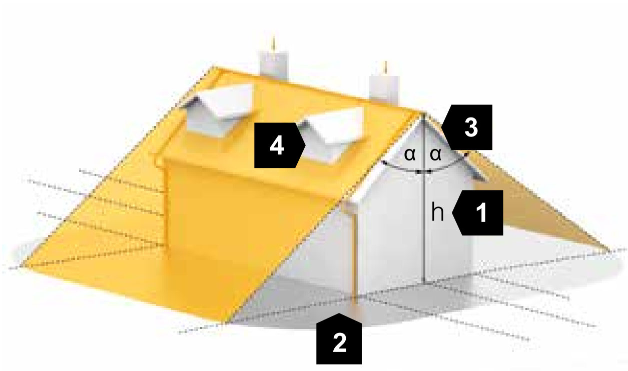
Figure 2.41: Building with pitched roof and lightning protection system

1	Roof conductor holder for ridge tiles
2	Vario quick connector
3	Roof cable holder
4	Round conductor
5	Air-termination rod
6	Cable bracket
7	Gutter clamp

1st step: Determining the height of the building

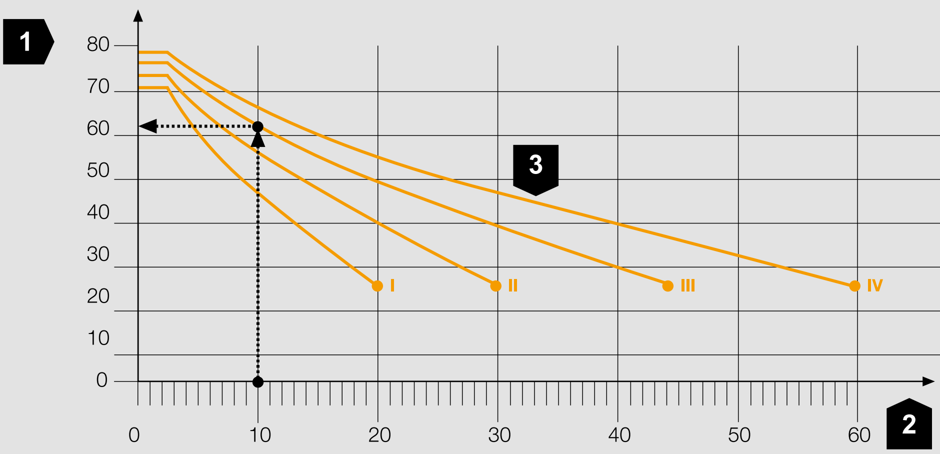
(Figure 2.42)

Determine the ridge height of the building. This height is the starting point for planning the entire lightning protection system. The ridge conductor is arranged on the ridge and thus forms the “backbone” for the air-termination system. In our example, the building is 10 m high. All parts of the building that do not fall under the protective angle are at risk from direct lightning strikes.



1	h: Building height
2	Protected area
3	Protective angle α
4	Dormer windows not protected by the ridge cable

Figure 2.42: Protective angle method on roof ridge



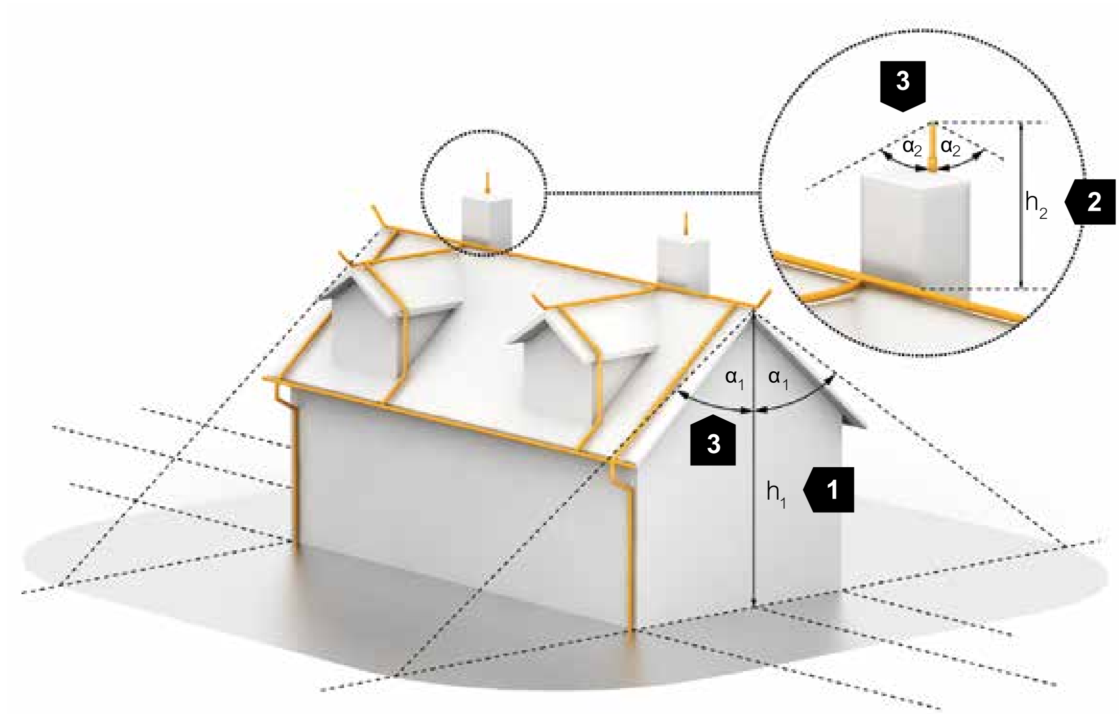
1	Lightning protective angle α
2	Ridge height h in m
3	Fire protection classes I, II, III, IV

Figure 2.43: Diagram to assist in determining the protective angle

2nd step: Determining the protective angle

Example:

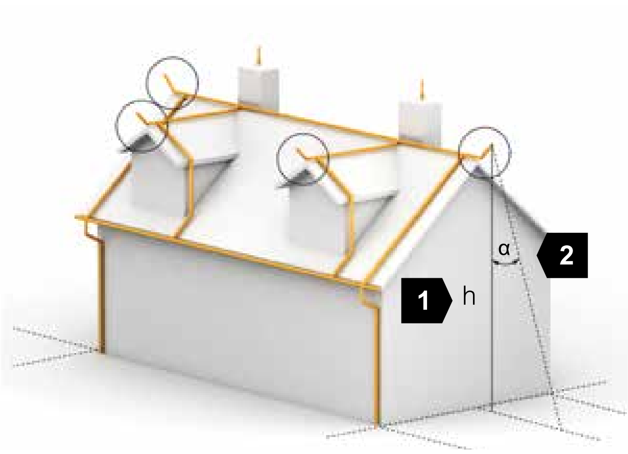
The height of the building (in this case: 10 m) is entered onto the horizontal axis on the diagram (Figure 2.43) (see dot on axis 2 in graph above). Then proceed vertically until you meet the curve for your lightning protection class (in this case: III). You can now read the protective angle (α) off the vertical axis (“1”). In our example, the angle is 62°. Transfer the protective angle to the building. All building parts within this angle are protected. (Figure 2.42)



1	h_1: building height
2	h_2: interception rod height
3	Protective angle α

Figure 2.44: Protective angle method for air termination rods

3rd step: Building sections outside the protective angle (Figure 2.41)
Building parts outside of the protective angle require additional protection. The chimney in our example has a diameter of 70 cm and therefore requires a 1.50 m long air-termination rod. Always observe the protective angle. Dormer windows are given their own ridge conductor.



1	h: Building height
2	Protective angle α

Figure 2.45: Air termination systems and arrest down conductor system

4th step: Completing the interception system (Figure 2.45)
Take the air-termination system down to the arrester equipment. The ends of the ridge conductor should protrude and curve upwards by 0.15 m. This also protects any projecting canopies.

The following roof structures must be protected with interception systems against direct lightning strikes:
- Metallic materials higher than 0.3 m
- Non-conductive materials (e.g. PVC pipes) with a height greater than 0.5 m

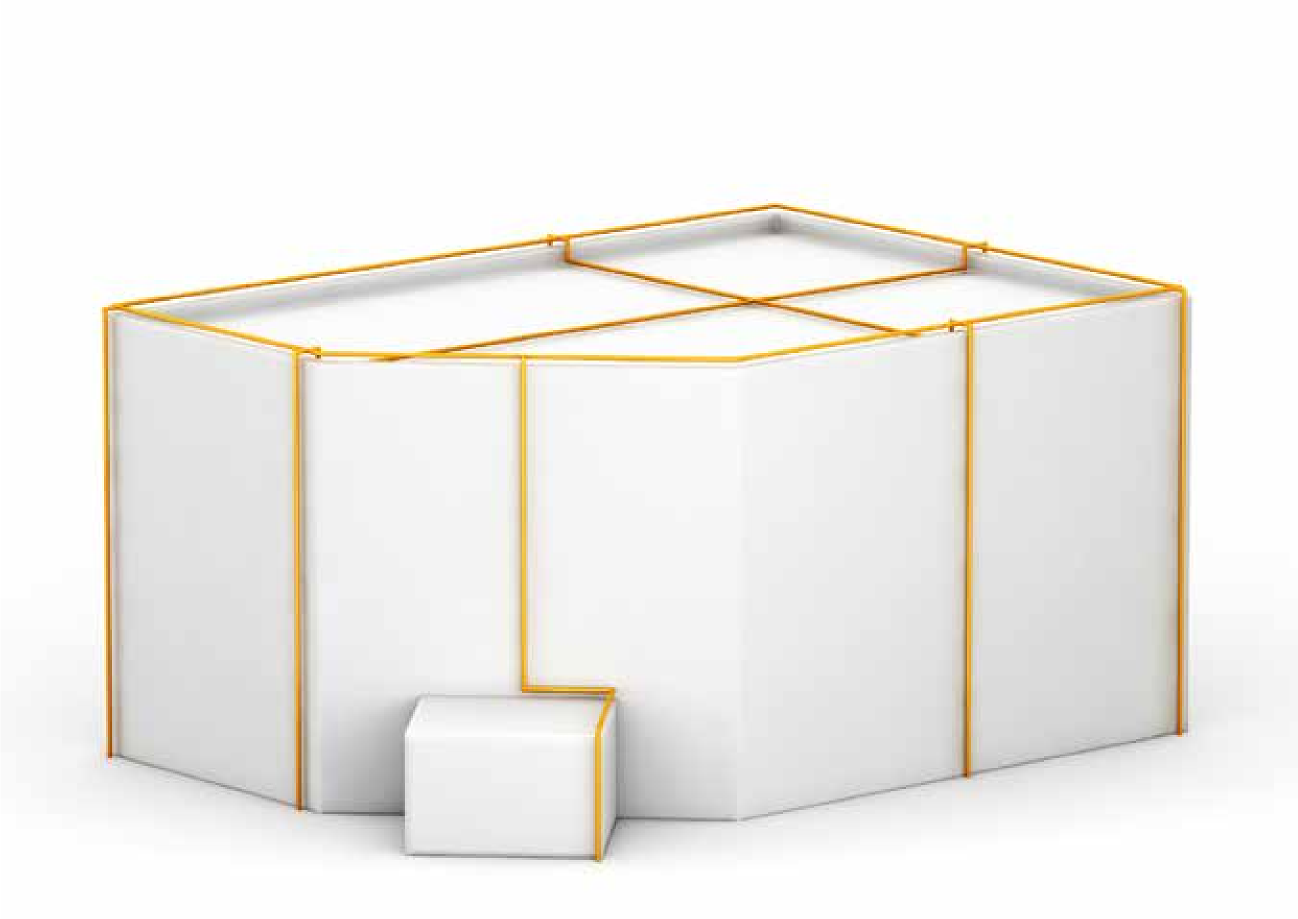


Figure 2.46: Down-conductor system according to IEC 62305-3 (VDE 0185-305-3)

2.2 Down-conductors

Down-conductors are the part of the external lightning protection system designed to route the lightning current from the interception system to the earthing system. **(Figure 2.46)**
In order to reduce the probability of damage from the lightning current flowing through the lightning protection system, the down-conductors should be attached in such a way that, between the impact point and the earth:

- Multiple parallel current routes exist
- The length of the arresters is kept as short as possible
- Equipotential bonding is created between the conductive parts of the building structure.

The down-conductor system routes the lightning current from interception system to earthing system. The number of arresters is derived from the scope of the building to be protected although at least two arresters are required in every case. Care must be taken to ensure that the current paths are short and installed without loops. The table **(Table 2.22)** shows the distances between the down-conductors and the corresponding lightning protection classes.

2.2.1 Planning methods

The down-conductors connect the interception system with the earthing system via a short, direct connection.

2.2.1.1 Number and arrangement

The arresters should preferably be installed near the corners of the building. In order to achieve optimum splitting of the lightning current, the arresters must be evenly distributed around the outer walls of the building. **(Figure 2.47)**

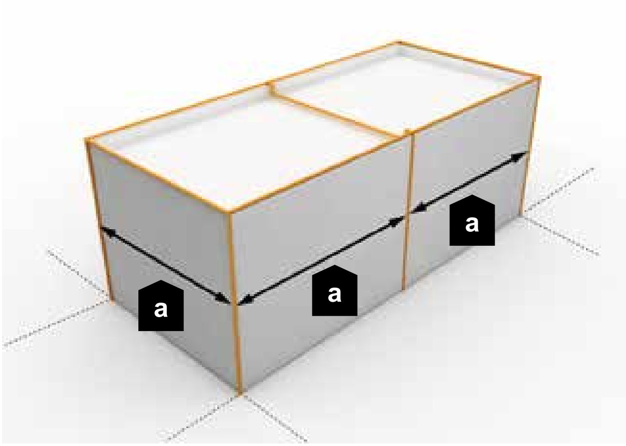


Figure 2.47: Distance (a) between the down-conductors

Lightning protection class	Distance between the down-conductors
I	10 m
II	10 m
III	15 m
IV	20 m

Table 2.22: Distances between down-conductors for different lightning protection classes

A measuring point must be created at the point where each down-conductor meets the earthing system.

To enable easy identification, the measuring points should be marked, for example with numbers.

Figure 2.48: Measuring point at the point of entry into the earth

Figure 2.49: Building with glass facade

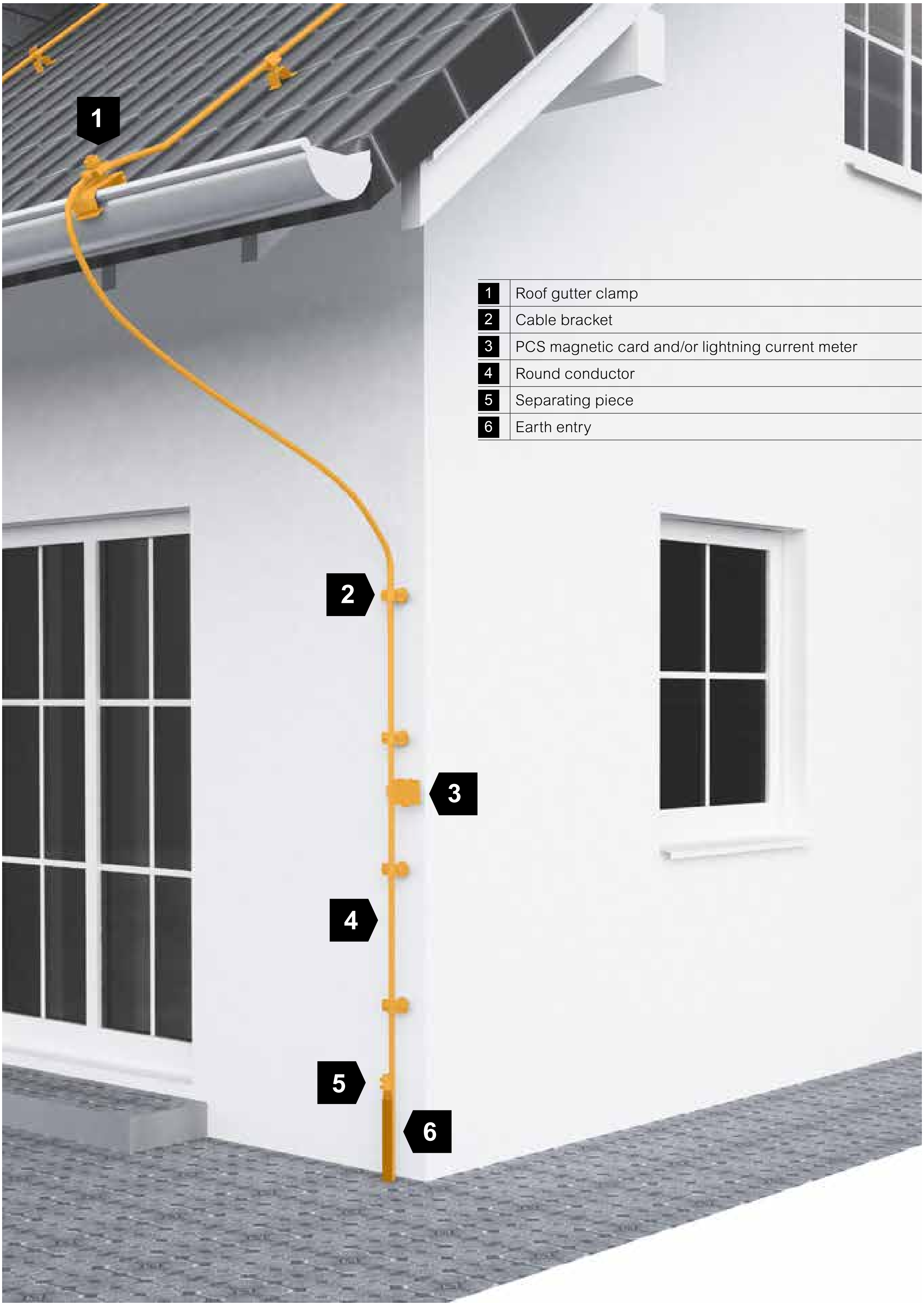
Down-conductors: special considerations
If it is not possible to arrange arresters on one side or a side part of the building, then these down-conductors should be installed on the other sides. The distances between these down-conductors should not be smaller than 1/3 of the distances in Table 2.22.

General information: non-isolated down-conductors/connection of internal supports

Building structures with a large area (such as typical industrial plants, trade fair halls, etc.) with dimensions larger than the quadruple arrester distance should be equipped with additional internal down-conductorswith a spacing of 40 m, as far as is possible. All the internal supports and all internal partition walls with conductive parts, such as steel reinforcement rods, which do not fulfil the conditions for the separation distance, should be connected to the interception system and the earthing system at suitable points.

If, for architectural reasons, the down-conductors cannot be routed on the surface, then they should be installed in gaps in the masonry, for example.

The following should be noted in this regard:
- Plaster can be damaged by heat expansion.
- Plaster may be discoloured by chemical reactions.
- Conductors with PVC jacketing avoid such stains.



1	Roof gutter clamp
2	Cable bracket
3	PCS magnetic card and/or lightning current meter
4	Round conductor
5	Separating piece
6	Earth entry

Figure 2.50: Installation principle, down-conductor unit

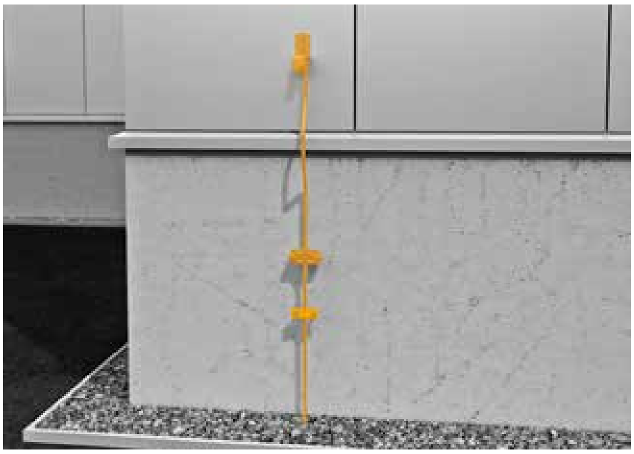


Figure 2.51: Example: vertical facade elements

Where natural arresters (e.g. reinforced concrete or steel sup ports) are used, it is not possible to isolate the lightning protection system and earthing system, and measuring points can be omitted.

2.2.1.2 Using natural components

Metallic installations can be used as natural components of an down-conductor system, provided that:

- Electrical continuity is permanent.
- Their dimensions correspond at least to the values for standardised arresters. **(Table 2.5, page 51)**
- Pipelines with combustible or explosive contents are not permitted, if the seals in flange couplings are not connected so that they are electrically conductive.

Precondition for facade elements and metallic constructions:

- Their dimensions must correspond to the requirements for down-conductors and the thickness of the metal plates/pipes must be at least 0.5 mm.
- Their electrical continuity in the vertical direction must meet the requirements.
- Facade elements can also be used as down-conductors systems, provided that they are electrically interconnected.

Metallic installations can be covered in insulating material, e.g. a coat of paint.

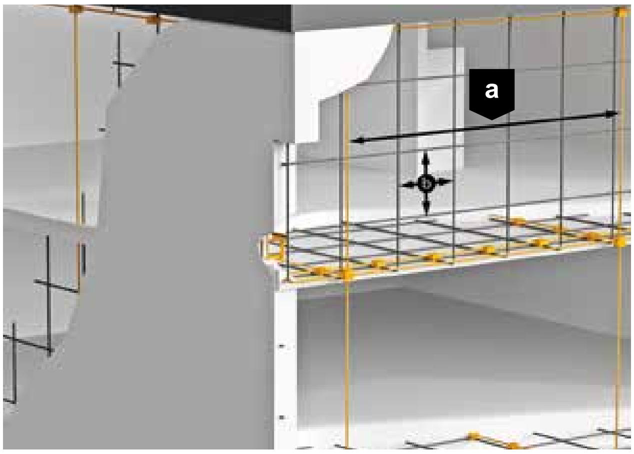
- Natural elements for down-conductors systems must be executed according to IEC 62365-3 (VDE 0185-305-3).

Metallic or electrically connected reinforced concrete/reinforcement can be used as natural components of a down-conductor system if:

- In prefabricated reinforced concrete parts, connection points are available.
- The prefabricated concrete parts are interconnected during mounting on the construction site.
- In stressed concrete, the risk of impermissible mechanical influences due to exposure to lightning current is taken into account.

Figure 2.52: Example: use of horizontally connected facade elements as an down-conductor system

Figure 2.53: Example: use of reinforced concrete supports/ down-conductor system



a	Down-conductor grid width = 5 m
b	Reinforcement mesh width = 1 m

Figure 2.54: Example: use of reinforced concrete supports/ down-conductor system

In building structures with reinforced concrete supports or walls **(Figure 2.53)**, the arresters must be routed in the reinforcement. The arresters must be routed in sections. This requires exact coordination. The connection points must be created carefully with clamp connectors. The down-conductors must also be additionally connected to the reinforcement.

Reinforced concrete elements are ideally suited as an arrester system, provided that this use is included in the planning process in good time. Exact specifications are required for the manufacture of the reinforced concrete elements. Production must be checked and documented in photographs. Earthing fixed points should be used as connection points for arresters and the equipotential bonding.

Continuous reinforcement of the building structure

If the reinforcement or reinforced concrete in the building structure is being used as a natural-down-conductor, it must be joined to the air termination system using lightning protection connection components in accordance with IEC 62561-1 (DIN EN 62561-1). A connection to the earthing system capable of withstanding lightning current must also be executed, at least to the main earthing rail. If the natural down-conductor is also to be optimised as protection against LEMP (lightning electromagnetic impulse), corresponding grids within the system should be realised. Here grid widths of a = 5 m and b = 1 m are recommended.

(Figure 2.54)
With systems made of prefabricated concrete and pre-stressed concrete sections, the electrical continuity must be checked with a continuity test between the top section and the earth.

Measurement

The total electrical resistance should be measured using a testing unit suitable for this purpose (DC source, 10 A measuring current).

Two types of measurement must be carried out:

- The resistance of the connection point of the reinforcement to the next connection point should be < 10 mΩ.
- The connection point of the reinforcement with the main earthing busbar should not exceed 10 mΩ per metre of building height.

Tests should ideally be carried out before and after filling with concrete. If these values are not achieved, then the steel reinforcement may not be used as an arrester. In this case, we recommend the erection of an external down-conductor. In building structures made of prefabricated concrete sections, the electrical continuity of the steel reinforcement of the individual prefabricated concrete sections with the neighbouring prefabricated concrete sections must be guaranteed.

Figure 2.55: Components of the isCon® system

2.2.1.3 High-voltage-resistant, insulated arrester

For architectural reasons, it is often not possible to maintain the required separation distance in contemporary buildings. In these cases, and in industrial plants, the high-voltage-resistant, insulated isCon cable enables compliance with IEC 62305 (VDE 0185-305) and offers an equivalent separation distance of 0.75 m in air and 1.5 m in solid materials.

Overview of product benefits:

- Replaces 0.75 m of separation distance in the air
- Universal: simple termination on the construction site
- Conforms to the standard: cross-section of 35 mm² copper
- Tested: by independent testing institutes
- Flame-resistant
- Weatherproof
- Up to 150 kA lightning current per arrester
- Environmentally friendly: halogen-free
- Tested: can be used in potentially explosive areas

Insulated arresters are the best solution in situations where, for design or architectural reasons, separation distances cannot be adhered to.

Complete flexibility in design of the lightning protection system

The isCon® cable is a high-voltage-resistant arrester without creeping discharge. It permits adherence to separation distances according to IEC 62305-3 (VDE 0185-305-3) and can replace a separation distance of 0.75 m in the air and 1.5 metres in the case of solid materials. These are properties confirmed by independent testing institutes.

Structure of the isCon cable

The OBO isCon® cable consists of five parts. Its copper core has a cross-section of 35 mm^2 (IEC 62305 demands min. 25 mm^2). It is surrounded by an internal conductive layer and high-voltage-resistant PEX insulation. In turn, this is surrounded by an external conductive layer and with an additional weakly conductive material. The lightning current flows through the copper core. For operation, the copper core must be connected to the weakly conductive jacket using a connection element. Only the tested connection element may be connected to the interception unit or forwarding arrester of the external lightning protection. The cable must be located in the protection area of the interception system and be fastened at a distance of maximum one metre using the installation material indicated. If cables are routed in the building, then specified protective measures, such as fire insulation, must be taken into account.

Figure 2.56: Example: protection of a gas distribution point with isCon® cable

2.2.2 Down-conductor versions

2.2.2.1 Non-isolated lightning protection system

If the necessary separation distance between the lightning protection system and the metallic systems of the building/the installation cannot be adhered to, further measures are required. To prevent dangerous sparking and a resulting fire risk, the following measures should be taken:

- Increase safety distance
- Increase number of arresters (recalculate safety distance!)
- Create a connection between the systems that is capable of carrying lightning current

Figure 2.57: Isolated lightning protection with insulating beams

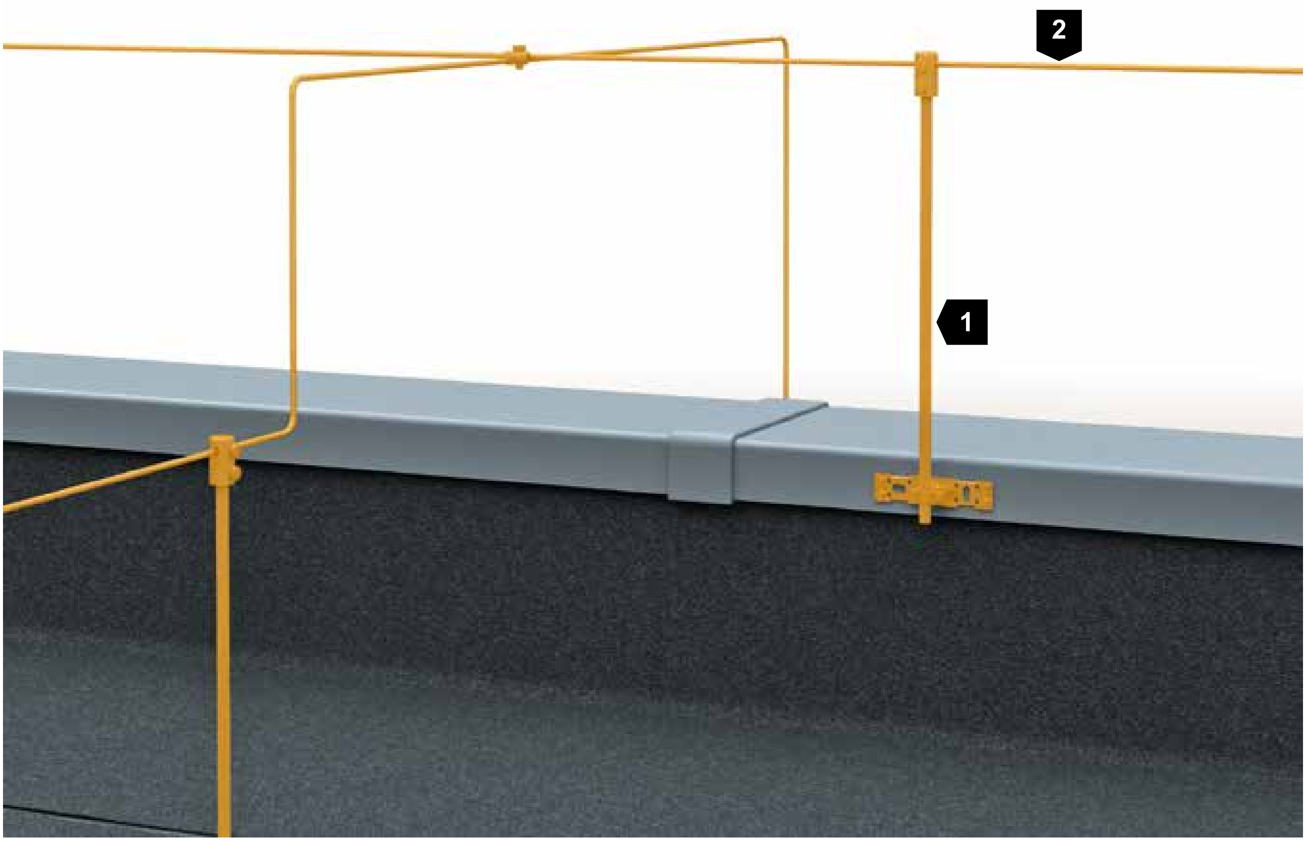
2.2.2.2 Isolated lightning protection system

Isolated lightning protection systems allow standard-compliant lightning protection according to IEC 62305. The separation distance to electronic systems required by the standard can be maintained by the different versions of the insulated lightning protection. **(Figures 2.56-2.59)** The individual components and systems allow the creation of a very wide range of different solutions, according to requirements.

Figure 2.58: Isolated lightning protection with isCon®

It is vital to avoid sparks in installations with an increased risk of explosion or fire.

Figure 2.59: Isolated lightning protection with interception rods



1	Insulated GRP holder
2	Round conductor

Figure 2.60: Insulated lightning protection with GRP rods

Insulated lightning protection on an interception rod

The insulated lightning protection system consists of GRP rods with a diameter of 16 or 20 mm:

- There is a comprehensive range of system accessories available for both variants
- Two material thicknesses
- Can be obtained as a set for different applications

16 mm GRP rods	20 mm GRP rods
0.75–1.5 and 3 m length	3 and 6 m length
UV-stable	UV-stable
Light grey	Light grey
Material factor (k_m): 0.7	Material factor (k_m): 0.7
Load torque: > 400 mm³	Load torque: > 750 mm³
Support load: 54 N (1.5 m)	Support load: 105 N (1.5 m)

Table 2.23: Properties of the insulated GRP rods

2.2.2.3 IsCon high-voltage-resistant conductor Tasks of an insulated, high-voltage-resistant arrestor

Insulated conductors are used in the field of external lightning protection to reduce or avoid the separation distance according to IEC 62305-3 (VDE 0185-305-3). isCon® has an equivalent separation distance of 0.75 m in air and 1.5 m in solid materials.

Requirements:

• Conductor connection with lightning current carrying capacity to the interception system, earthing system or standard exposed arresters run on towards the earth

• Maintenance of the necessary separation distance (s) within the limits specified by the manufacturer through sufficient electrical voltage resistance of the arrester, both in the area of the supply point as well as in the entire onward course

• Sufficient current carrying capacity through a standard conformant conductor cross-section of the arrester (OBO isCon = 35 mm^2, standard requires min. 25 mm^2)

Normative requirements

Currently only the general requirements for

• IEC 62561 (VDE 0185-561) Lightning protection system components – Part 1: Requirements for connection components e.g. lightning current carrying capacity of the connection points

• IEC 62305 (VDE 0185-305) Protection against lightning – Part 3: Protection of structural facilities and persons, e.g. conductor system, min. cross-sections, equipotential bonding

• At an international level, work is currently underway on a draft standard: IEC 62561: Lightning Protection System Components (LPSC) – Part 8: Requirements for components for isolated LPS

• Currently, no standard describes special requirements and tests of insulated arresters.

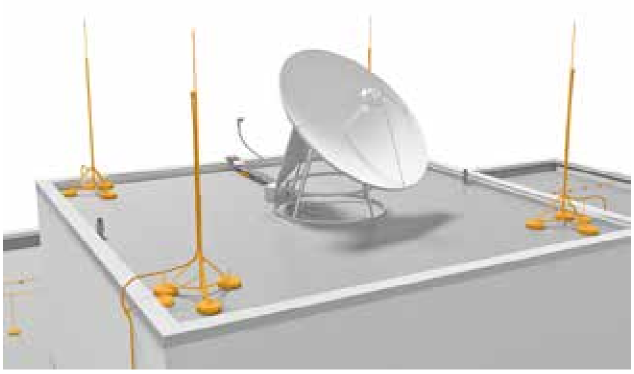


Figure 2.61: Isolated lightning protection with interception rods

isCon system: Areas of application – application examples

Insulated conductors are installation solutions for external lightning protection which can be used primarily in locations where the separation distance cannot be maintained or is not applied for aesthetic reasons. **(Figure 2.61)**

Areas of application:

- Mobile telecommunications antennas
- Computer centres
- Expansions of lightning protection systems
- Architectural solutions
- Separation distance cannot be maintained

Geometry	Minimum cross-section[a]	Comments
Strip	50 mm²	Minimum thickness 2.0 mm
Round[a]	50 mm²	Diameter 8 mm
Cable	50 mm²	Minimum diameter of each wire 1.7 mm
Round	200 mm²	Diameter 16 mm

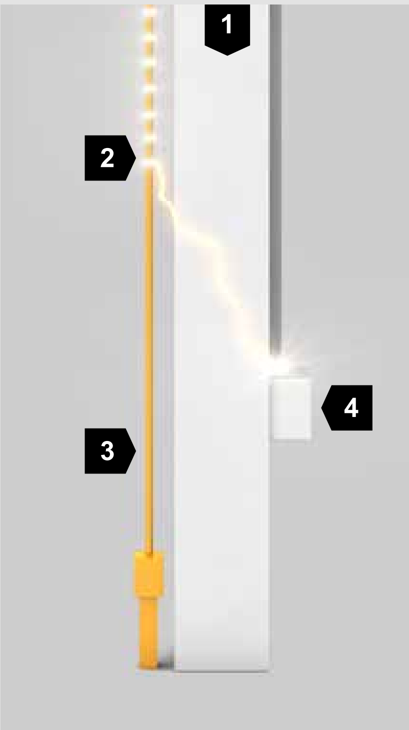
Table 2.23: Minimum cross-sections for conductors

[a] In certain situations, 50 mm^2 (8 mm diameter) can be reduced to 25 mm^2 if mechanical resistance is not a primary criterion. In this case, the spacing of the cable brackets should be reduced.

Purpose of the insulated conductors

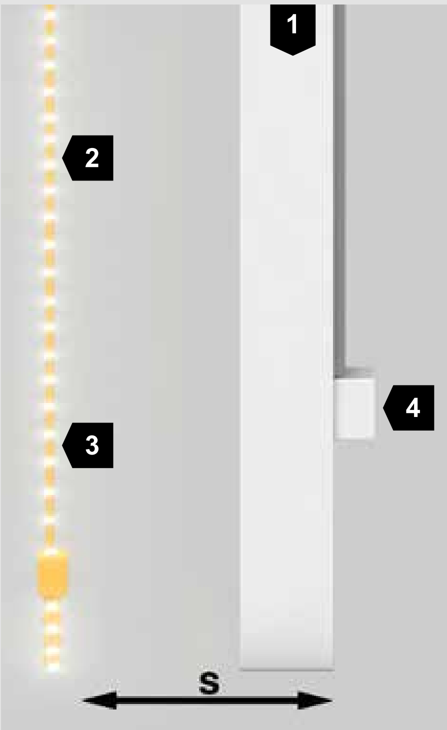
If a direct lightning strike hits an installation with non-isolated lightning protection, arcing will take place onto earthed metal constructions or into electrical installations.

In an isolated system, a correctly calculated separation distance will ensure that the lightning current flows right through to the earthing system. If this is not practicable, a high-voltage-resistant insulated arrester (Figure 2.64) can be used to maintain an equivalent separation distance.



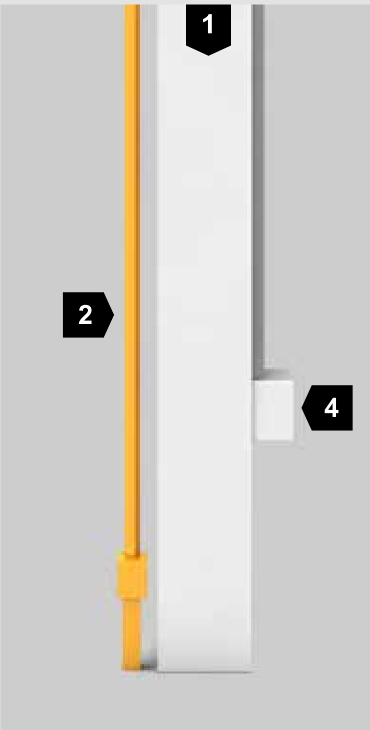
1	Masonry
2	Lightning current
3	8 mm conductor
4	Electrical installation

Figure 2.62: Lightning current coupling into the electrical Installation.



1	Masonry
2	Lightning current
3	8 mm conductor
4	Electrical installation
S	Separation distance

Figure 2.63: No direct coupling



1	Masonry
2	isCon conductor
3	Electrical installation

Figure 2.64: No direct coupling

isCon® =
Insulated Conductor

1	Weakly conductive EVA (ethylene vinyl acetate copolymer), UV-resistant
2	Conductive PEX (cross-linked polyethylene)
3	Insulating PEX (cross-linked polyethylene)
4	35 mm² copper cable

Figure 2.65: Structure of the high-voltage-resistant OBO isCon® insulated conductor

OBO isCon system
Insulated conductors are used in the field of external lightning protection to reduce or avoid the separation distance according to IEC 62305 (VDE 0185-305). isCon® creates an equivalent separation distance of 0.75 m in air.
• In contrast to standard shielded medium-voltage cables with a metallic shield, insulated arresters possess a weakly conductive jacket for field control, de-energising the high voltage in the area of the supply point.

This thus prevents arcing via the cable jacketing of the insulated arrester.
• After the first potential connection of the cable jacket, the insulated conductor secures the specified equivalent separation distance.

Structure of the high-voltage-resistant OBO isCon insulated arresters (Figure 2.65)
The isCon® conductor is a single wire cable with a coaxial structure. It consists of several layers of conductive, slightly conductive and insulating material, and the internal conductor with corresponding conductivity. Thanks to this structure, both a sufficient dielectric strength of the insulation in case of lightning voltage impulses and targeted manipulation of the electrical field strength at both ends of the cable is possible. This prevents the creeping discharges that would otherwise occur.

Creeping discharges always occurs on boundary surfaces between a solid and gaseous insulating material. Due to the heterogeneous electrical fields, local peaks in field strength occur which, when the inception voltage for creeping discharge is reached, trigger discharge along the surface of the conducts.

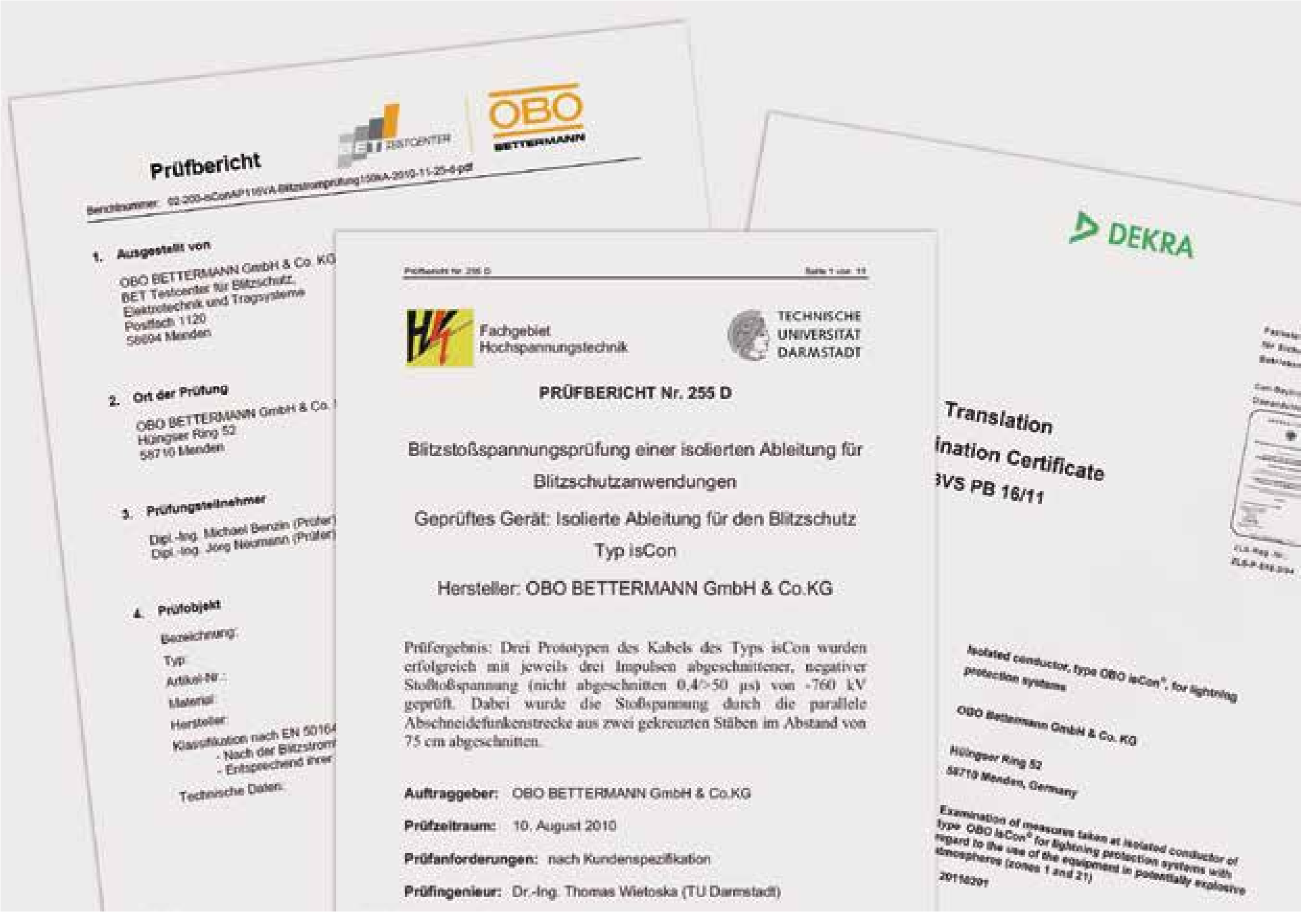


Figure 2.66: Test reports for the isCon® cable

Separation distance

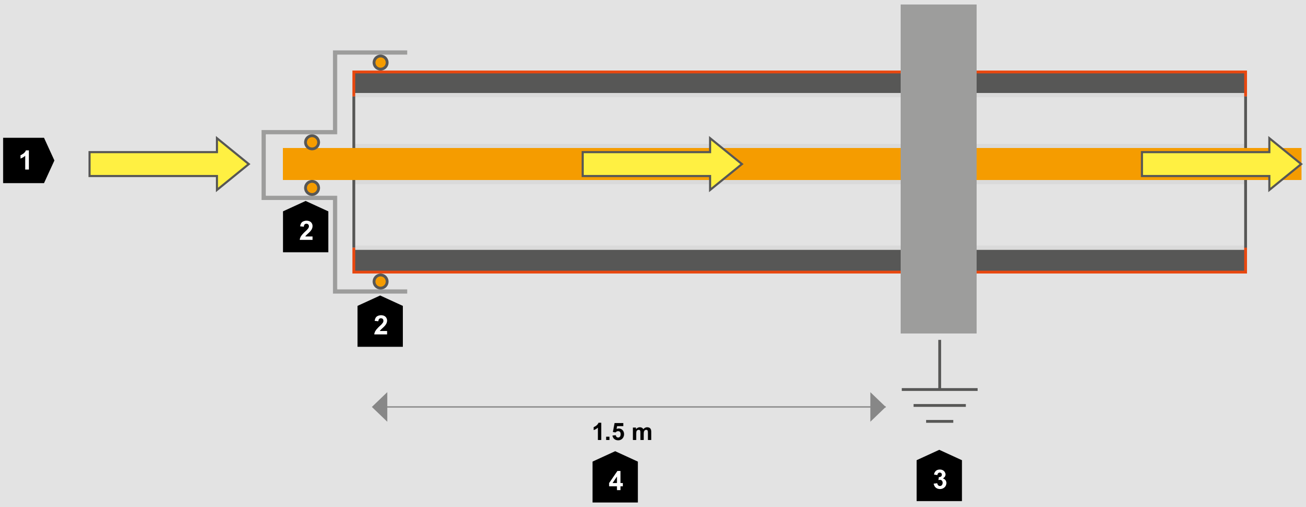
Calculation of the separation distance according to IEC 62305-3 (VDE 0185-305-3) Section 6.3 at the point the isCon® conductor is connected. The length (l) should be measured from the connection point of the isCon® conductor to the next level of the lightning protection equipotential bonding (e.g. earthing system). It must be checked whether the calculated separation distance (s) is less than the specified equivalent separation distance of the isCon® cable. If the specified separation distance is exceeded, then additional conducts must be installed.

Note

The values in the table apply to all type B earthers and to those type A earthers in which the earth resistance of the neighbouring earther electrodes does not differ by more than a factor of 2. If the earther resistance of individual electrodes deviates by more than a factor of 2, $k_c = 1$ should be assumed. Source: Table 12 of IEC 62305-3 (VDE 0185-305-3).

LPS lightning protection class	Number of down-conductors	Length at s = 0.75 m
I	1	-
I	2	14.20
I	3 and more	21.30
II	1	12.50
II	2	18.94
II	3 and more	28.40
III + IV	1	18.75
III + IV	2	28.40
III + IV	3 and more	42.61

Table 2.25: Calculation of maximum down-conductor length when using the isCon conductor. Unit: m



1	Lightning current, several kA
2	Connections between copper cable and jacket
3	Electrical connection to building, conductive structure, local PAS
4	Minimum spacing (smaller values are possible based on calculation)

Fig. 2.67: Functioning of the isCon® conductor

isCon®: Rules for planning and installation: Parallel conductors

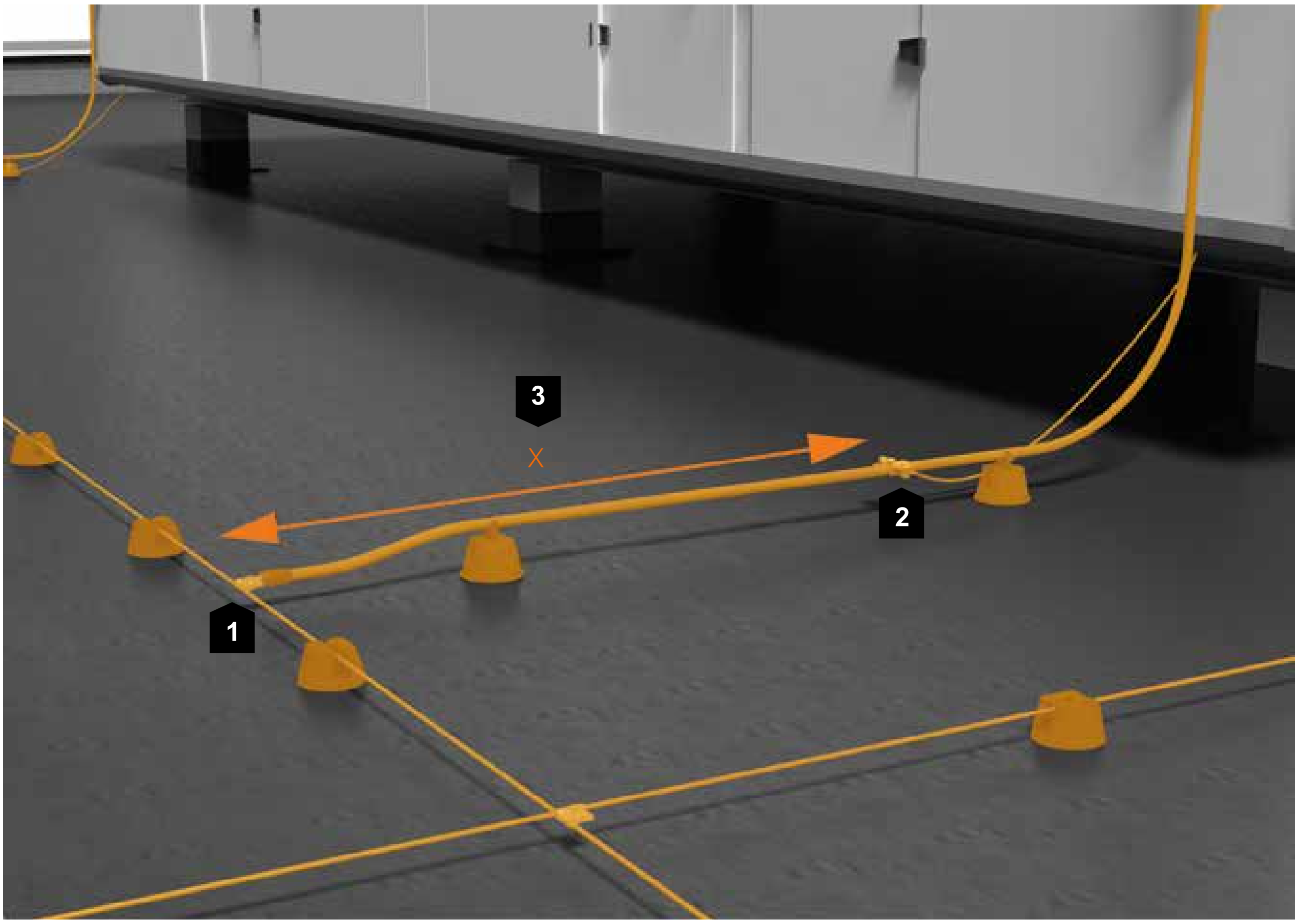
Current division occurs in an installation of multiple insulated arresters, run in parallel. The reduced current division coefficient k_c thus also reduces the calculated separation distance (s).

To keep the magnetic fields as small as possible and avoid interference between the isCon® cables, it is wise to keep the conductors at least 20 cm apart. Ideally, the second cable should be run to the ground on the other side of the building.

In the case of cables routed directly beside one another, the inductance of the total arrangement is not reduced by the factor n and the current division coefficient is not reduced accordingly.

isCon®: Parallel conduct
An exact calculation of the separation distance provides evidence of whether the isCon conductor can be used, see Table 2.25, page 89.

The high-voltage-resistant, insulated isCon® conductor fulfils the normative requirements by offering an “equivalent separation distance”.



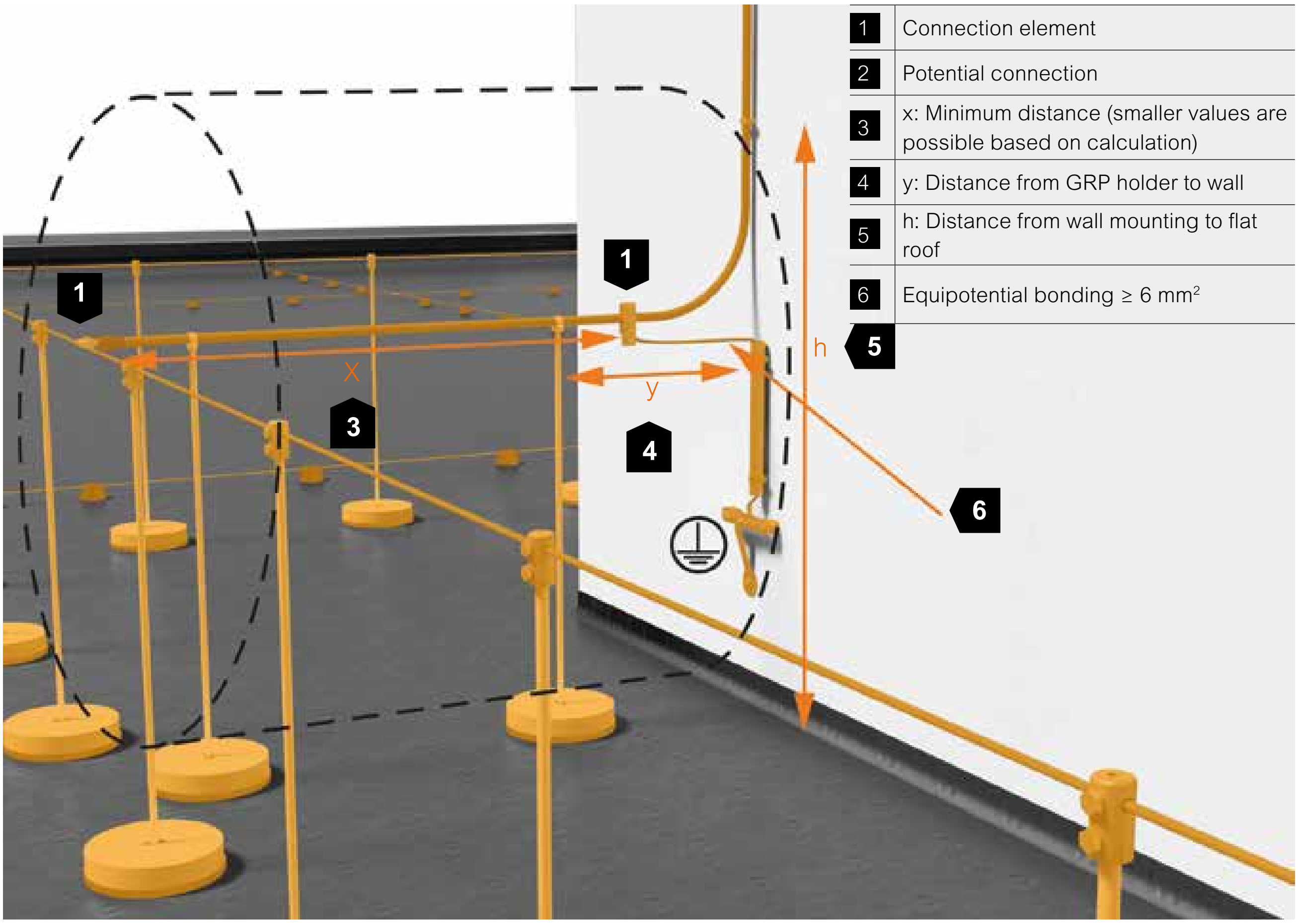
1	Connection element
2	Potential connection with e.g. Cu cable of ≥ 6 mm²
3	x: minimum distance (smaller values are possible based on calculation)

Figure 2.68: Connection of isCon® to mesh

isCon®: Potential connection

- The potential control element should be connected to a reference potential using ≥ 6 mm² Cu or an equivalent conductivity. **(Figure 2.68)**
- Lightning current must not flow through the reference potential and it must be in the protective angle of the lightning protection system.
- This means that the potential connection can be made via a local equipotential bonding rail, metallic and earthed roof structures, earthed parts of the building structure and via the protective conductor of the low-voltage system.
- Equipotential bonding (connection ≥ 6 mm²) not necessary for separation distance ≤ 0.15 m
- Throughout both connection areas, the respective calculated separation distance (s) to the metal parts must be maintained.

No electrically conductive or earthed parts may be located in the area between the connection element and the potential connection in the radius of the calculated separation distance. These include, for example, metallic construction parts and cable brackets as well as assemblies. If the calculated separation distance (s) is less than 75 cm in air, then the distance between the potential connection clip and the connection element (x) can be reduced accordingly.



1	Connection element
2	Potential connection
3	x: Minimum distance (smaller values are possible based on calculation)
4	y: Distance from GRP holder to wall
5	h: Distance from wall mounting to flat roof
6	Equipotential bonding ≥ 6 mm²

Figure 2.69: Example: isCon® cable on isolated ring circuit

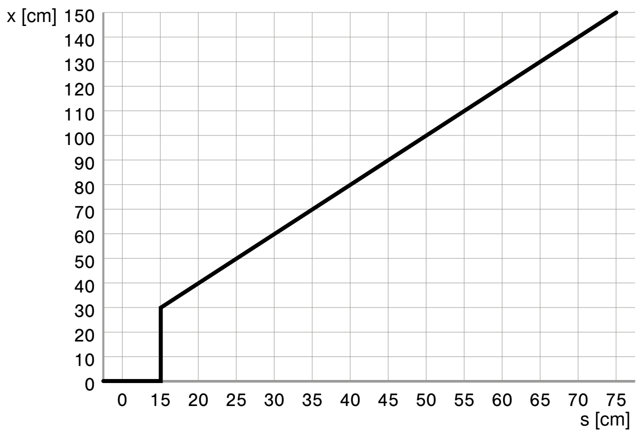


Table 2.26: Minimum required distance between connection element and potential connection terminal for s = 0.75 m in air

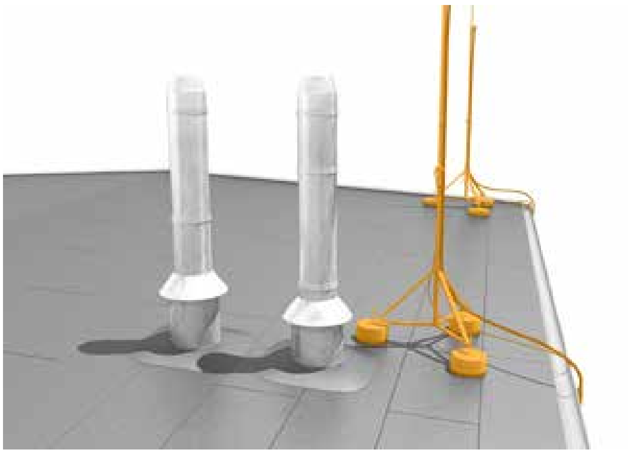


Figure 2.70: isFang interception rods with external isCon® conductor

In complex installations, the required separation distance can often no longer be implemented with conventional arresters, as the structural conditions do not permit the required distances between the interception systems and the electrical installations. Insulated lightning protection systems, such as the OBO isCon® conductor, are used to maintain the required separation distance nonetheless.

Tested: 0.75 m separation distance and up to 150 kA lightning current

After the first potential connection behind the connection element, the isCon® conductor creates an equivalent separation distance of 0.75 metres in the air according to IEC 62305-3 (VDE 0185-305-3). This means that installation is possible directly on metallic and electrical structures. There is no direct arcing between the down-conductor and the building to be protected.

Total flexibility on the construction site

The OBO isCon® conductor can be used flexibly. The isCon® conductor is delivered on disposable cable rolls. This means that the user can cut them to the exact size they require and terminate them as necessary. This means: no ordering of pre-terminated conductors, but rather flexible working according to actual conditions on the construction site. Special knowledge is required to be able to carry out the planning and routing of the isCon® conductor correctly. This knowledge is imparted by the current installation instructions, but can also be deepened in special OBO workshops.

Halogen freedom

The use of halogen-free cables prevents the formation of corrosive and toxic gases during construction. The gases can cause considerable damage to people and property. The costs resulting from the corrosiveness of the fire gases are often higher than the costs caused by direct fire damage. The OBO isCon® conductor is made from halogen-free materials.

Combustion behaviour

A fire can spread along a non-flame-resistant cable in just a few minutes. Those cables are considered flame-resistant that prevent the spread of fire and which extinguish themselves after the ignition flame is removed. The flame resistance of the OBO isCon® conductor was proven according to DIN EN 60332-1-2.

Weathering resistance

The outer jacket of the OBO isCon® conductor is made of a very ageing-resistant material (EVA = ethylene vinyl acetate). The resistance to weathering was confirmed by the following tests:

- Ozone resistance according to DIN EN 60811-2-1 Section 8
- Sunlight Resistance Test according to UL 1581 Section 1200
- Coldness impact resistance according to DIN EN 60811-1-4 Section 8.5

Application example: soft-covered roofs

Soft-covered roofs (Figure 2.71) such as straw, thatch and reed require extra protection against lightning and the associated fire risk.

An isolated lightning protection system achieved by using isCon® conductor is recommended in order to comply with the aesthetic expectations of builders and architects. The interception system is implemented using interception rods, which allow the conductor to be routed in their interior (type isFang IN). The grey version of the isCon® conductor guarantees a high level of protection and can be used for soft roofs. In this way, the conductor can be routed under the soft roof.

Figure 2.71: Soft-covered roof with isCon®

Application example: mobile telecommunications system

Installations such as mobile telecommunications systems must be included in the lightning protection concept, particularly in the case of refitting work. **(Figure 2.72)**

Spatial restrictions, as well as the influence of transmission signals, can be overcome by constructing the lightning protection system using an isCon® conductor. Simple inclusion in the existing lightning protection system as well as separate lightning protection can be implemented simply and in accordance with the standards.

Aesthetic aspects

In easily visible areas, as well as wherever aesthetics are important, we recommend routing the isCon® conductor in the interception rod. **(Figure 2.73)** Equipotential bonding after the first 1.5 metres takes place in the rod. The entire retaining pipe is earthed, guaranteeing comprehensive equipotential bonding. A simple and visually perfect installation solution.

Figure 2.72: Cell tower with isCon® conductor

Figure 2.73: CCTV cameras with isCon® conductor

Installation principle for isCon in potentially explosive areas

In Ex zones 1 and 21, after the first potential connection, the OBO isCon® conductor should be connected at regular intervals (0.5 m) with metallic cable brackets (e.g. isCon H VA or PAE) to the equipotential bonding. If there is a lightning strike, lightning current must not flow through the equipotential bonding and it must be in the protection angle of the lightning protection system.

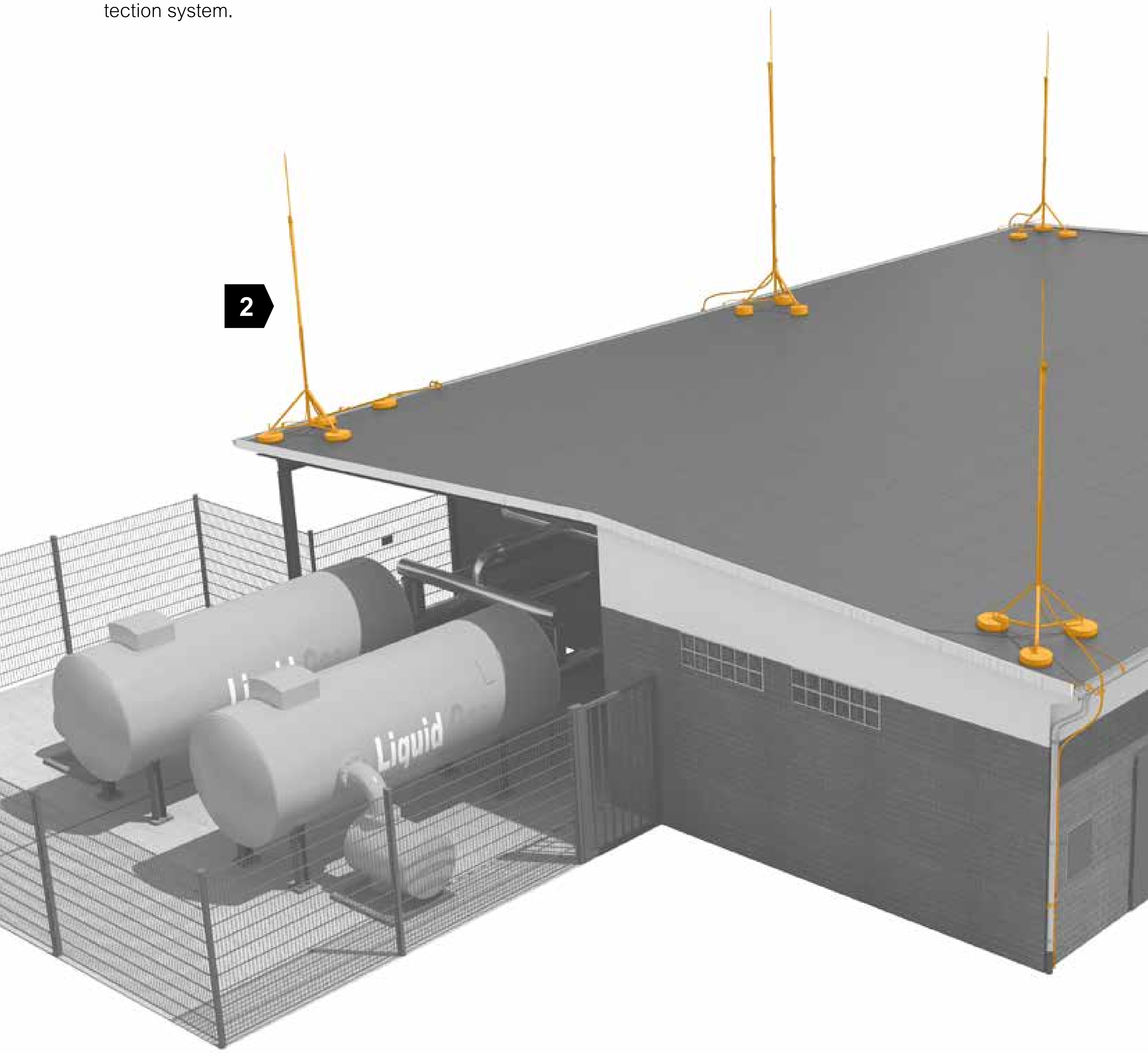
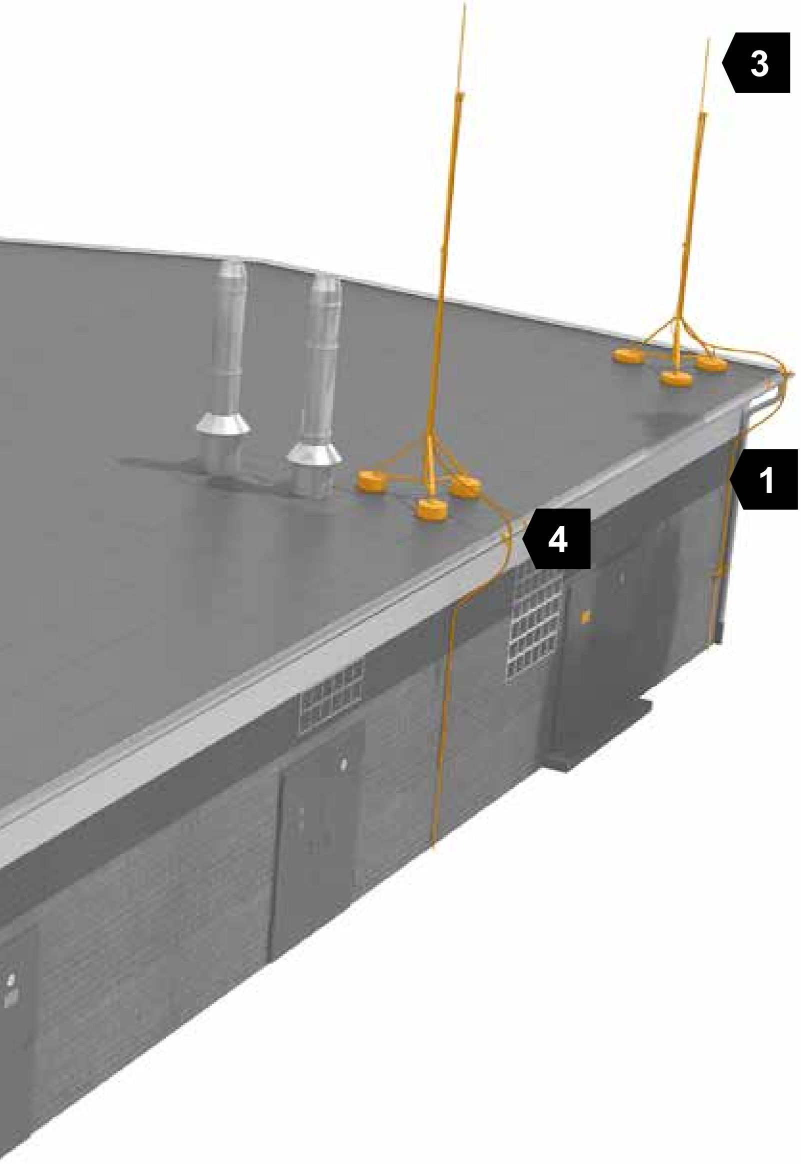


Figure 2.74: Installation principle for isCon® in potentially explosive areas



1	isCon® conductor
2	4 m isFang interception rod with external isCon® cable
3	6 m isFang interception rod with external isCon® cable
4	Potential connection

Figure 2.75: Installing a foundation earther

2.3 Earthing systems

The standards specify that each system must include an earthing system.

What do we mean by an "earthing system"?
We can find the required definitions in DIN VDE 0100-200 (IEC 60050-826) – Low-voltage electrical installations: Terms.

- "Totality of the electrical connections and equipment used to earth a network, a system or a resource." as well as:
- "Conductive element, embedded in the earth or in another specific conductive medium in electrical contact with the earth."

The tasks of an earthing system are:

- Arresting of the lightning current into the earth
- Equipotential bonding between the down-conductors
- Potential control near conductive walls of the building structure

Consequences of an improperly created earthing system:

- Dangerous surge voltages at the equipotential bonding
- No even potential course on the earthing system
- Destruction of the foundation through insufficient arresting area of the energy-rich lightning current
- Destruction of the foundation through improperly made connections (no terminal connection)
- Electrical decoupling of high amounts of lightning energy

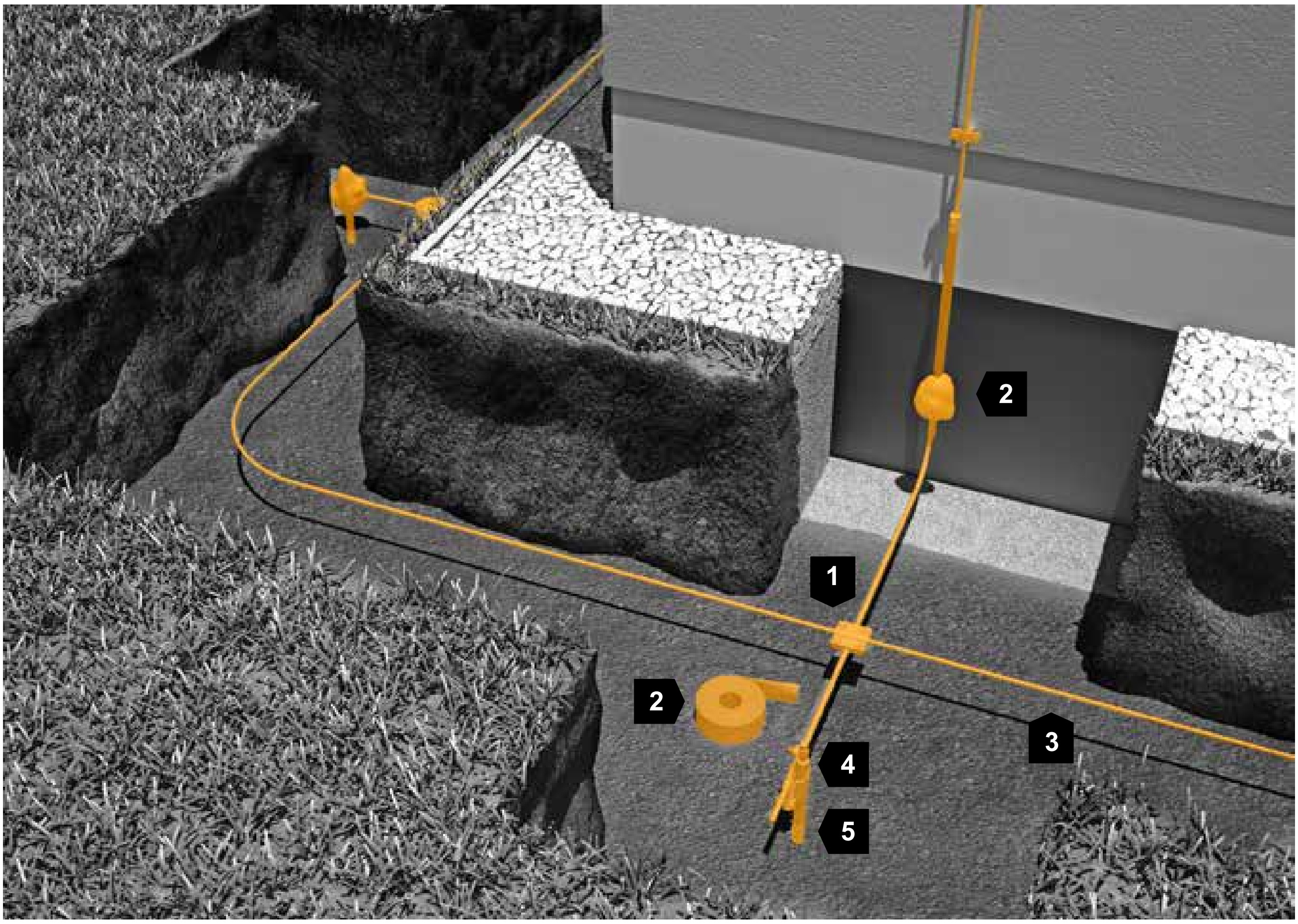
Types of earth electrodes as per VDE 0185-305-3	
Type A • Horizontal earth electrodes • Vertical earth electrodes (earth rods or earth conductor)	**Type B** • Ring earth electrodes (surface earth electrodes) • Foundation earth electrodes

Figure 2.76: External and internal lightning protection systems

2.3.1 Planning methods

IEC 62305-3 (VDE 0185-305-3) demands continuous lightning protection equipotential bonding. This means individual earthing systems must be connected together to create a global earthing system.

The standard differentiates between type A and type B earthing systems. Type A earth electrodes are vertical or horizontal earth electrodes (earth rods, earth conductors). A type B earth electrode is any surface earther (ring earth electrodes, foundation earth electrodes).



1	Cross-connector
2	Corrosion protection strip
3	Round conductor
4	Connection clips
5	Earthing rods (observe corrosion protection for connectors)

Figure 2.77: Type A earth rods with ring equipotential bonding

2.3.1.1 Type A erath rods structure

Functional method

As single earth electrode, a rod of 9.0 m in length is recommended. This should be installed at a distance of 1.0 m from the foundation of the building.

As a minimum dimension (according to IEC 62305-3 (DIN VDE 0185-305-3), a length of 2.5 m for vertical installation and 5 m for horizontal installation apply for type A earth electrodes for lightning protection classes III and IV. Depending on the soil conditions, deep earth rods can be driven into the earth by hand or using suitable electric, petrol or pneumatic hammers.

All earth rods must be connected with a ring earth electrode inside or outside of the building and with an entry to the equipotential bonding rail.

The necessary earther lengths can be divided up into several separate lengths connected in parallel.

Information on arrangement of type A earthers

- In general, earth rods are inserted vertically into the earth to fairly large depths. They are driven into natural soil, which is usually only found beneath foundations.

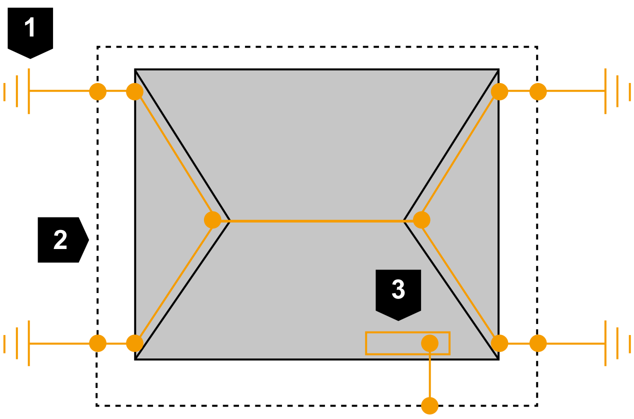
- Often, the specific ground resistance cannot be determined in the densely built-up areas.

  In these cases, when determining the minimum length of the earther, it is sufficient to assume a specific ground resistance of 1,000 Ohm/m.

- In type A earthing systems, there is a minimum requirement of two earth rods.

- Earther arrangement, type A: connection inside and outside the building structure.

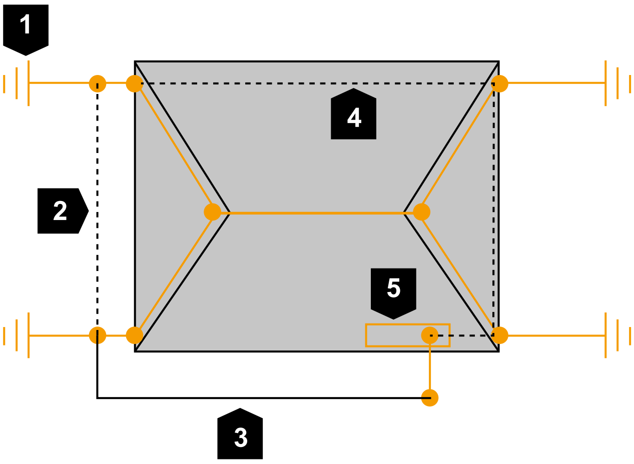
- Down-conductors are interconnected near the surface of the ground. (Figure 2.74)



1	Earth rod, type A
2	Underground connection
3	Main earthing rail (MER)

Figure 2.78: Earthing system, type A: Connection outside the building structure

The type A fan or earth rods do not fulfil the requirements for equipotential bonding and potential control. A type A earthing system is suitable for low building structures (e.g. single-occupancy dwellings), existing building structures, for LPS with interception rods or tension cables or for an isolated LPS. This type of arrangement comprises horizontal and vertical earth electrodes, connected to each down-conductor.



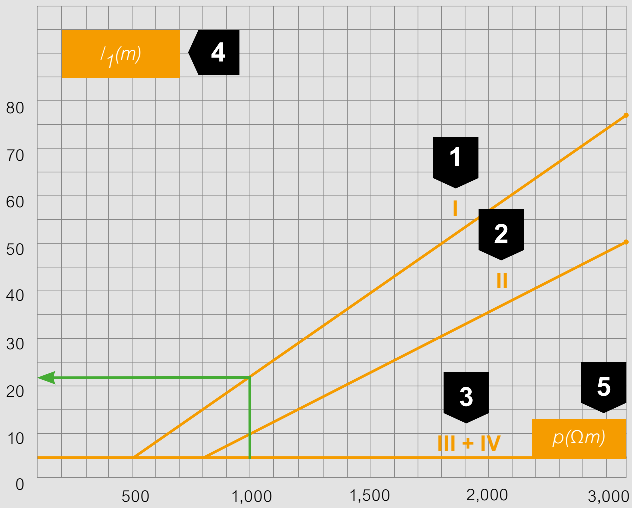
1	Earth rod, type A
2	Underground connection
3	Surface-mounted connection
4	Connection inside the building
5	Main earthing rail (MER)

Figure 2.79: Earthing system, type A: Connection inside and outside the structure

If it is not possible to connect the earth rods in the ground, this can take place in or on the building. **(Figure 2.79)**

Connection cables should be as short as possible and not installed higher than 1 m above the ground. If the lightning protection equipotential bonding was only connected to a single earther, then high potential difference to other earthers would result. This could cause unapproved arcing or lethal voltage differences.

The minimum length of each earth electrode – based on the protection class of the LPS – is not relevant if the earthing resistance of the individual earther is ≤ 10 Ω (recommendation). The minimum length of each earth rod is l_1 for horizontal earth electrodes and 0.5 x l_1 for vertical earth electrodes.



1	Lightning protection class I
2	Lightning protection class II
3	Lightning protection class III + IV
4	Minimum earth rod length l_1(m)
5	Specific earth resistance p(Ωm)

Figure 2.80: Minimum lengths of earthers

Example
- Lightning protection class 1
- Sand, gravel, top layers (dry) 1,000 Ωm

Result **(Figure 2.76)**
- Lightning protection class 1: 22 m
- Earth rod: 11 m

Materials

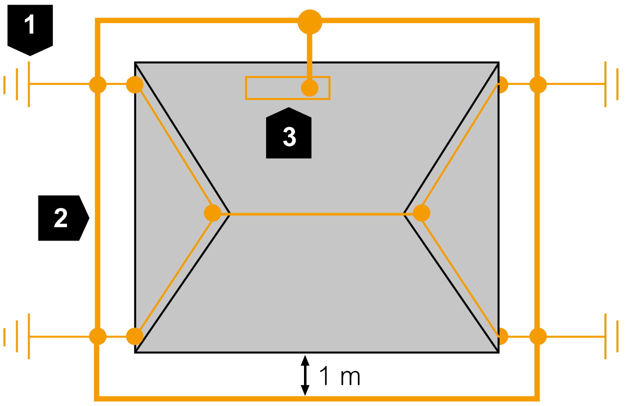
The following materials can be used:

- Stainless steel rods, Ø 20 mm
- Galvanised steel rods, Ø 20 mm
- Copper coated steel rods, Ø 20 mm
- Stainless steel rods, Ø 25 mm
- Galvanised steel flat conductors, 30 x 3.5 mm
- Stainless steel flat conductors, 30 x 3.5 mm
- Galvanised steel pipes, Ø 25 mm

Corrosion protection

In potentially corrosive areas, rust-proof stainless steel with a molybdenum content of ≥ 2%, e.g. 1.4404 or 1.4571, should be used. Detachable connections in the ground must be protected against corrosion (plastic corrosion protection strip).

In the earth, rustproof stainless steel with a molybdenum content of ≥ 2% should be used.



1	Earth rods (optional)
2	Underground connection
3	Main earthing busbar (MEB)

Figure 2.81: Installation principle, ring earther

2.3.1.2 Type B ring earth electrodes

The type B ring earth electrodes are laid around the building. **(Figure 2.81)**

Functional method

Outside the building, at least 80% of the ring earther's (surface earther's) overall length must be in contact with the ground. It must be installed as a closed ring at a distance of 1.0 m and a depth of 0.5 m (or 0.8 m according to DIN 18014) around the external foundation of the building **(see Figure 2.82)**. A ring earther is an earther according to arrangement type B.

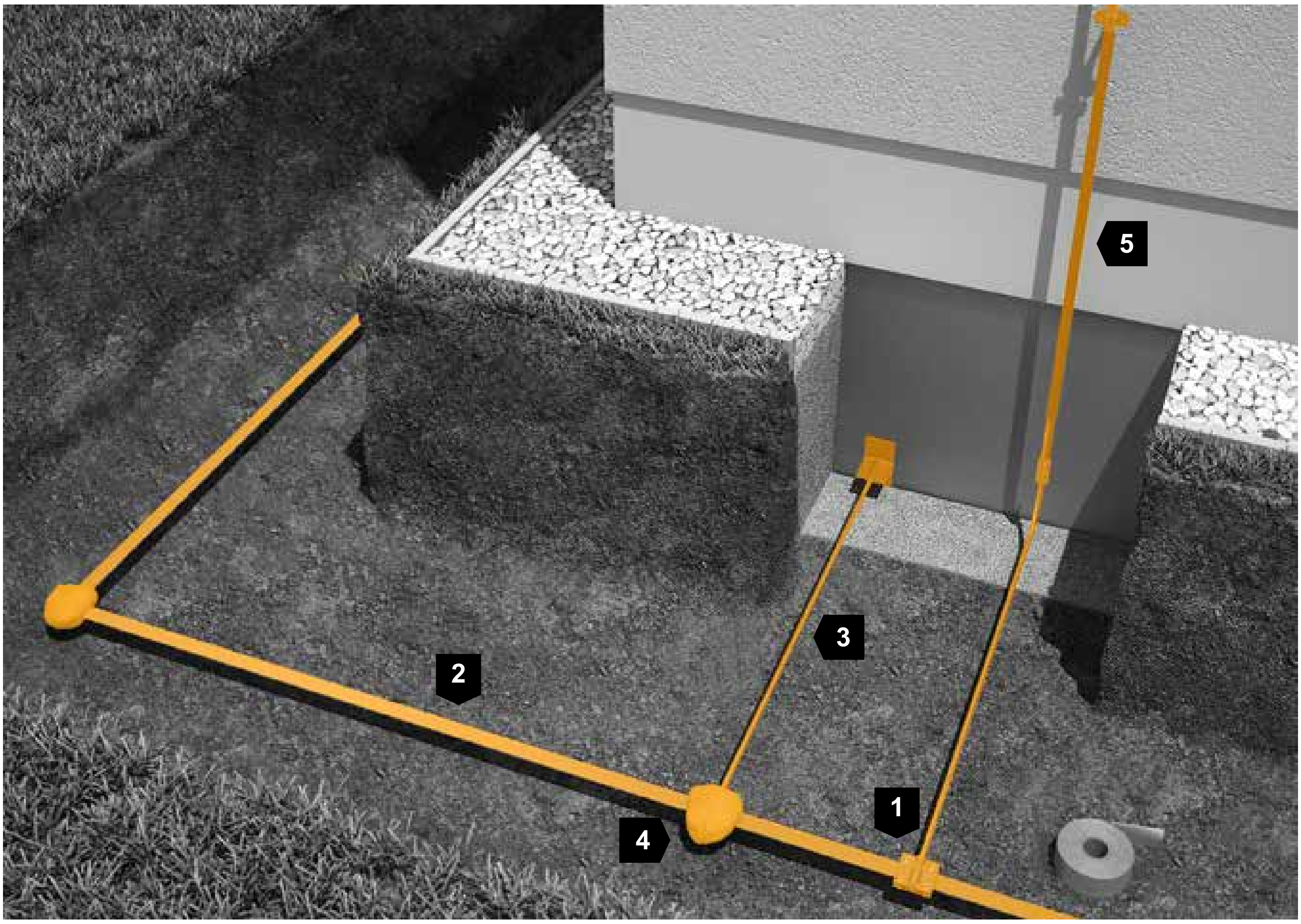
Materials

The following materials can be used:

- Stainless steel flat conductors, 30 x 3.5 mm
- Galvanised steel flat conductors, 30 x 3.5 mm
- Copper round conductors, Ø 8 mm
- Stainless steel round conductors, Ø 10 mm
- Galvanised steel round conductors, Ø 10 mm

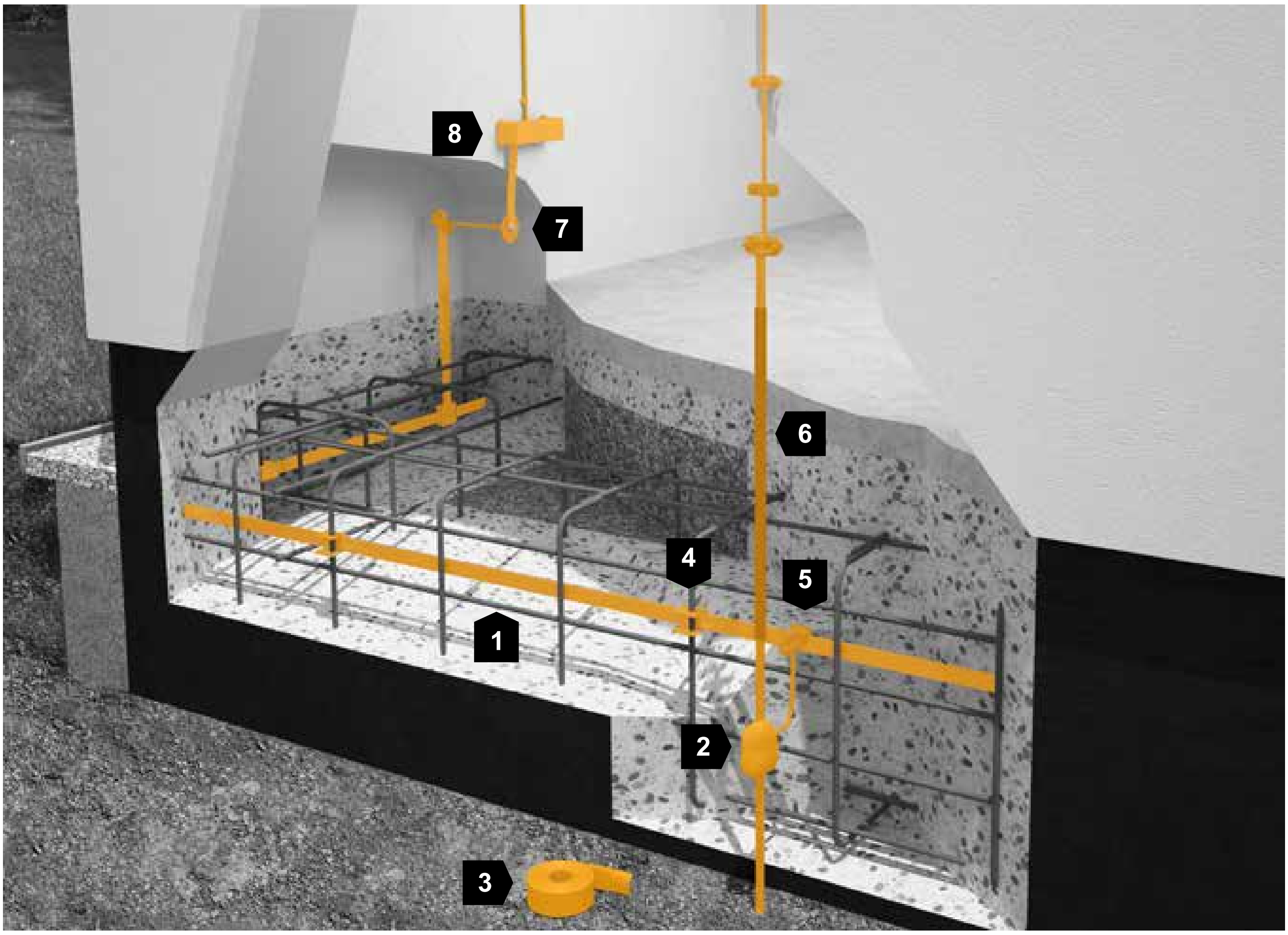
Corrosion protection

In the earth, rustproof stainless steel with a molypdenum content of ≥ 2%, e.g. 1.4404 or 1.4571, should be used. Detachable connections in the ground must be protected against corrosion (plastic corrosion protection strip).



1	Cross-connector
2	Flat conductor
3	Round conductor
4	Corrosion protection strip
5	Earth lead-in rod

Figure 2.82: Type B ring earth electrode



1	Flat conductor
2	Cross-connector with corrosion protection
3	Corrosion protection strip
4	Connection terminal for reinforced steels
5	Cross-connector
6	Earth lead-in rod
7	Earthing fixed point
8	Main earthing busbar (MEB)

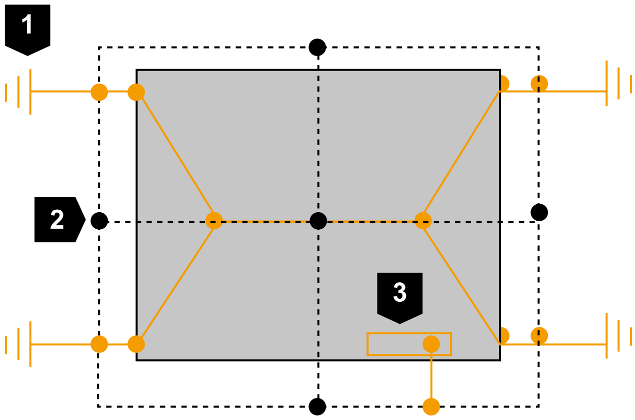
Figure 2.83: Type B foundation earther

2.3.1.3 Type B foundation earth electrode

The oundation earther electrode is a component of the electrical installation of the building.

Functional method

A foundation earth electrode **(Figure 2.83)** is an earth electrode that is embedded into the concrete foundation of a building. It acts as a lightning protection earther if the lugs required for connecting the down-conductors protrude from the foundation. The steel strip is to be connected to reinforcements at intervals of approx. 2 m. DIN 18014 forms the basis for constructing the foundation earther. Wedge connectors must not be used in mechanically compacted concrete.



1	Earth rods (optional)
2	Ring earth electrodes
3	Main earthing busbar(MEB)

Figure 2.84: Installation principle, foundation earther with functional equipotential bonding cable

In order to achieve a clean insertion, the use of strip holders is recommended for the installation of foundation earth electrodes. The holders must be inserted at a distance of approx. 2 m.

In accordance with DIN 18014, connect the foundation earthers of each individual foundation on the lowest storey into a closed ring. If necessary, insert transverse conductors, in order to create a grid of 20 x 20 m. If the earth electrodes do not have the necessary contact with the earth electrodes in the foundation, then a grid ring earther should additionally be installed. The foundation earth electrodes becomes a functional equipotential bonding conductor. **(Figure 2.80)**

This is the case when using:
- Impermeable concrete according to DIN 206-1 and 1045-2 (white trough)
- Bitumen seals (black trough), e.g. bitumen membranes
- Polymer-modified bitumen thick coating
- Impact-resistant plastic webs
- Heat insulation (perimeter insulation) on the underside and side walls of the foundations
- Additionally attached, capillary breaking, poorly electrically conductive earth strata, e.g. made of recycled material or crushed glass

For further information see chapter 2.3.2

This grid ring earther must be connected with the functional equipotential bonding conductor and must be executed as follows either outside of or within the floor plate:
- Grid width of 10 x 10 m with lightning protection measures
- Grid width of 20 x 20 m without lightning protection measures

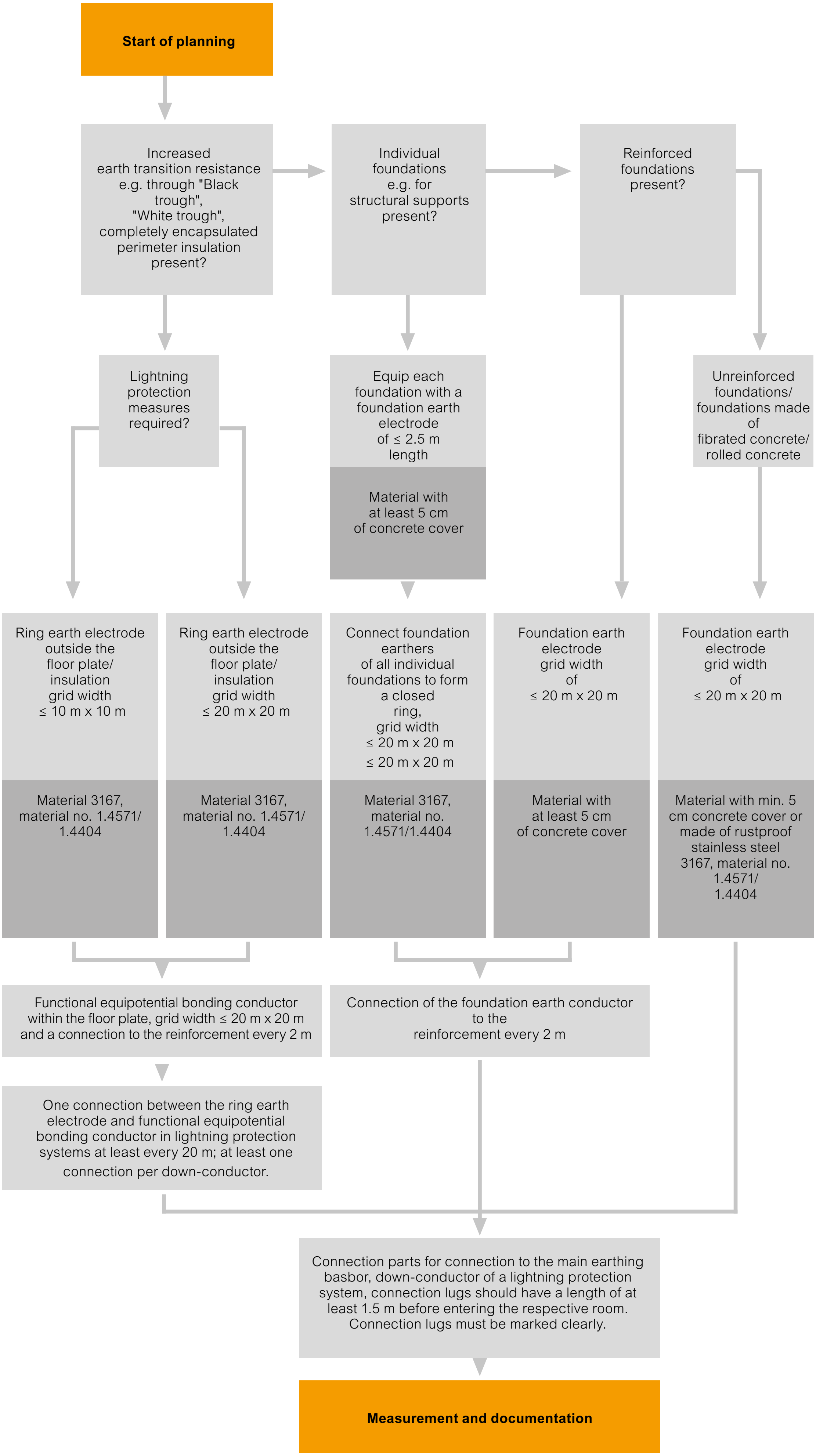
Materials

Foundation/functional equipotential bonding conductor
The following materials can be used:
- Galvanised steel flat conductors, 30 x 3.5 mm
- Stainless steel flat conductors, 30 x 3.5 mm
- Copper cable, 50 mm^2
- Galvanised steel round conductors, Ø 10 mm
- Stainless steel round conductors, Ø 10 mm

Connection lugs
Connection lugs must be made of materials with permanent corrosion protection. Either hot galvanised steels with plastic jacketing or rustproof stainless steels with a molybdenum content ≥ 2% must be used, e.g. 1.4404 or 1.4571. The connection lugs should be clearly marked with protective caps during the construction phase, e. with the OBO ProtectionBall.

Ring earth electrodes
The following materials can be used for the grid ring earther:
- Stainless steel flat conductors, 30 x 3.5 mm
- Stainless steel round conductors, Ø 10 mm
- Copper cable, 50 mm^2

Figure 2.85: OBO ProtectionBall (item no. 5018 01 4) for marking earthing lugs


Start of planning
Increased earth transition resistance e.g. through "Black trough", "White trough", completely encapsulated perimeter insulation present?
Individual foundations e.g. for structural supports present?
Reinforced foundations present?
Lightning protection measures required?
Equip each foundation with a foundation earth electrode of ≤ 2.5 m length
Material with at least 5 cm of concrete cover
Unreinforced foundations/ foundations made of fibrated concrete/ rolled concrete
Ring earth electrode outside the floor plate/ insulation grid width ≤ 10 m x 10 m
Material 3167, material no. 1.4571/ 1.4404
Ring earth electrode outside the floor plate/ insulation grid width ≤ 20 m x 20 m
Material 3167, material no. 1.4571/ 1.4404
Connect foundation earthers of all individual foundations to form a closed ring, grid width ≤ 20 m x 20 m
≤ 20 m x 20 m
Material 3167, material no. 1.4571/1.4404
Foundation earth electrode grid width of ≤ 20 m x 20 m
Material with at least 5 cm of concrete cover
Foundation earth electrode grid width of ≤ 20 m x 20 m
Material with min. 5 cm concrete cover or made of rustproof stainless steel 3167, material no. 1.4571/ 1.4404
Functional equipotential bonding conductor within the floor plate, grid width ≤ 20 m x 20 m and a connection to the reinforcement every 2 m
Connection of the foundation earth conductor to the reinforcement every 2 m
One connection between the ring earth electrode and functional equipotential bonding conductor in lightning protection systems at least every 20 m; at least one connection per down-conductor.
Connection parts for connection to the main earthing basbor, down-conductor of a lightning protection system, connection lugs should have a length of at least 1.5 m before entering the respective room. Connection lugs must be marked clearly.
Measurement and documentation

The following planning aid can be used to determine grid widths and versions for the foundation earthing system for ndividual projects.

Figure 2.86: Wall penetration sealed against pressurised water DW RD10, item no. 2360 04 1

Connecting parts
If connections are made in the earth, e.g. in the case of the ring earth electrodes, these must be implemented in such a way that they are permanently resistant to corrosion. It is recommended that stainless steel with a molybdenum content of ≥ 2%, e.g. 1.4404 or 1.4571, is used. These connectors must additionally be fitted with a corrosion protection strip.

Connections between foundation earth electrodes/ functional equipotential bonding conducts and the reinforcement or between functional equipotential bonding conductors and the ring earth electrodes and with the connection lugs can take the form of bolted joints, clamped joints or welded joints; tying wire is not acceptable. Only tested connection components in accordance with IEC 62561-1 (DIN EN 62561-1) may be used.

Connections from the ring earth electrodes into the building should be located above the maximum groundwater level. Alternatively, wall penetrations sealed against pressurised water (type OBO DW RD10) should be used. **(Figure 2.86)**

Corrosion protection
Inside sealing troughs and in contact with perimeter insulation (DIN 18014) and in potentially corrosive areas, rustproof stainless steel with a molybdenum content of ≥ 2%, e.g. 1.4404 or 1.4571, must always be used. Detachable connections in the ground must be protected against corrosion (plastic corrosion protection strip).

2.3.2 Versions
Earthing systems can consist of either a type A or a type B earth electrode. Different versions of each are available, to suit different application situations.

1	Type: OMEX
2	Type: BP
3	Type: Standard
4	Type: LightEarth

Figure 2.87: Deep earther versions

2.3.2.1 Earth rods

Earth rods are differentiated according to the type of connection of the individual earth rods; the external diameter; and the material.

Earth rods consist of combinable individual rods of length 1.5 m. The connection is made using a coupling consisting of a hole and stud. This has the advantage that the coupling closes automatically at the time of installation and creates a secure connection from both a mechanical and an electrical point of view.
When a earth rod is driven in, this compacts the ground around it. This is conducive to a good electrical contact. **(Figure 2.87)**

Striking tools are generally used for driving in thee-arth rods. The possible penetration depth of the earth depends on various geological factors.

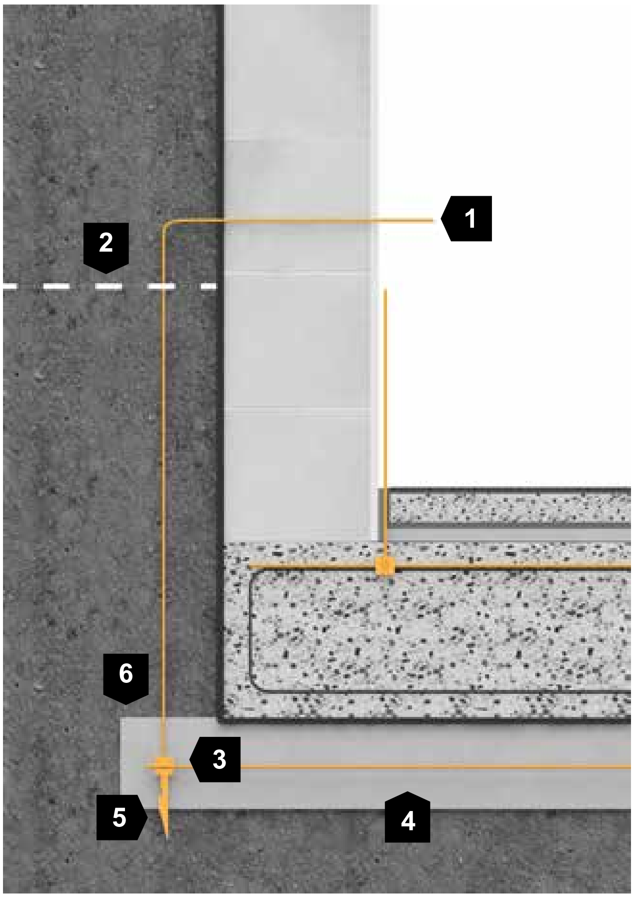
Because earth rods penetrate into soil strata of constant moisture and temperature, this produces constant resistance values.

2.3.2.2 Black trough

The black trough is a bitumen or plastic seal surrounding the structure on all sides in the area in which it is in contact with the earth. Because the foundation earth electrodes no longer has contact with the earth here, an additional grid ring earth electrodes must be created. A functional equipotential bonding conductor must be created in the foundation. Connection lugs must be routed into the building in such a way that they are resistant to pressurised water or above the maximum groundwater level. **(Figure 2.88)**

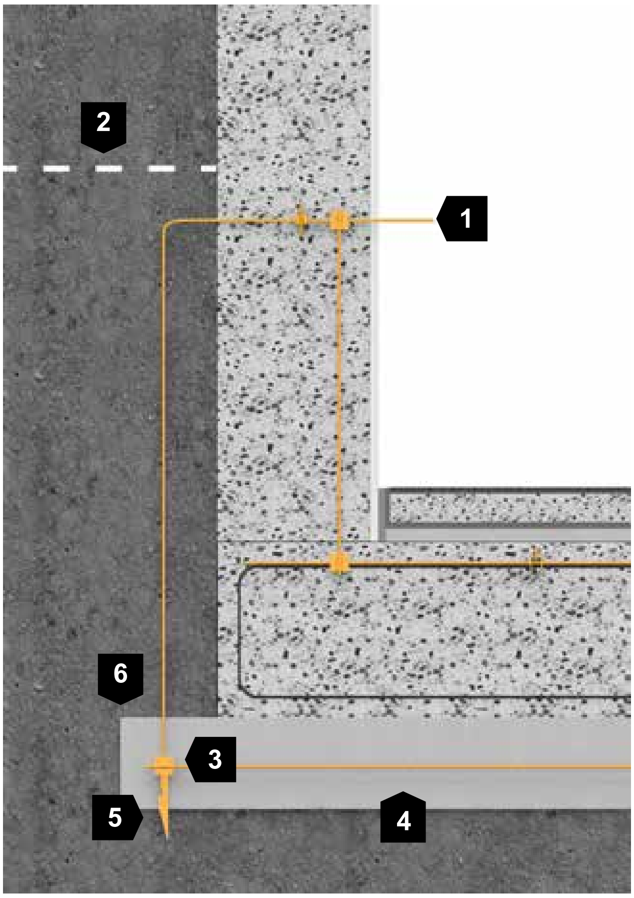
2.3.2.3 White trough

The white trough is a construction consisting of water-impermeable concrete, i.e. water cannot penetrate right through the concrete. Because the foundation earth electrode no longer has contact with the earth here, an additional ring earth electrode must be created. Concrete of grades such as C20/25 or C25/30 is considered water-impermeable concrete. **(Figure 2.89)**



1	Connection lug, min. 1.50 m
2	Maximum groundwater level
3	Ring earth electrode
4	Blinding layer
5	Spacer
6	Min. 5 cm concrete cladding is used as corrosion protection

Figure 2.88: Black trough



1	Connection lug, min. 1.50 m
2	Maximum groundwater level
3	Ring earth electrode
4	Blinding layer
5	Spacer
6	Min. 5 cm concrete cladding is used as corrosion protection

Figure 2.89: White trough

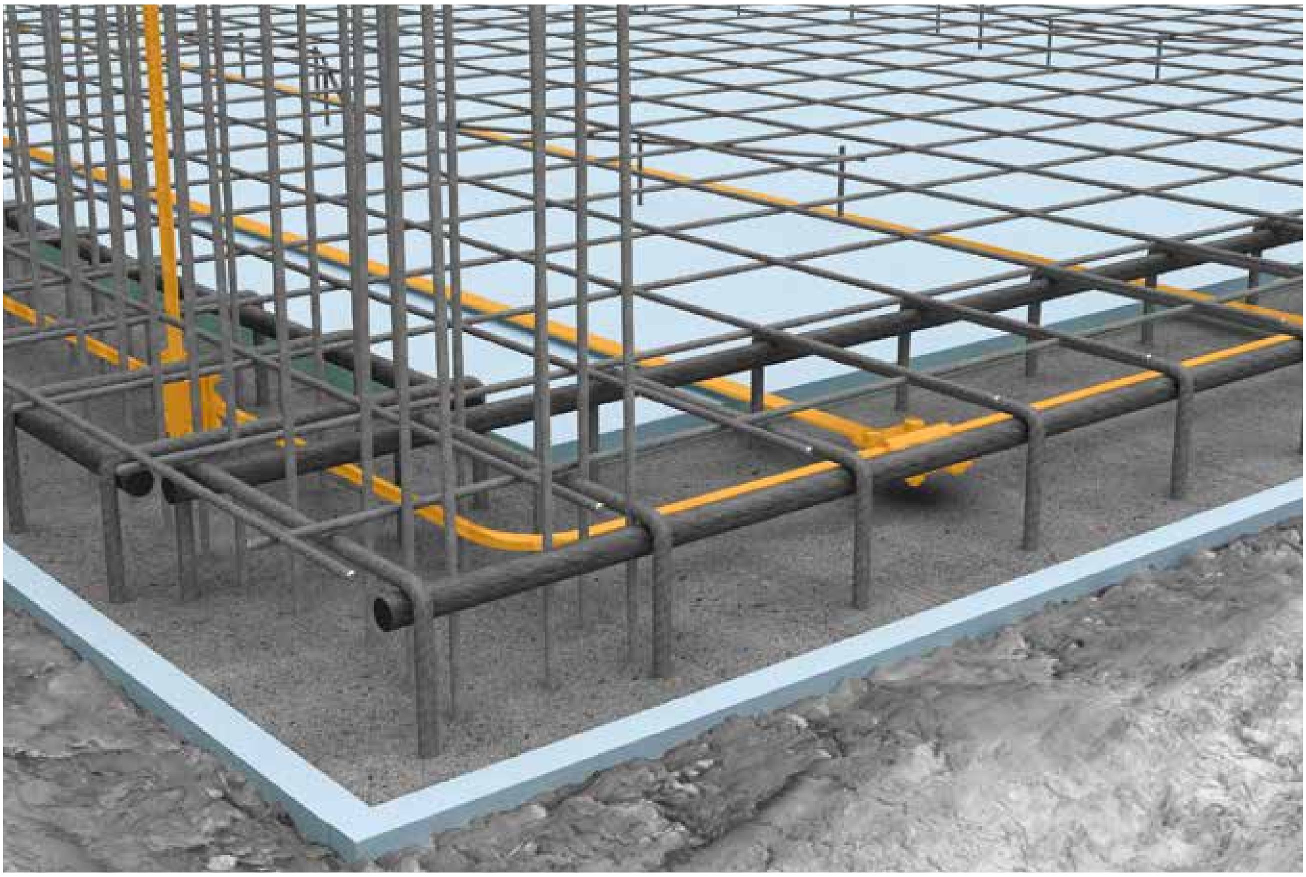


Figure 2.89: Insulated floor plate (perimeter insulation, shown here in blue)

2.3.2.4 Perimeter insulation

Perimeter insulation is heat insulation, which surrounds the area of the structure in contact with the earth from outside. It generally consists of polyurethane foam sheets or crushed glass.

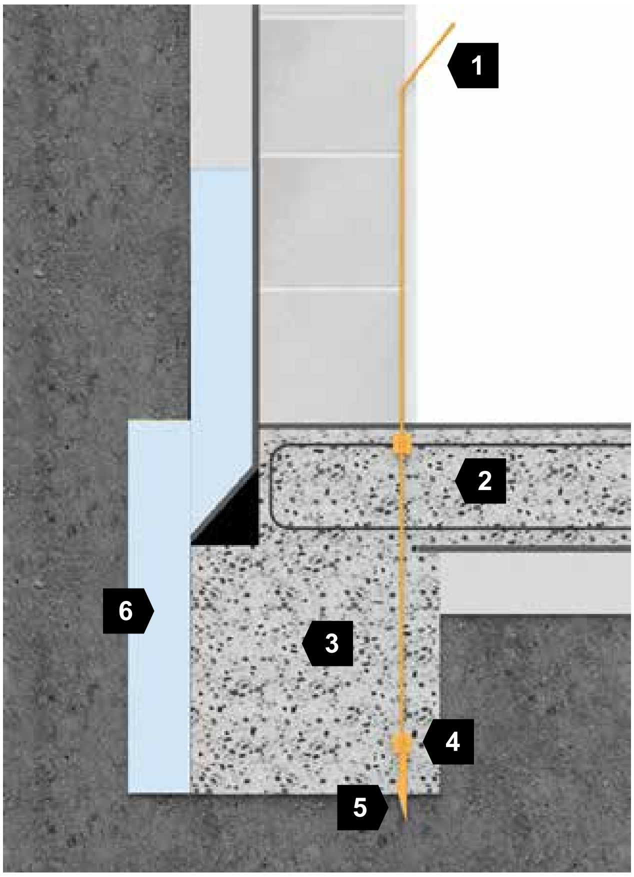
If the building structure is surrounded on all sides by perimeter insulation, i.e. all surrounding walls, strip foundations and the bottom of the foundation, the function of the foundation earth electrode is no longer fulfilled.

Because the foundation earth electrode no longer has contact with the earth here, an additional grid ring earth electrode must be created. A functional equipotential bonding conducts must be created in the foundation. Connection lugs must be routed into the building in such a way that they are resistant to pressurised water or above the maximum ground-water level.

If the perimeter insulation is only on the surrounding walls, earther contact is often still intact. The foundation earther can be implemented in the concrete. **(Figure 2.89)**

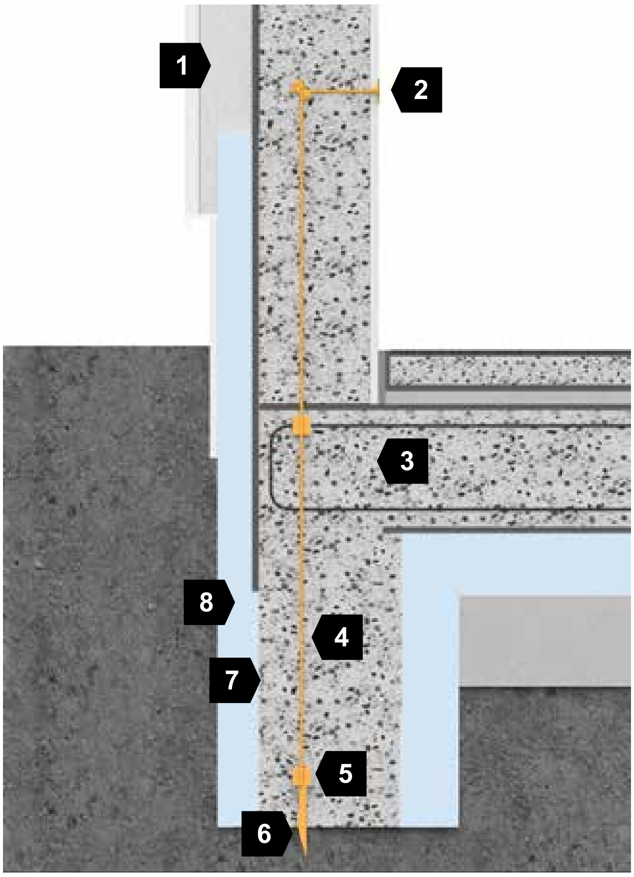
To ensure contact with the earth, water-impermeable concrete must not be used.

If the exterior walls and the foundation plate are surrounded with perimeter insulation, the earther in the floor plate still has some earthing effect if the strip foundation is open at the bottom.



1	Connection lug, min. 1.50 m
2	Floor plate
3	Strip foundation
4	Foundation earth electrode
5	Spacer
6	Perimeter insulation

Figure 2.90: Perimeter insulation only on the surrounding walls



1	Insulation
2	Earthing fixed point
3	Reinforced floor plate
4	Strip foundation
5	Foundation earth electrode
6	Spacer
7	Min. 5 cm concrete cladding is used as corrosion protection
8	Perimeter insulation

Figure 2.91: Perimeter insulation to the side of and beneath the foundation plate

Figure 2.92: Example: studded plastic strips

Influence of plastic films on the earthing resistance

Generally there is a negative influence between the strip foundation or foundation plate and the earth in this area.

"Simple" films

- In the case of simple films the foundation earther effect is impaired
- However, earthing resistance is usually still sufficient. The foundation earther is effective as an earther in the strip foundation or in the foundation plate.

Studded plastic strips

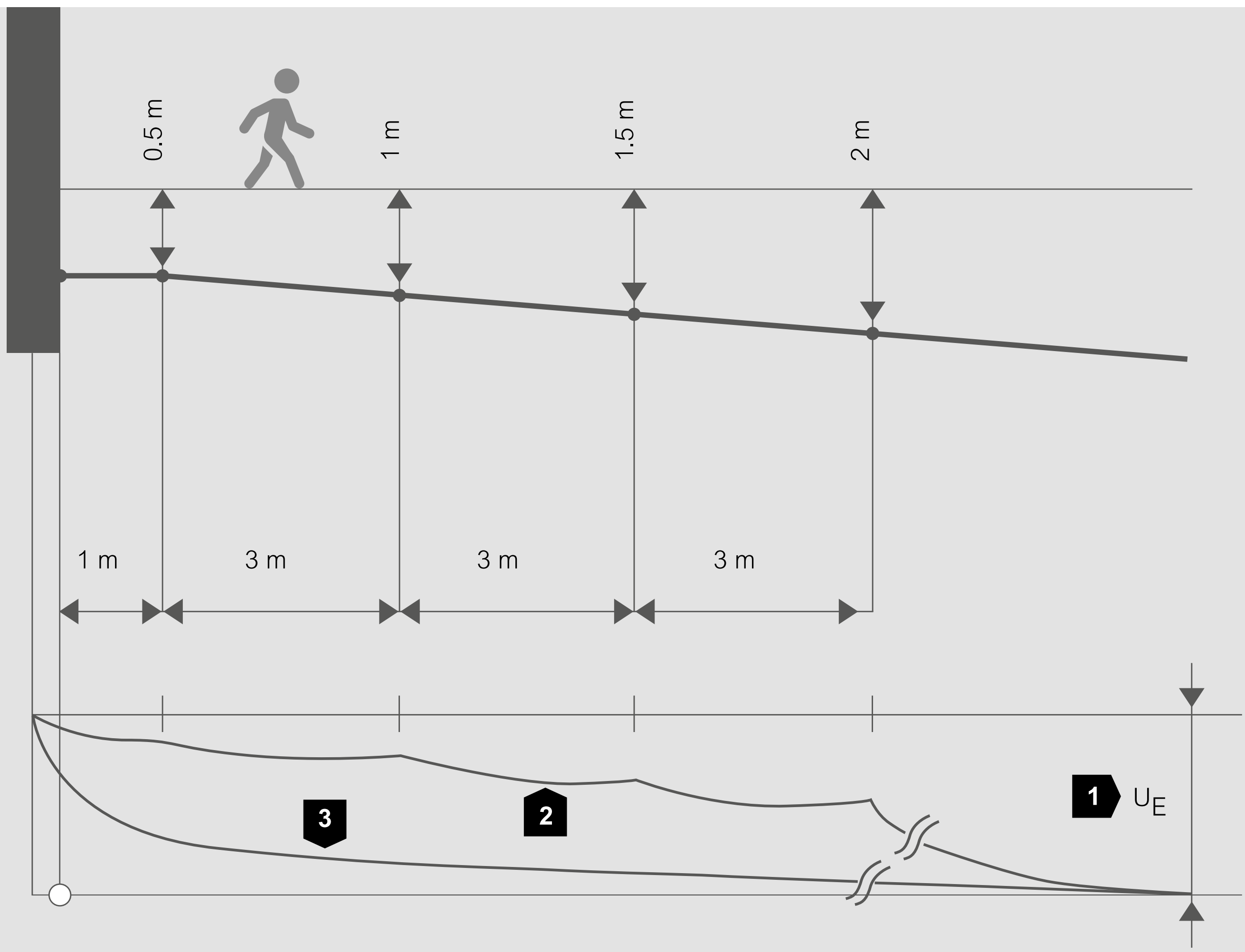
- Made of special, high-density polyethylene. If the individual membranes overlap, the earth contact of the foundation earther is impaired.
- Further studded strips on the exterior walls produce a very strong electrical insulating effect. In this case the earth contact of the foundation earther is no longer intact.

Because the foundation earther no longer has contact with the earth here, an additional grid ring earther must be created. **(Figure 2.92)**

2.3.2.5 Potential control

The potential control reduces the step voltage close to rods or down conductors on a building. Additional earth conducts are laid and connected with one another in a grid format.

The lightning current is distributed through the metal grid system and the voltage drop and the resulting step voltage are reduced. As the distance from the rod or arrester increases, the depth of the earther cable also increases (in increments of 0.5 m). (Figure 2.93) The earthers are typically laid 3 m apart.



1	Earthing voltage U_E
2	With potential control
3	Without potential control

Figure 2.93: Potential control on a street-light pole

Step voltage and touch voltage

The step voltage is the voltage between a person's feet placed 1 m apart. Here the current flows between the person's feet through their body. The touch voltage is the voltage between a component (e.g. the down-conductor) and earth potential. Here the current flows from the hand to the foot through the body. (Figure 2.94) Both types of voltage can be harmful to the body. These voltages need to be reduced via potential control or insulation.

1	U_E: Earthing voltage
2	U_{B1}: Touch voltage without potential control (on foundation earther)
3	U_{B2}: Touch voltage with potential control (foundation earther and control earther)
4	U_S: Step voltage (without control earther)
5	φ: Earth surface potential
6	FE: foundation earth electrode
7	CE: control earth electrode (ring earth electrode)

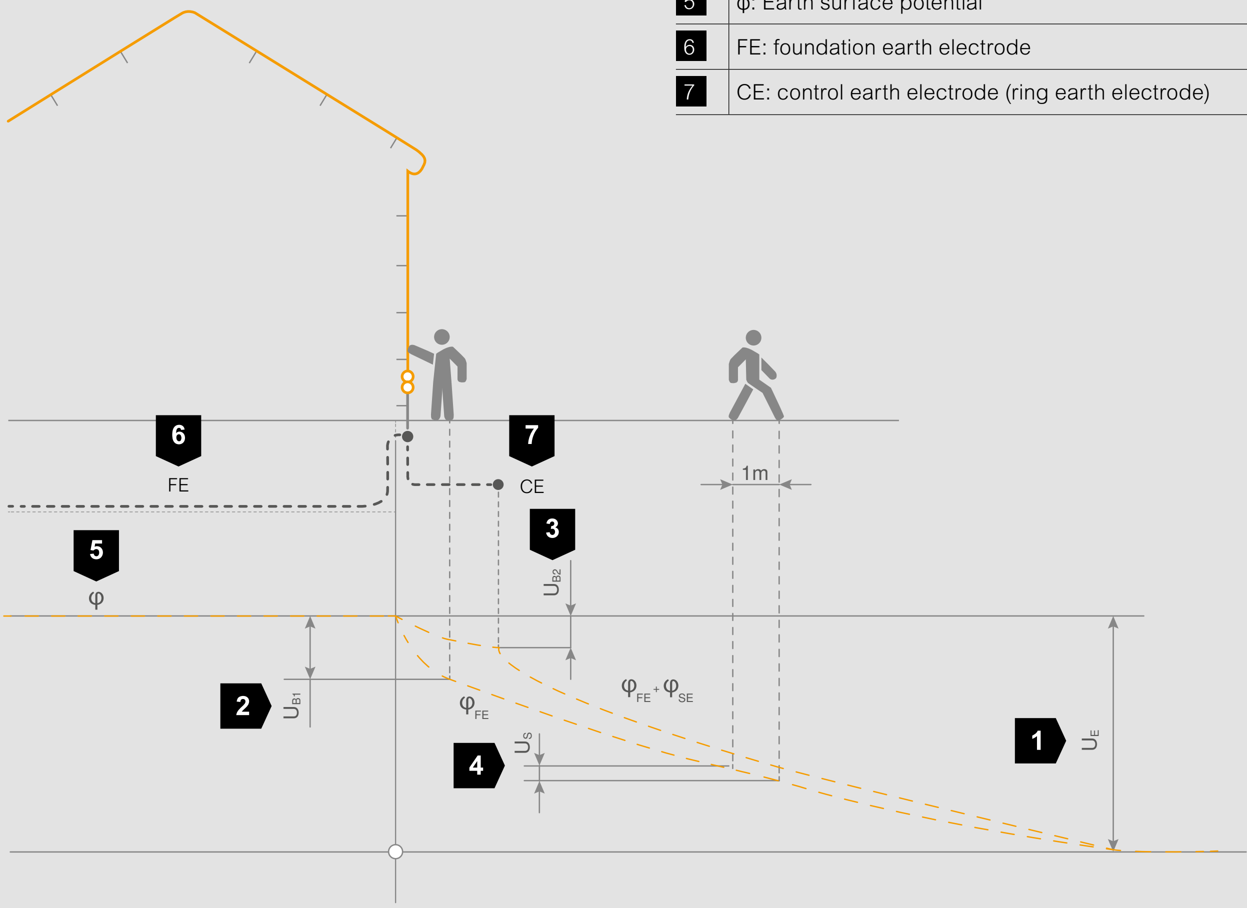


Figure 2.94: Electrical potential on the earth surface and voltages as current passes through the foundation earther (FE) and control earther (CE)

2.4 Materials and corrosion protection

The following materials are preferred for use in external lightning protection systems: hot galvanised steel, rustproof steel, copper and aluminium. All metals in direct contact with the ground or water can corrode due to stray current or aggressive soils.
Corrosion is when a metal material reacts with its surroundings to the detriment of the material's properties.

Causes of corrosion
Corrosion occurs when different metals are connected with one another in soil, water or molten salt, e.g. aluminium round cables as arresters and copper/steel as earthing material. It can also occur when a single type of metal is embedded in two distinct environments, e.g. steel in earth and concrete.

Minimum cross-sections, forms and materials depend on the respective application.

Material	Form	Minimum dimensions
Copper Tin-plated copper	Strip, solid Round, solid **b** Cable **b** Round, solid	20 x 2.5 mm ø 8 mm 50 mm^2 ø 15 mm
Aluminium	Round, solid Cable	ø 8 mm 50 mm^2
Copper-coated aluminium alloy	Round, solid **c**	ø 8 mm
Aluminium alloy	Strip, solid Round, solid Cable **b** Round, solid	20 x 2.5 mm ø 8 mm 50 mm^2 ø 15 mm
Hot galvanised steel	Strip, solid Round, solid Cable **b** Round, solid	20 x 2.5 mm ø 8 mm 50 mm^2 ø 15 mm
Copper-coated steel **c**	Round, solid Strip, solid	ø 8 mm 20 x 2.5 mm
Rustproof steel **a**	Strip, solid Round, solid Cable **b** Round, solid **d**	20 x 2.5 mm ø 8 mm 50 mm^2 ø 15 mm

a Chromium ≥ 16%; Nickel ≥ 8%; Carbon ≤ 0.08%
b Diameter of 8 mm can in certain applications be reduced to 25 mm^2 (diameter 6 mm) if mechanical resistance is not a primary criterion.
c At least 70 µm copper plating with 99.9% copper content
d Can be used for interception rods and base

Table 2.27: Material, form and minimum dimensions of interception cables, interception rods, earth entry rods and arresters

2.4.1 Materials for air-termination and down-conductor systems

The following materials are preferred for use in external lightning protection systems: hot galvanised steel, rustproof steel, copper and aluminium.

Corrosion

Especially when different materials are connected with one another, there is a risk of corrosion. For this reason, no copper parts may be installed above galvanised surfaces or above aluminium parts as copper particles worn away by rain or other environmental influences can penetrate the galvanised surface. In addition, a galvanic element occurs, which accelerates corrosion of the contact surface. If two different materials need to be joined (not recommended) bi-metal connectors (Figure 2.95) can be used.

The example (Figure 2.96) shows the use of bi-metal connectors on a copper gutter to which an aluminium round cable is attached. Points at increased risk of corrosion, such as insertion points into the concrete or soil, must be corrosion-protected. A suitable coating must be applied as corrosion protection to connection points in the ground.

Figure 2.95: Variable bi-metal quick connector with bi-metal intermediate plate (copper/aluminium)

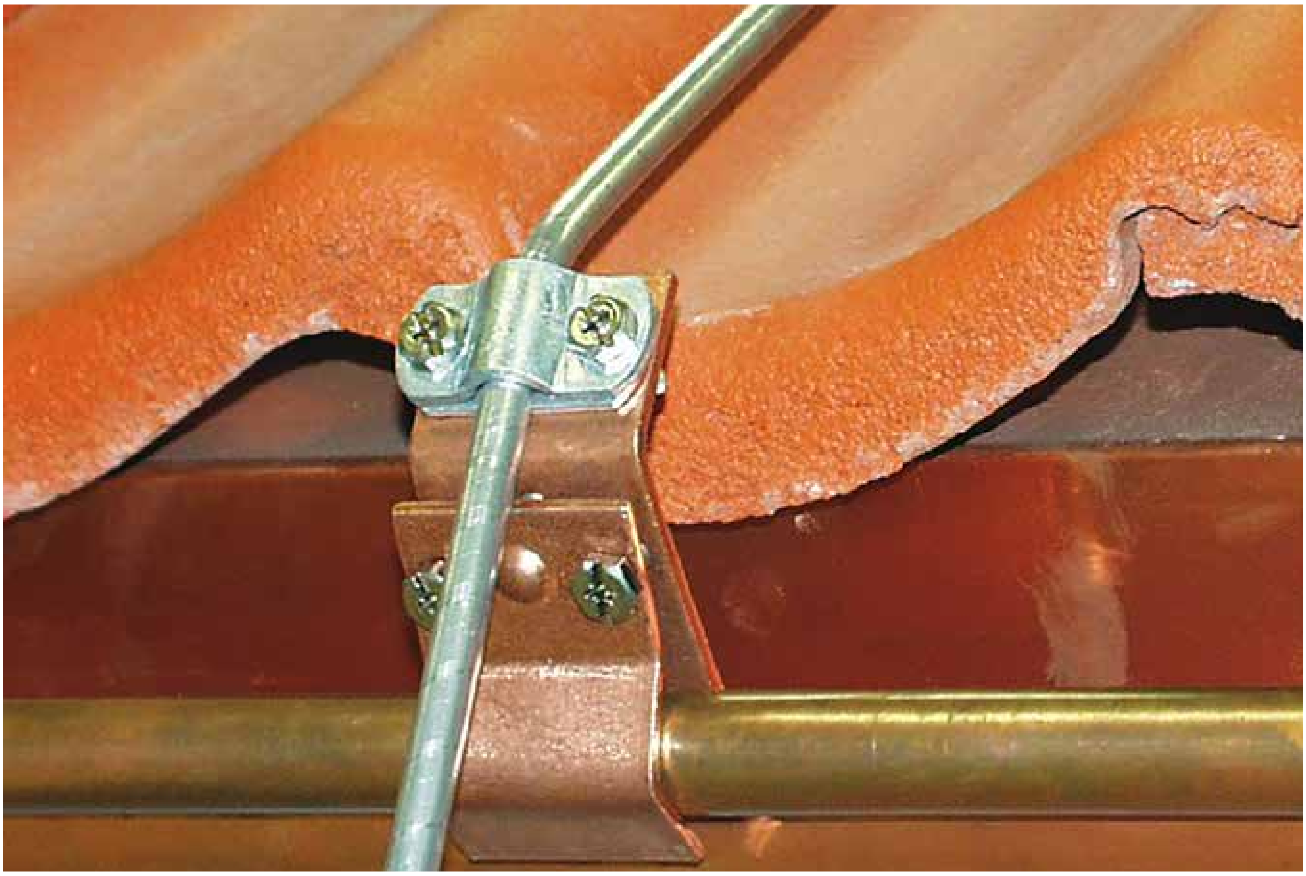


Figure 2.96: Bi-metal roof gutter clamp (aluminium round conductor and copper roof gutter)

Aluminium must not be placed directly (without a distance) on, in or under plaster, mortar or concrete or in the earth. In the "Material combinations" table, possible metal combinations are evaluated with regard to contact corrosion in air.

	Steel, galvanised	Aluminium	Copper	Stainless steel	Titanium	Tin
Steel, galvanised	Yes	Yes	No	Yes	Yes	Yes
Aluminium	Yes	Yes	No	Yes	Yes	Yes
Copper	No	No	Yes	Yes	No	Yes
Stainless steel	Yes	Yes	Yes	Yes	Yes	Yes
Titanium	Yes	Yes	No	Yes	Yes	Yes
Tin	Yes	Yes	Yes	Yes	Yes	Yes

Table 2.28: Permitted material combinations (no = increased corrosion)

The minimum cross-sections, forms and materials depend on the client's application.

2.4.2 Materials for earthing systems

Material	Form	Minimum dimensions		
		Earth rod	Earth conductor	Earth plates
Copper **Tin plated copper**	Cable Round, solid Strip, solid Round, solid Pipe Solid sheet Grid mesh	 ø 15 mm ø 20 mm 	50 mm² ø 8 mm 20 x 2.5 mm 	 500 x 500 mm 600 x 600 mm
Hot galvanised steel	Round, solid Round, solid Pipe Strip, solid Solid sheet Grid mesh Profile [a]	 ø 14 mm ø 25 mm 290 mm²	ø 10 mm 30 x 3 mm 	 500 x 500 mm 600 x 600 mm
Bright steel [b]	Cable Round, solid Strip, solid	ø 8 mm 	70 mm² ø 10 mm 25 x 3 mm	
Copper-coated steel	Round, solid [c] Round, solid [d] Round, solid [d] Strip, solid	ø 14 mm 	 ø 8 mm ø 10 mm 30 x 3 mm	
Rustproof steel [e]	Round, solid Round, solid Solid strip	 ø 15 mm 	ø 10 mm 30 x 3.5 mm	

a Various profiles with a cross-section of 290 mm² and a minimum thickness of 3 mm are permitted, e.g. cross profiles
b Must be embedded in concrete to a depth of at least 50 mm
c With at least 250 µm copper support with 99.99% copper content
d With at least 70 µm copper support with 99.99% copper content
e Chromium ≥ 16%; nickel ≥ 5%; molybdenum ≥ 2%; Carbon ≤ 0.08%

Table 2.29: Materials, forms and cross-sections of earthers according to IEC 62561-2 (VDE 0185-561-2)

Figure 2.97: BET lightning current generator and BET test mark

2.5 Tested lightning protection components

Connection components
Components for lightning protection systems are tested for functionality according to IEC 62561-1 (VDE 0185-561-1) – Requirements for connection components. After a conditioning phase lasting 10 days, the components are impacted with three lightning strikes. The lightning protection components for interception systems are tested with 3 x Iimp 100 kA (10/350). This corresponds to test class H.

Components for down-conductors along which the lightning current can spread (at least two arresters) and connections in the earthing system are tested with 3 x Iimp 50 kA (10/350). This corresponds to test class N.

Test class	Tested with	Application
IEC 62561-1 (VDE 0185-561-1)	3 Iimp 100 kA (10/350)	Air-termination system
IEC 62561-1 (VDE 0185-561-1)	3 Iimp 50 kA (10/350)	Multiple (at least two) down-conductors, along which the lightning current can spread

Table 2.30: Test classes of connecting components

3

The lightning protection equipotential bonding is a building's internal lightning protection system. When lightning strikes, a voltage drop occurs at the earthing resistor, producing dangerous voltage differences between the metal building components and the power and data cables, which need to be prevented. The equipotential bonding connects together all metal installations (gas and water pipes, etc.), electrical systems (power and data cables), the lightning protection system and the earthing system, either directly or via lightning current down conductors.

The lightning current arresters should ideally be located directly at the point of entry into the building structure. This ensures that no lightning current is diverted into the installation that could disrupt electrical systems. Surge arresters must be connected after the lightning current arresters in order to protect electronic devices. The surge down conductors reduce the surge voltage to a very low protection level that devices can withstand.

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3. The internal lightning protection system

Our dependency on electrical and electronic equipment continues to increase, in both our professional and private lives. Data networks in companies or emergency facilities such as hospitals and fire stations are lifelines for an essential real time information exchange. Sensitive databases, e.g. in banks or media publishers, need reliable transmission paths.

It is not only lightning strikes that pose a latent threat to these systems. More and more frequently, today's electronic devices are damaged by surge voltages caused by remote lightning discharges or switching operations in large electrical systems.

During thunderstorms too, high volumes of energy are instantaneously released. These voltage peaks can penetrate a building though all manner of conductive connections and cause enormous damage. **(Figure 3.1)**

Current statistics and estimates of insurance companies show: Damage levels caused by surges – excluding consequential or outage costs – long since reached drastic levels due to the growing dependency on electronic devices. It's no surprise, then, that property insurers are checking more and more claims and stipulating the use of devices to protect against surges. Information on protection measures can be found e.g. in the Directive VDS 2010 (German guideline of the insurance accosiation).

Surge protection devices reduce downtime in electronic systems.

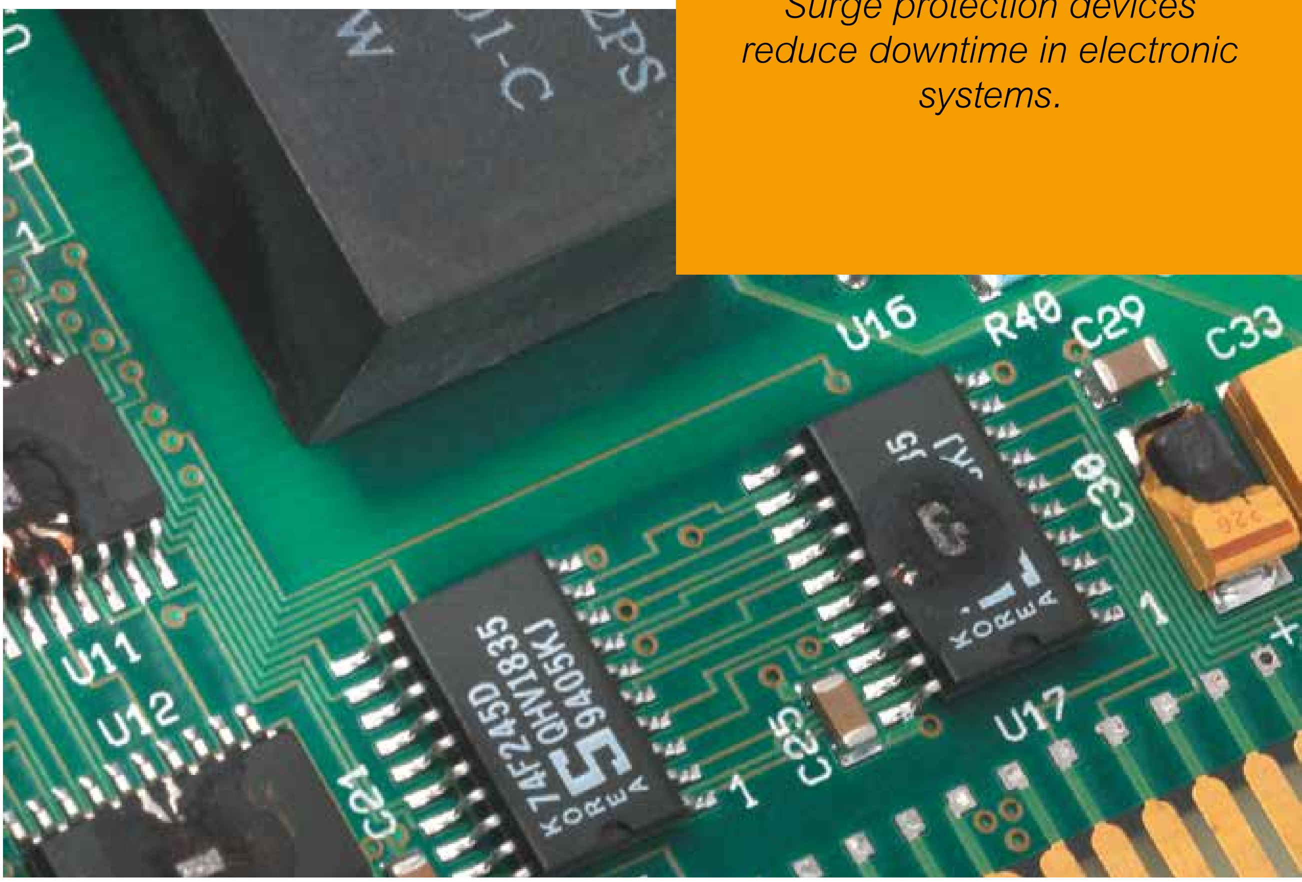


Figure 3.1: Surge voltage damage in a circuit board

Internal lightning protection systems and surge voltage protection concepts are covered by current standards and meet the very latest requirements.

Overview of current standards:

- Internal lightning protection
  IEC 62305-4 (VDE 0185-305-4)
- Surge protection
  IEC 60364-5-53 (VDE 0100-534)

3.1 Equipotential bonding systems

Correct use of equipotential bonding systems prevents dangerous touch voltages between system components.

Normative requirements for equipotential bonding:

- IEC 60364-4-41 (VDE 0100-410)
  Equipotential bonding
- IEC 60364-5-54 (VDE 0100-540)
  Protective equipotential bonding cable
- IEC 60364-7-701 (VDE 0100-701)
  Bathroom
- IEC 60364-7-702 (VDE 0100-702)
  Swimming pools
- IEC 60364-7-705 (VDE 0100-705)
  Agriculture
- IEC 61784 (VDE 0800)
  Telecommunication systems
- IEC 60728-11 (VDE 0855-1)
  Antenna earthing
- IEC 62305 (VDE 0185-305)
  Lightning protection equipotential bonding
- DIN 18014 (foundation earthers)
  Lightning protection equipotential bonding

A distinction is drawn between “protective equipotential bonding” and “additional protective equipotential bonding”.

Protective equipotential bonding

All extraneous conductive parts routed into the building must be connected with one another in order to prevent differences in potential.

Connection of all extraneous conductive parts to the main earthing busbar (MEB)

- Foundation earth electrodes
- Lightning protection earthing
- Conductor for protective equipotential bonding
- Protective conductors within the electrical system
- Metallic water, gas and heating pipes
- Antenna earthing
- Metal parts of the building, e.g. air-conditioning ducts, lift guide rails, etc.
- Metal cable shields

Additional protective equipotential bonding

The lightning protection equipotential bonding is an extension of the general protective equipotential bonding. It is achieved by using surge protection devices to create an additional equipotential bonding system for all supply lines of the low-voltage system and information technology.

For installations under special environmental conditions, e.g. potentially explosive areas, or where explicit normative requirements apply, additional protective equipotential bonding must be implemented.

The bodies of all fixed (non-portable) equipment in the immediate vicinity of the place of installation that can be touched at the same time must be connected with all extraneous conductive parts that can be touched at the same time. This includes the functional equipotential bonding cable as per DIN 18014 and the metal main reinforcement in reinforced concrete.

3.1.1 Planning methods

To avoid potential differences, the following system components must be connected, via the main earthing basbar, with equipotential bonding cables in accordance with IEC 60364-5-54 (VDE 0100-540):

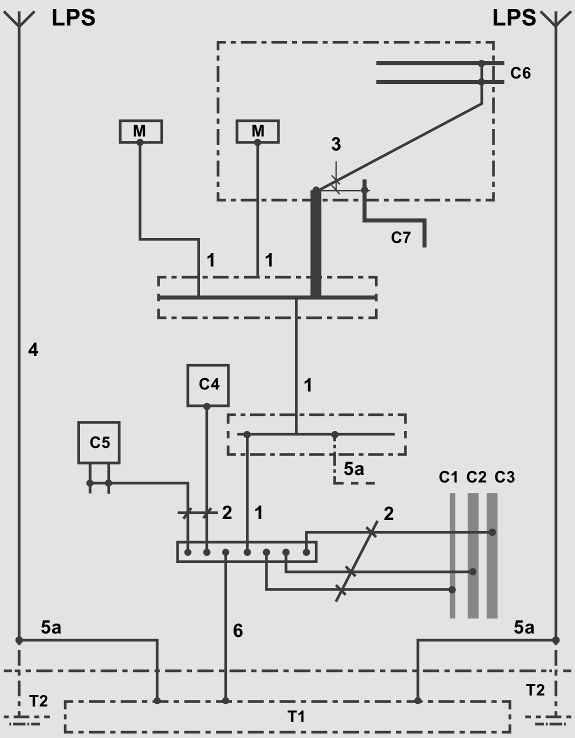
- Electrically conductive pipelines
- Other conductive components
- Protective conductors
- Functional earth electrodes

The main earthing busbar must be located in the main connection area or close to the building connections. In each building, the earthing cable and the following conductive parts must be connected to the protective equipotential bonding via the main earthing busbar:

- Metal pipes of supply systems
- Extraneous conductive parts of the building structure
- Metallic central heating and air-conditioning systems
- Protective conductors within the electrical system
- Metal reinforcements in building structures made from reinforced concrete

The protective equipotential bonding cables must meet the requirements of IEC 60364-441/ IEC 60364-5-54 (DIN VDE 0100-410/- 540). In the lightning protection equipotential bonding, the cables of the equipotential bonding must be dimensioned for higher currents. Cross-sections must be designed according to IEC 62305 (VDE 0185-305).

Requirements to be met by equipotential bonding: Must be possible to isolate conductors Reliable connection Can only be undone with tools



M	Bodies (electrical equipment)
C	Extraneous conductive part
B	Main earthing busbar
T1	Foundation earth electrodes
T2	Earth electrodes for lightning protection
LPS	Lightning protection system
1	Protective conductors (PE)
2	Protective equipotential bonding cable for connection with the main earthing busbar
3	Protective equipotential bonding cable (for the additional protective equipotential bonding)
4	Lightning protection down-conductor
5	Earthing conductor
5a	Functional earthing conductors for lightning protection
C4	Air-conditioning system
C5	Heating
C6/C7	Metal (waste/drinking) water pipes in a bathroom

Figure 3.2: Equipotential bonding system in a building

Equipotential bonding according to IEC 60364-4-41 and IEC 60364-5-54 (DIN VDE 0100-410/-540)
Protective conductors must be protected in a suitable manner against mechanical damage, chemical or electrochemical destruction as well as against electrodynamic and thermodynamic forces. Switching devices must not be inserted into the protective conductor. Connections for testing purposes are permitted.

Material	Cross-section of cables connecting the internal metallic installations with the equipotential busbar
Copper	6 mm²
Aluminium	10 mm²
Steel	16 mm²

Table 3.1 Minimum dimensions of cables

Minimum cross-sections according to IEC 62305-3 (VDE 0185-305-3) for lightning protection equipotential bonding

Material	Cross-section of cables connecting different equipotential bonding rails with one another or with the earthing system
Copper	16 mm²
Aluminium	25 mm²
Steel	50 mm²

Table 3.2: Minimum dimensions of cables, protection class I to IV

3.1.2 Versions
Each system has different environmental and normative requirements relating to equipotential bonding. To implement equipotential bonding correctly, it is therefore necessary to select the right components to use. Equipotential bonding rails and earthing clips are key components of this kind of installation. In the context of lightning protection equipotential bonding, these must fulfil the requirements and undergo tests as defined in IEC 62561-1 (VDE 0185-561-1).

Figure 3.3: OBO "BigBar" equipotential bonding rail for industrial applications

Figure 3.5: Equipotential bonding rail 1809

Figure 3.4: OBO 927 strip earthing clip

Figure 3.6: Equipotential bonding rail 1801

3.1.2.1 Industrial applications

In an industrial environment, it is particularly important that the products used are thermally and mechanically stable. The OBO type 1802 "BigBar" equipotential bonding rail can be used without problems in these situations as a main earthing or equipotential bonding rail.

OBO 1802 "BigBar": (Figure 3.3)

- Tested with 100 kA (10/350) as per IEC 62561-1 (VDE 0185-561-1)
- Can be used indoors and outdoors
- Stainless steel and copper versions available
- 5–20 pin versions available
- Quick mounting with carriage bolts

When connecting metallic pipes to the equipotential bonding, strip earthing clips such as OBO type 927 **(Figure 3.4)** are generally used. These offer a wide range of advantages over pipe clamps during assembly. With their rustproof stainless steel tightening strap, they are suitable for a wide range of pipe diameters and materials.

3.1.2.2 Residential and office buildings

Even though the environmental conditions in residential buildings and office buildings are less challenging, here, too, it is necessary to ensure that no dangerous touch voltages can occur. Equipotential bonding rails types 1801 and 1809 **(Figures 3.5 and 3.6)** meet all requirements for main earthing rails or equipotential bonding rails in these applications. They ensure secure contact for all standard cross-sections. For specialised applications, OBO offers its equipotential bonding system type 1809 NR, made from renewable raw materials with a lead-free contact strip.

Figure 3.7: PAS equipotential bonding rail for potentially explosive areas

Innovative. Unique. Patented.

3.1.2.3 Explosive areas

Systems in potentially explosive areas require equipotential bonding according to IEC 60079-14 (VDE 0165-1). All the bodies of electrically conductive parts must be connected to the equipotential bonding system. Secure equipotential bonding connections against self-loosening according to IEC 60079-14 (VDE 0165-1) and the Technical Rules for Operating Safety (TRBS) 2152 Part 3.

According to TRBS 2152 Part 3 and IEC 62305-3 (VDE 0185-305-3), the arresting paths of the lightning must be created in such a way that heating or ignitible sparks or spray sparks cannot become the ignition source of the potentially explosive atmosphere.

Potentially explosive areas ATEX zones 1/ 21 and 2/ 22

The unique EX PAS equipotential bonding rail **(Figure 3.7)** (equipotential bonding rail for potentially explosive areas) is used for lightning protection equipotential bonding according to IEC 62305-3 (VDE 0185-305-3) and protective/functional equipotential bonding according to DIN VDE 0100 Part 410/540. Thanks to its patented design, the equipotential bonding rail can be used for installation according to IEC 60079-14 (VDE 0165 Part 1) and IEC 62305-3 (VDE 0185-305-3) in the Ex zones 1/21 and Ex zones 2/22.

The lack of ignition sparks in an explosive atmosphere has been tested on the basis of IEC 62561-1 (VDE 0185-561-1) according to explosion group IIC and can thus also be used for the explosion group IIA and IIB. The EX PAS equipotential bonding rails do not have their own potential ignition source and are thus not subject to the European Directive 94/9/EC. It is confirmed that the EX PAS type equipotential bonding rails are suitable for use in potentially explosive areas of Zone 1/2 (gases, vapours, mist) as well as Zone 21/22 (dusts).

The EX PAS (equipotential bonding rail for potentially explosive areas) offers the following advantages:

- Free of ignition sparks
- Tested by independent testing body up to 75 kA
- Explosion groups IIC, IIB and IIA

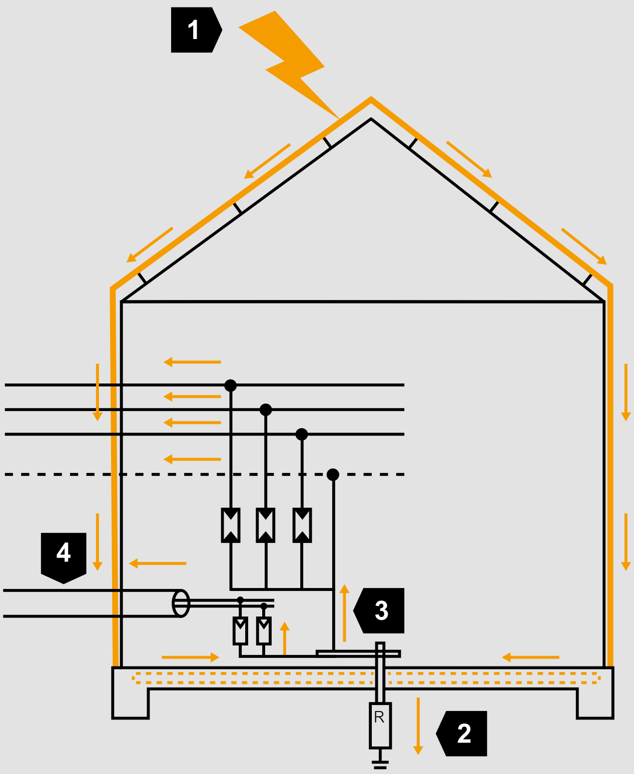
3.2 Surge protection system for energy systems

Very large surge voltages are caused mainly by lightning strikes on or close to energy systems. Even from several hundred metres away, lightning currents can also cause impermissible surge voltages in conductor loops, through either capacitive, inductive or galvanic coupling. Large surge voltages are coupled over a radius of up to 2 km. Switching operations involving inductive loads create dangerous surge voltages in the medium and low-voltage power networks. For further information on types of damage (S1–S4) see chapter 1.3 (starts p. 15).

3.2.1 Lightning discharges (LEMP: Lightning Electro Magnetic Impulse)

The international lightning protection standard IEC 62305 describes how direct lightning strikes of up to 200 kA are safely arrested. The current is coupled into the earthing system and, due to the voltage drop at the earthing resistor, half of the lightning current is coupled into the internal installation. The partial lightning current then divides itself among the power lines entering the building (number of cores of power line entering building), while around 5% enters data cables.

The voltage drop at the earthing resistor is calculated from the product of the partial lightning current (i) and the earthing resistance (R). This is then the potential difference between the local earth (equipotential bonding) and the live cables, which are earthed some distance away.



The biggest surge voltages are caused by lightning strikes. According to IEC 62305 (VDE 018 305), lightning strikes are simulate with lightning surge currents of up 200 kA (10/350 µs).

1	Lightning strike	100%	I_{imp} = max 200 kA (IEC 62305)
2	Earthing system	~ 50%	I = 100 kA (50%)
3	Electrical installation	~ 50%	I = 100 kA (50%)
4	Data cable	~ 5%	I= 5 kA (5%)

Figure 3.8: Typical distribution of lightning current

Example split between earth/installation: 50% - 50%

i = 50 kA; R=1 Ohm
U = i x R=50,000 A x 1 Ohm=50,000 V

U	Surge voltage
i	Surge current
R	Earthing resistance

The voltage resistance of the components is exceeded and uncontrolled arcing occurs. Only surge arresters can safely arrest these dangerous voltages.

3.2.1.1 Switching operations (SEMP: Switching electromagnetic pulse)

Switching operations occur due to the switching of large inductive and capacitive loads, short circuits, and interruptions to the power system. They are the most common cause of surge voltages. These surge voltages simulate surge currents of up to 40 kA (8/20 µs). Sources include e.g. motors, ballasts and industrial loads.

3.2.1.2 Electrostatic discharge (ESD)

Electrostatic discharges are caused by friction. When a person walks on a carpet, charge separation occurs – in this instance it is however harmless to humans. However, it can interfere with and destroy electronic components. Equipotential bonding is necessary here to avoid this charge separation.

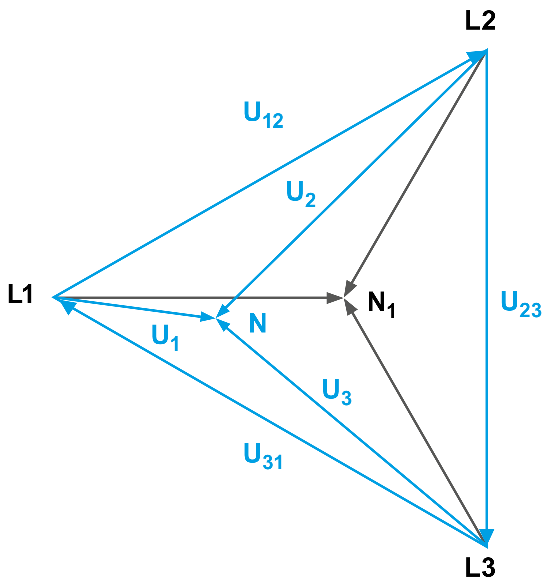
3.2.2 Types of surge voltage

3.2.2.1 Transient surges

Transient surges are short-lived surge voltages lasting for a matter of microseconds. Lightning and switching operations generate large transient surges that can be prevented with surge protection devices.

3.2.2.2 Temporary and permanent surge voltages

Temporary, or transient, surge voltages occur due to faults in the mains power supply. For example, a break in a neutral cable can generate an impermissible increase in voltage in the three-phase power system. The voltage exceeds the maximum permissible nominal voltage and electronic devices are damaged – surge protection devices cannot protect against these long-lasting mains frequencies. Mains frequency faults of this kind can last for between everal seconds and several hours.



U1	Between phase (L1) and neutral conductor (N)
U2	Between phase (L2) and neutral conductor (N)
U3	Between phase (L3) and neutral conductor (N)
U12	Between phase (L1) and phase (L2)
U23	Between phase (L2) and phase (L3)
U31	Between phase (L3) and phase (L1)

Figure 3.9: Effect of a break in a neutral wire: neutral point displacement in case of asymmetry

3.2.3 Planning methods

Part 4 of the lightning protection standard IEC 62305 (VDE 0185-305) describes how to protect electrical and electronic systems. The safety and installation standards IEC 60364 (VDE 0100) additionally stipulate that surge voltage protection measures are required as an important protective measure in low-voltage systems.

3.2.3.1 Lightning protection zone concept

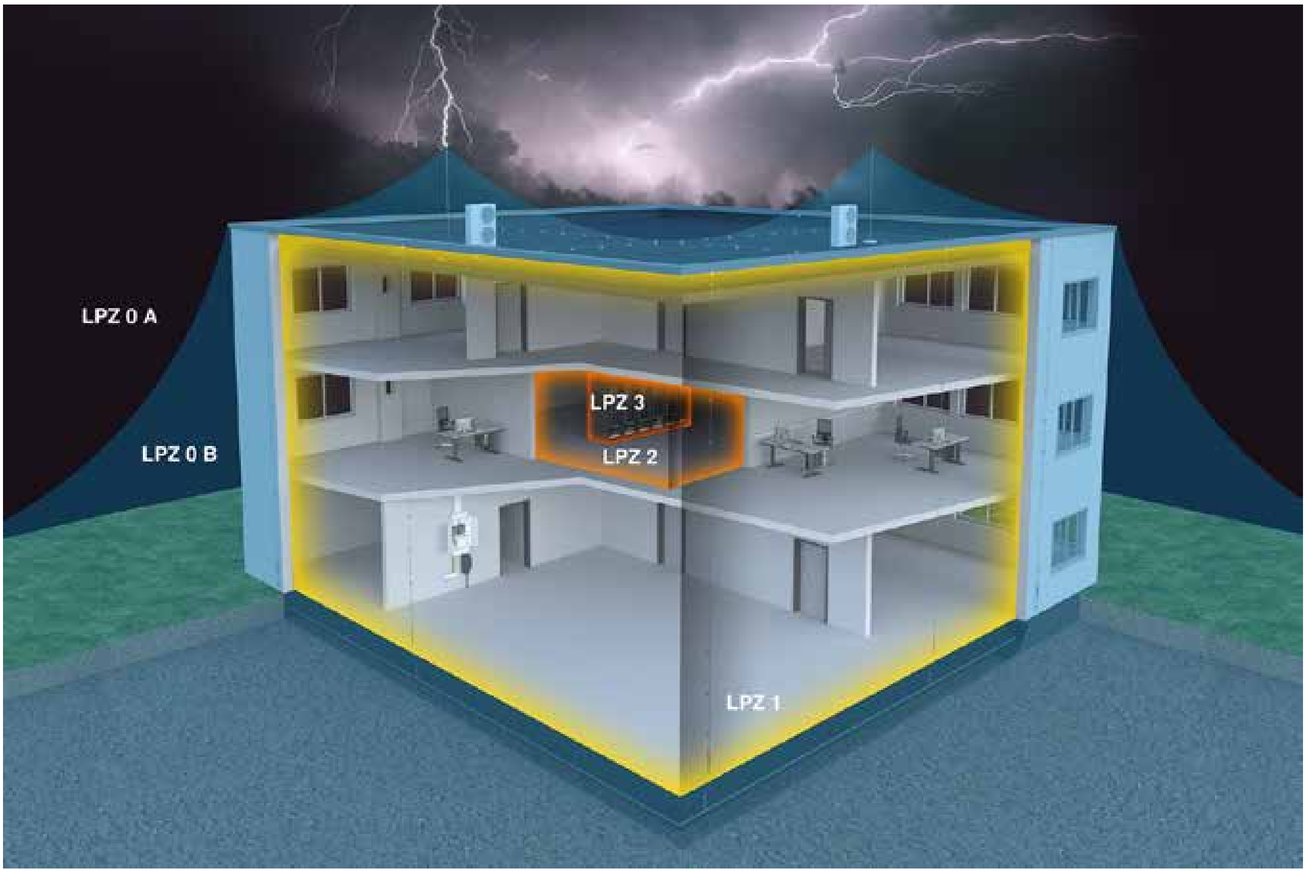
The lightning protection zone (LPZ) concept described in international standard IEC 62305-4 (VDE 0185-305-4) has proved to be practical and efficient. The lightning protection zone concept is based on the principle of gradually reducing surges to a safe level before they reach terminal devices and cause damage. In order to achieve this situation, a building's entire energy network is split into lightning protection zones.

A zone is an area or building section in which all equipment requires the same level of protection. Equipotential bonding is created at each transition from one zone to another. Metal parts are connected directly to the equipotential bonding, while surge protection corresponding to the relevant requirements class (type 1, 2 or 3) is installed between the active conductors and the earth potential.

Advantages of the lightning protection zone concept

- Minimises coupling of surge voltages into other cable systems by arresting the energy-rich, dangerous lightning currents directly at the building entry point and at the cable's point of transition between zones.

- Local equipotential bonding within the protection zone.
- Reduction of malfunctions due to magnetic fields.
- Economical, conveniently plannable, flexible protection concept for new and old buildings and conversions.



LPZ 0 A		Unprotected zone outside the building. Direct lightning strike, no shielding against electromagnetic interference pulses LEMP (Lightning Electromagnetic Pulse)
LPZ 0 B		Zone protected by external lightning protection system. No shielding against LEMP
LPZ 1		Zone inside the building. Low partial lightning energies possible
LPZ 2		Zone inside the building. Low surges possible
LPZ 3		Zone inside the building (can also be the metal housing of a consumer) No interference pulses through LEMP or surges

Figure 3.10: Division of the building into lightning protection zones (LPZ)

3.2.3.1.1 Type classes of surge protection devices

In accordance with IEC 61643-11 (VDE 0675-6-11), OBO SPDs (surge protection devices) are divided into three type classes – type 1, type 2 and type 3 (classes I, II and III). These standards contain regulations, requirements and tests for surge protection devices used in AC networks with nominal voltages of up to 1,000 V AC and nominal frequencies of between 50 and 60 Hz.

T1

Lightning current arrester type 1

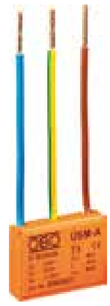
Lightning arresters of type 1/class I are used at the entry to the building. The connection is effected parallel to the external lines of the energy network. The direct lightning strike is simulated with test impulses of up to 100 kA with the pulse shape 10/350 µs. The protection level must lie below 4,000 V. Following consultation with the local energy provider and in accordance with the VDN Directive, use before the main meter device is also possible.

T2

Surge arrester type 2

Surge arresters of type 2/class II are used in main and sub-distributors. The protection devices must be used before a residual current protective device (RCD), as it would otherwise interpret the surge current as a residual current and interrupt the power circuit. The surge voltages are simulated with test impulses, typically of 20 kV with the pulse shape 8/20 µs. To protect sensitive controllers, the protection level must be below 1,500 V.

T3



Surge arrester, type 3

Type 3/class III surge arresters are used to protect against inductive coupling and switching surges in the device power circuits. These surge voltages occur primarily between the phase (L) and the neutral cable (N). The Y circuit protects the L and N lines with varistor circuits and makes the connection to the PE line through a spark gap. Thanks to this protection circuit, transverse voltages are arrested without the residual current device (RCD) interpreting the surge current as a residual current and interrupting the power circuit. The surge voltages are simulated with hybrid test impulses of up to 20 kV and 10 kA with the pulse shape 1.2/50 µs and 8/20 µs. To protect sensitive controllers, the protection level must be below 1,500 V. A surge voltage protection concept must take account of all electrically conductive connections and must be structured in levels. Each protection level builds on the one before it and reduces the energy content of the surge.

3.2.3.1.2 Choosing the right surge protection devices

The classification of surge protection devices into types means they can be matched to different requirements with regard to location, protection level and current-carrying capacity. Table 3.3 below provides an overview of the zone transitions. It also shows which OBO surge protection devices can be installed in the energy supply network and their respective function.

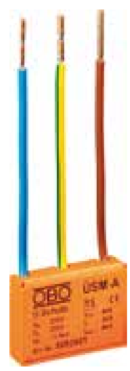
Zone transition	Protection device and device type	Product example	Product figure
LPZ 0 B to LPZ 1	Protection device for lightning protection equipotential bonding in accordance with IEC 62305 (VDE 0185-305) for direct or close lightning strikes. Devices: Type 1 (class I), e.g. MCD50-B Max. protection level according to standard: 4 kV OBO protection level: < 1.3 kV Installation, e.g. in the main distributor box/at entry to building	MCD Item no.: 5096 87 9	T1 
LPZ 1 to LPZ 2	Protection device for lightning protection equipotential bonding in accordance with IEC 62305 (VDE 0185-305) for direct or close lightning strikes. Devices: Type 2 (class II), e.g. V20 Max. protection level according to standard: 1.5 kV OBO protection level: < 1.3 kV Installation, e.g. in the main distributor box/at entry to building	V20 Item no.: 5095 25 3	T2 
LPZ 2 to LPZ 3	Protection device, designed for surge protection of portable consumers at sockets and power supplies. Devices: Type 3 (class III), e.g. ÜSM-A Max. protection level according to standard: 1.5 kV OBO protection level: < 1.3 kV Installation, e.g. at end consumer	ÜSM-A Item no.: 5092 45 1	T3 

Table 3.3: Zone transitions (LPZ = lightning protection zone)

3.2.3.2 Protection devices in various power supply systems

4-wire networks, TN-C network system

In the TN-C network system, the electrical unit is supplied through the three external lines (L1, L2, L3) and the combined PEN line. Usage is described in IEC 60364-5-53 (VDE 0100-534). **(Figure 3.11)**

Lightning current arrester type 1

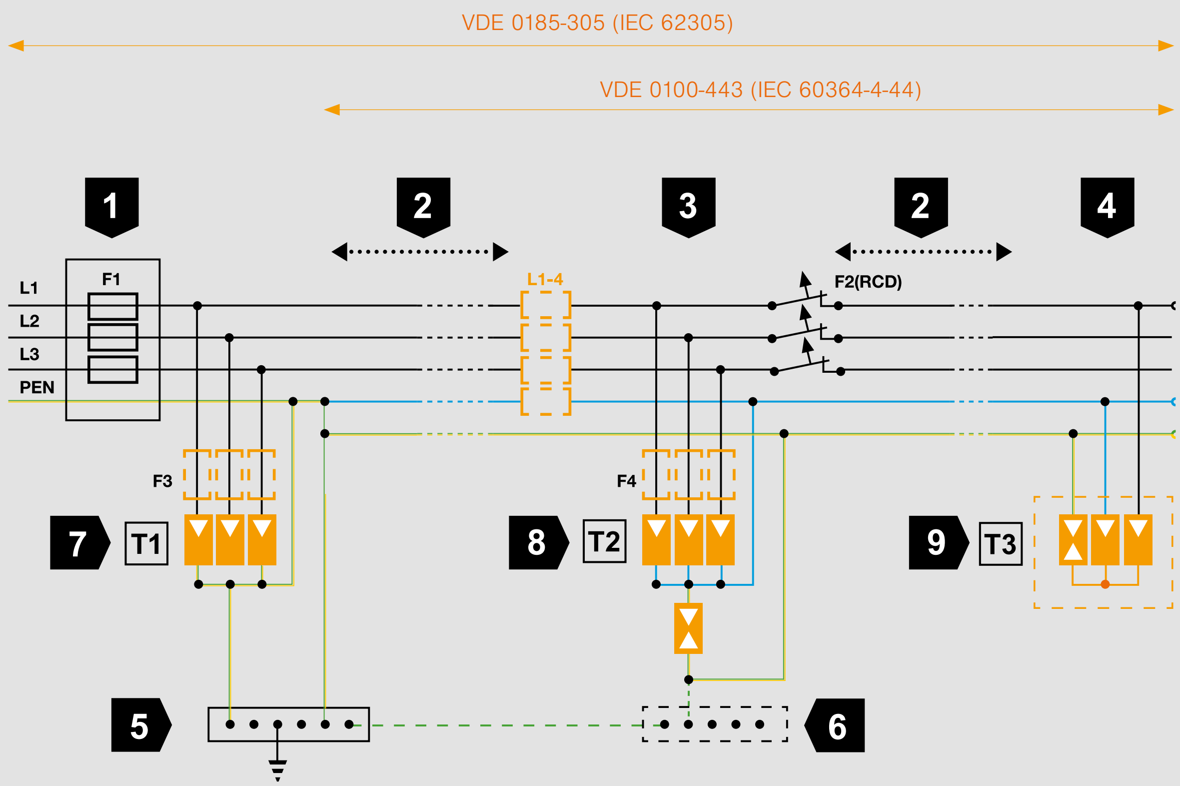
Type 1 lightning current arresters and combination arresters are used in the 3-pin circuit (e.g.: 3 x MCD 50-B).

Surge arrester type 2

Surge arresters type 2 are used in the 3+1 circuit (e.g. V20 3+NPE). With the 3+1 circuit, the external lines (L1, L2, L3) are connected to the neutral cable (N) via arresters. The neutral cable (N) is connected to the protective earth via a collective spark gap.

Surge arrester type 3

Surge arresters type 3 are used in the device power circuits. A Y circuit protects the L and N lines with varistor circuits and makes the connection to the PE line through a collective spark gap (e.g.: ÜSM-A).

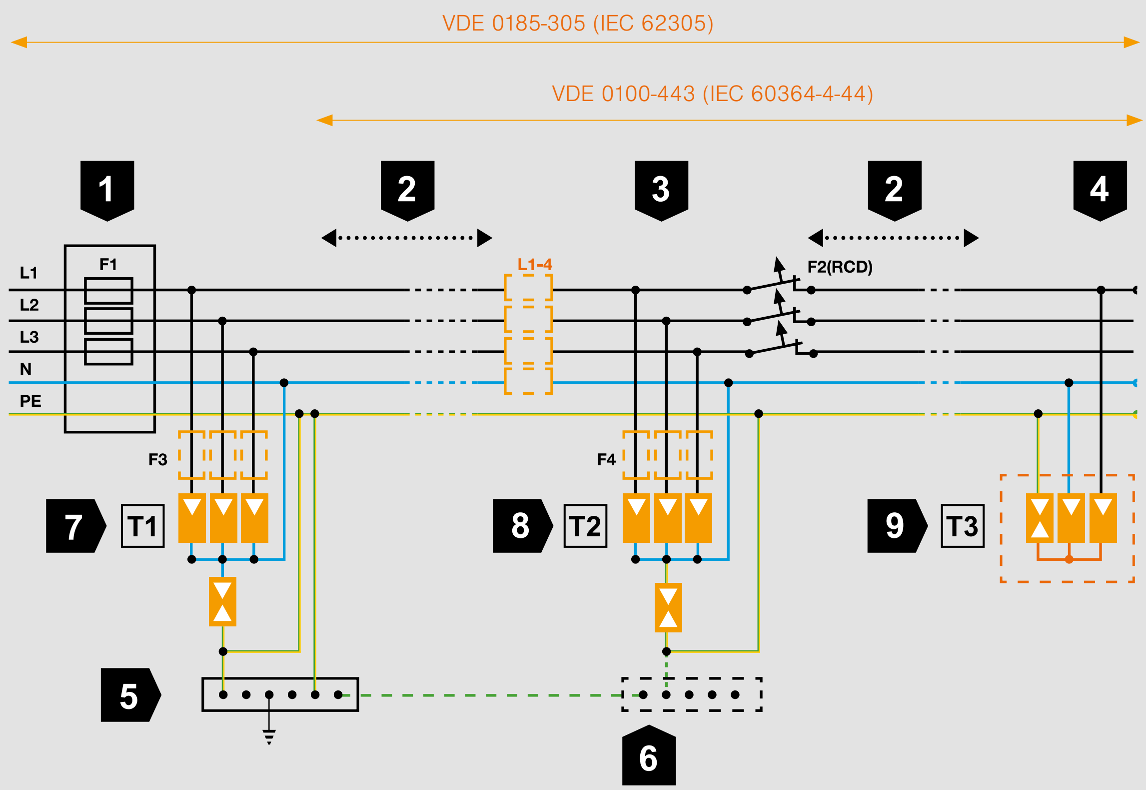


1	System fuse F1
2	Cable length between arresters
3	Circuit distribution board, e.g. sub-distributor
4	Final circuit
5	Main earthing rail (MER)
6	Local equipotential bonding rail (PAS)
7	Type 1 (class I) surge arrester
8	Type 2 (class II) surge arrester
9	Type 3 (class III) surge arrester

Figure 3.11: 4-wire networks, TN-C network system and scope of standards

5-wire networks, TN-S and TT network system

In the TN-S network system, the electrical unit is supplied through the three external lines (L1, L2, L3), the neutral cable (N) and the earth cable (PE). In the TT network, however, the electrical unit is supplied through the three external lines (L1, L2, L3), the neutral cable (N) and the earth cable (PE). Usage is described in IEC 61643-11 (VDE 0100-534).



1	System fuse F1
2	Cable length between arresters
3	Circuit distribution board, e.g. sub-distributor
4	Final circuit
5	Main earthing rail (MEB)

6	Local equipotential bonding rail (PAS)
7	Type 1 (class I) lightning arrester
8	Type 2 (class II) surge arrester
9	Type 3 (class III) surge arrester

Figure 3.12: 5-wire networks, TN-S and TT network system

Advantages of the 3+1 circuit:
- *Universally suitable for TN and TT networks*
- *Insulating spark gap between neutral line (N) and earth (PE)*
- *Low protection level between phase (L) and neutral line (N)*

Lightning current arrester type 1
Type 1 lightning arresters are used in the 3+1 circuit (e.g.: 3 x MC 50-B and one MC 125-B NPE). With the 3+1 circuit, the external lines (L1, L2, L3) are connected to the neutral cable (N) via arresters. The neutral cable (N) is connected to the protective earth via a collective spark gap. Following consultation with the local energy provider and in accordance with the VDN Directive, use before the main meter device is also possible.

Surge arrester type 2
Surge arresters type 2 are used in the 3+1 circuit (e.g. V20 - 3+NPE). With the 3+1 circuit, the external lines (L1, L2, L3) are connected to the neutral cable (N) via arresters.
The neutral cable (N) is connected to the protective earth via a collective spark gap. The arresters must be used before a residual current protective device (RCD), as it would otherwise interpret the surge current as a residual current and interrupt the power circuit.

Surge arrester type 3
Surge arresters type 3 are used to protect against surges in the device power circuits. These transverse surges occur primarily between L and N. A Y circuit protects the L and N lines with varistor circuits and makes the connection to the PE line through a collective spark gap (e.g.: ÜSM-A). This protection circuit between L and N prevents surge currents from transverse voltages being conducted towards PE, the RCD thus interprets no residual current. You can find the relevant technical data on the product pages.

3.2.3.3 Selection criteria (voltage resistance of devices – protection levels) – Selection aid

The rated surge voltage resistance against transient surges is defined according to the installation standard IEC 60664 (VDE 0110) for the various installation locations. The voltage resistance of the devices must be coordinated with the protection levels of the lightning and surge protection devices. Coordination of insulation should take place according to EN 60664 (VDE 0110).

Nominal voltage of power supply system **1** (mains) according to IEC 60038 **3**		Voltage between phase and neutral wire derived from the nominal AC or nominal DC voltage up to and including V	Rated surge voltage **2** V			
			Surge voltage category **4**			
Three-phase	Single-phase		I	II	III	IV
	120/240	50	330	500	800	1,500
		100	500	800	1,500	2,500
		150	800	1,500	2,500	4,000
230/400 277/480		300	1,500	2,500	4,000	6,000
400/690		600	2,500	4,000	6,000	8,000
1,000		1,000	4,000	6,000	8,000	12 000

1 For application to different low-voltage networks and their nominal voltages see Annex B
2 Equipment with this rated surge voltage may be used in systems in accordance with IEC 60364-4-443.
3 The slash ("/") indicates a three-phase, 4-wire system. The lower value represents the voltage between the phase and the neutral conductor while the higher value is the voltage between phases. Where only one value is given, it relates to three-phase, 3-wire systems and describes the voltage between phases.
4 For more information on the surge voltage categories see 2.2.2.1.1.

Table 3.4: Rated surge voltage for equipment in accordance with installation standard IEC 60664 (VDE 0110)

The rated surge voltage depends on the surge voltage category. In surge voltage category I, for example, for a single-phase connection to a 230 V AC network, the minimum rated surge voltage is 1.5 kV. A surge voltage arrester must limit the voltage to this or a smaller value.
The protection level of a surge voltage arrester is the maximum voltage when the nominal surge current is applied to it. If the actual surge current is smaller than the nominal surge current, the response voltage and hence also the protection level drops.

Required protection level for 230/400 V equipment in accordance with IEC 60364-4-443 (VDE 0100-443)

1	Resource at the feed-in point of the system
2	Resource as a part of the fixed installation
3	Resource for connection to the fixed installation
4	Resource requiring special protection
5	Installation location, e.g. main distributor
6	Installation location, e.g. sub-distributor
7	Installation location, e.g. devices
8	Specification (green line)
9	OBO protection devices (orange line)

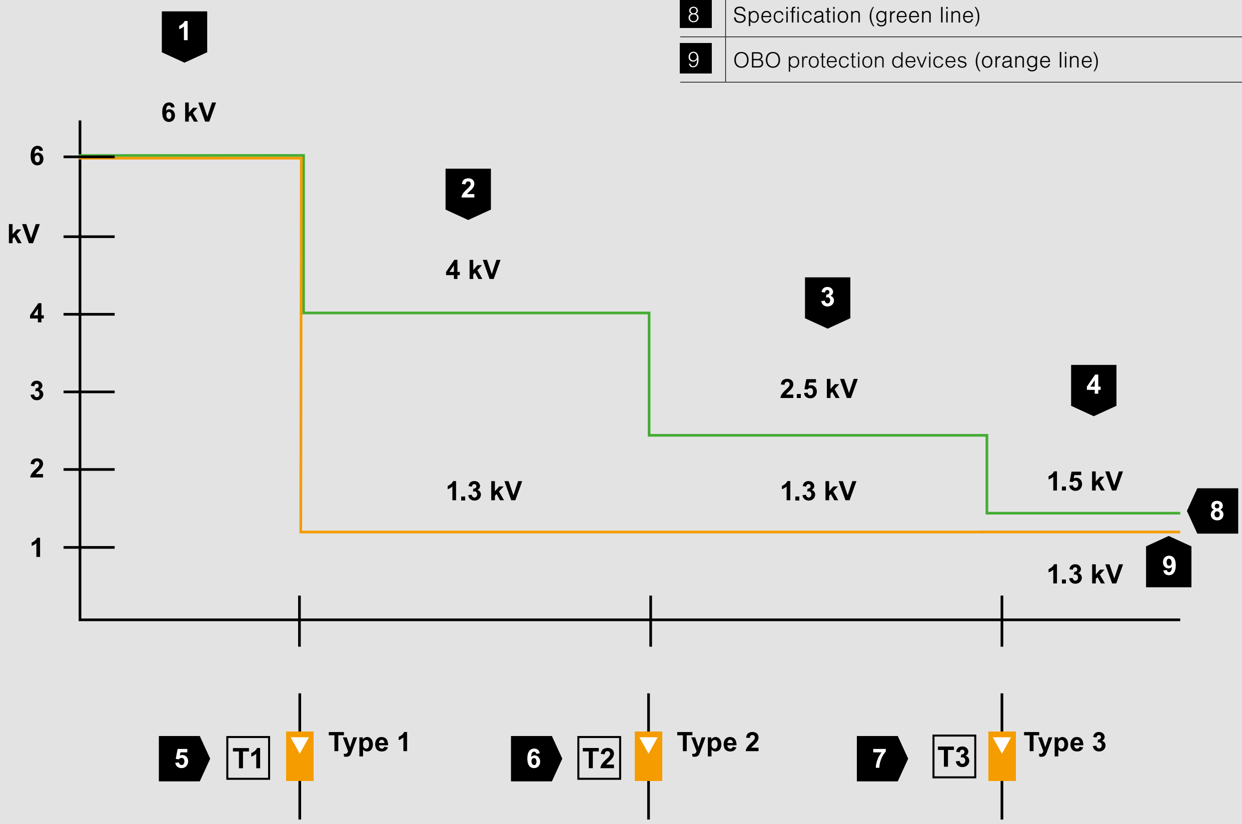


Figure 3.13: Coordination of insulation as per EN 60664-1 (VDE 0110-1)

3.2.3.4 Installation requirements

The installation standard for surge protection devices, IEC 60364-5-53 (VDE 0100-534), covers protection against surge voltages resulting from indirect and remote lightning strikes and switching operations. Surge protection devices can also be known as "surge protective devices" and "devices for protection against overvoltages". The standard offers help in selecting and installing surge protection devices in order to reduce downtime in low-voltage systems.
In buildings with an external lightning protection system as per IEC 62305 (VDE 0185-305), type 1 surge protection devices must be used to connect the supply lines routed in from outside the building to the lightning protection equipotential bonding at the transitions between lightning protection zones 0 and 1.

For buildings without lightning protection systems, IEC 60364-4-43 (VDE 0100-443) describes when and how surge protection devices should be used.

3.2.3.4.1 Minimum cross-sections for lightning protection equipotential bonding

The length of the connection cable for surge protection devices is a significant aspect of the installation standard IEC 60364-5-53 (VDE 0100-534).
To ensure adequate protection of systems and devices, the maximum surge voltage that can occur must be smaller than or equal to the surge voltage resistance of the devices to be protected. The sum of the protection level of the surge protection devices and the voltage drop on the supply lines must remain below the voltage resistance.
To minimise the voltage drop on the supply line, the length, and hence inductance, of the cable must be kept as low as possible. IEC 60364-5-53 (VDE 0100-534) recommends a total length for the connection cable to the surge protection device of less than 0.5 m and certainly no more than 1 m.

The following minimum cross-sections must be observed for lightning protection equipotential bonding: for copper 16 mm^2, for aluminium 25 mm^2 and for iron 50 mm^2. At the lightning protection zone, transition from LPZ 0B to LPZ 1, all metal installations must be integrated into the equipotential bonding system. Active lines must be earthed using suitable surge arresters.

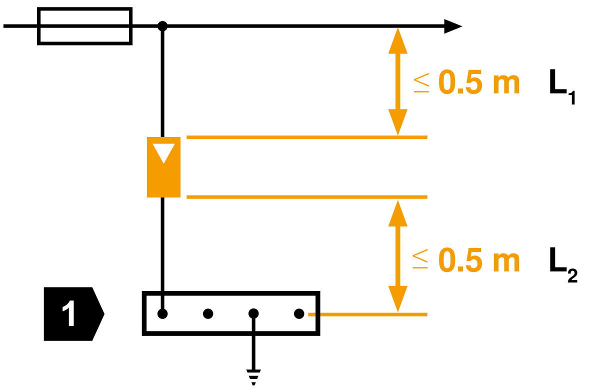


Figure 3.14: Maximum length of supply line as per IEC 60364-5-53 (VDE 0100-534)

1	Main earthing busbar or protective conductor rail
L_1	Supply line to protection device
L_2	Connection between protection device and equipotential bonding

3.2.3.4.2 Connection length, alternative V wiring and cross-sections

If the surge protection device is tripped by a surge voltage, the supply lines, fuse and protection device conduct surge current. This produces a voltage drop at the impedances of the lines. The ohmic component is negligible compared to the inductive component.

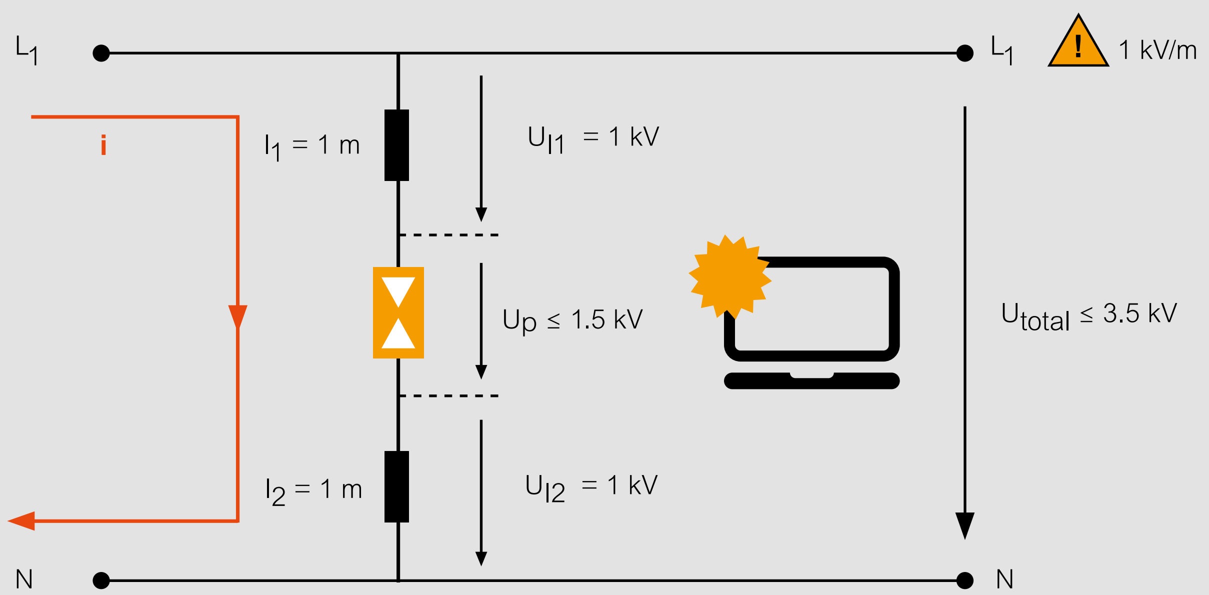
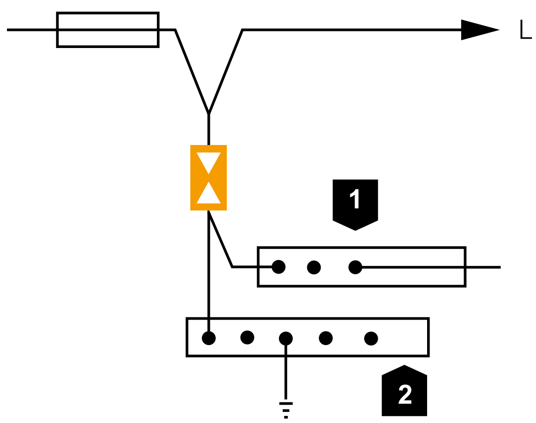


Figure 3.15: Voltage drop on the supply line when surge current is applied (i = lightning current, U_{total} = surge voltage at protection device)

Account must be taken of the lengths of the connection cables. Due to the inductance (L), rapid increases in current (100–200 kA/µs) result in large voltage increases.
Assumption: 1 kV per m

For the dynamic voltage drop (U_{dyn}) the following equation applies:
U_{dyn} = i x R + (di/dt) L
U_{dyn} = 10 kA x 0.01 Ohm + (10 kA / 8 µs) x 1 µH
U_{dyn} = 100 V + 1,250 V = 1,350 V

U_{dyn}	Voltage drop on the cable
i	Surge current
R	Ohmic line resistance
di/dt	Δ current change / Δ time
L	Inductance of cable (assumption: 1µ H/m)



1	Protective rail
2	Main equipotential bonding rail

Figure 3.16: V wiring

The dynamic voltage drop (U_{dyn}) is calculated on the basis of the product of the inductive component and the change in current over time (di/dt). These transient surges are several 10 kA high.

V wiring
Surge protection devices can alternatively be connected in a V shape. In this case no separate branch conductors are used for connecting the protection devices.

The connection cable to the protection device is crucial for achieving an optimum protection level. In accordance with IEC installation directives, the length of the branch line to the arrester and the length of the line from the protection device to the equipotential bonding should in each case be less than 0.5 m. If the cables are longer than 0.5 m, V wiring must be selected.

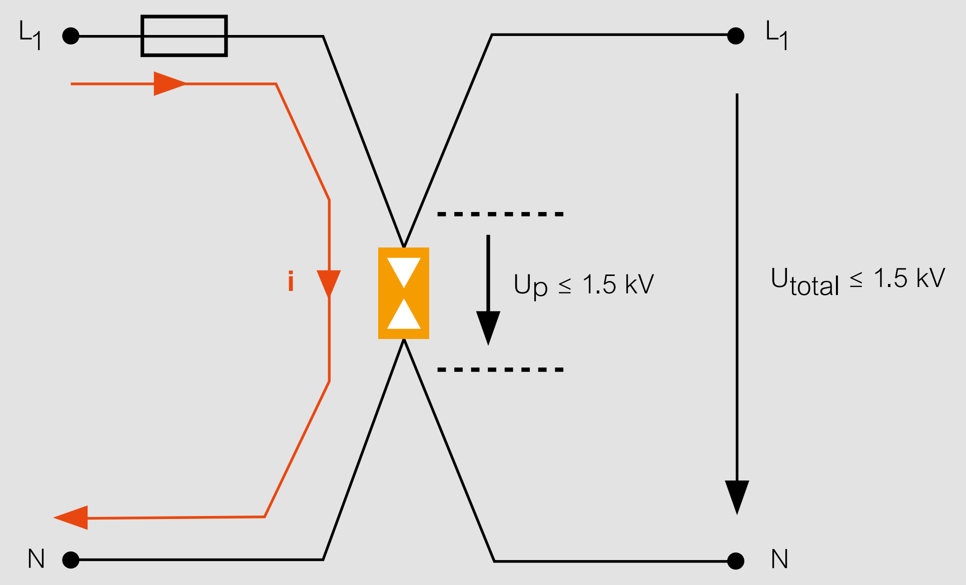
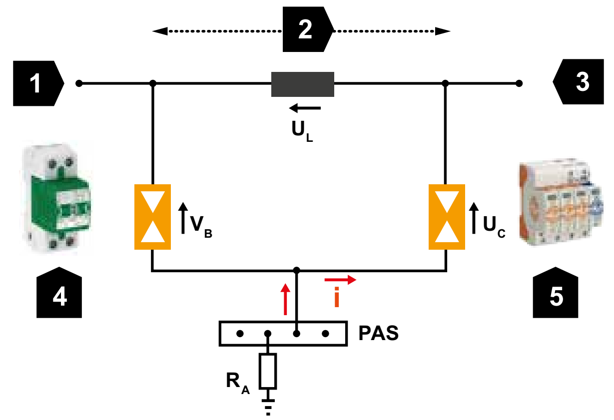


Figure 3.17: V wiring on a surge arrester according to VDE 0100-534 (IEC 60634-5-53)
(i = lightning current | U_{total} = surge voltage at protection device)



1	Power supply
2	Cable length
3	Consumer load
4	Lightning current arrester MC 50-B with response voltage 2 kV
5	Surge arrester V20 with response voltage 1.3 kV

Figure 3.18: Coordinated use of protection devices

Lightning current and surge arresters perform a number of functions. T2 surge arresters based on varistors respond and limit dangerous surge voltages very quickly, whereas T1 lightning current arresters can additionally withstand the very strongest lightning currents (including currents from direct strikes) and arrest them without being destroyed. These arresters must be used in coordination. This coordination is guaranteed by the existing line length or special lightning current arresters (MCD series). For example, in the protection set, type 1 and type 2 arresters (Classes B and C) can be used adjacent to each other.

Example
1. Cable length > 5 m
No additional decoupling required

2. Cable length < 5 m
Use decoupling: MC 50-B VDE +
LC 63 + V20-C

Alternatively
MCD 50-B + V20-C
No additional decoupling required
(e.g. protection set)

Material	Cross-section of cables connecting different equipotential bonding rails together or with the earthing system	Cross-section of cables connecting the internal metallic installations with the equipotential bonding rail
Copper	16 mm²	6 mm²
Aluminium	25 mm²	10 mm²
Steel	50 mm²	16 mm²

Table 3.5: Minimum dimensions of equipotential bonding cables, protection class I to IV

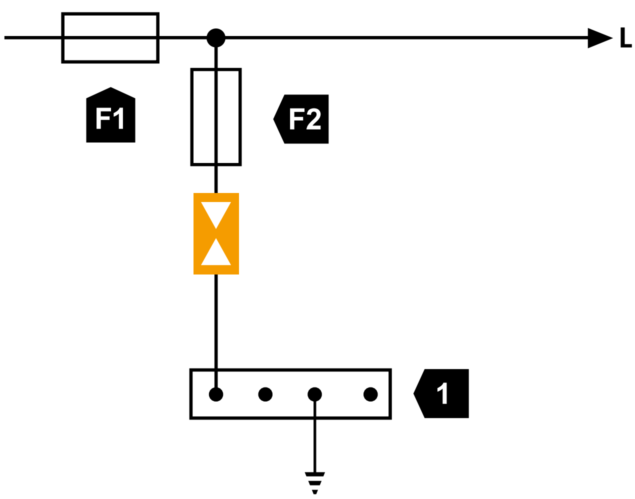
Cross-sections

According to IEC 60364-5-53 (VDE 0100-534), type 1 or 1+2 lightning arresters with a cross-section of at least 16 mm² of copper capable of carrying lightning current are required. Type 2 surge protection devices with a minimum cross-section of 4 mm² copper, or the standard commercial minimum connection cross-section of 6 mm², must be connected. Account must additionally be taken of the maximum short-circuit currents occurring at the place of installation.

3.2.3.4.4 Back-up fuse

To provide protection in case of short circuits in surge protection devices, a back-up fuse (F2) is used. OBO specifies a maximum fuse rating for all devices. If an upstream fuse (F1) has a smaller or equal value than the maximum fuse current, a separate fuse/back-up fuse (F2) is however not needed before the surge protection device. If the rating of the system fuse (F1) is higher than the maximum fuse current, a fuse corresponding to the specified maximum fuse current must be fitted before the protection device. The rating of the fuse (F2) before the protection device should be as high as possible. The pulse resistance of a higher-rated fuse is greater than that of a lower-rated one.

Small fuses can be destroyed by high-energy surge currents.



1	Main earthing rail
F1	System fuse
F2	Back-up fuse

Figure 3.19: Back-up fuse on surge protection device

3.2.3.5 Protection circuit

Only an effective protection circuit providing uninterrupted surge protection can prevent dangerous potential differences in devices/systems. When implementing a surge protection concept it is necessary to obtain information on the devices and system components to be protected and, where possible, gather them into lightning protection zones (LPZs).

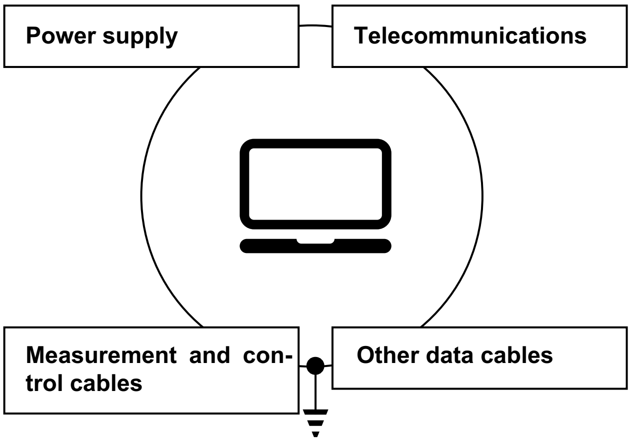


Figure 3.20: Protection circuit around an electronic device

Circuits that need to be incorporated into the equipotential bonding system:

- Power supply lines
- Network and data cables
- Telecommunications cables
- Antenna cables
- Control cables
- Metal pipes
  (e.g. water and drainage pipes)

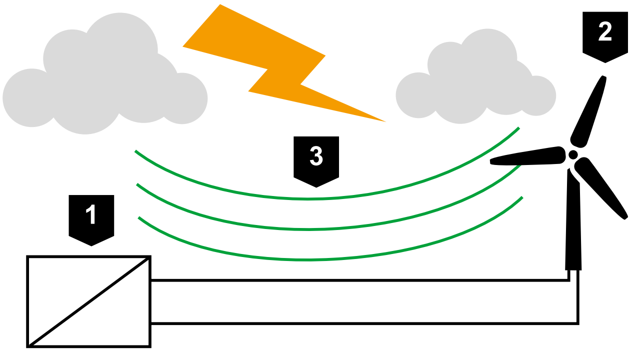
The cables must be incorporated into the local equipotential bonding system either directly or using suitable arresters. The best lightning and surge protection concept is useless unless every electrical and metal line entering the building or the protection circuit is included in the protection concept.

3.2.4 Versions

In building structures and electrical systems, measures for lightning and surge protection and e.g. structural fire safety must be taken into account and tailored to one another right from the planning stage. Requirements in laws such as the German state building regulations and the current standards must be observed. Suitable protection concepts must be agreed upon jointly by planners, lightning protection engineers, electricians and the operator/client. The stipulations of insurance companies and network operators should also be taken into account.

3.2.4.1 Installation with residual current devices (RCDs)

For a fraction of a second, surge protection devices generate all-pole equipotential bonding. To ensure maximum availability, surge arresters must fitted upstream of the RCDs. In this way the surge current is arrested to earth first, preventing accidental tripping of the RCD. According to IEC 60364-5-53 (VDE 0100-534), use upstream of an RCD in the TT network is only permitted in the case of the “3+1 circuit”. Here the three external conductors are connected to the neutral wire via the surge arresters and an insulating N-PE spark gap is used in the earthing line. If the surge arrester can only be fitted after the RCD, a surge-current-proof RCD must be used.



1	Substation/connection to grid
2	Wind power plant
3	Couplings due to lightning currents

Figure 3.21: Lightning and surge protection measures in wind power plants

Chapter 3.2.2.1 Wind power plants

According to IEC 62305, lightning discharges can produce surge currents of up to several hundred kA. The large impulse currents produced, with their rapid rise times, generate a magnetic field that changes over time and which spreads outwards concentrically from the lightning channel. This magnetic field can penetrate the conductor loops of power and IT systems within a wind power plant. The mutual inductances, M, that form, can induce large surge voltages which can disrupt or even destroy electronic components. This process is based on the law of induction and can be represented as follows:

M is the mutual inductance of the conductor loop. The larger the surface area, and the faster the rise time of the lightning current, the greater the coupled surge voltage will be.

$$u = M \times \frac{di}{dt}$$

M	Mutual inductance
di/dt	Current change/time

Protection measures in energy technology systems

A type 2 surge arrester is essential for protecting sensitive electronic components within the wind power plant. However, VDE 0100-534 states that certain technical requirements must be met for these arresters to be used; these are described in further detail below. A basic requirement of wind power plant operators is that the electronic supply system is executed in such a way as to comply at all times with EMC (electromagnetic compatibility) requirements so as to prevent interference currents on cable shields and PE. Different power networks and voltages can be encountered in wind power plants: 230/400 V and 400/690 V. Particularly in 400/690 V networks, special requirements relating to surge voltage protection must be observed.

Taking account of the sensors in wind power plants

The latest wind power plants use so-called pitch controls. Lightning and surge protection is required to protect the electronic controls and speed control against failure.

Recommended installation locations in wind power plants

Because the coupled surge voltage is always at both ends of the cable, each device inside the structure must be protected. Because, particularly in large wind power plants, long cable lengths with large surface areas are not uncommon, a surge protection device (SPD) should be fitted immediately before each of the sensitive devices within the bus. In areas of high humidity and low temperatures, the sensor can freeze which can impair the measurement signal. Most sensors used in locations of this kind are fitted with a heating system. These sensors need an SPD that is designed to withstand not just the measurement signal itself, but also large nominal load currents. OBO Bettermann offers a space-efficient solution: the MDP. Despite its small installation width, this high-performance surge arrester developed for use in wind power plants is suitable for large nominal load currents of up to 10 A. This enables it to protect even high-bandwidth sensors simply yet effectively.

3.2.4.2 Residential and industrial applications

Transient surges resulting from lightning strikes and switching operations cause the failure and destruction of electronic devices. Damage to terminal devices in homes and the failure of computer-controlled systems in everything from industry and commerce to agriculture, lead to downtimes, costly repairs or even the loss of important files such as documents, photographs and customer enquiries and orders. Surge protection measures should be taken for the following devices and systems **(Figure 3.22)**:

Antenna systems

- Cable connection
- Antennas
- E.g. TVs, videos and DVD recorders, stereos

Telephone systems

- Analogue
- ISDN NTBA
- IP telephony systems

Construction engineering/installations

- Heating controls
- Solar and photovoltaic systems
- Building automation

Terminal devices

- Computers
- Home appliances, burglar alarm systems, etc.

Using surge protection devices reduces downtimes.

3.2.4.3 PV systems (Figure 3.23)

Surge voltages can lead to the failure of PV systems and hence failure to achieve the expected yields. To prevent loss of investments, relevant insurance-related questions need to be considered. Only a protected system can withstand these loads and reliably produce electricity. Under VdS Directive 2010, property insurers require PV systems of 10 kWp or more to be fitted with lightning protection and internal surge voltage protection.

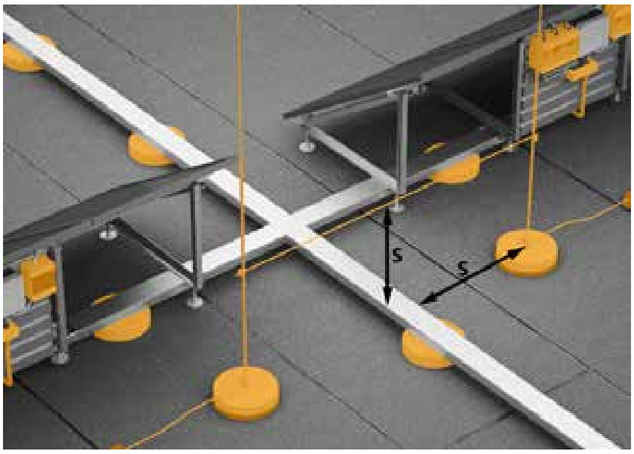


Figure 3.23: PV system in the protection area of the interception system situated at a separation distance of s

Figure 3.22: House with lightning protection system and internal lightning protection system

Avoiding shade from the lightning protection system

Shading (Figure 3.22)
The position of the interception masts or interception rods should be chosen so that there is no shading of the PV modules. A core shadow can cause performance reductions of the whole string. An interception rod must be at least 108 x diameter from the PV module (DIN EN 62305-3 Suppl. 5).

Diameter of the interception system (m)	Distance between the interception system and the PV module (m)
0.008	0.86
0.010	1.08
0.016	1.73

Table 3.6: Minimum distance from the interception systems, to avoid a core shadow

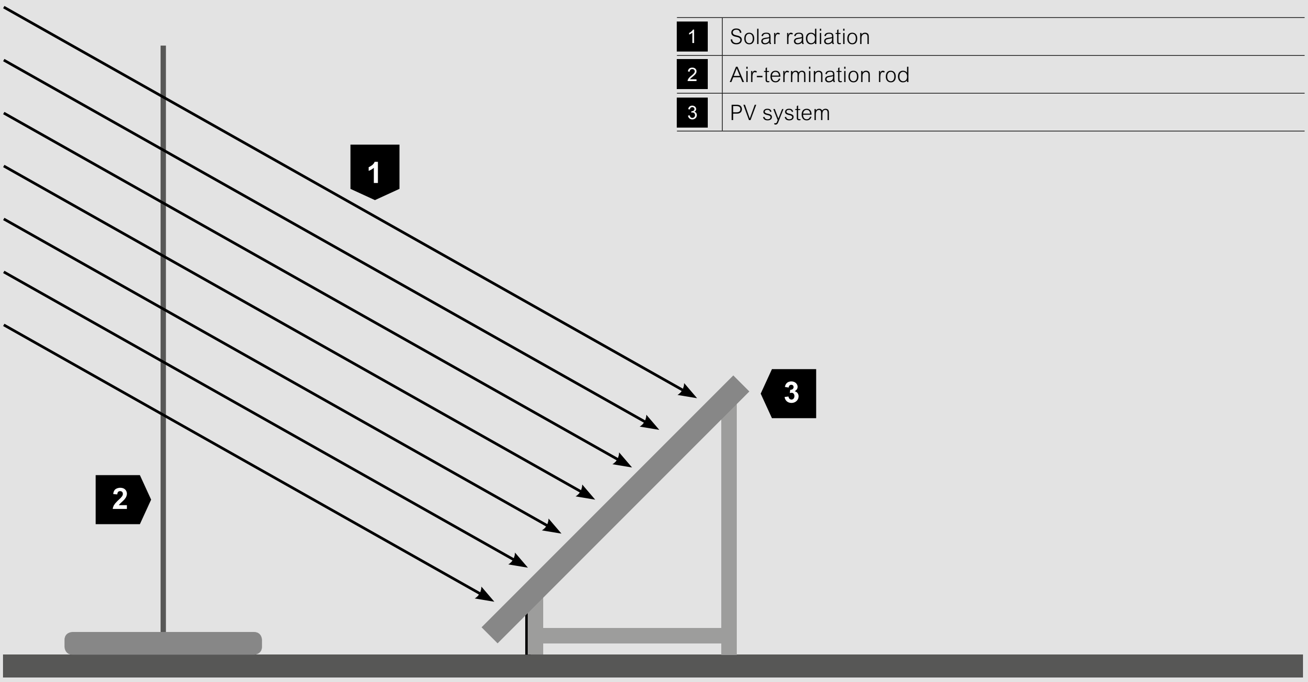


Figure 3.22: An air termination rod casting a shadow on a PV module

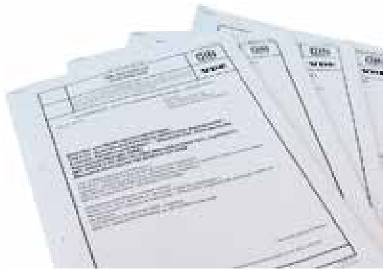
Four steps to comprehensive protection

Step 1:
Check the separation distance
If the required separation distance cannot be complied with, then the metallic parts must be intercon-nected to be able to carry lightning current.

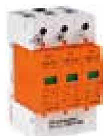
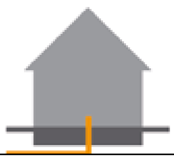
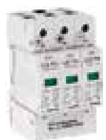
Step 2:
Check the separation distance
Check the protection measures
Example: measures for lightning protection equipotential bonding are used on the DC and AC side, e.g. lightning arrester (Type 1).

Step 3:
Include data cables
Data cables must be included in the protection concept.

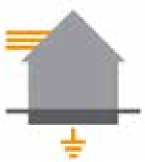
Step 4:
Carrying out the equipotential bonding
Local equipotential bonding must be provided on the inverter.



Overview of protection measures

Initial situation	Measure	Separation distance according to IEC 62305 maintained	Equipotential bonding	Surge protection	Sample product picture
• External lightning protection system (according to IEC 62305) 	Adapt the lightning protection system according to IEC 62305	Yes	min. 6 mm²	DC: Type 2	
				AC: Type 1	
		No	min. 16 mm²	DC: Type 1	
				AC: Type 1	
• No outside lightning protection system • Earthing cable connection 	Requirements' testing: LBO, Vds 2010, risk analysis, ...	-	min. 6 mm²	DC: Type 2	
				AC: Type 2	

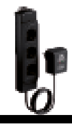
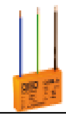
Selection aid, energy technology
AC combination arrestor and surge protection; type 1, type 1+2, type 2 and type 3

		Installation location 1 **Installation in the main distributor box / combined distributor** **Basic protection / type 1, type 2**				
Initial situation	Building type	Description	Type	Item no.	Test mark	Product figure
• No external lightning protection system • Earthing cable connection 	Private building	TN-/TT Type 2 + 3 2.5 Division Secondary counter zone	V10 Compact	**5093 380**		
		TN-/TT Type 2 + 3 4 Division Secondary counter zone	V10-C 3+NPE	**5093 391**		
	Multiple dwelling/ industry, commerce	TN-/TT Type 2 4 Division Secondary counter zone	V20 3+NPE	**5095 253**	VDE ÖVE UL	
			V20 3+NPE+FS with remote signalling	**5095 333**	VDE ÖVE UL	
• External lightning protection system (according to DIN EN 0185-305) 	Buildings of lightning protection classes III and IV (e.g. housing, offices and commercial buildings)	TN-/TT Type 1 + 2 4 Division Secondary counter zone	V50 3+NPE	**5093 526**	VDE ÖVE UL	
			V50 3+NPE+FS with remote signalling	**5093 533**	VDE ÖVE UL	
• Outdoor connection 	Buildings of lightning protection classes I to IV (e.g. industry)	TN-C Type 1 6 Division Pre-metered or secondary counter zone	MCD 50-B 3	**5096 877**		
		TN-S Type 1 8 Division Pre-metered or secondary counter zone	MCD 50-B 3+1	**5096 879**		

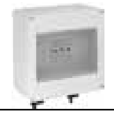
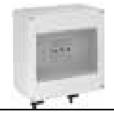
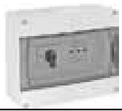
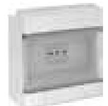
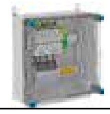
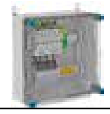
Installation location 2
Installation in the sub-distributor
Medium protection / type 2
Only required if distance ≥ 10m

Description	Type	Item no.	Test mark	Product figure
TN/TT Type 2 + 3 2.5 Division	V10 Compact	**5093380** Page: 249		
	V10 Compact FS, with remote signalling	**5093382** Page: 252		
TN/TT Type 2 4 Division	V20 3+NPE	**5095253** Page: 208	VDE ÖVE UL	
	V20 3+NPE+FS with remote signalling	**5095333** Page: 209	VDE ÖVE UL	
TN/TT Type 2 4 Division	V20 3+NPE	**5095253** Page: 208	VDE ÖVE UL	
	V20 3+NPE+FS with remote signalling	**5095333** Page: 209	VDE ÖVE UL	
TN/TT Type 2 4 Division	V20 3+NPE	**5095253** Page: 208	VDE ÖVE UL	
	V20 3+NPE+FS with remote signalling	**5095333** Page: 209	VDE ÖVE UL	

Installation location 2
Installation before the terminal
Fine protection / type 3

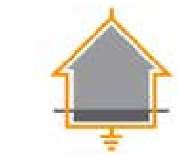
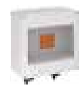
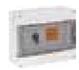
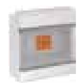
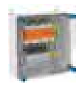
Description	Type	Item no.	Product figure
Plug-in	FC-D	**5092 800** Page: 268	
	FC-TV-D	**5092 808** Page: 269	
	FS-SAT-D	**5092 816** Page: 270	
	FC-TAE-D	**5092 824** Page: 271	
	FC-ISDN-D	**5092 812** Page: 272	
	FC-RJ-D	**5092 828** Page: 273	
	CNS-3-D-D	**5092 701** Page: 274	
Fixed installation	ÜSM-A	**5092 451** Page: 276	
	ÜSM-A ST-230 1P+PE	**5092 441** Page: 279	
	ÜSS 45-o-RW	**6117 473** Page: 280	
Series installation in distributor	V10 Compact L1/L2/L3/N	**5093 380** Page: 249	
	VF230-AC/DC	**5097 650** Page: 287	
	VF230-AC-FS with remote signalling	**5097 858** Page: 289	

Selection aid
Photovoltaic system solutions

Energy technology, type 2, protection of the DC side								
Initial situation	Max. DC voltage	Max. number of MPP per inverter	Max. number of strings per MPP terminal	Connection (DC side)	Version	Type	Item no.	Product figure
• No external lightning protection system • Earthing cable connection The following are required: • Surge voltage protection, type 2 • Lightning protection equipotential bonding 6.5 mm²	600 V	1	1In/1Out	MC 4 connector		VG-C DCPH-Y1000	**5088 670**	
	1000 V	1	1In/1Out	MC 4 connector		VG-C DCPH-Y1000	**5088 672**	
		1	2	Terminals	Circuit breaker	VG-C DC-TS1000	**5088 660**	
		1	4	Terminals	4 fuse holders, unequipped	VG-C PV1000KS4	**5088 654**	
		1	8	Terminals		VG-C DCPH1000-4K	**5088 650**	
		1	1 0	Terminals		VG-C DCPH-MS1000	**5088 691**	
		2	4	Terminals		VG-CPV1000K 22	**5088 568**	
		2	6	Terminals		VG-CPV 1000K 330	**5088 582**	
		3	6	Terminals		VG-CPV 1000K 333	**5088 585**	
		2	6	Terminals		VG-CPV 1000K 330	**5088 582**	
		3	2In/1Out	MC 4 connector		VG-C DCPH1000-31	**5088 648**	
		3	6	Terminals		VG-CPV 1000K 333	**5088 585**	

You can find the selection aid for AC combination arrestors and surge protection in the chapter Surge Protection in Energy Technology.

Energy technology, Type 1+2, protection of the DC side

Initial situation	Max. DC voltage	Max. number of MPP per in-verter	Max. number of strings per MPP terminal	Connection (DC side)	Version	Type	Item no.	Product figure
● External lightning protec-tion system according to DIN EN 0185-305	600 V	1	1 0	Terminal		VG-BC DCPH-MS600	**5088 693**	
The following are required: ● Lightning and surge protection Type 1+2 ● Lightning protection equipotential bonding 16 mm² ● Separating distance could not be maintained 	900 V	1	1In/1Out	MC 4 con-nector		VG-BC DCPH-Y900	**5088 678**	
		1	2	Terminals	Circuit break-er	VG-BC DC-TS900	**5088 635**	
		1	8	Terminals		VG-BC DCPH900-4K	**5088 632**	
		1	1 0	Terminals		VG-BC DCPH-MS900	**5088 692**	
		2	4	Terminals		VG-BCPV900K 22	**5088 566**	
		2	6	Terminals		VG-BCPV 900K 330	**5088 576**	
		3	2In/1Out	MC 4 con-nector		VG-BC DCPH900-31	**5088 629**	
		3	6	Terminals		VG-BCPV 900K 333	**5088 579**	

Data technology

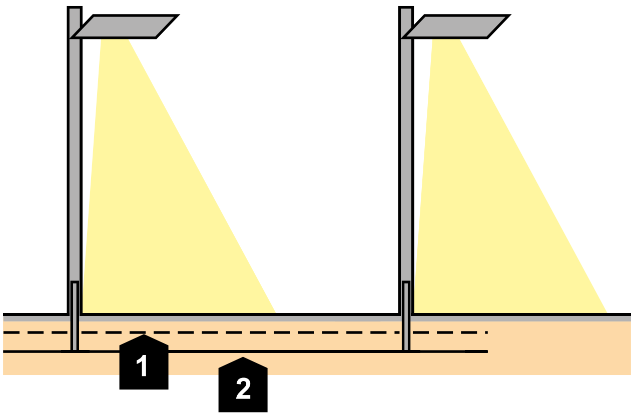
Initial situation		RJ 45	Terminal	Type	Item no.	Product figure
	● No external lightning protection system ● Earthing cable connection	●		ND-CAT6A/EA	**5081 800**	
	● External lightning protection system (according to DIN EN 62305)		●	FRD 24 HF	**5098 575**	

3.2.4.4 LED street lighting systems

Figure 3.25

Damage and repair costs
In the field of street lighting, the replacement of the defective components, alongside the hardware costs, also incurs high costs through the use of elevating platforms and personnel. Upstream surge protection devices reduce the pulses and protect the luminaire. Whole streets are supplied via central distribution boxes, containing the controllers and protection components. The supply voltage is fed in via buried cables in the connection compartment of the mast. The luminaire is supplied from the connection compartment.

Creation of the earthing systems
In a new installation, the supply cable can be protected against destruction from lightning currents in the earth by an optional earthing line above it. According to the current lightning protection standard IEC 62305-3 German supplement 2 (VDE 0185-305-3), this earthing line must be located 0.5 metres above the supply cable. The earthing line compensates potential differences and minimises arcing to the supply cable. Figure 3.24 shows the earthing line routed above the supply cable.



1	Earthing line, uninsulated
2	Supply cable

Figure 3.26 Cable routing

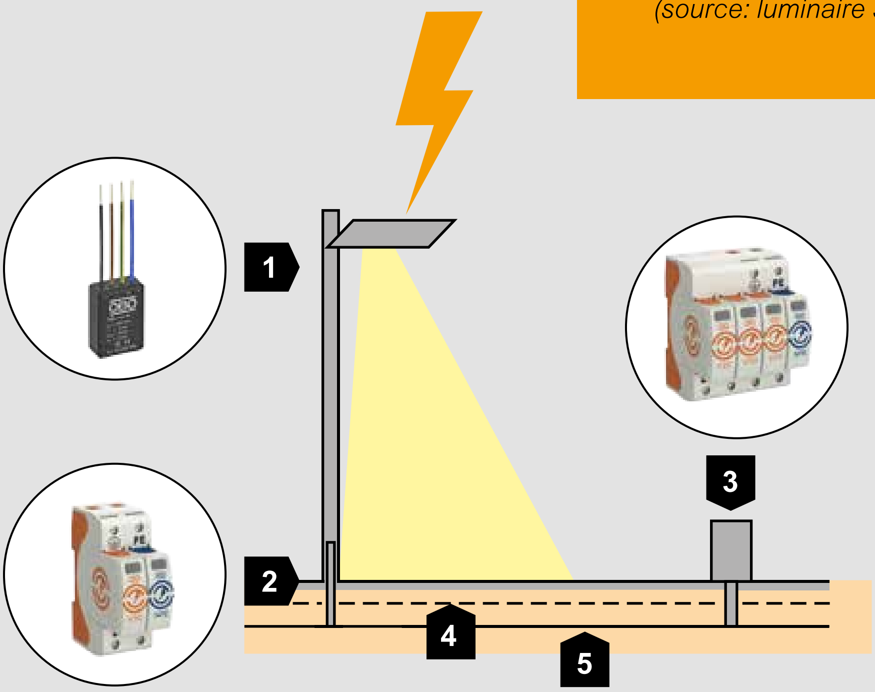
Installation location of the lightning and surge protection

The use of surge protection is required for safe operation. According to the American ANSI and IEEE standard, a surge voltage resistance of 20 kV is required for outdoor lighting at a surge current load of 10 kA. However, of decisive importance for the protection action is that the protection level of the surge protection device is below the surge voltage resistance of the lights and the LED driver. Surge protection devices must correspond to the testing standard IEC 61643-11 (VDE 0675) and must be able to arrest surge currents of several thousand amps multiple times without destruction. According to the testing standard, each protection device must have thermal monitoring and must be isolated safely if there is a defect. The luminaire standard "Fpr EN 60598-1: 2012-11 Luminaires – Part 1: General Requirements and Tests", Point 4.32 specifies: "Surge protection devices must meet IEC 61643."

If there is a direct lightning strike in the mast luminaire (Figure 3.25), a large portion of the lightning current will flow directly into the earth, creating a potential difference to the supply cable. Powerful lightning current / combination arresters can arrest the energy-rich currents.

Surge protection systems must meet the standards of IEC 61643 (VDE 0675).

(source: luminaire standard EN 60598-1)

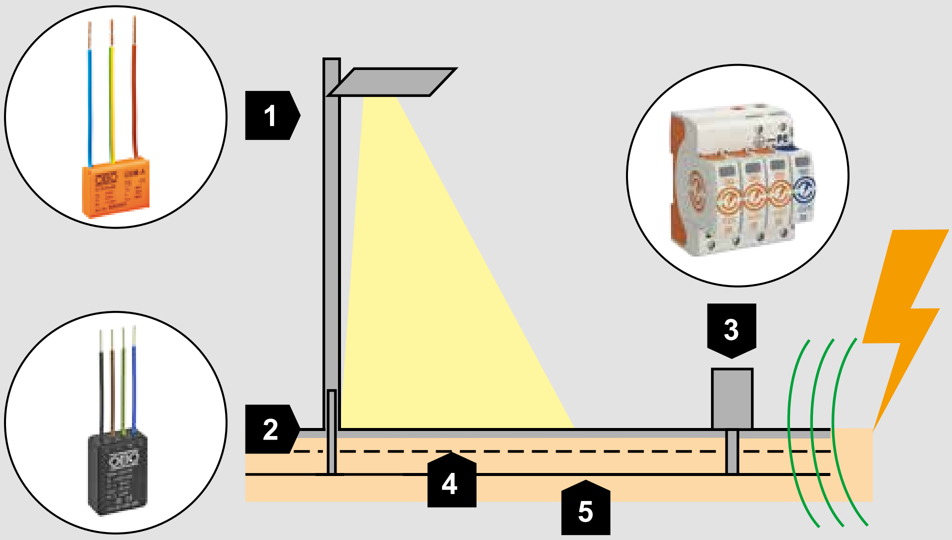


	Installation location	Description	Protection device	Item no.
1	Lamp head with LED system, before the LED driver	Surge protection type 2	ÜSM-LED 230	5092 48 0
2	Connection compartment of the mast luminaire	Surge protection type 1+2	V50 combination arrester	5093 52 2
3	Control cabinet with electronics, supply	Surge protection type 1+2	V50 combination arrester	5093 52 6
4	Earthing line, uninsulated	Flat or round cable	5018 73 0	
5	Supply cable			

Figure 3.27: Direct lightning strike into the mast luminaire

Remote strike and inductive coupling

A lightning strike within 1.5 km generates a surge voltage which hits the lighting via the supply cable (Figure 3.26). These surge voltages have less energy than the direct lightning strike, but can still destroy electronic components. Inductive couplings are considerably reduced through a metallic mast and a luminaire with a metallic housing. Here too, surge voltage pulses along cables from the supply network need to be considered. In this case, the surge protection in the mast connection compartment is easily accessible and easy to check.



	Installation location	Description	Protection device	Item no.
1	Lamp head with LED system, before the LED driver	Surge protection type 2	ÜSM-LED 230	5092 48 0
		Alternatively: Type 3 surge protection	ÜSM-A 230	5092 45 1
2	Connection compartment of the mast luminaire	Surge protection type 2	ÜSM-LED 230	5092 48 0
3	Control cabinet with electronics, Supply, 3-phase	Surge protection type 2	V20 3+NPE-280	5095 25 3
	Alternatively: control cabinet with electronics, supply 1-phase	Surge protection type 2	V20 1+NPE-280	5095 25 1
4	Earthing line, uninsulated	Flat or round cable	5018 73 0	
5	Supply cable			

Figure 3.28: Remote strike and inductive coupling

Figure 3.29: LED lighting system in an indoor car park

3.2.4.4.1 Internal lighting in buildings and halls

LED lighting systems in industrial plants and administrative buildings are usually destroyed by high voltages, coupled inductively or by switching operations.

A risk analysis according to IEC 62305 (VDE 0185-305) can be used to determine whether an external lightning protection system is required or not. In a lightning protection system, the supply cables at the entrance to the building must be protected using suitable lightning current arresters. Independently of this, the surge protection system should be installed for the entire lighting system.

In industrial and sports halls, the luminaires are installed at a great height. After damage, the lights or the LED drivers can only be repaired at a high cost. As the minimum lighting strength required at the workstation can lead to accidents or errors, immediate action is required.

The usually very long supply lines have a high potential for inductive coupling of surge voltages.

Surge protection devices must be used in the sub-distributor to be supplied. However, the luminaires are often 10 m from this distributor. To protect the LED drivers and the light, a protection device is then required directly in front of the electronic components. If the luminaires are, for example, mounted directly beneath the cable support systems, then the surge protection can also be inserted in a junction box in front of the luminaires. To use the shielding function of the metallic cable support systems, these must be included in the equipotential bonding on both sides.

Connection of the protection device

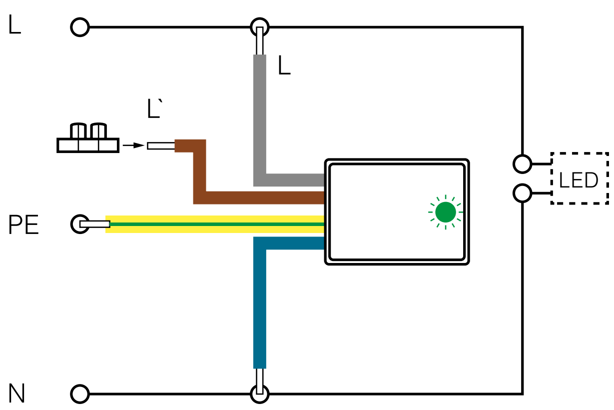
The protection device ÜSM-LED 230 can be installed in series with or in parallel to the luminaires. The differing connection can be used to maximise availability (parallel connection) or to switch off the luminaire if there is a defect on the protection device (serial connection).

Parallel connection (Figure 3.27)
The surge protection device is located upstream of the LED luminaire.

Failure behaviour: The display on the ÜSM-LED goes out. The surge protection is disconnected. The LED luminaire remains lit without protection.

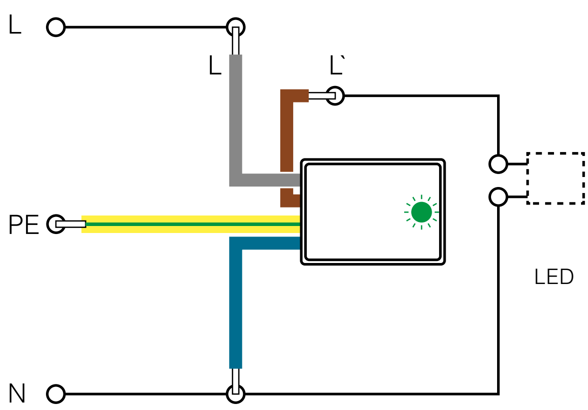
Series connection (Figure 3.28)
The surge protection is switched in series to the LED luminaire.

Failure behaviour: The display on the ÜSM-LED goes out. The surge protection and the circuit (L') are disconnected. The failure is signalled by the luminaire going out. A suitable protection device upstream of the electronic LED drivers is a safe barrier against surge voltages. This guarantees the lifespan of the LED luminaires, securing the investment.



L	Phase feed line
L`	Phase from the protection device (switch-off in case of failure)
PE	Earth
N	Neutral conductor
LED	Luminaire

Figure 3.30: Parallel connection (max. availability)

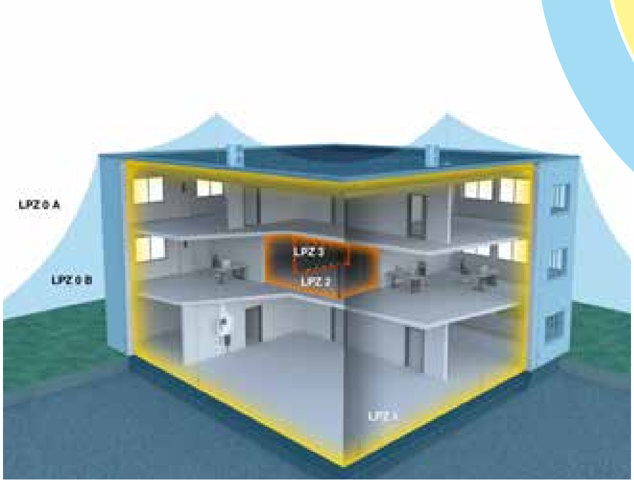


L	Phase feed line
L`	Phase from the protection device (switch-off in case of failure)
PE	Earth
N	Neutral conductor
LED	Luminaire

Figure 3.31: Series connection (luminaire goes off)

In the commercial section and in the field of street lighting, with long lifespans, enormous cost savings are possible, despite the increased procurement price. However, premature failure from surge voltage damage can push the return on investment back into the future. The investments can be protected through suitable protection measures.

1	Energy cable
2	Data cable
3	Equipotential bonding system



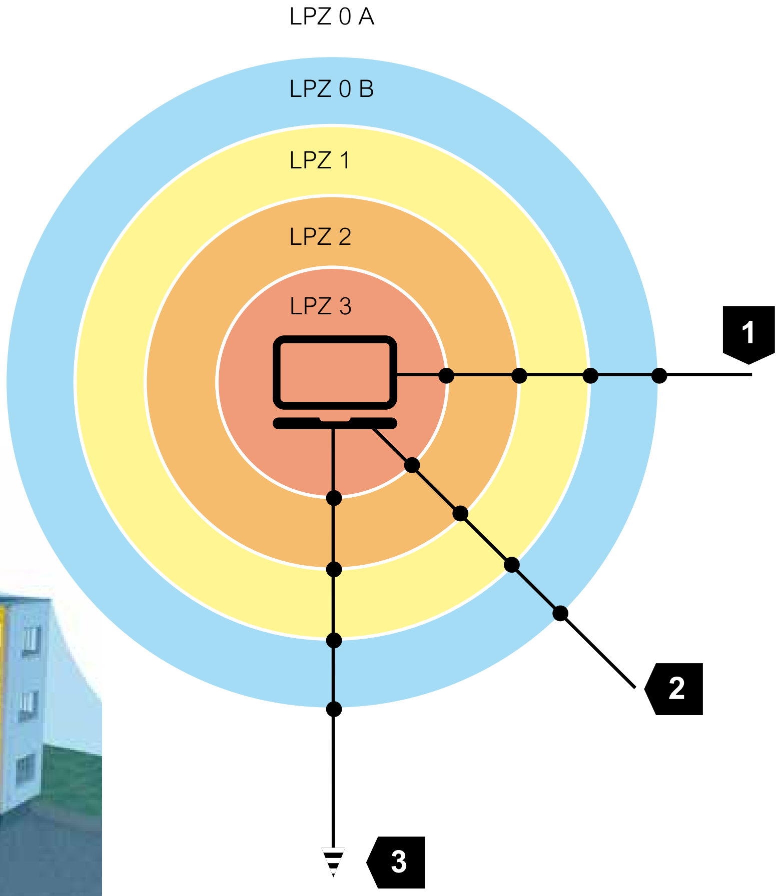


Figure 3.32: Protection principle based on lightning protection zone concept

3.3 Surge protection systems for data and information technology

Data and information technology systems are used in many different applications. Almost every electronic system used to process information is considered extremely important. Ever increasing volumes of data are being stored and must be accessible at all times at very short notice. It has become even more important to protect these systems too against dangerous surges. In order to prevent failure or even destruction of these systems, they must be integrated into the lightning and surge protection concept.

3.3.1 Planning methods

Basic principles

These days, communication and IT systems are the lifelines of almost every company. In the worst-case scenario, surge voltages, caused by galvanic, capacitive or inductive couplings in data cables, can destroy IT equipment and communication technology. To avoid such failures, suitable protection measures have to be taken.

In practice, the wide range of standard information, telecommunication and measurement systems often makes the selection of the right surge protection device complex. The following factors must be taken into account:

- The connection system of the protection device must fit the device to be protected.
- Parameters such as maximum signal level, maximum frequency, maximum protection level and installation environment.
- The protection device can only have a minimal effect on the transmission path (in terms of e.g. attenuation and reflection).

Protection principle

A device is only protected against surge voltages if all energy and data cables connected to the device are integrated into the equipotential bonding system at the lightning protection zone transitions (Figure 3.29) (local equipotential bonding). OBO Bettermann offers a complete range of tried-and-tested, highly functional and reliable data cable protection devices for all standard telecommunication and information technology systems.

Standards in data and information technology

Various standards have a role in the field of data and telecommunications technology. From structured building cabling through equipotential bonding up to EMC, various different standards must be taken into account. Some important standards are listed here.

Standard	Contents
IEC 61643-21 (VDE 0845-3-1)	Low-voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signalling networks. Performance requirements and testing method.
IEC 61643-22 (VDE 0845-3-2)	Low-voltage surge protective devices – Part 22: Surge protective devices connected to telecommunications and signalling networks. Selection and application principles
DIN EN 50173-1	Information technology – Generic cabling systems – Part 1: General requirements.
DIN VDE 0845-1	Protection of telecommunication systems against lightning, electrostatic discharges and surge voltages from electric power installations; provisions against surge voltages.
DIN VDE 0845-2	Protection of data processing and telecommunications equipment against the impact of lightning, discharge of static electricity and surge voltages from heavy current systems – Requirements and tests of surge voltage protection devices.
DIN EN 50310 (VDE 0800-2-310)	Application of equipotential bonding and earthing in buildings with information technology equipment.
EN 61000-4-5 (VDE 08457-4-5)	Electromagnetic Compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test.
EN 60728-11 (VDE 855-1)	Cable networks for television signals, sound signals and interactive services – Part 11: Safety (IEC 60728-11:2005).

Table 3.7: Standards referring to surge protection in information technology

Comparison

Like the surge protective devices used in the field of energy technology, data cable protection devices are also categorised by class. Here too, the classes correspond to the lightning protection zones.

	Surge protection for energy technology	Surge protection for data cables
IEC testing standard	IEC 61643-11	IEC 61643-21
IEC application principles	IEC 61643-12	IEC 61643-22
LPZ 0B/1 (10/350 µs)	Class I	Class D1
LPZ 1/2 (8/20 µs)	Class II	Class C2
LPZ 2/3 (8/20 µs)	Class III	Class C2/C1

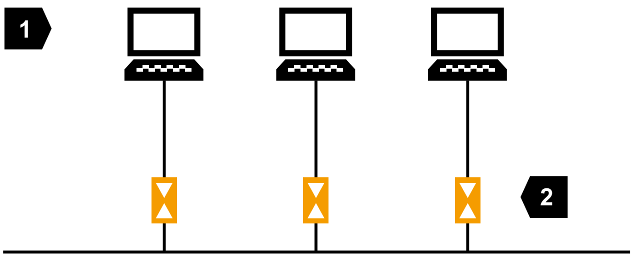
Table 3.8: Comparison of standards for surge protection devices

3.3.1.1 Topologies

In information technology, devices communicate with one another electrically via cables that can be arranged in various configurations; these configurations are called "topologies". The surge protection concept selected must take account of the system topology. The most common topologies are presented below, along with information on where to position the surge protective devices in each case.

Bus topology (Figure 3.30)

In a bus topology, all devices are connected in parallel. At its end, the bus must have an anechoic closure. Typical applications are 10Base2, 10Base5 and machine controllers such as PROFIBUS and telecommunication systems such as ISDN.

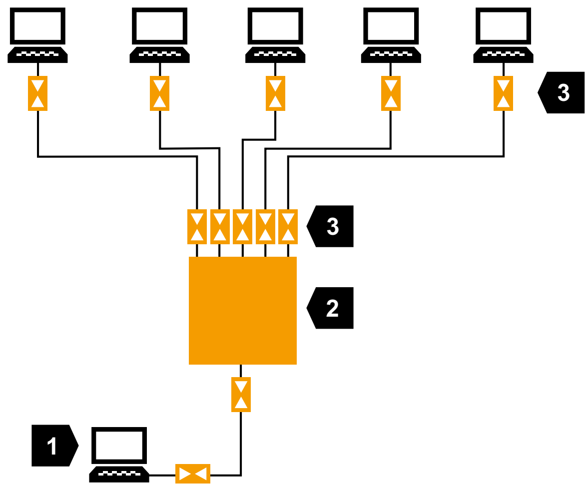


1	IT terminals
2	Surge protective devices

Figure 3.33: Bus topology

Star topology (Figure 3.31)

In the star topology, every workstation is supplied by a separate cable from a central star point (HUB or Switch). Typical applications include 10BaseT and 100BaseT, but also 10 Gbit applications.

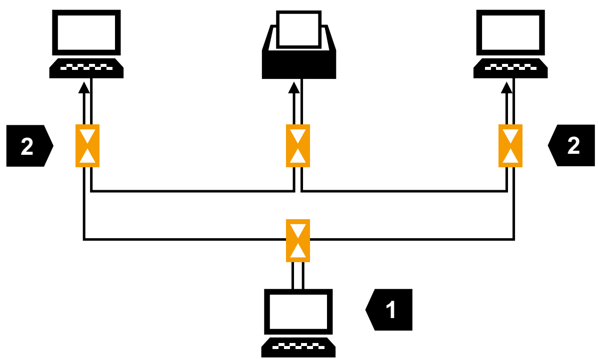


1	Server
2	Switch/Hub
3	Surge protection devices

Figure 3.34: Star topology

Ring topology (Figure 3.32)

In a ring topology, every workstation is connected to precisely one predecessor and one successor via a ring-shaped network. If one station fails, the entire network fails. Ring networks are used e.g. in Token Ring applications.



1	Server
2	Surge protective devices

Figure 3.35: Ring topology

3.3.1.2 Interference in information technology systems

Lightning currents and surge voltages can be coupled into data cables in different ways. Transients and lightning currents can be transmitted by the lightning directly, or via cables in which interference factors are already coupled.

Because surge voltages can occur even without lightning, for example due to switching operations in the supply network, terminal devices and cables always need to have a certain amount of dielectric withstand to enable the device or cable to remain in operation following a brief surge voltage. The following table shows typical dielectric withstand values for common terminal devices/cables.

Every electrical component has a specific dielectric withstand value.

Application	Typical dielectric withstand	OBO surge protection Protection level
Telecoms terminals/devices	1.5 kV	< 600 V
Measurement/control terminals	1 kV	< 600 V
Telephone device cable (star quad) • Wire-wire • Wire-shield	 0.5 kV 2 kV	 < 300 V < 300 V
Installation cable – telecommunication systems (F-vYAY) • Wire-wire • Wire-shield	 0.5 kV 2 kV	 < 60 V < 800 kV
Installation cable – tube wire – intercoms • Wire-wire • Wire-shield	 1 kV 1 kV	 < 60 V < 600 V
CAT7 cable • Wire-wire • Wire-shield	 2.5 kV 2.5 kV	 < 120 V < 700 V
Installation data cable – J-Y(ST)Y • Wire-wire • Wire-shield	 0.5 kV 2 kV	 < 60 V < 800 V
Jumper wire – telecoms distribution board	2.5 kV	< 1 V
Profibus cable	1.5 kV	< 800 V
50 Ohm coaxial cable	2 kV–10 kV	< 800 V
75 Ohm SAT coaxial cable	2 kV	< 800 V
J YY BMK (JB-YY) fire alarm cable Wire-wire Wire-shield	 0.8 kV 0.8 kV	 < 60 kV < 600 kV

Table 3.9: Voltage resistance of IT components

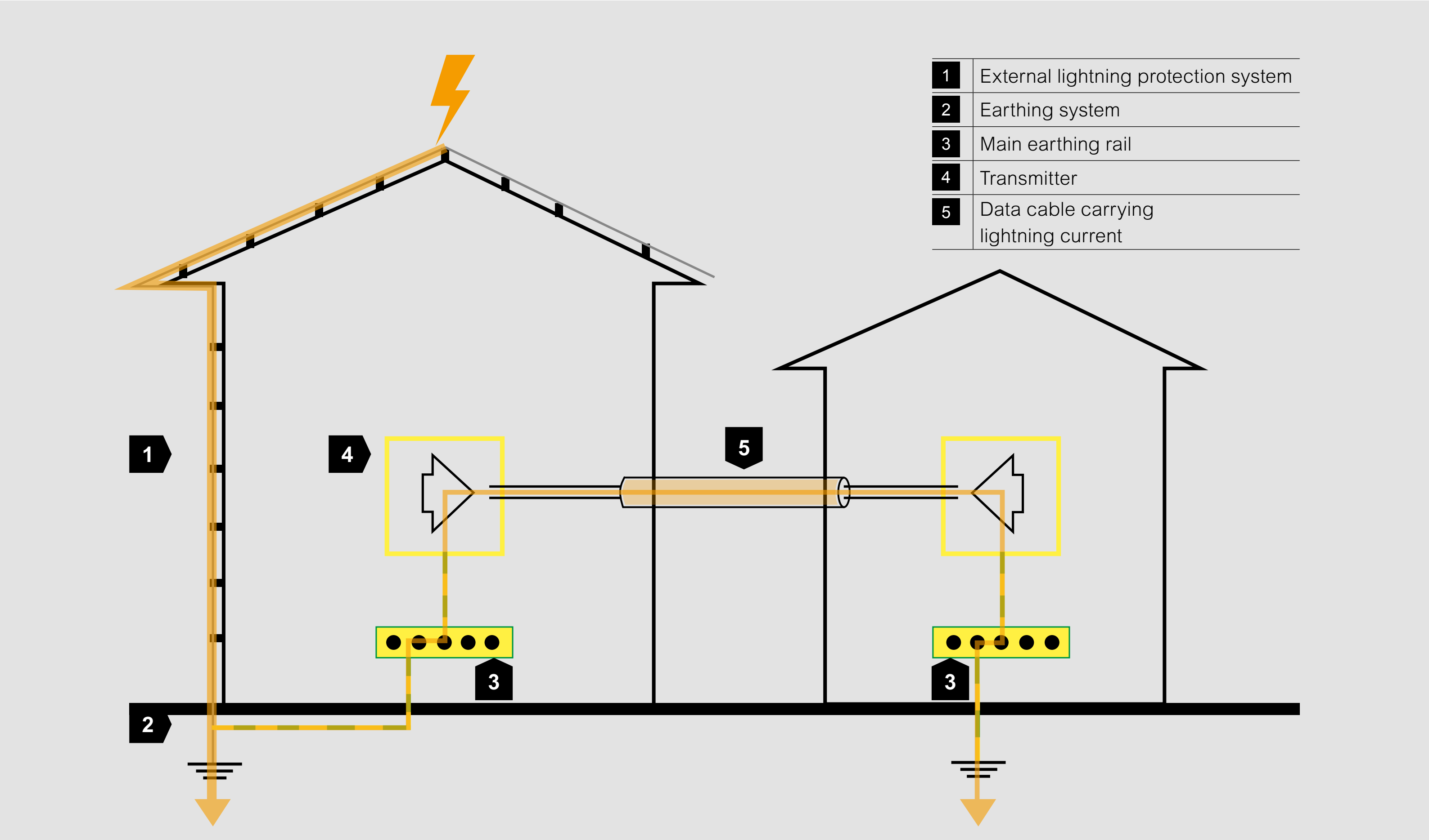


Figure 3.36 Galvanic coupling into a data cable via the external lightning protection system

Galvanic

When a lightning current, e.g. in the case of a lightning strike, passes into the cable directly, this is known as galvanic coupling. **(Figure 3.36)**

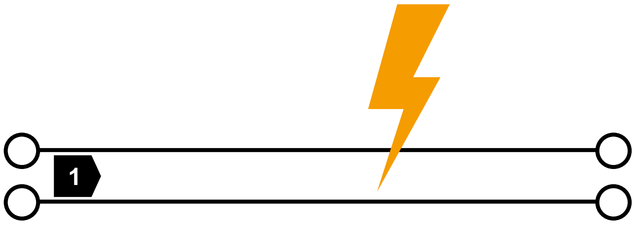
If lightning strikes and the lightning current flows into an interception rod and to earth via the external lightning protection system, approximately 50% of the lightning current enters the building via the building's equipotential bonding system and hence couples galvanically.

Coupled lightning currents are not always due to the external lightning protection system: in principle any external cable that ends in the house can couple lightning currents, for example an overhead line connected to the house, or if lightning strikes a substation. Lightning current can also enter the building via the telecommunications cable. A metal rodent guard can turn even an EMC-insensitive fibre optic cable into a conductor of lightning current.

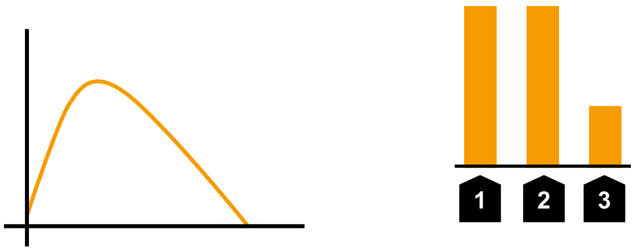
Surge protection devices conduct the lightning current in the incoming cables towards earth via the equipotential bonding system. (Figure 3.37)

The coupled lightning current has a high energy and high frequency. Due to the curve with waveform 10/350 µs, this type of coupling is short in duration.

It should be ensured that all supposed protection elements on cables entering the building, such as shields, rodent guards, etc., are connected to the equipotential bonding system in such a way as to carry lightning current.



1	Telecoms line



1	Power
2	Frequency
3	Time

Figure 3.37: Characteristics of galvanic coupling

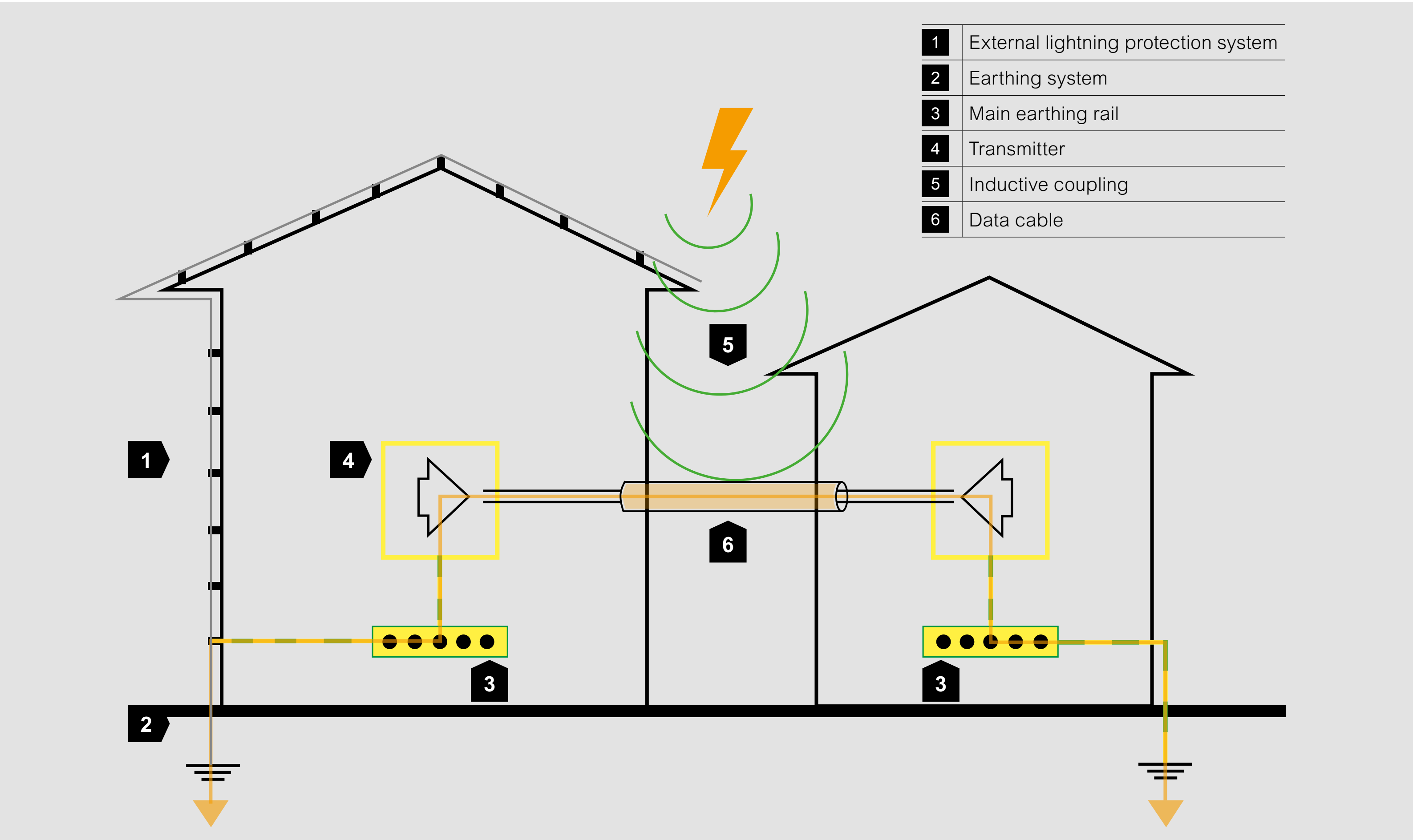
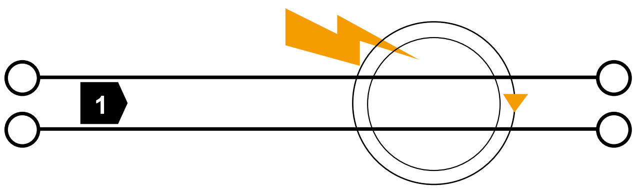


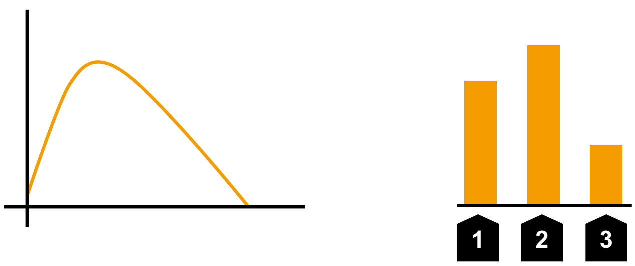
Figure 3.38: Inductive coupling in the case of a direct strike

Inductive

A conductor carrying current creates a magnetic field around itself. If the lightning current is strong, the magnetic field is correspondingly larger and can couple into conductors or conductor loops located suitably nearby. Remote lightning strikes also emit electromagnetic waves that can couple into conductor loops. **(Figure 3.38)**



1	Data cable



1	Power
2	Frequency
3	Time

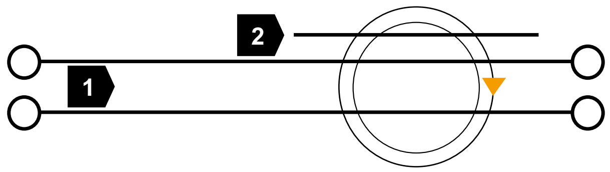
Figure 3.39 Inductive coupling resulting from a lightning strike

This induces a surge voltage that can disrupt or damage connected electrical devices. In a data cable this often results in the destruction of the sensitive electronic components connected to it. As with lightning current, it can be assumed that the frequency will be high and the pulse duration short. The induced surge voltages have the waveform 8/20 µs. The energy level is lower than in the case of the 10/350 µs pulse. (Figure 3.40)

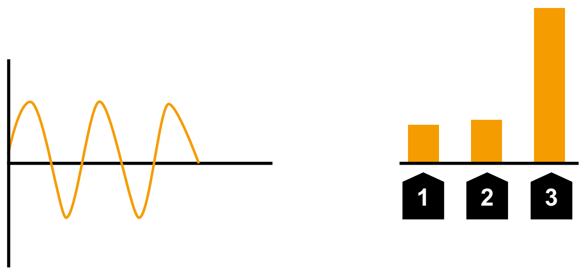
However, it is not only lightning current that can induce interference voltages; any electrical cable carrying current can do this. For example 230 V power lines:

If the communication cable is located inside the magnetic field of an electrical conductor, an interference voltage can be induced. The magnitude of the interference voltage induced on the communication cable depends on both the conductor of the magnetic field, and the structure of the communication cable. A shield on the communication cable can considerably reduce the magnitude of the interference induced.

Essentially induction from cables takes place as follows: (Figure 3.41)
Current (I) flowing through an electrical conductor generates a magnetic field all around it. If an electrical conductor is formed into a loop and placed in a variable magnetic field, a voltage (U) can be measured at the ends of the conductor. The magnitude of the induced voltage varies depending on the size of the magnetic field and of the conductor loop inside the magnetic field.

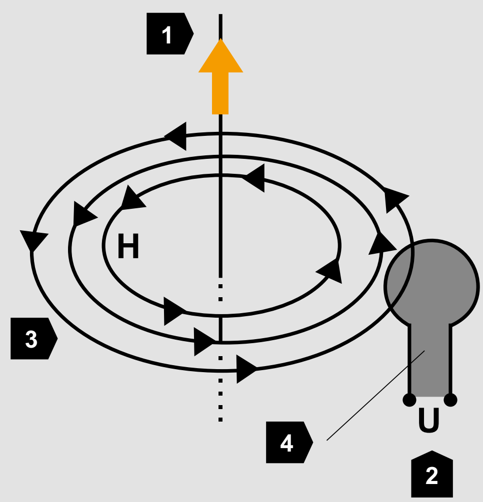


1	Data cable
2	Energy cable



1	Power
2	Frequency
3	Time

Figure 3.40: Inductive coupling from a parallel power cable



1	Current-carrying conductor
2	Conductor loop with voltage U
3	Variable magnetic field
4	Induction surface

Figure 3.41: Induction in a conductor loop

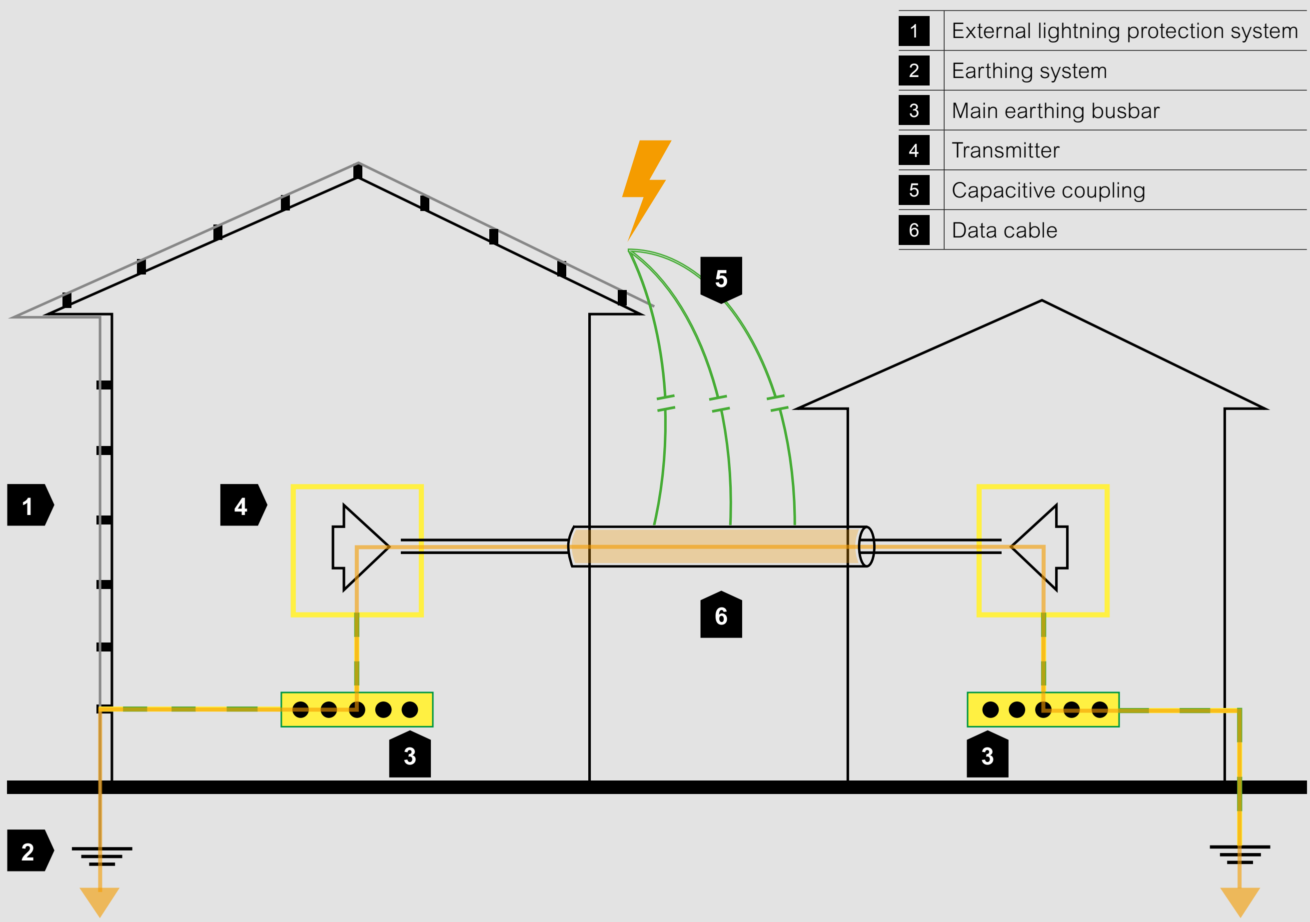


Figure 3.42: Capacitive coupling due to a direct lightning strike

Capacitive

Capacitive coupling occurs where there is a voltage between two points with a high difference in potential. Charge is transferred through the medium between the two points in an attempt to even out the potentials; this creates a surge voltage. **(Figure 3.42)**

3.3.1.3 Building and area shielding

Critical infrastructures such as data centres, power stations, chemical plants and electricity and water supply systems can be protected from the effects of electromagnetic waves by creating shielded areas.

This is done by covering all walls, the ceiling and the floor with conductive materials (e.g. sheet steel or copper foil). Doors and windows must be connected with the wall shielding via spring contacts. All cable glands must also be shielded.

Figure 3.43: Mobile telecommunications mast

Figure 3.44: SAS clamp clip to connect the shielding braid with MDP surge protection devices

3.3.1.4 Cable shielding (Figure 3.44)

Cables are shielded with foil or weave shields, or a combination of the two. Foil shields are particularly effective at high frequencies, whereas screened shields are better suited to low frequencies. The measure of shielding quality is the “shielding efficiency”. Existing cables and lines can also be shielded using earthed cable support or metal pipe systems. In recent years, the use of electronic circuits has increased continually. Whether in industrial systems, medicine, households, in telecommunications systems or electrical building installations – everywhere there are powerful electrical equipment and systems, which switch ever greater currents, achieve greater radio ranges and transport ever more energy in smaller spaces.

If for technical reasons, e.g. in order to prevent 50 Hz ground loops, a direct connection at both ends is not possible, one end should be earthed directly and the other indirectly. By creating an indirect earth connection via a gas-discharge tube, in normal operation the cable shield is insulated at one end. If a large coupling occurs, the potentials can be equalised through the ignited gas-discharge tube. (Figure 3.45)

However, the use of state-of-the-art technology means that the complexity of applications also increases. The consequence of this is that ever more opposing influences (electromagnetic interference) can occur from system parts and cables, causing damage and economic losses.

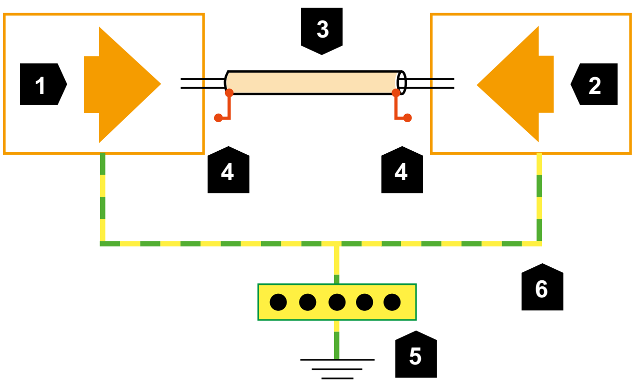
Here, we talk of electromagnetic compatibility (EMC):
Electromagnetic compatibility (EMC) is the ability of an electrical unit to function satisfactorily in its electromagnetic environment, without inappropriately influencing this environment, to which other units also belong (VDE 0870-1). In terms of standardisation, electromagnetic compatibility is dealt with by the EMC directive 2004/108/EC. This means that electrical resources emit electromagnetic interferences (emission), which are picked up by other devices or units (immission) which act as receivers (interference sink). This means that the function of an interference sink can be severely reduced, meaning, in the worst case, total failure and economic losses. The interferences can spread along cables or in the form of electromagnetic waves.

Data cable without shield
A systematic planning process is necessary to guarantee EMC. The interference sources must be identified and quantified. The coupling describes the spread of the interference from the interference source up to the influenced device, the interference sink. The task of EMC planning is to ensure the compatibility at the source, coupling path and sink using suitable measures. During their daily work, planners and installation engineers are confronted with this subject on an increasingly regular basis. This means that EMC is a basic factor to be taken into consideration during the planning of installations and cabling systems.

Due to the high complexity of electromagnetic compatibility, the problems of EMC must be analysed and solved using simplifying hypotheses and models as well as experiments and measurements.

Cable support systems and their contribution to EMC
Cable support systems can make an important contribution to the improvement of EMC. They are passive and can thus make a safe, long-lasting contribution to EMC through the fact that cables are run within cable support systems or are shielded by them. Routing cables inside cable support systems greatly reduces the galvanic decoupling and coupling due to electrical and magnetic fields in the cables. Thus cable support systems can make a contribution to the reduction of coupling from the source to the sink. The shielding action of cable support systems can be quantified by the coupling resistance and the shield attenuation. This gives the planner important engineering parameters for cable support systems for the EMC engineering.

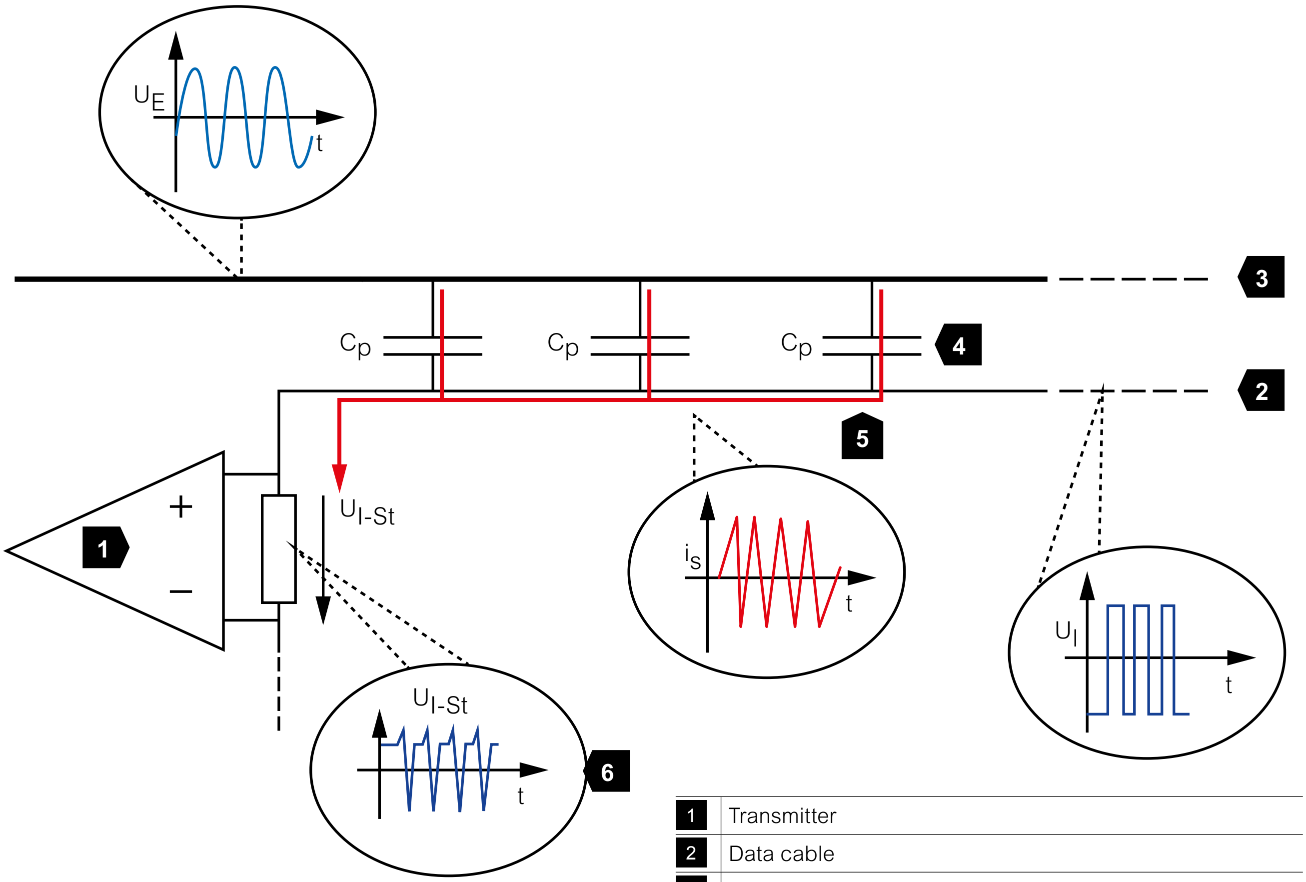
In distributed systems, cable lengths of several hundred metres are not uncommon. Depending on the cable type, shields can be used on data cables to protect the signal lines from interference. These should be connected to the equipotential bonding system to enable the coupled interference factors to be conducted away. The various shield types are presented below.
(Figure 3.42)



1	Device 1
2	Device 2
3	Data cable
4	Shield not connected
5	Equipotential bonding rail
6	Earth connection

Figure 3.45: Cable without shield connected

Example:
There is an electric field between different components in a system. The parasitic capacitances cause interference currents that affect nearby cables:



1	Transmitter
2	Data cable
3	Nearby cable with potential difference
4	Parasitic capacitance
5	Interference currents
6	Disturbed signal

Figure 3.46: Effect of capacitive coupling on a transformer

An unconnected shield does not protect the system from the influence of interference such as:

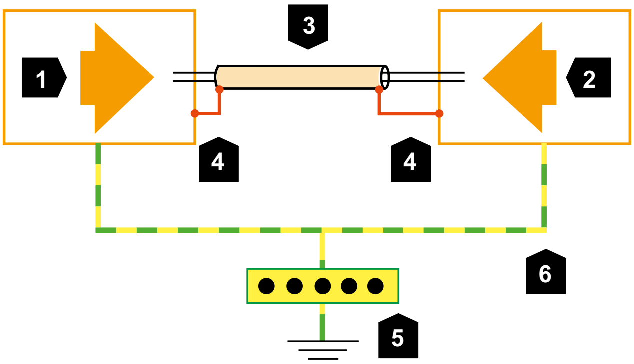
- *Crosstalk*
- *Inductive coupling*
- *Capacitive coupling*

Voltages U_I and U_E relate to absolute protective earth. Due to the parasitic capacitances (C_P), the current (Is) flows via the transmitter to earth. The resulting interference voltage overlaps with the input voltage and disrupts signal transmission. Parasitic capacities occur, for example, in the HF range.

Data cable with shield

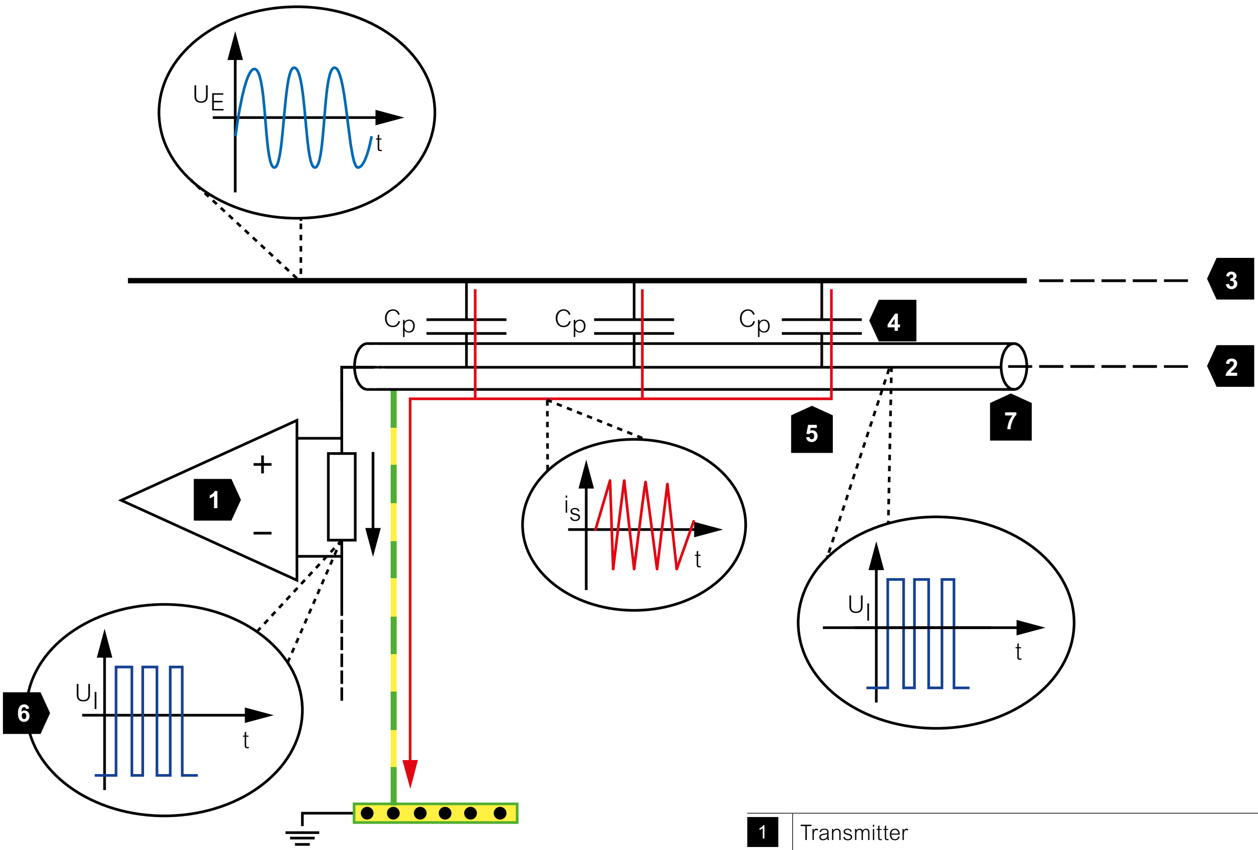
When laying the cable it must be ensured that the shield connection is continuous and earthed at both ends. A cable shield that is only earthed at one end is only effective against capacitive coupling. Shields that are earthed at both ends are additionally effective against inductive coupling.

The cable in the example is connected at both ends so is shielded against both capacitive and inductive coupling. Depending on the coupling resistance of the cable and the shield cross-section, the shield may be able to withstand lightning current.



1	Device 1
2	Device 2
3	Data cable
4	Shield connected at both ends
5	bonding rail
6	Earth connection

Figure 3.47: Cable shield earthed at both ends



1	Transmitter
2	Data cable
3	Adjacent cable with potential difference
4	Parasitic capacitances
5	Interference currents
6	Interference-free signal
7	Shield for conducting interference currents away

Figure 3.48: Capacitive coupling onto the transmitter is prevented by the shield

Cable shields minimise interference by conducting away the currents from the parasitic capacitances. (Figure 3.47)

Equalising currents are, however, still able to flow through the shield. This happens when the earth resistance is different in different earthing systems, thus creating a potential difference. As the two systems are connected via the shield, the equalising currents attempt to eliminate the potential difference. The larger the difference in potential, the greater the equalising currents. If the current is too great and the shield cannot withstand it, cable fires can occur. In TN-C networks, severe interference can also occur in the data cable.

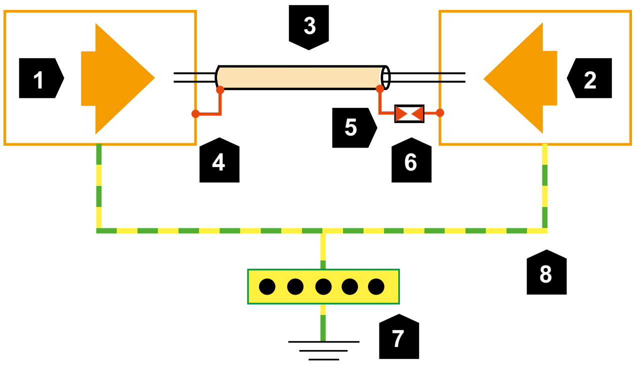
Data cable with indirect earth on one side

One way of avoiding equalising currents is by earthing the shield indirectly at one end. This is done by connecting the shield to the equipotential bonding via a gas-discharge tube. Because the gas-discharge protector has a resistance of several gigaohms, there is no direct connection between the individual earthing systems and hence, because of the high impedance at one end, equalising currents do not flow.

If the shield is impacted by lightning, the gas-discharge tube ignites. The connection at the other end has a low resistance, as it leads directly to the equipotential bonding, so the lightning current or surge voltage can be arrested at both ends. This ensures that the shield is not exposed to the full current at just one end.

3.3.1.5 Transmission characteristics

Due to their sensitive signal levels, data cables are particularly susceptible to interference. This can lead to connection errors or a complete interruption of the signal. In case of interventions in the cable, for example the integration of connection sockets, plugs and adapters, or even if the bending radius is too small, it can safely be assumed that signal losses will occur. If the losses are too great, certain transmission standards will no longer be complied with. The integration of surge protection devices also counts as an intervention in the cable.



1	Device 1
2	Device 2
3	Data cable
4	Direct connection to earth
5	Indirect connection to earth
6	Gas-discharge table
7	Equipotential bonding rail
8	Earthing cable

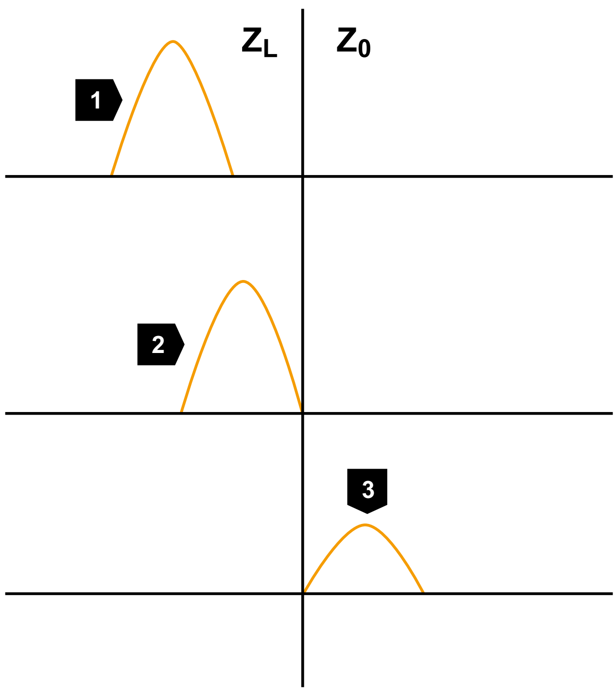
Figure 3.49: Indirect earth on one side

To keep losses to a minimum, it is important to verify the cables' transmission characteristics.

Transmission characteristics can be determined using suitable measuring devices. What is important is that the measuring device, connection cables and surge protection device have the same impedance, in order to avoid excessive reflection and attenuation at the joints. Calibration is also necessary so that the measurement results are not distorted. Key transmission characteristics are presented below:

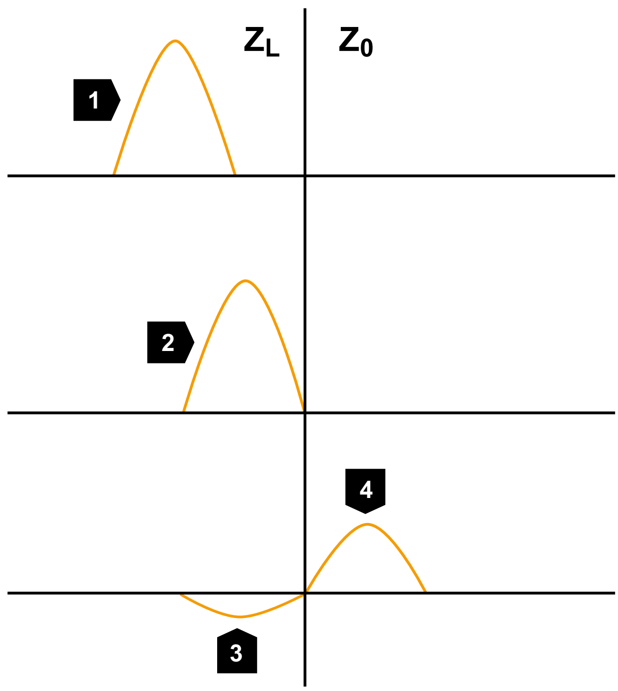
Insertion loss (Figure 3.50)
Insertion loss describes the attenuation of a system from input to output. It shows the transfer function of the system and accommodates the 3 dB point.

Return loss (Figure 3.51)
This parameter indicates in dB how much input power is reflected back. In well-matched systems, these values are around -20 dB in 50 Ω systems. This value is important for antenna systems. If the impedances are different, reflections occur at the joint. The device no longer receives the full power available because the reflected power runs back along the line to the supply source.



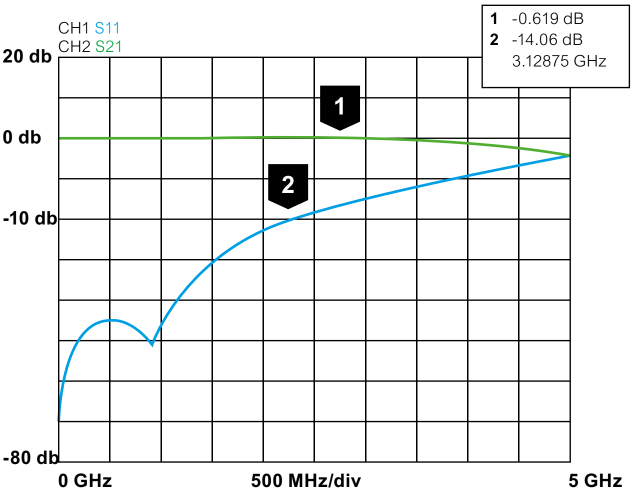
1	Incoming wave
2	Wave hits change in impedance
3	Wave is attenuated at the joint
Z_L	Impedance of the incoming cable
Z_0	Impedance after joint

Figure 3.50: Damped wave



1	Incoming wave
2	Wave hits change in impedance
3	Wave is partially reflected and returns
4	attenuated wave
Z_L	Impedance of the incoming cable
Z_0	Impedance after joint

Figure 3.51: Return loss



1	Insertion loss
2	Return loss

Figure 3.52: Diagram: insertion loss and return loss measured using a network analyser.

The diagram **(Figure 3.52)** shows the insertion and return loss of a coaxial arrester measured using a high-frequency network analyser.

VSWR

The (VSWR) Voltage Standing Wave Ratio is the ratio between an outgoing and reflected wave. Standing waves can occur if, for example, there is no terminating impedance on the cable, or if two cables of different cable impedances are connected together, for example a 50 Ohm coaxial cable with a 75 Ohm coaxial cable.

If there is a mismatch, e.g. in case of an open or short circuited end of a cable, this can result in the doubling or cancellation of the signal wave.

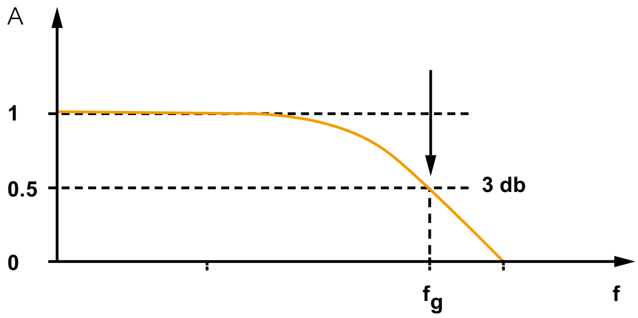
Bandwidth

The bandwidth (B) describes the difference in magnitude between the two frequencies at either end of a frequency band.
The bandwidth is generally defined as the width of the frequency band where power damping is less than 3 dB.

In data technology the bandwidth is often described as the "data volume". Technically, the "data volume" is, however, in fact the data rate. The data rate and bandwidth are often different from one another.

Cut-off frequency f_g (Figure 3.50)

The cut-off frequency f_g describes the frequency-dependent behaviour of the arresters. Capacitive and/or inductive component properties ensure signal attenuation at higher frequencies. The critical point is described as the cut-off frequency fg. From this point onwards, the signal has lost 50% (3 dB) of its input power. The cut-off frequency is determined according to certain measuring criteria. In the absence of any values, the cut-off frequency generally relates to so-called 50 Ω systems.



A	Signal amplitude
f	Frequency
fg	Cut-off frequency at 3 db

Figure 3.53: Cut-off frequency f_g

NEXT

Due to capacitive or inductive coupling, signal components from a pair of wires can be coupled onto another pair and cause interference there. This effect is known as Near End Cross Talk (NEXT). Transmission standards such as the network classes according to EIA/TIA 568A/B or EN 50173-1 specify the maximum NEXT values for a transmission path. The curves below show the transmission characteristics of high-quality and inferior cables.

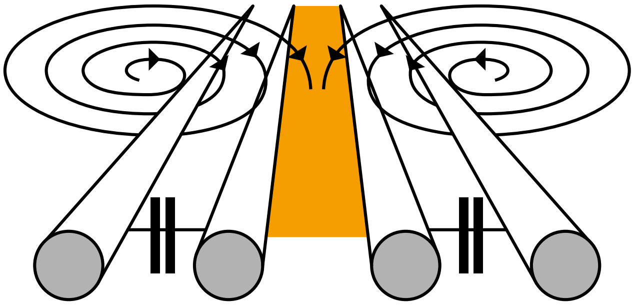
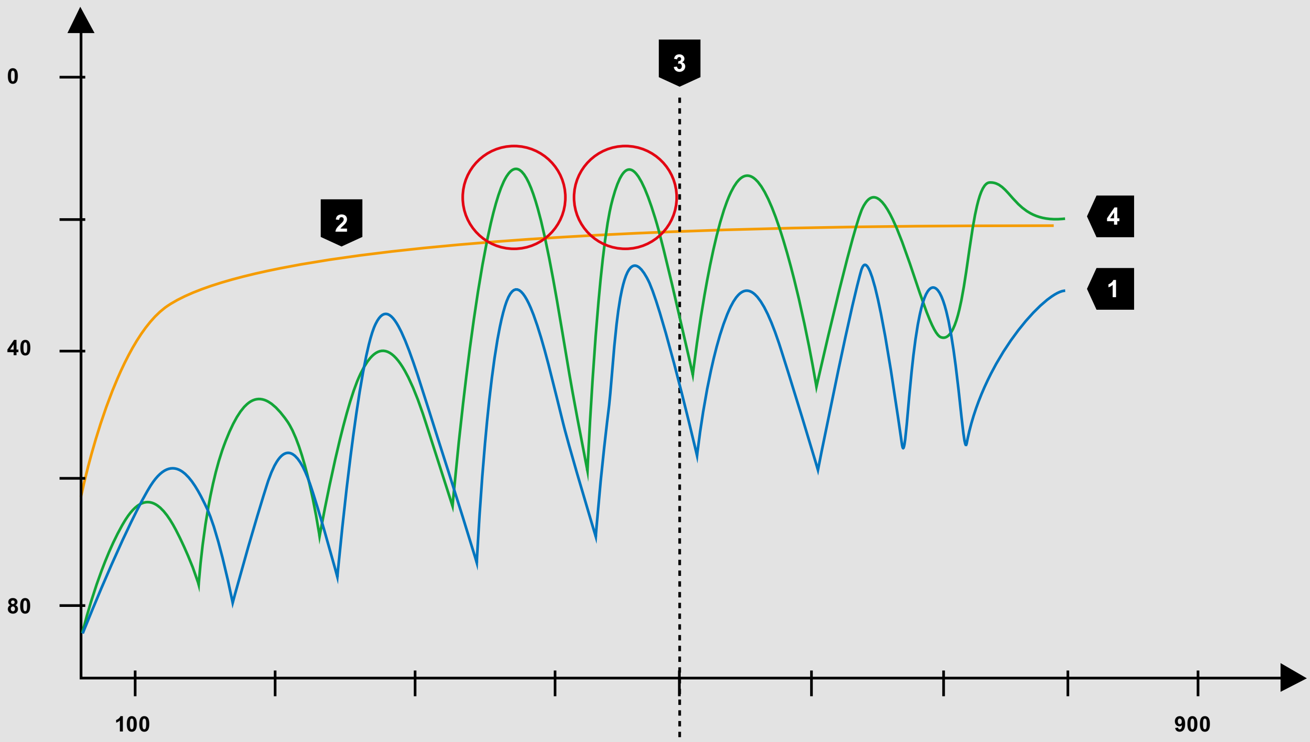


Figure 3.54: Crosstalk in pairs of wires



1	Good NEXT values
2	Limit values
3	Relevant frequency range
4	Poor NEXT values

Figure 3.55: Schematic diagram of a NEXT measurement: comparison of good and poor NEXT values

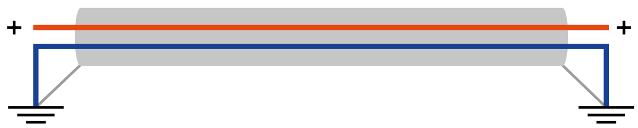
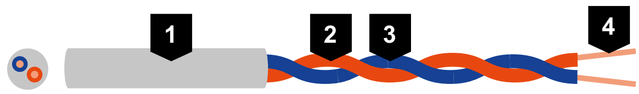
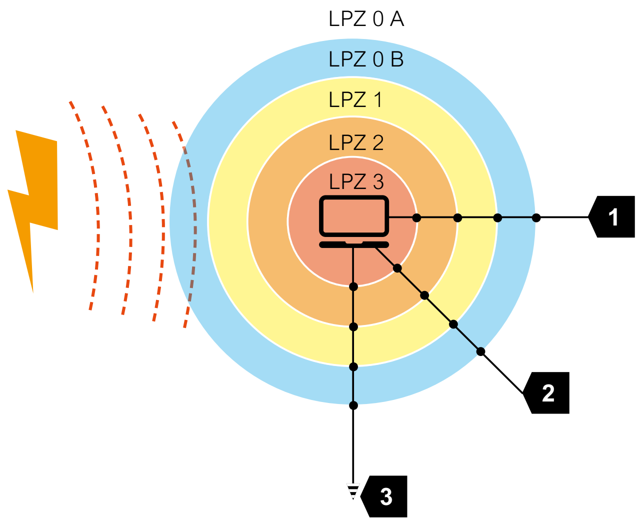


Figure 3.53: Asymmetrical cable



1	Cable jacketing
2	Insulation of wire A
3	Insulation of wire B
4	Conductors of wires A/B

Figure 3.57: Symmetrical cable



1	Energy cable
2	Data cable
3	Equipotential bonding system

Figure 3.58: Cables passing through all lightning protection zones

3.3.1.6 Symmetrical and asymmetrical data transfer

Asymmetrical interfaces (Figure 3.56) consist of a data conductor and an earth wire. In this case the signal voltage changes in relation to a reference potential/ earth.

In symmetrical data transmission (Figure 3.57) , instead of one data cable, two data cables are used to carry a signal, for example in the case of Twisted Pair cables. The two wires are 180° out of phase. If a fault is coupled onto a signal-carrying wire, it will couple onto the second wire as well. Due to the phase difference, the interference signal is virtually cancelled out. The terms (a)symmetrical and (a)synchronous are also used in relation to transmission systems such as DSL. These terms refer to the symmetry or synchronicity of the data rate. During downlink/download, the data rate generally differs considerably from that during uplink/upload. For example, with ADSL, data can be downloaded faster than they can be uploaded. In SDSL the two data rates are the same.

3.3.1.7 Device protection classes

Objects at risk from lightning and surge voltage are classified into lightning protection zones (LPZs). The aim of these LPZs is to reduce the amplitude of the lightning current/surge voltage in individual zones to at least value of the voltage resistance of the devices in that zone. Supply lines such as energy and data cables often run through all of the zones. (Figure 3.58)

A suitable surge protection device must be chosen for each zone. The protection class is marked on many OBO surge protection devices.

1	Unprotected side
2	Protection class, basic protection
3	Protected side/device

Figure 3.59: LPZ 0 B - 2, final code B = basic protection, red colour coding

Basic protection (Figure 3.59)
Basic protection devices are class 1 lightning arresters that can directly arrest lightning currents and surge voltages. The single-stage protection circuit contains gas-discharge tubes. These devices are installed where the lines enter the building. They serve to arrest lightning current with waveform 10/350 µs coupled from outside the building via the data cables.

1	Unprotected side
2	Protection class, basic protection
3	Protected side/device

Figure 3.60: LPZ 0 B - 3, final code C = combi-protection, blue colour coding

Fine protection (Figure 3.60)
The fine protection devices use transzorb diodes to limit surge impulses. The devices are earthed with powerful gas-discharge tubes.. The decoupling required for basic and fine protection is achieved when the line section between basic and fine protection device is at least five metres. Fine protection devices should always be installed on the device to be protected itself.

1	Unprotected side
2	Protection class, basic protection
3	Protected side/device

Figure 3.61: LPZ 1 - 3, final code: F = fine protection, green colour coding

Combined protection (Figure 3.61)
The combined protection devices limit the transients with gas-discharge protectors or transzorb diodes, which are decoupled through resistors. These correspond to classes 1, 2 and 3 or categories D1 and C2 as defined in the standard DIN EN 61643-21. The devices can be installed as basic protection where the lines enter the building, or as fine protection directly before the terminal device. In the latter case it should be noted that the distance to the device needing protection should not exceed 10 metres. If it does, then a further fine protection device should be installed before the device.

Versions

To ensure the correct functioning of data cable protection devices, various aspects must be considered when installing them. The following chapters are dedicated to discussing these aspects.

Choosing the right surge protection device

Later in this guide you can find an extensive selection aid that will help you greatly in choosing the right surge protection device for a given application. If the required interface is not listed, check the following technical properties of your signal interface and compare it with the characteristics of the surge protection device:

1. System type (telecommunications application, measurement and control technology, etc.)

2. Polarity/number of wire connections required

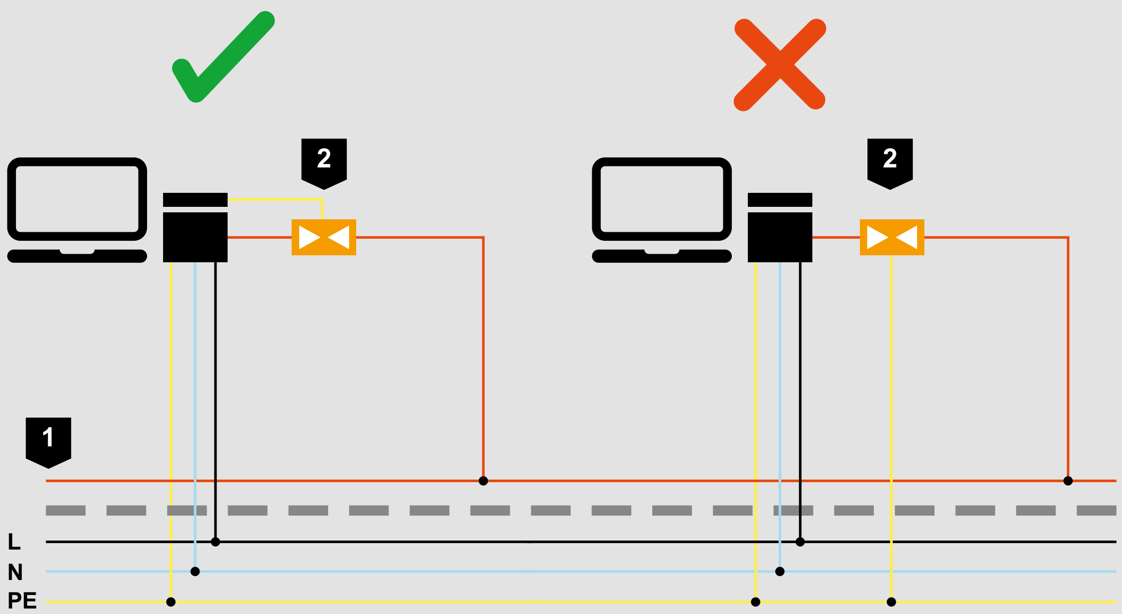
3. Maximum permissible continuous voltage of surge protection device

4. Maximum permissible load current of surge protection device

5. Frequency range supported
6. Installation location and options (hat rail, adapter connector, etc.)

7. Protection class required (basic protection, fine protection, combination protection)

An unsuitable surge protection device can considerably impair the application itself, for example by causing excessive attenuation of the signal circuit. If the voltage or the load current of the system exceeds the characteristics of the surge protection device, the surge protection device can be destroyed due to overloading.



1	Signal line
2	Protection device
L	Phase
N	Neutral conductor
PE	Protective conductor

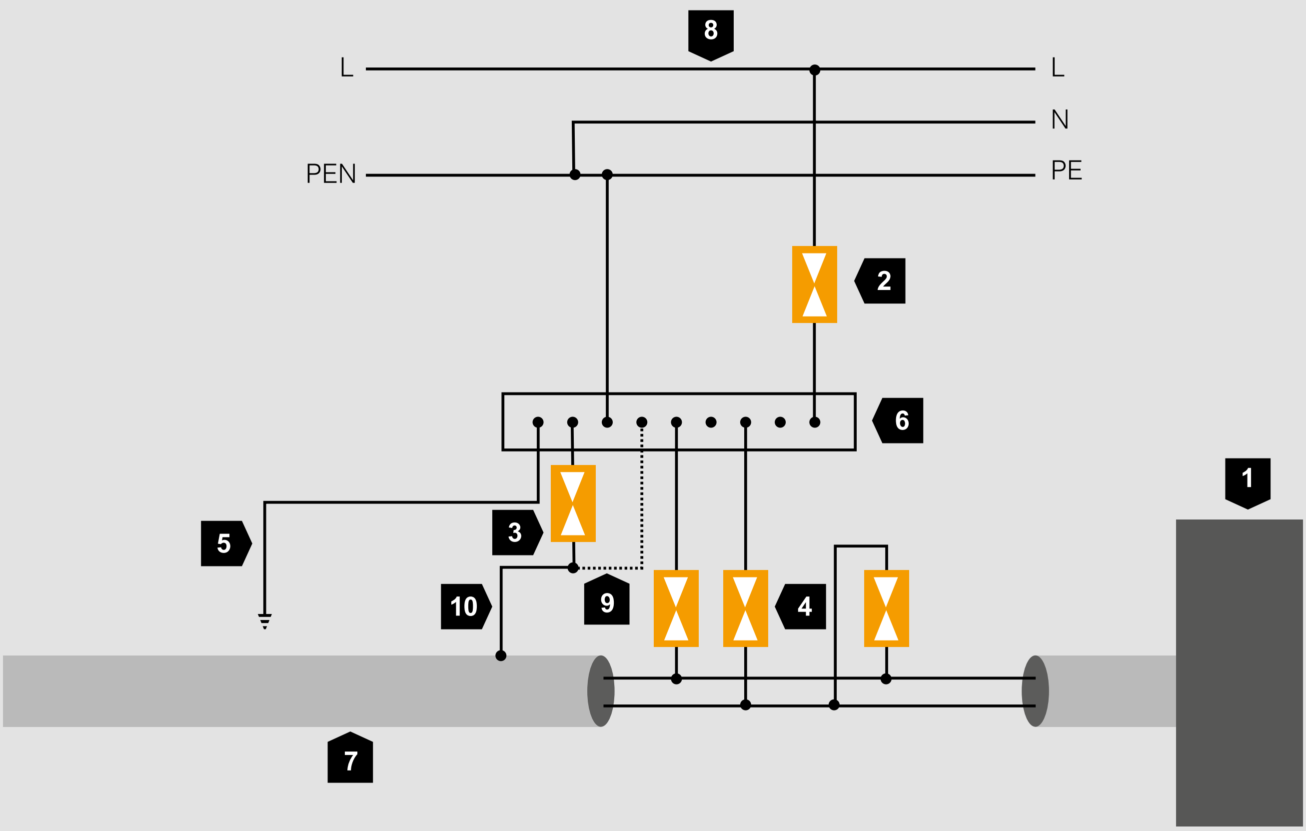
Figure 3.62: Installation example showing correct and incorrect potential connection on protection device

3.3.2 Installation of data cable protection devices

If the cables are too long, a voltage drop will occur due to the high inductance, which will have a negative impact on the protection level of the surge protection device. The voltage protection level can increase so dramatically that the voltage resistance of the terminal device is exceeded and the device is damaged despite the presence of surge protection.

3.3.2.1 Equipotential bonding of data cables

Unlike in energy technology, in data technology longitudinal and transverse voltages occur which must be minimised using suitable arresters with voltage-limiting components. To achieve low voltage protection levels, these surge protective devices must be incorporated as directly as possible into the equipotential bonding system. Long cable lengths should be avoided. The best solution is the local equipotential bonding. (Figure 3.63) Shields are also extremely important. Complete shield action against capacitive and inductive coupling can only be effective when the shield is included with low impedance on both sides in the equipotential bonding.



1	Device to be protected/telecoms line
2	Surge protective device (energy technology)
3	Gas discharge tube (indirect shielding)
4	Gas discharge tube
5	Connection to equipotential bonding
6	Equipotential bonding rail

7	Telecommunications line
8	Electric cable
9	Direct connection to equipotential bonding (preferred)
10	Conductive shield of the data cable
L	Phase
N	Neutral conductor
PE	Protective conductor

Figure 3.63: Equipotential bonding of data cables

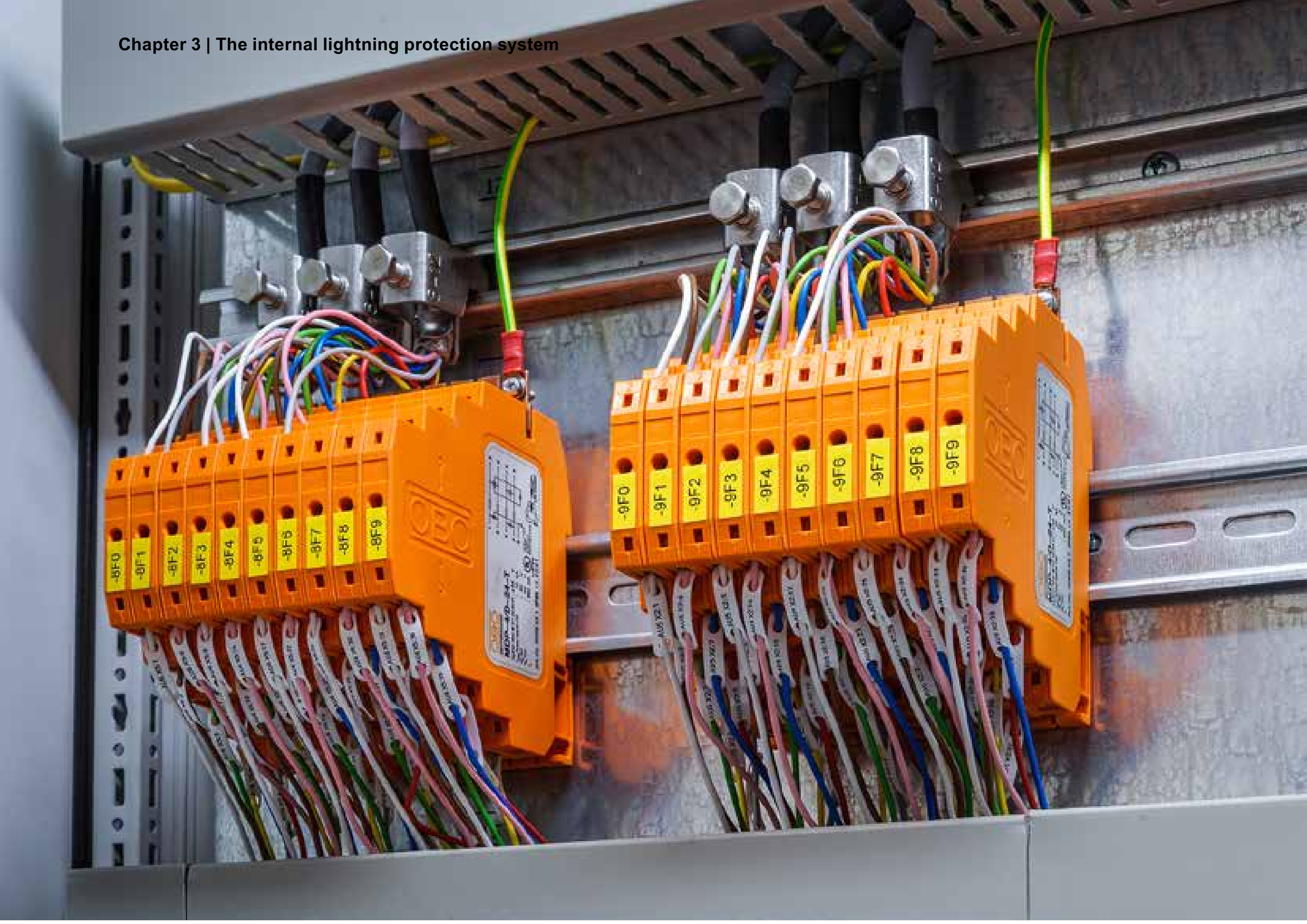


Figure 3.64: MDP lightning barriers in an switching cabinet

3.3.2.2 Measurement and control technology

Measurement and control technology and fieldbus systems allow automated control of production lines or remote monitoring of many different types of sensors and actuators. Today, this technology forms the core of any modern industrial company. Their failure would result in high financial losses. To prevent this, the systems must be protected against surge voltages from inductive and capacitive couplings.

Lightning barriers TKS-B, FRD, FLD, FRD 2 and FLD 2 protect electronic measuring, controlling and regulating systems from surges. In areas where a particularly narrow installation width but large number of terminals is needed, type MDP lightning barriers are used.

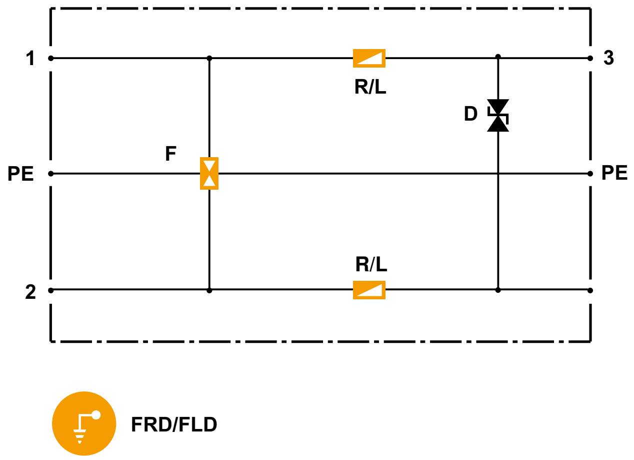


Figure 3.65: Circuit diagram of lightning barrier FRD/FLD

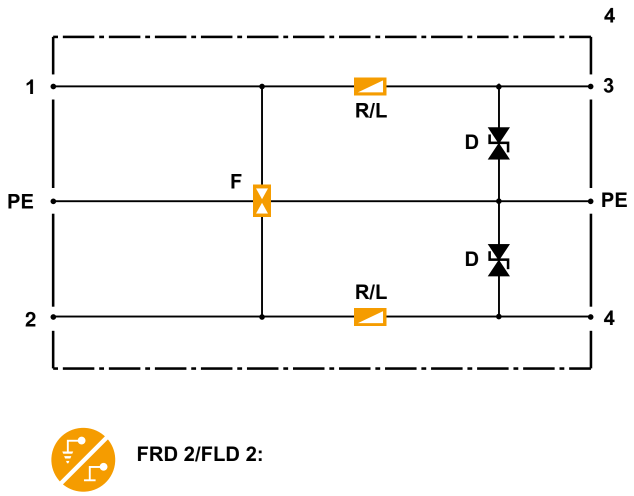


Figure 3.66: Circuit diagram of lightning barrier FRD2/FLD2

Type series FRD/FLD (Figure 3.65)
Type FRD, FLD and MDP lightning barriers are designed for use in so-called floating (asymmetrical, potential-free) two-core systems. These are systems whose signal circuits have no common reference potential with other signal circuits, e.g. 20 mA current loops. These devices can be universally applied.

Type series FRD2/FLD2 (Figure 3.66)
Type FRD2 and FLD2 are intended for use in ground-referenced (symmetrical, potential-referenced) single-wire systems.

Ground-referenced systems are signal circuits that have a common reference potential with other signal circuits. In these systems, two further data cables besides earth are protected. The decision to use FRD (with resistive decoupling) or FLD (with inductive decoupling) depends on the system to be protected.

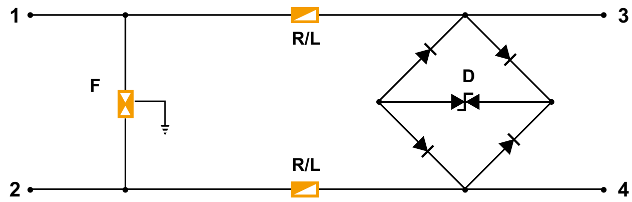


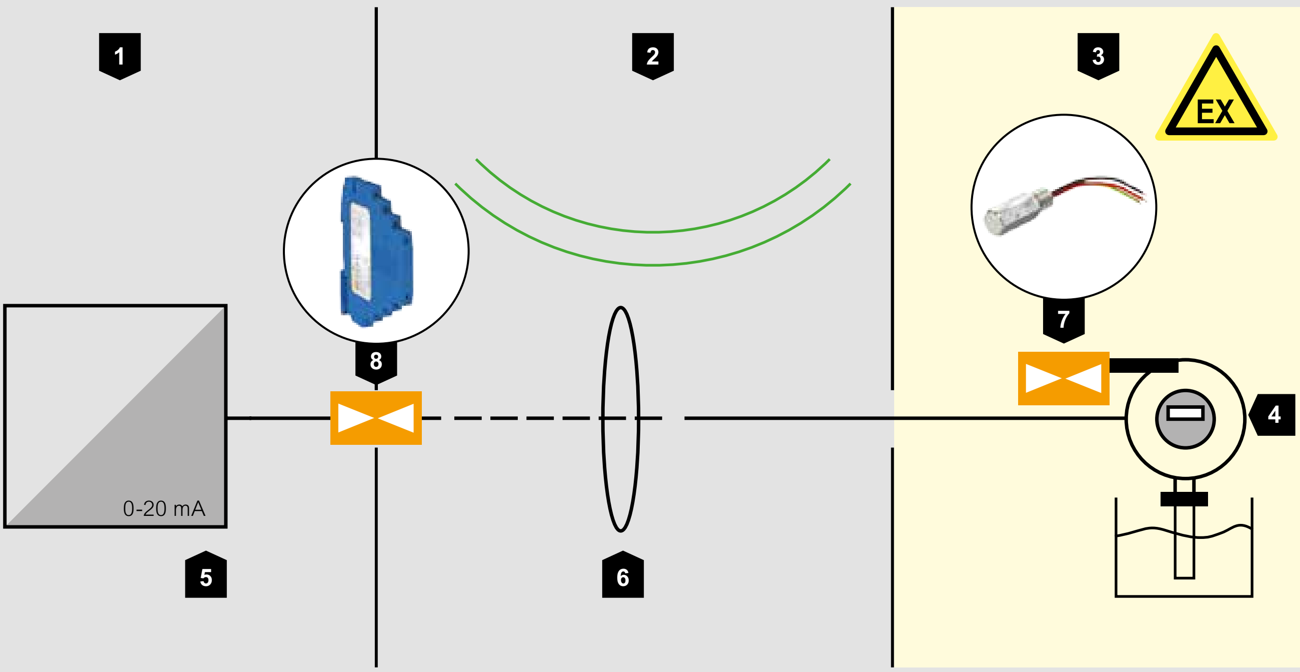
Figure 3.67: Basic protection circuit in measuring circuit

Use of lightning barriers in measuring circuits (Figure 3.67)
Before lightning barriers are used in measuring circuits, it must first be confirmed whether a resistance increase is permitted. Depending on the decoupling, resistance increases in the measuring circuits can occur with types FRD and FRD2. This can result in errors with current loop measurements. FLD/FLD2 and/or MDP devices should therefore be used in this case. The maximum operating current should also be verified to ensure that the dissipated energy does not cause thermal destruction of the decoupling elements.

In the case of arresters with integrated inductances for decoupling, the signal is attenuated at high transfer frequencies. Therefore, when used in measuring circuits with high transfer frequencies, lightning barriers with resistive decoupling elements are the preferred solution.

Surge protection for explosive areas (Figure 3.68)
Surge protection is an important topic in potentially explosive areas. It is important here to protect costly measuring technology against the influence of surge voltages through atmospheric discharges. Sensitive measuring technology, whose cables are often routed outdoors, are particularly at risk from surge voltages and lightning strikes. A typical set-up is shown below for a 0-20 mA interface.

Figure 3.66: Sensor with Petrol Field Protector
(see item 7 in Figure 3.68)



1	Protected side
2	Field
3	Ex area zone 1, 2
4	Protected sensor
5	Signal source
6	Coupling
7	Surge protective device on sensor (e.g. FDB)
8	Surge protection device in front of the signal source (e.g. MDP)

Figure 3.68: Application example – protection of a measurement/control signal line in an ex area

Figure 3.69: Protection of an ISDN + DSL connection with TeleDefender

3.3.2.3 Telecommunications

Today telecommunications are used in all kinds of different applications. Many people associate the term "telecommunications" only with the traditional telephone. But that is only part of the story. Telecommunications means the transmission, over a substantial distance, of any kind of information via technical infrastructures. That includes everything from high-speed transmissions via optical fibre to sending a simple fax.

Telephone systems

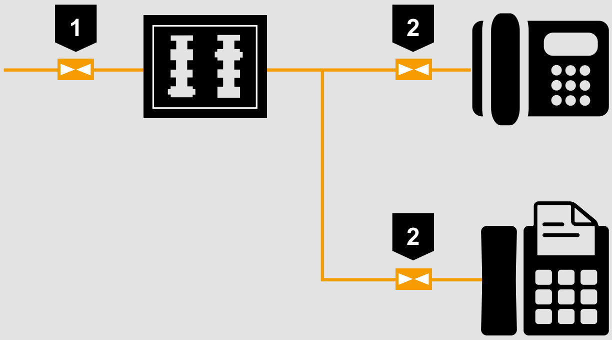
In many cases, modern telephone systems also act as interfaces for a number of different data services, e.g. the Internet. Many terminal devices that enable this access are connected into the lines themselves and must be integrated into the surge protection concept accordingly. As there are now a number of different systems, these devices must have selective protection. There are three distinctly different essential systems.

Standard analogue connection

Unlike other systems, the standard analogue connection offers no additional services. One or several telephones are wired in a star-shape and ring simultaneously when a call comes in. Access to the Internet is via a separate modem. Because the analogue connection without technical accessories provides only one channel, the Internet cannot be accessed while telephoning and likewise, no telephone call is possible while surfing.

ISDN (Integrated Services Digital Network System)

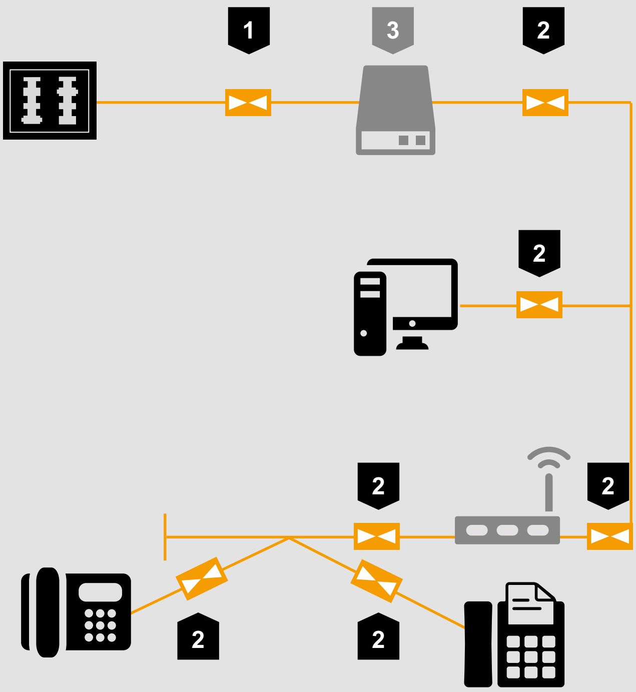
In contrast to the analogue connection, ISDN allows two conversations to take place at the same time via a special bus system (S0 bus), which provides two channels. This enables the user to surf on the Internet while telephoning and at higher data rates than is possible with the analogue connection (64 kBit/s over one channel). ISDN also offers other services such as call waiting, call back, etc.



	Device	Item no.
1	TKS-B or TD-4/I	5097 97 6 5081 69 0
2	RJ11-TELE 4-F	5081 97 7

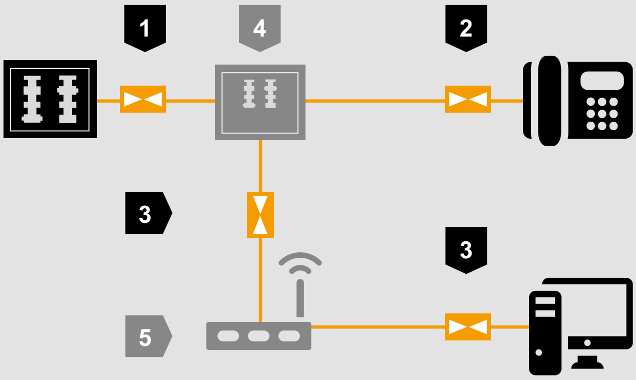
Figure 3.70: Protection of an analogue telephone connection

Analogue connection (Figure 3.70)
Analogue telephone system
- One line (without system connection)
- Low data throughput (56 Kbit/s)



	Device	Item no.
1	TKS-B or TD-4/I	5097 97 6 5081 69 0
2	ND-CAT6A/EA	5081 80 0
3	NTBA	-

Figure 3.71: Protection of an ISDN connection



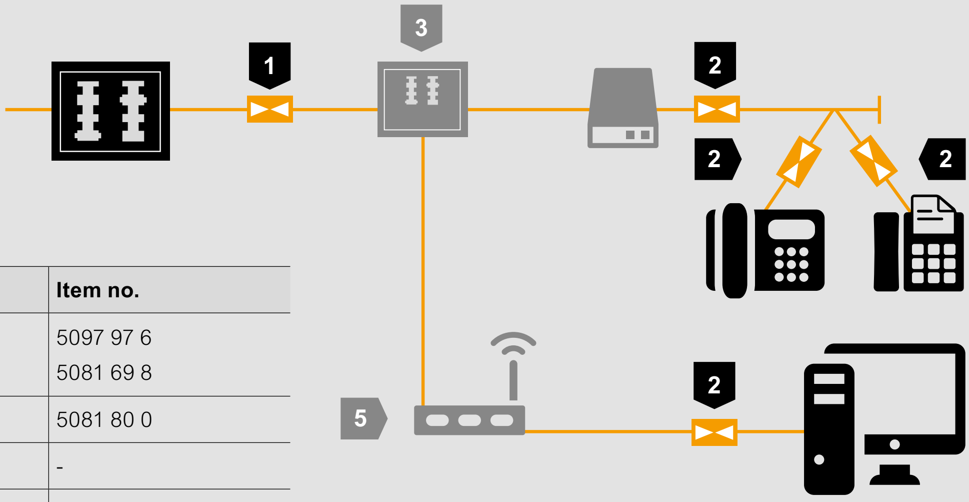
	Device	Item no.
1	TKS-B or TD-2D-V	5097 97 6 5081 69 8
2	RJ11-TELE 4-F	5081 97 7
3	ND-CAT6A/EA	5081 80 0
4	Splitter	-
5	DSL modem	-

Figure 3.72: Protection of a DSL+ analogue telephone connection

DSL system (Digital Subscriber Line)
The currently most widely used system is probably DSL. Speech and data channels are separated by splitters and the data channel is routed to a special modem (NTBBA), which is connected to the PC via a network card. DSL data rates are higher than those of analogue and ISDN systems and therefore enable fast downloading of music and films from the Internet.

Because there are a number of different DSL versions such as ADSL and SDSL, the general DSL is also designated XDSL. XDSL permits the use of analogue telephones without additional hardware, as well as a combination with ISDN. The following circuit diagram shows how it is possible to protect a typical ISDN/analogue + DSL connection. **(Figure 3.70-3.74)** You can find a comprehensive overview in the selection aids starting on page 196.

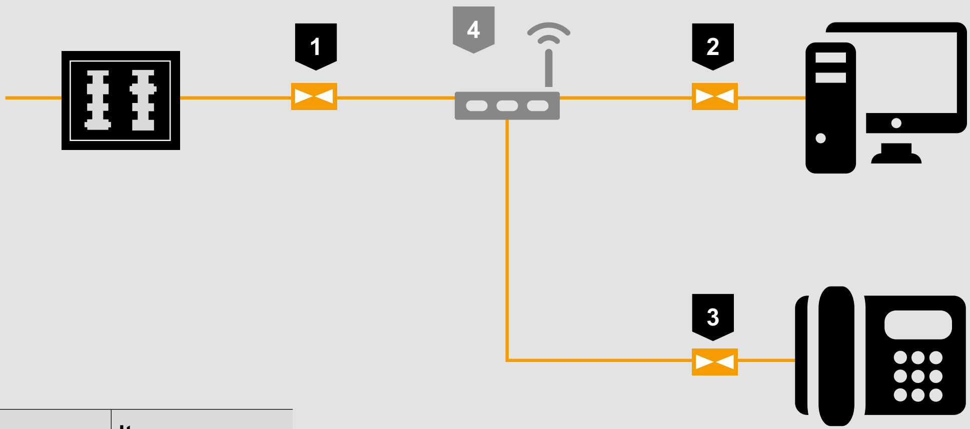
DSL connection in combination with an ISDN connection



	Device	Item no.
1	TKS-B or TD-2D-V	5097 97 6 5081 69 8
2	ND-CAT6A/EA	5081 80 0
3	NTBA	-
4	Splitter	-
5	DSL modem	-

Figure 3.73: Protection of an ISDN + DSL connection with TeleDefender

IP connection



	Device	Item no.
1	TD-2D-V	5081 69 8
2	ND-CAT6A/EA	5081 80 0
3	ND-CAT6A/EA (IP/ISDN telephone)	5081 80 0
3	RJ11-TELE 4-F (analogue telephone)	5081 97 7
4	IP modem	-

Figure 3.74: Protection of an IP connection

3.3.2.4 High-frequency technology

High-frequency technology is often used in systems for the wireless transmission of information such as voice, data or video. This section introduces several of the best-known technologies:

GSM

GSM stands for Global System for Mobile Communications and is a global standard for all-digital mobile communications. It is used primarily for pure telephony between mobile telephone subscribers. However, it also offers the possibility of circuit-switched and packet data transport. GSM was introduced in Germany in 1992.

UMTS/LTE

The Universal Mobile Telecommunications System (UMTS) allows a much higher data rate than GSM. This third-generation standard permits a transmission speed of 42 Mbit/s with HSDPA+ or up to 300 Mbit with the fourth-generation standard, LTE (Long Term Evolution). LTE is also used for supplying broadband data services to rural regions to eliminate blank spots, i.e. areas with less than 1 Mbit/s data connection.

TETRA/BOS

TETRA is a standard for digital trunked radio and stands for "terrestrial trunked radio". It can be used for classic voice transmission but also for data, signalling and positioning services. It is therefore very versatile. The service is also used by authorities and organisations performing safety and security tasks (BOS).

GPS

GPS, or Global Positioning System, is a satellite system for determining location. Possibly the best-known application of this technology is navigation systems.

SAT-TV

Like GPS, SAT-TV uses a satellite system for transmission and is used for transferring analogue and digital TV programmes. To receive the signals a satellite dish and an LNB (Low Noise Block) are needed; the LNB converts the frequencies from satellite transmission into frequencies that can be used in coaxial cables.

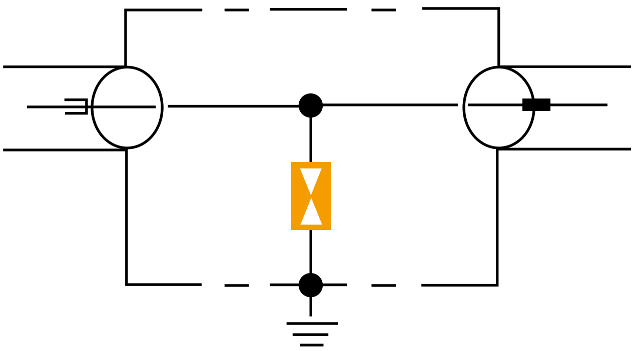


Figure 3.75: Coaxial surge protective device with gas-discharge protector

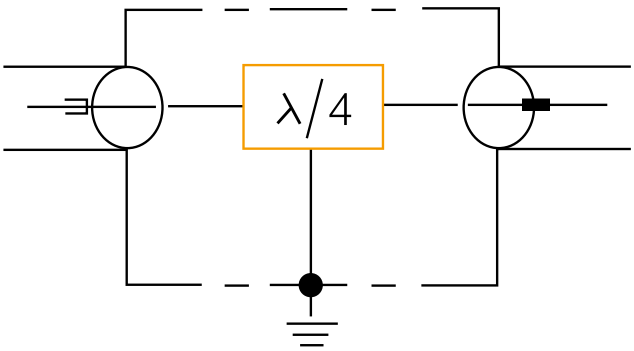


Figure 3.76: Coaxial surge protective device with Lambda/4 technology

These sensitive, high-frequency systems need to be protected from lightning currents and surge voltages. Suitable arresters for these applications include the DS coaxial surge arrester from OBO Bettermann. These offer optimal transmission behaviour with low damping values and are connected in series to the transmission path. They are available for all standard connections. Coaxial arresters come in two types: with either a gas-discharge protector or with Lambda/4 technology.

Coaxial surge protective devices with gas-discharge protector

The first type is coaxial surge protective devices with a gas-discharge tube. **(Figure 3.75)** These enable transmission from a frequency of 0 Hz (DC). They are available for virtually all plug systems. They can therefore be used in a wide range of applications. The gas-discharge tube can additionally be replaced in case of defect. Due to the capacity of the gas-discharge tube they are however limited in their bandwidth: the cut-off frequency is currently around 3 GHz. For example, no WLAN signals according to the 802.11n standard with a frequency of up to 5.9 GHz can be transmitted.

Surge arresters with Lambda/4 technology

The second variant is the surge arrester with Lambda/4 technology. **(Figure 3.76)** These arresters are band-pass filters that only pass frequencies within a specific range. For signals outside the frequency range supported, this arrester type is a galvanic short circuit. The advantages of this technology are its support for frequencies of up to around 6 GHz, and its very low protection level of approximately 30 V. They also require virtually no servicing because they do not use a gas-discharge protector.

The disadvantages of these devices are that it is not possible to transmit DC supply voltage along the signal line, and their scope of application is generally limited to just one application, depending on whether the necessary frequencies lie within the frequency range supported.

Standards governing the lightning protection of antenna systems

The rules for the connection of an antenna (Figure 3.77) to a lightning protection system are contained in various standards:

- DIN EN 60728-11 VDE 0855-1:2011

According to DIN DIN EN 60728-11 VDE 0855-1:2011-06, order on Section 11, the antenna system is never a substitute for a lightning protection system. It is accepted that partial lightning currents can occur due to direct strike and inductive coupling.

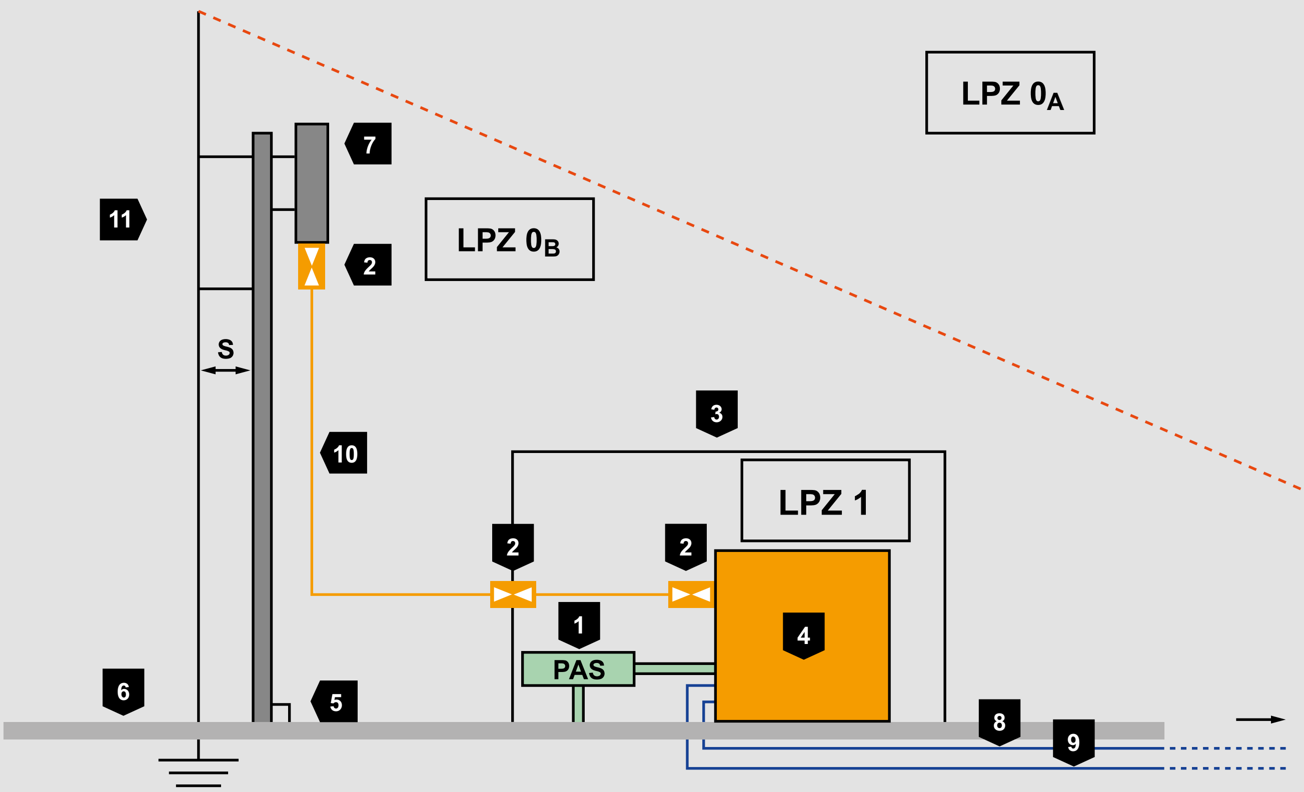
This standard describes the minimum requirements for non-isolated lightning protection.

- IEC 62305-3 DIN VDE 0185-305-3

The antenna mast on the roof of a building should only be connected with the interception system if the antenna system is not within the protected area of the interception system.

Surge protective devices should be installed in order to limit surge voltages.

The figure below shows how an antenna system can be protected against lightning:



1	Equipotential bonding rail (energy and data technology)
2	Coaxial surge protective devices (variable)
3	Shielded building
4	Transmitter/receiver
5	Connection lug
6	Foundation earther
7	Antenna
8	Energy cable
9	Data cable
10	Coaxial cable
11	Interception system with separation distance (s)

Figure 3.77 Protection of an antenna system

The insulated structure means that no partial lightning current is able to flow through the antenna cable (Figure 3.78), provided that the separation distance (s) is maintained. The power and data cables must be integrated into the lightning protection equipotential bonding at the entry to the building. In case of a direct strike on the insulated interception system, partial lightning currents can occur in the cable due to the increase in potential at earth and presence of different earthing systems. Careful use should therefore be made of lightning arresters in this area. In order to avoid arcing from the shield of the cable onto the signal line, the lightning arrester equalises the potential of the shield and the signal line.

1	bonding rail
2	Coaxial surge protective devices (variable)
3	Shielded building
4	Transmitter/receiver
5	Connection lug
6	Foundation earther
7	Antenna
8	Energy cable
9	Data cable
10	Coaxial cable
11	Interception system with separation distance (s)

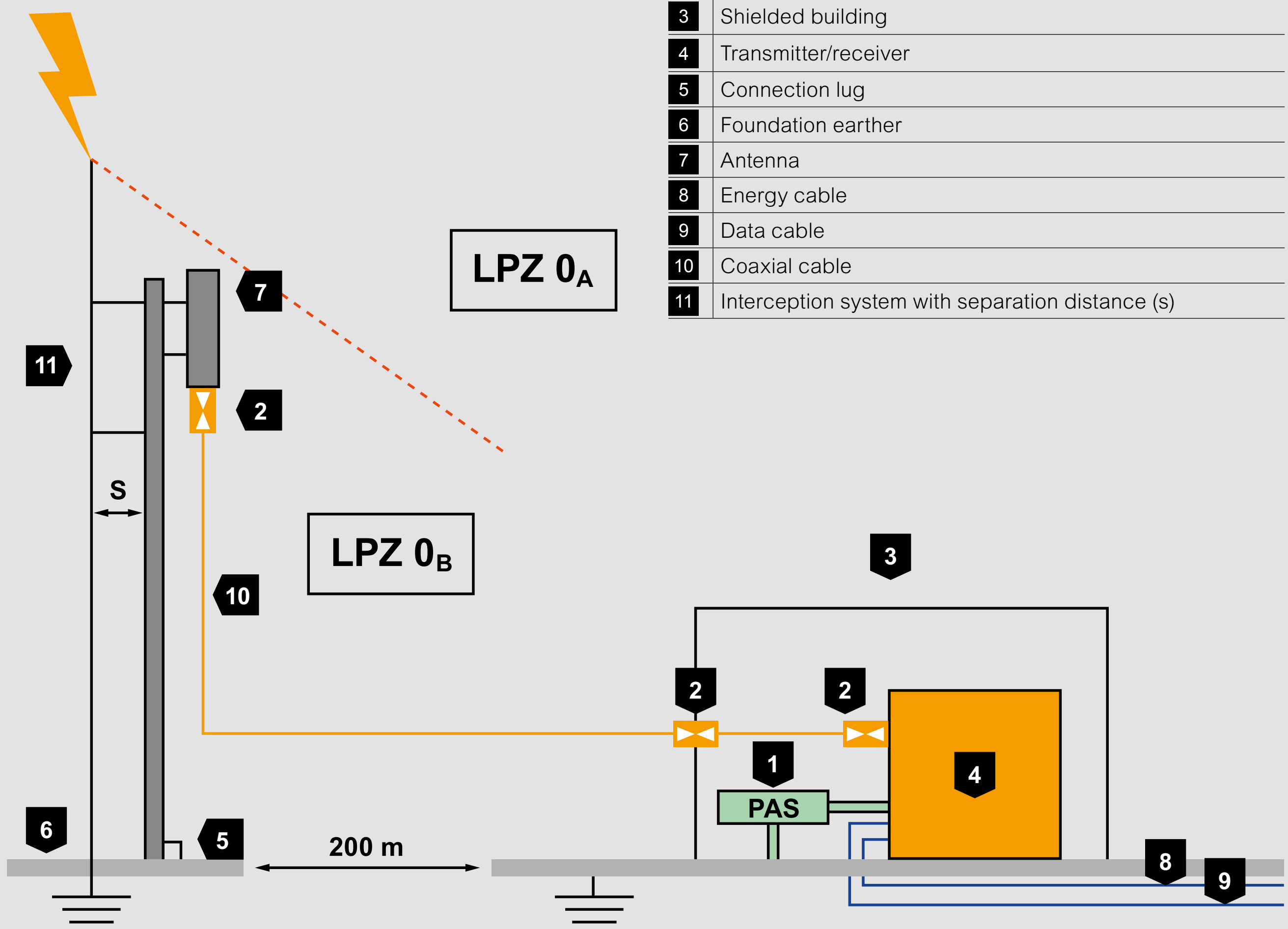
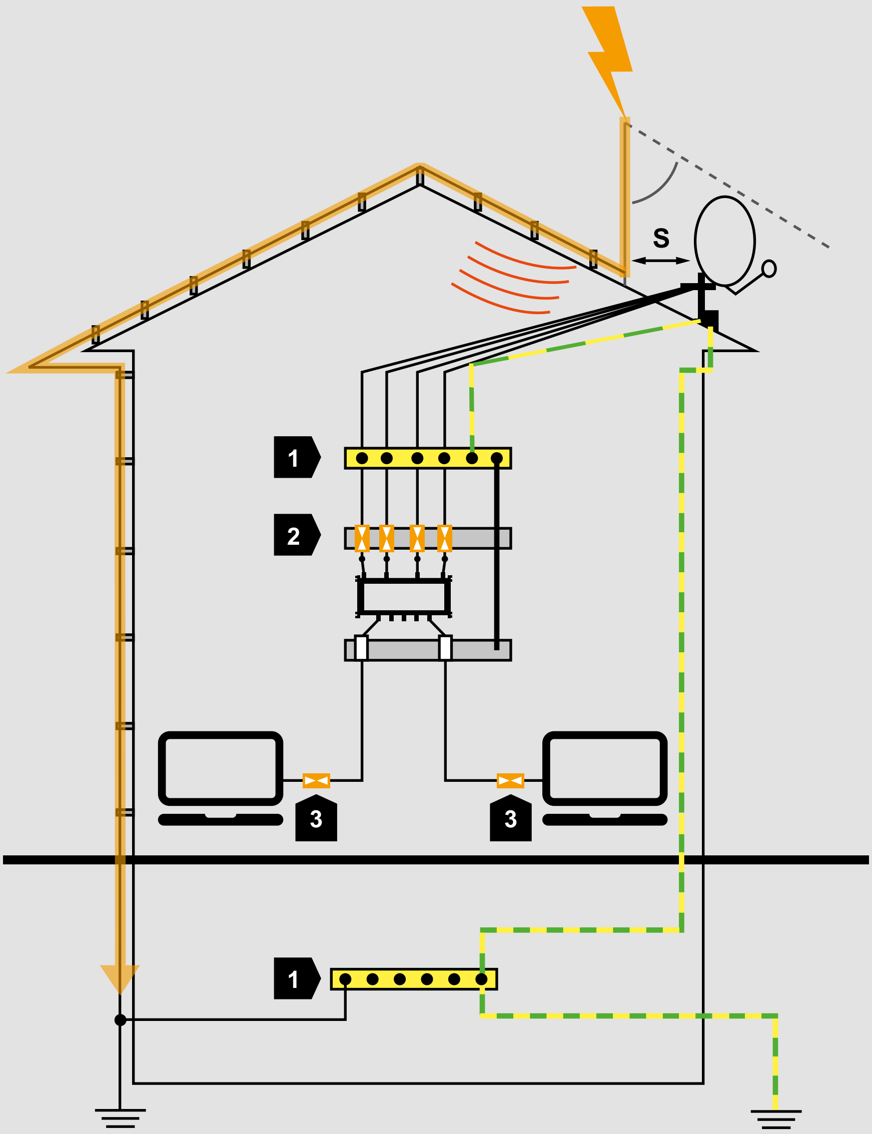


Figure 3.78: Insulated lightning protection on an antenna system and various earthing systems

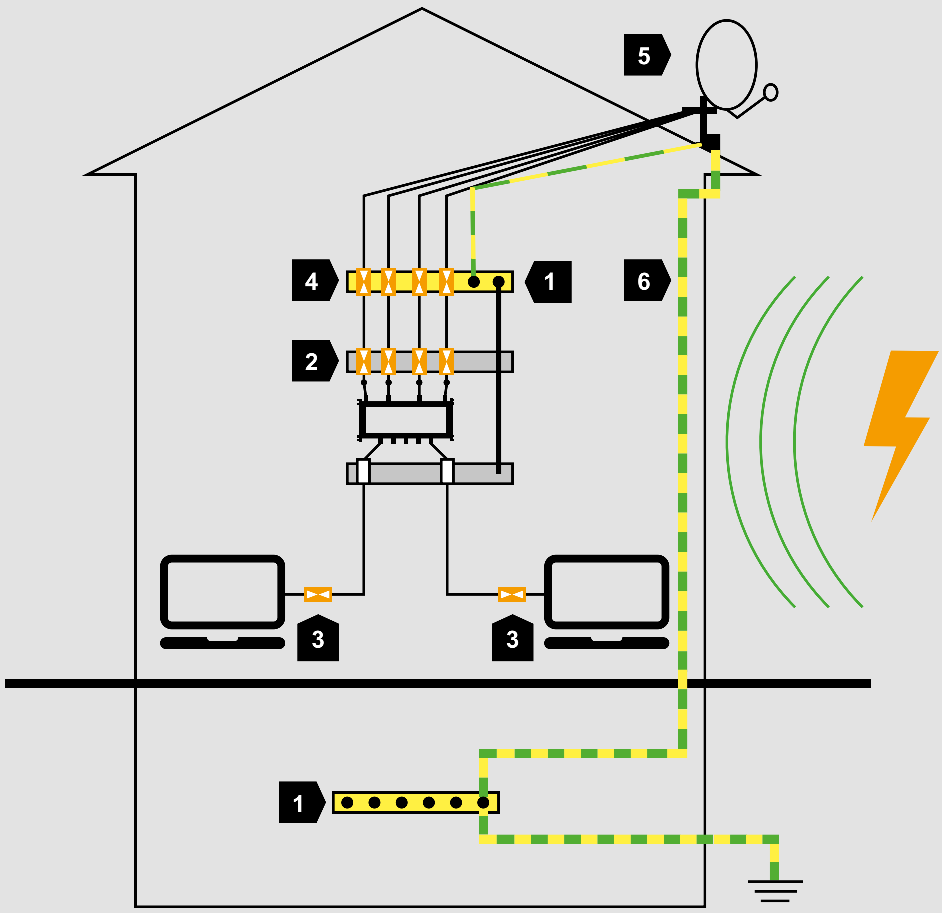
Satellite systems (Figure 3.79)
Like interception rods, satellite systems and antennas are often in exposed locations on roofs. For this reason interception rods must be used to protect these systems against direct lightning strikes, to prevent them from serving as lightning interception systems themselves. Ideally, in the finished lightning protection system the satellite antenna should be located within the protective angle of the interception rod. This rules out any risk of direct strikes on the satellite cables.

However, if the interception rod is struck, surge voltages will be coupled. Using, for example, a surge protective device like the OBO TV 4+1 (for protecting for example multiswitches) or FC-SAT-D (for protecting a TV set), these surge voltages can be limited to a level that is safe for the device in question. Here, it is vital that the required separation distance (s) is maintained between the interception rod and the antenna system. The following figure shows the lightning and surge protection for a satellite TV system:



	Device	Item no.
1	Equipotential busbar, e.g. 1801 VDE	5015 65 0
2	Coaxial surge protection, e.g. TV 4+1	5083 40 0
3	Fine protective device for SAT and 230 V supply line, e.g. OBO FC-SAT-D	5092 81 6

Figure 3.79: Current path in case of a direct strike close to a satellite dish



	Device	Item no.
1	Equipotential bonding rail, e.g. 1801 VDE	5015 65 0
2	Coaxial surge protection, e.g. TV 4+1	5083 40 0
3	Fine protection device for SAT and 230 V supply line, e.g. OBO FC-SAT-D	5092 81 6
4	OBO DS-F lightning arrester	5093 27 5 / 5093 27 2
5	Antenna earthing with 4 mm² Cu	-
6	min. 16 mm² Cu earthing conductor	-

Figure 3.80: Induction of surge voltage into a satellite TV system

With appropriate coordination of the lightning and surge protective components, lightning currents and surges can be safely arrested. If there is no external lightning protection on the building, the exposed satellite system is at risk of attracting a direct strike, like an interception rod. For this reason class D1 lightning arresters are needed in addition to the surge protection. As well as the standard antenna earthing using 4 mm² Cu, the antenna system must additionally be connected with the main earthing rail using a copper earthing conductor of minimum 16 mm².

3.3.2.5 Data technology

Data technology is used in a wide range of applications, from the simple connection of a printer to a PC to complex networks involving several thousand clients. In all cases, careful planning of surge protection measures is required, taking account of the data interfaces at hand.

Ethernet

Ethernet is the standard technology for networked computer systems today. Specified data transmission rates range from 10 Mbit/s to as much as 10 Gbit/s today, and the data can be transmitted over both classic copper cables and fibre optic cables. The standard includes cable and connector types such as RJ45.

Interfaces

External devices such as printers, scanners and control systems activated via serial or parallel interfaces must be additionally integrated into the surge protection concept.

There is a range of interfaces for different applications: from bus lines for telecommunication and data transfer through to simple terminal devices such as printers or scanners. OBO also offers a host of protective devices that are simple to install, depending on the particular application.

- **RS232 interface**

The RS232 is a frequently used interface. It is used, for example, for modems and other peripherals. Although now largely replaced by the USB interface, the RS232 standard is still frequently used for control lines.

- **RS422 interface**

The RS422 is a serial high-speed standard suitable for communication between a maximum of ten users, which is designed as a bus. The system can be designed for a maximum of eight data lines, although two are always used as send and receive lines.

- **RS485 interface**

The RS485 industrial bus interface differs slightly from the RS422 in that the RS485 enables the connection of several transmitters and receivers (up to 32 users) via a protocol. The maximum length of this bus system, when twisted-pair cables are used, is approx. 1.2 km with a data rate of 1 Mbit/s (dependent upon serial controllers).

- **TTY system**

Unlike the RS232 or other serial interfaces, the TTY system is not voltage-controlled instead it delivers an imposed current (4-20 mA). This enables cable lengths of up to several hundred metres to be realised.

- **V11 interface**

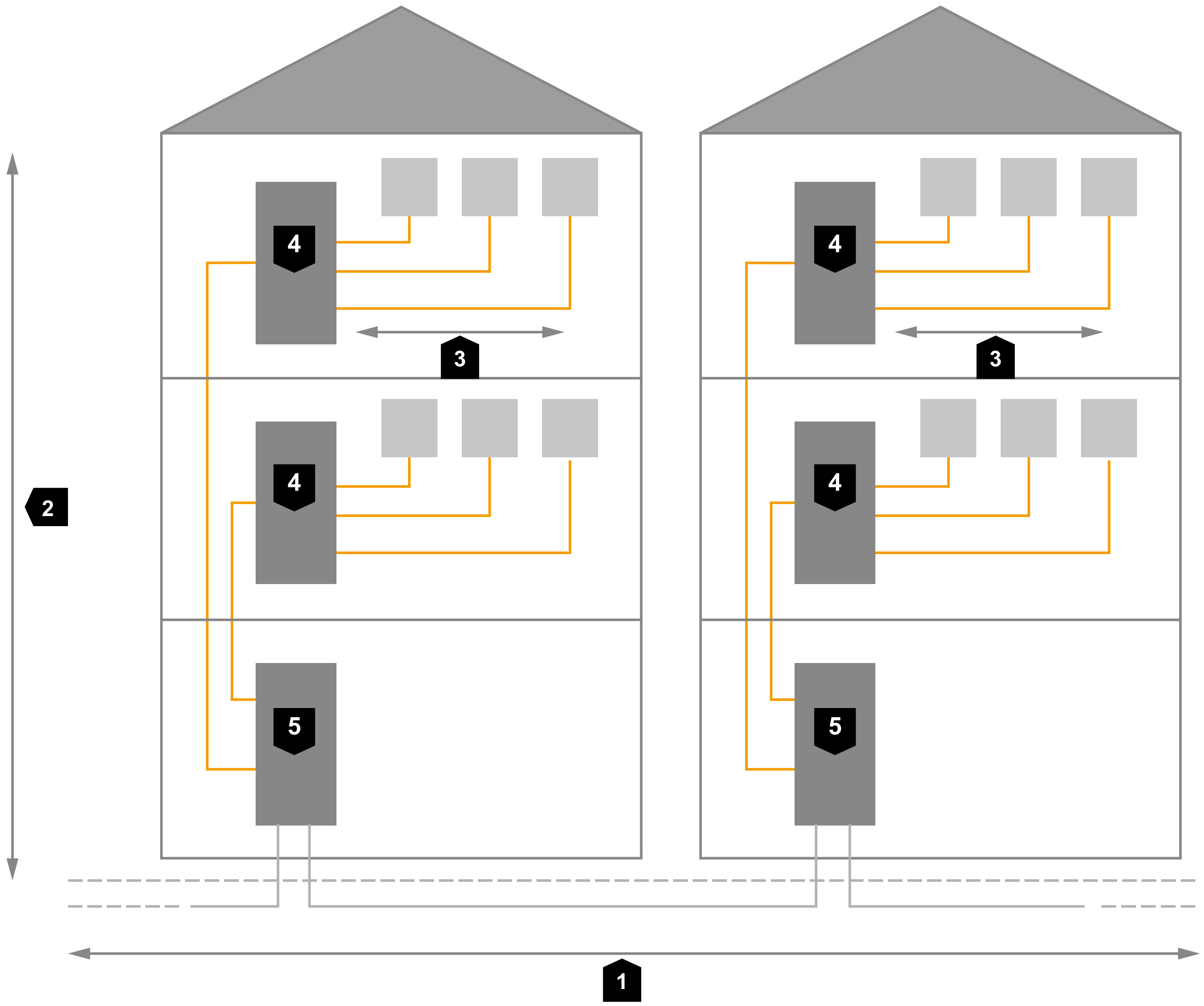
V11 is the German designation for the RS422. The American nomenclature, however, is the most widely used.

- **V24 interface**

V24 is the German designation for the RS232. The American nomenclature, however, is the most widely used.

Structured cabling

The standard for structured cabling defines how to cable a building in a universal way. "Universal" in this sense means that the emphasis is on generic cabling, in other words the lines are not just for one specific service, such as network connections, but for many different ones (speech, data, audio, telephone, measurement and control, etc.). The advantage of this approach is that a cable can quickly and effortlessly be switched to a different application with no need to install new cables. Structured cabling is covered by the standard CENELEC EN 50173-1.



1	Primary cabling
2	Secondary cabling
3	Tertiary cabling
4	FD: floor distributor
5	BD: building distributor

Figure 3.81: Basic principles of structured cabling

In structured cabling, the cabling is divided into three subsections:

1. Primary cabling
The primary cabling is for connecting building complexes (horizontal). The connection point is the building distributor (BD). Primary cabling can be characterised by long cable lengths due to the locations of different buildings. The speed of the connection also plays an important role. For fast transmission rates to be achieved, fibre optic technology is often used as the transmitting medium in the primary cabling, as this offers higher data rates than conventional copper cables and is also less susceptible to interference from electromagnetic impulses.

2. Secondary cabling
The secondary cabling connects the individual floors of the building with one another (vertical). The floor distributors are directly linked to the building distributor and, at the same time, offer connection opportunities for the various terminal devices/connections sockets. Here, too, fibre optic technology is used as the transfer medium.

3. Tertiary cabling
In tertiary cabling, fibre optic cables can be used as the transmission medium as an alternative to copper network cabling. The tertiary cabling is the cabling that links terminal devices/connection sockets with floor distributors within a floor of the building (horizontal). Various transmission media are used here. In fibre-to-the-desk, the floor distributor and terminal device are linked by a fibre optic cable. However, the most widespread option is the classic connection via Twisted Pair cable.

Lightning and surge protection measures should be installed to ensure that this infrastructure remains free from faults and is not destroyed by powerful currents. Where a building is fitted with external lightning protection, lightning currents and surge voltages pose a particularly high risk. If the separation distance (s) is not maintained, there is a risk of arcing from the external arrester system onto internal cables running along the building wall, for example in dado trunking.

In buildings with an external lightning protection system, internal protection against partial lightning currents and surges is needed.

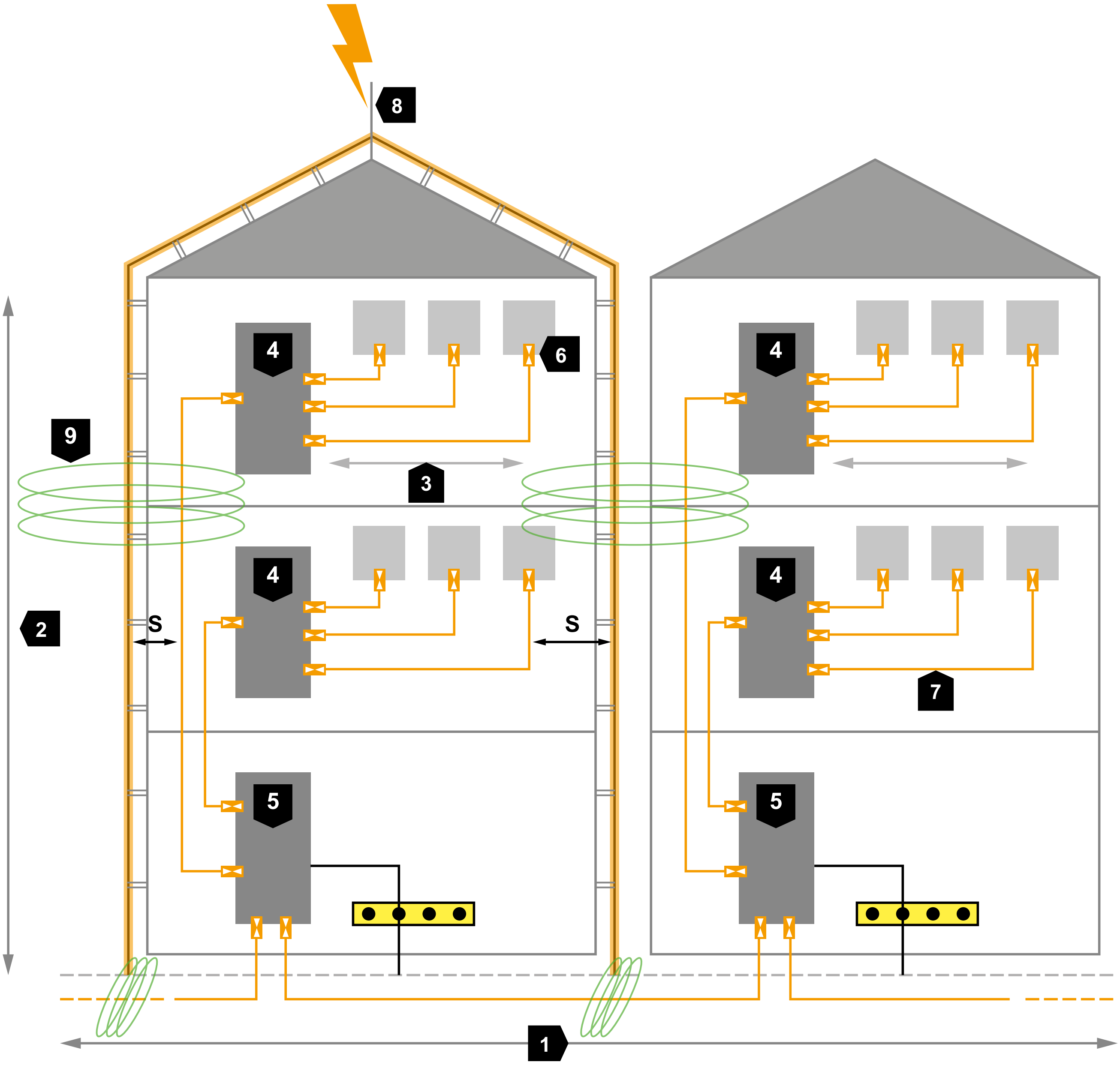


Figure 3.82: Lightning current and surge voltage in a building with structured cabling

1	Primary cabling
2	Secondary cabling
3	Tertiary cabling
4	FD: floor distributor
5	BD: building distributor
6	Surge protection
7	Data cables (orange)
8	External lightning protection (grey)
9	Inductive coupling

The diagram shows the protection of data cables only. Energy cables also need to be protected.

The connection of the primary cabling with the building distributor and the connections from building distributor to the floor distributor only need to be protected where copper cables are used. An exception is fibre optic cables incorporating metallic elements, e.g. rodent guards. These can couple lightning currents and surge voltages into the building. These metal elements must be connected to the equipotential bonding system in such a way as to be able to withstand lightning current.

The following figures show how the OBO Net Defender can be used to protect network infrastructure and terminal devices:

Figure 3.81: Suggested protection for switch with patch panel. The surge protection devices are earthed via the hat rail.

Figure 3.82: Suggested protection for terminal device. To keep the protection level low, the surge protection device uses the protective conductor of the PC case as the PE connection.

Selection aid, HF, video and satellite TV

Technology	Connection	Protected wires	Frequency range	Type	Gender	Item no.	Protection rating
CATV	F	1	0 - 863 MHz	DS-F	Plug/connector	5093 27 5	Combined protection
					Connector/ connector	5093 27 2	Combined protection
DCF 77	SMA	1	0 - 3.7 GHz	DS-SMA	Connector/ connector	5093 27 7	Combined protection
	BNC	1	0 - 2.2 GHz	DS-BNC	Plug/connector	5093 25 2	Combined protection
					Connector/ connector	5093 23 6	Combined protection
					Plug/plug	5093 26 0	Combined protection
DCS 1800	SMA	1	0 - 3.7 GHz	DS-SMA	Connector/ connector	5093 27 7	Combined protection
	N	1	0 - 3 GHz	DS-N	Plug/connector	5093 99 6	Combined protection
					Connector/ connector	5093 98 8	Combined protection
	BNC	1	0 - 2.2 GHz	DS-BNC	Plug/connector	5093 25 2	Combined protection
					Connector/ connector	5093 23 6	Combined protection
					Plug/plug	5093 26 0	Combined protection
	7/16	1	0 - 3 GHz	DS-7 16	Plug/connector	5093 17 1	Combined protection
DOCSIS	F	1	0 - 863 MHz	DS-F	Plug/connector	5093 27 5	Combined protection
					Connector/ connector	5093 27 2	Combined protection
DVB-T / terrestrial	F	1	0 - 863 MHz	DS-F	Plug/connector	5093 27 5	Combined protection
					Connector/ connector	5093 27 2	Combined protection
	F	1	0.5 - 2.8 GHz	TV4+1	connector	5083 40 0	Fine protection
Radio installa-tions	UHF	1	0 - 1.3 GHz	S-UHF	Plug/connector	5093 02 3	Combined protection
					Connector/ connector	5093 01 5	Combined protection
	BNC	1	0 - 2.2 GHz	DS-BNC	Plug/connector	5093 25 2	Combined protection
					Connector/ connector	5093 23 6	Combined protection
					Plug/plug	5093 26 0	Combined protection
	N	1	0 - 3 GHz	DS-N	Plug/connector	5093 99 6	Combined protection
					Connector/ connector	5093 98 8	Combined protection
	SMA	1	0 - 3.7 GHz	DS-SMA	Connector/ connector	5093 27 7	Combined protection
	7/16	1	0 - 3 GHz	DS-7 16	Plug/connector	5093 17 1	Combined protection
	F	1	0 - 863 MHz	DS-F	Plug/connector	5093 27 5	Combined protection
					Connector/ connector	5093 27 2	Combined protection
	TNC	1	0 - 4 GHz	DS-TNC	Plug/connector	5093 27 0	Combined protection
GPS	SMA	1	0 - 3.7 GHz	DS-SMA	Connector/ connector	5093 27 7	Combined protection
	BNC	1	0 - 2.2 GHz	DS-BNC	Plug/connector	5093 25 2	Combined protection
					Connector/ connector	5093 23 6	Combined protection
					Plug/plug	5093 26 0	Combined protection
	N	1	0 - 3 GHz	DS-N	Plug/connector	5093 99 6	Combined protection
					Connector/ connector	5093 98 8	Combined protection
	7/16	1	0 - 3 GHz	DS-7 16	Plug/connector	5093 17 1	Combined protection
	TNC	1	0 - 4 GHz	DS-TNC	Plug/connector	5093 27 0	Combined protection

Selection aid, HF, video and satellite TV

Technology	Connection	Protected wires	Frequency range	Type	Gender	Item no.	Protection rating
GSM 900 / 1800	SMA	1	0 - 3.7 GHz	DS-SMA	Connector/ connector	5093 27 7	Combined protection
	BNC	1	0 - 2.2 GHz	DS-BNC	Plug/connector	5093 25 2	Combined protection
					Connector/ connector	5093 23 6	Combined protection
					Plug/plug	5093 26 0	Combined protection
	N	1	0 - 3 GHz	DS-N	Plug/connector	5093 99 6	Combined protection
					Connector/ connector	5093 98 8	Combined protection
	TNC	1	0 - 4 GHz	DS-TNC	Plug/connector	5093 27 0	Combined protection
	7/16	1	0 - 3 GHz	DS-7 16	Plug/connector	5093 17 1	Combined protection
LTE	SMA	1	0 - 3.7 GHz	DS-SMA	Connector/ connector	5093 27 7	Combined protection
	N	1	0 - 3 GHz	DS-N	Plug/connector	5093 99 6	Combined protection
					Connector/ connector	5093 98 8	Combined protection
	TNC	1	0 - 4 GHz	DS-TNC	Plug/connector	5093 27 0	Combined protection
	7/16	1	0 - 3 GHz	DS-7 16	Plug/connector	5093 17 1	Combined protection
PCS 1900	SMA	1	0 - 3.7 GHz	DS-SMA	Connector/ connector	5093 27 7	Combined protection
	BNC	1	0 - 2.2 GHz	DS-BNC	Plug/connector	5093 25 2	Combined protection
					Connector/ connector	5093 23 6	Combined protection
					Plug/plug	5093 26 0	Combined protection
	N	1	0 - 3 GHz	DS-N	Plug/connector	5093 99 6	Combined protection
					Connector/ connector	5093 98 8	Combined protection
	7/16	1	0 - 3 GHz	DS-7 16	Plug/connector	5093 17 1	Combined protection
Satellite TV	F	1	0 - 863 MHz	DS-F	Plug/connector	5093 27 5	Combined protection
					Connector/ connector	5093 27 2	Combined protection
	F	1	0.5 - 2.8 GHz	TV4+1	connector	5083 40 0	Fine protection
	F	3	0 - 863 MHz	FC-SAT-D	Plug/connector	5092 81 6	Fine protection
C band	N	1	0 - 6 GHz	DS-N-6	Plug/connector	5093 98 8	Combined protection
Sky DSL	F	1	0 - 863 MHz	DS-F	Plug/connector	5093 27 5	Combined protection
					Connector/ connector	5093 27 2	Combined protection
TETRA / BOS	SMA	1	0 - 3.7 GHz	DS-SMA	Connector/ connector	5093 27 7	Combined protection
	BNC	1	0 - 2.2 GHz	DS-BNC	Plug/connector	5093 25 2	Combined protection
					Connector/ connector	5093 23 6	Combined protection
					Plug/plug	5093 26 0	Combined protection
	N	1	0 - 3 GHz	DS-N	Plug/connector	5093 99 6	Combined protection
					Connector/ connector	5093 98 8	Combined protection
	7/16	1	0 - 3 GHz	DS-7 16	Plug/connector	5093 17 1	Combined protection

Selection aid, HF, video and satellite TV

Technology	Connection	Protected wires	Frequency range	Type	Gender	Item no.	Protection rating
TV	F	1	0 - 863 MHz	DS-F	Plug/connector	5093 27 5	Combined protection
					Connector/ connector	5093 27 2	Combined protection
	F	3	0 - 863 MHz	FC-TV-D	Plug/connector	5092 80 8	Fine protection
UMTS	SMA	1	0 - 3.7 GHz	DS-SMA	Connector/ connector	5093 27 7	Combined protection
	BNC	1	0 - 2.2 GHz	DS-BNC	Plug/connector	5093 25 2	Combined protection
					Connector/ connector	5093 23 6	Combined protection
					Plug/plug	5093 26 0	Combined protection
	N	1	0 - 3 GHz	DS-N	Plug/connector	5093 99 6	Combined protection
					Connector/ connector	5093 98 8	Combined protection
	TNC	1	0 - 4 GHz	DS-TNC	Plug/connector	5093 27 0	Combined protection
	7/16	1	0 - 3 GHz	DS-7 16	Plug/connector	5093 17 1	Combined protection
Video/CCTV	BNC	1	0 - 65 MHz	Coax B-E2 MF-F	Plug/connector	5082 43 2	Fine protection
				Coax B-E2 MF-C	Plug/connector	5082 43 0	Combined protection
	BNC	1	0 - 160 MHz	Koax B-E2 FF-F	Plug/plug	5082 43 4	Fine protection
WLAN (2.4 GHz)	SMA	1	0 - 3.7 GHz	DS-SMA	Connector/ connector	5093 27 7	Combined protection
	N	1	0 - 3 GHz	DS-N	Plug/connector	5093 99 6	Combined protection
					Connector/ connector	5093 98 8	Combined protection
	TNC	1	0 - 4 GHz	DS-TNC	Plug/connector	5093 27 0	Combined protection
WLAN (> 5 GHz) stan- dard: a/h, n, ac	N	1	0 - 6 GHz	DS-N-6	Plug/connector	5093 98 8	Combined protection
WiMAX	N	1	0 - 6 GHz	DS-N-6	Plug/connector	5093 98 8	Combined protection

Data technology selection aid

Technology		Connection	Protected wires	Type	Item no.	Protection rating
Arcnet		BNC	1	CoaxB-E2 FF-F	5082 43 4	Fine protection
		BNC	1	CoaxB-E2 MF-F	5082 43 2	Fine protection
		BNC	1	CoaxB-E2 MF-C	5082 43 0	Combined protection
ATM		RJ45	8	ND-CAT6A/EA	5081 80 0	Fine protection
		RJ45	8	RJ45 S-ATM 8-F	5081 99 0	Fine protection
Ethernet	up to class 6A / EA	RJ45	8	ND-CAT6A/EA	5081 80 0	Fine protection
	up to class 5 / D	RJ45	8	RJ45 S-ATM 8-F	5081 99 0	Fine protection
	10 Base 2 / 10 Base 5	BNC	1	CoaxB-E2 FF-F	5082 43 4	Fine protection
		BNC	1	CoaxB-E2 MF-F	5082 43 2	Fine protection
		BNC	1	CoaxB-E2 MF-C	5082 43 0	Combined protection
FDDI, CDDI		RJ45	8	ND-CAT6A/EA	5081 80 0	Fine protection
		RJ45	8	RJ45 S-ATM 8-F	5081 99 0	Fine protection
Industrial Ethernet		RJ45	8	ND-CAT6A/EA	5081 80 0	Fine protection
		RJ45	8	RJ45 S-ATM 8-F	5081 99 0	Fine protection
		Wire-to-terminal connection	20	LSA-B-MAG	5084 02 0	Basic protection
		Wire-to-terminal connection	2	LSA-BF-180	5084 02 4	Combined protection
		Wire-to-terminal connection	2	LSA-BF-24	5084 02 8	Combined protection
Power over Ethernet		RJ45	8	ND-CAT6A/EA	5081 80 0	Fine protection
Token Ring		RJ45	8	ND-CAT6A/EA	5081 80 0	Fine protection
		RJ45	8	RJ45 S-ATM 8-F	5081 99 0	Fine protection
		BNC	1	CoaxB-E2 FF-F	5082 43 4	Fine protection
		BNC	1	CoaxB-E2 MF-F	5082 43 2	Fine protection
		BNC	1	CoaxB-E2 MF-C	5082 43 0	Combined protection
RS232, V24		Wire-to-terminal connection	2	MDP-2 D-24-T	5098 42 2	Combined protection
		Wire-to-terminal connection	4	MDP-4 D-24-EX	5098 43 2	Combined protection
		Wire-to-terminal connection	2	FDB-2 24-M	5098 38 0	Combined protection
		Wire-to-terminal connection	2	FDB-2 24-N	5098 39 0	Combined protection
		Wire-to-terminal connection	2	FRD 24 HF	5098 57 5	Fine protection
		Wire-to-terminal connection	4	MDP-4 D-24-T	5098 43 1	Combined protection
		Wire-to-terminal connection	4	MDP-4 D-24-EX	5098 43 2	Combined protection
		Wire-to-terminal connection	4	ASP-V24T 4	5083 06 0	Fine protection
		Connector	9	SD09-V24 9	5080 05 3	Fine protection
		Connector	15	SD15-V24 15	5080 15 0	Fine protection
VG AnyLAN		RJ45	8	ND-CAT6A/EA	5081 80 0	Fine protection
Voice over IP		RJ45	8	ND-CAT6A/EA	5081 80 0	Fine protection
4-wire information technology systems		RJ45	4	RJ45 S-E100 4-B	5081 00 1	Basic protection
		RJ45	4	RJ45 S-E100 4-C	5081 00 3	Combined protection
		RJ45	4	RJ45 S-E100 4-F	5081 00 5	Fine protection

Selection aid, telecommunications

Technology	Connection	Protected wires	Mounting / Note	Type	Item no.	Protection rating
a/b - analogue	RJ11	4	Various	RJ11-TELE 4-C	5081 97 5	Combined protection
	RJ11	4	Various	RJ11-TELE 4-F	5081 97 7	Fine protection
	RJ45	4	Various	RJ45-TELE 4-C	5081 98 2	Combined protection
	RJ45	4	Various	RJ45-TELE 4-F	5081 98 4	Fine protection
	Wire-to-terminal connection	2	Hat rail	TD-2/D-HS	5081 69 4	Combined protection
	Wire-to-terminal connection	4	Wall mounting	TD-4/I	5081 69 0	Combined protection
	Wire-to-terminal connection	4	Wall mounting	TD-4/I-TAE-F	5081 69 2	Combined protection
	Wire-to-terminal connection	2	Wall mounting	TD-2D-V	5081 69 8	Combined protection
	Wire-to-terminal connection	20	LSA	LSA-B-MAG	5084 02 0	Basic protection
	Wire-to-terminal connection	2	LSA	LSA-BF-180	5084 02 4	Combined protection
	Wire-to-terminal connection	2	Hat rail	TKS-B	5097 97 6	Basic protection
	TAE / RJ11 / con-nector	2	Socket	FC-TAE-D	5092 82 4	Fine protection
ADSL	Wire-to-terminal connection	20	LSA	LSA-B-MAG	5084 02 0	Basic protection
	Wire-to-terminal connection	2	LSA	LSA-BF-180	5084 02 4	Combined protection
	Wire-to-terminal connection	2	Hat rail	TD-2/D-HS	5081 69 4	Combined protection
	Wire-to-terminal connection	4	Wall mounting	TD-4/I	5081 69 0	Combined protection
	Wire-to-terminal connection	4	Wall mounting	TD-4/I-TAE-F	5081 69 2	Combined protection
	Wire-to-terminal connection	2	Wall mounting	TD-2D-V	5081 69 8	Combined protection
	Wire-to-terminal connection	2	Hat rail	TKS-B	5097 97 6	Basic protection
ADSL2+	Wire-to-terminal connection	20	LSA	LSA-B-MAG	5084 02 0	Basic protection
	Wire-to-terminal connection	2	LSA	LSA-BF-180	5084 02 4	Combined protection
	Wire-to-terminal connection	2	Wall mounting	TD-2D-V	5081 69 8	Combined protection
	Wire-to-terminal connection	2	Hat rail	TKS-B	5097 97 6	Basic protection
SDSL / SHDSL	Wire-to-terminal connection	20	LSA	LSA-B-MAG	5084 02 0	Basic protection
	Wire-to-terminal connection	2	LSA	LSA-BF-180	5084 02 4	Combined protection
	Wire-to-terminal connection	2	Wall mounting	TD-2D-V	5081 69 8	Combined protection
	Wire-to-terminal connection	2	Hat rail	TKS-B	5097 97 6	Basic protection
VDSL	Wire-to-terminal connection	20	LSA	LSA-B-MAG	5084 02 0	Basic protection
	Wire-to-terminal connection	2	LSA	LSA-BF-180	5084 02 4	Combined protection
	Wire-to-terminal connection	2	Wall mounting	TD-2D-V	5081 69 8	Combined protection
	Wire-to-terminal connection	2	Hat rail	TKS-B	5097 97 6	Basic protection

Selection aid, telecommunications

Technology	Connection	Protected wires	Mounting / Note	Type	Item no.	Protection rating
VDSL2	Wire-to-terminal connection	20	LSA	LSA-B-MAG	5084 02 0	Basic protection
	Wire-to-terminal connection	2	LSA	LSA-BF-180	5084 02 4	Combined protection
	Wire-to-terminal connection	2	Wall mounting	TD-2D-V	5081 69 8	Combined protection
	Wire-to-terminal connection	2	Hat rail	TKS-B	5097 97 6	Basic protection
ISDN basic connection (U_{k0})	Wire-to-terminal connection	2	Hat rail	TD-2/D-HS	5081 69 4	Combined protection
	Wire-to-terminal connection	4	Wall mounting	TD-4/I	5081 69 0	Combined protection
	Wire-to-terminal connection	4	Wall mounting	TD-4/I-TAE-F	5081 69 2	Combined protection
	Wire-to-terminal connection	20	LSA / can only be used WITH LSA-A-LEI or LSA-T-LEI	LSA-B-MAG	5084 02 0	Basic protection
	Wire-to-terminal connection	2	LSA / can only be used WITH LSA-A-LEI or LSA-T-LEI	LSA-BF-180	5084 02 4	Combined protection
	Wire-to-terminal connection	2	Hat rail	TKS-B	5097 97 6	Basic protection
	RJ11	4	Various	RJ11-TELE 4-C	5081 97 5	Combined protection
ISDN basic connection (U_{k0})	RJ11	4	Various	RJ11-TELE 4-F	5081 97 7	Fine protection
	RJ45	4	Various	RJ45-TELE 4-C	5081 98 2	Combined protection
	RJ45	4	Various	RJ45-TELE 4-F	5081 98 4	Fine protection
ISDN basic connection (S_0)	RJ45	8	Various	ND-CAT6A/EA	5081 80 0	Fine protection
	Wire-to-terminal connection	20	LSA	LSA-B-MAG	5084 02 0	Basic protection
	Wire-to-terminal connection	2	LSA	LSA-BF-180	5084 02 4	Combined protection
	Wire-to-terminal connection	2	LSA	LSA-BF-24	5084 02 8	Combined protection
	RJ11 / connector	4	Socket	FC-ISDN-D	5092 81 2	Fine protection
ISDN Primary Rate Interface (S_{2m}/ U_{2m})	RJ11	4	Various	RJ11-TELE 4-C	5081 97 5	Combined protection
	RJ11	4	Various	RJ11-TELE 4-F	5081 97 7	Fine protection
	RJ45	4	Various	RJ45-TELE 4-C	5081 98 2	Combined protection
	RJ45	4	Various	RJ45-TELE 4-F	5081 98 4	Fine protection
	Wire-to-terminal connection	20	LSA	LSA-B-MAG	5084 02 0	Basic protection
	Wire-to-terminal connection	2	LSA	LSA-BF-180	5084 02 4	Combined protection
Datex-P	Spring terminal	4	Hat rail	MDP-4 D-24-T-10	5098 43 3	Combined protection
G.703 / G.704	RJ45	8	Various	RJ45 S-ATM 8-F	5081 99 0	Fine protection
	Wire-to-terminal connection	20	LSA	LSA-B-MAG	5084 02 0	Basic protection
	Wire-to-terminal connection	2	LSA	LSA-BF-180	5084 02 4	Combined protection
	Wire-to-terminal connection	2	LSA	LSA-BF-24	5084 02 8	Combined protection
	Wire-to-terminal connection	2	Hat rail	TKS-B	5097 97 6	Basic protection
	Wire-to-terminal connection	2	Hat rail	TD-2/D-HS	5081 69 4	Combined protection
	Wire-to-terminal connection	4	Wall mounting	TD-4/I	5081 69 0	Combined protection
	Wire-to-terminal connection	4	Wall mounting	TD-4/I-TAE-F	5081 69 2	Combined protection

Selection aid, telecommunications

Technology	Connection	Protected wires	Mounting / note	Type	Item no.	Protection rating
E1	RJ45	8	Various	RJ45 S-ATM 8-F	5081 99 0	Fine protection
	Wire-to-terminal connection	20	LSA	LSA-B-MAG	5084 02 0	Basic protection
	Wire-to-terminal connection	2	LSA	LSA-BF-180	5084 02 4	Combined protection
	Wire-to-terminal connection	2	LSA	LSA-BF-24	5084 02 8	Combined protection
Various telecom systems	Wire-to-terminal connection	20	LSA	LSA-B-MAG	5084 02 0	Basic protection
	Wire-to-terminal connection	2	LSA	LSA-BF-180	5084 02 4	Combined protection
	Wire-to-terminal connection	2	LSA	LSA-BF-24	5084 02 8	Combined protection
	Wire-to-terminal connection	2	Hat rail	TKS-B	5097 97 6	Basic protection
	Wire-to-terminal connection	2	Hat rail	TD-2/D-HS	5081 69 4	Combined protection
	Wire-to-terminal connection	4	Wall mounting	TD-4/I	5081 69 0	Combined protection
	Wire-to-terminal connection	4	Wall mounting	TD-4/I-TAE-F	5081 69 2	Combined protection
	RJ11	4	Various	RJ11-TELE 4-C	5081 97 5	Combined protection
	RJ11	4	Various	RJ11-TELE 4-F	5081 97 7	Fine protection
	RJ45	4	Various	RJ45-TELE 4-C	5081 98 2	Combined protection
	RJ45	4	Various	RJ45-TELE 4-F	5081 98 4	Fine protection
	RJ45	8	Various	RJ45 S-ATM 8-F	5081 99 0	Fine protection
	RJ45	8	Various	ND-CAT6A/EA	5081 80 0	Fine protection
	RJ11 / connector	4	Socket	RC-RJ-D	5092 82 8	Fine protection

[1] *Remote signalling*

Selection aid, measurement and control systems

Interface		Connection	Protected wires	Mounting	EX	FS[1]	Type	Item no.	Protection rating
(0)4 - 20 mA		Spring terminal	2	Hat rail			MDP-2 D-24-T	5098 42 2	Combined protection
		Spring terminal	2	Hat rail	✓		MDP-4 D-24-EX	5098 43 2	Combined protection
		Spring terminal	4	Hat rail			MDP-4 D-24-T	5098 43 1	Combined protection
		Spring terminal	4	Hat rail	✓		MDP-4 D-24-EX	5098 43 2	Combined protection
		Wire-to-terminal connection	2	Thread – metric	✓		FDB-2 24-M	5098 38 0	Fine protection
		Wire-to-terminal connection	2	Thread – NPT	✓		FDB-2 24-N	5098 39 0	Fine protection
		Wire-to-terminal connection	2	LSA			LSA-B-MAG	5084 02 0	Basic protection
		Wire-to-terminal connection	2	LSA			LSA-BF-24	5084 02 8	Combined protection
		Screw terminal	2	Hat rail			FLD 24	5098 61 1	Fine protection
0-10 V		Spring terminal	2	Hat rail			MDP-2 D-24-T	5098 42 2	Combined protection
		Spring terminal	2	Hat rail	✓		MDP-4 D-24-EX	5098 43 2	Combined protection
		Wire-to-terminal connection	2	Thread – metric	✓		FDB-2 24-M	5098 38 0	Fine protection
		Wire-to-terminal connection	2	Thread – NPT	✓		FDB-2 24-N	5098 39 0	Fine protection
		Screw terminal	2	Hat rail			FLD 24	5098 61 1	Combined protection
Various DC circuits	Earth potential-free	Spring terminal	2	Hat rail			FLD 5	5098 60 0	Combined protection
		Spring terminal	2	Hat rail			FLD 12	5098 60 3	Combined protection
		Spring terminal	2	Hat rail			FLD 24	5098 61 1	Combined protection
		Spring terminal	2	Hat rail			FLD 48	5098 63 0	Combined protection
		Spring terminal	2	Hat rail			FLD 60	5098 63 8	Combined protection
		Spring terminal	2	Hat rail			FLD 110	5098 64 6	Combined protection
	Common reference potentia	Spring terminal	2	Hat rail			FLD 2-5	5098 86 7	Combined protection
		Spring terminal	2	Hat rail			FLD 2-12	5098 80 8	Combined protection
		Spring terminal	2	Hat rail			FLD 2-24	5098 81 6	Combined protection
		Spring terminal	2	Hat rail			FLD 2-48	5098 82 4	Combined protection
		Spring terminal	2	Hat rail			FLD 2-110	5098 85 9	Combined protection
Various frequency-dependent circuits	Earth potential-free	Spring terminal	2	Hat rail			FRD 5 HF	5098 57 1	Combined protection
		Spring terminal	2	Hat rail			FRD 24 HF	5098 57 5	Combined protection
		Spring terminal	2	Hat rail			FRD 5	5098 49 2	Combined protection
		Spring terminal	2	Hat rail			FRD 12	5098 50 6	Combined protection
		Spring terminal	2	Hat rail			FRD 24	5098 51 4	Combined protection
		Spring terminal	2	Hat rail			FRD 48	5098 52 2	Combined protection
		Spring terminal	2	Hat rail			FRD 110	5098 55 7	Combined protection
Various frequency-dependent circuits	Common refe-rence potential	Spring terminal	2	Hat rail			FRD 2-24	5098 72 7	Combined protection

[1] *Remote signalling*

Selection aid, measurement and control systems

Interface	Connection	Protected wires	Mounting	Ex	FS[1]	Type	Item no.	Protection rating
RS232, V24	Spring terminal	2	Hat rail			MDP-2 D-24-T	5098 42 2	Combined protection
	Spring terminal	4	Hat rail	✓		MDP-4 D-24-EX	5098 43 2	Combined protection
	Spring terminal	4	Hat rail			MDP-4 D-24-T	5098 43 1	Combined protection
	Spring terminal	4	Hat rail	✓		MDP-4 D-24-EX	5098 43 2	Combined protection
	Wire-to-terminal connection	2	Thread – metric	✓		FDB-2 24-M	5098 38 0	Fine protection
RS232, V24	Wire-to-terminal connection	2	Thread – NPT	✓		FDB-2 24-N	5098 39 0	Fine protection
	Screw terminal	2	Hat rail			FRD 24	5098 51 4	Fine protection
	Screwless terminal	4	Miscellaneous			ASP-V24T 4	5083 06 0	Fine protection
	SUB-D-9	9	Connector			SD09-V24 9	5080 05 3	Fine protection
	SUB-D-15	15	Connector			SD15-V24 15	5080 15 0	Fine protection
RS422, V11	Wire-to-terminal connection	2	Thread – metric	✓		FDB-2 24-M	5098 38 0	Fine protection
	Wire-to-terminal connection	2	Thread – NPT	✓		FDB-2 24-N	5098 39 0	Fine protection
	Screw terminal	2	Hat rail			FRD 24	5098 51 4	Combined protection
	Spring terminal	2	Hat rail			MDP-2 D-24-T	5098 42 2	Combined protection
	Spring terminal	2	Hat rail	✓		MDP-4 D-24-EX	5098 43 2	Combined protection
	Spring terminal	4	Hat rail			MDP-4 D-24-T	5098 43 1	Combined protection
	Spring terminal	4	Hat rail	✓		MDP-4 D-24-EX	5098 43 2	Combined protection
RS485	Spring terminal	2	Hat rail			MDP-2 D-5-T	5098 40 4	Combined protection
	Spring terminal	2	Hat rail	✓		MDP-4 D-5-EX	5098 43 2	Combined protection
	Spring terminal	4	Hat rail			MDP-4 D-5-T	5098 41 1	Combined protection
	Spring terminal	4	Hat rail	✓		MDP-4 D-5-EX	5098 43 2	Combined protection
	Screw terminal	2	Hat rail			FRD 5 HF	5098 57 1	Combined protection
	SUB-D-9	9	Connector			SD-09-V11 9	5080 06 1	Fine protection
Binary signals, earth potential-free	Spring terminal	2	Hat rail			MDP-2 D-24-T	5098 42 2	Combined protection
	Spring terminal	2	Hat rail	✓		MDP-4 D-24-EX	5098 43 2	Combined protection
	Wire-to-terminal connection	2	Thread – metric			FDB-2 24-M	5098 38 0	Combined protection
Binary signals, earth potential-free	Wire-to-terminal connection	2	Thread – NPT			FDB-2 24-N	5098 39 0	Combined protection
	Screw terminal	2	Hat rail			FRD 5 HF	5098 57 1	Combined protection
	Screw terminal	2	Hat rail			FRD 5	5098 49 2	Combined protection
	Screw terminal	2	Hat rail			FLD 5	5098 60 0	Combined protection
Binary signals, common reference potential	Screw terminal	2	Hat rail			FRD 2-24	5098 72 7	Combined protection
	Screw terminal	2	Hat rail			FLD 2-24	5098 81 6	Combined protection

[1] *Remote signalling*

Selection aid, measurement and control systems

Interface	Connection	Protected wires	Mounting	EX	FS[1]	Type	Item no.	Protection rating
2-pin power supplies 5V	Spring terminal	4	Hat rail			MDP-4 D-5-T-10	5098 41 3	Combined protection
2-pin power supplies 12 V	Screw terminal	2	Hat rail			VF12-AC-DC	5097 45 3	Fine protection
	Screw terminal	2	Hat rail		✓	VF12-AC/DC-FS	5097 45 4	Fine protection
2-pin power supplies 24 V	Screw terminal	2	Hat rail			VF24-AC/DC	5097 60 7	Fine protection
	Screw terminal	2	Hat rail		✓	VF24-AC/DC-FS	5097 82 0	Fine protection
2-pin power supplies 48 V	Screw terminal	2	Hat rail			VF48-AC/DC	5097 61 5	Fine protection
	Screw terminal	2	Hat rail		✓	VF48-AC/DC-FS	5097 82 2	Fine protection
2-pin power supplies 60 V	Screw terminal	2	Hat rail			VF60-AC/DC	5097 62 3	Fine protection
	Screw terminal	2	Hat rail		✓	VF60-AC/DC-FS	5097 82 4	Fine protection
2-pin power supplies 110 V	Screw terminal	2	Hat rail			VF110-AC/DC	5097 63 1	Fine protection
2-pin power supplies 230 V	Screw terminal	2	Hat rail			VF230-AC/DC	5097 65 0	Fine protection
	Screw terminal	2	Hat rail		✓	VF230-AC-FS	5097 85 8	Fine protection
	Screw terminal	2	Hat rail		✓[2]	VF2-230-AC/ DC-FS	5097 93 9	Fine protection
PT 100	Spring terminal	2	Hat rail			FLD 5	5 98 60 0	Combined protection
	Spring terminal	2	Hat rail			FLD 2-5	5098 79 4	Combined protection
	Spring terminal	4	Hat rail			MDP-4 D-5-T-10	5098 41 3	Combined protection
PT 1000	Spring terminal	2	Hat rail			FLD 5	5098 60 0	Combined protection
	Spring terminal	2	Hat rail			FLD 2-5	5098 79 4	Combined protection
	Spring terminal	4	Hat rail			MDP-4 D-5-T-10	5098 41 3	Combined protection
TTL	Spring terminal	2	Hat rail			FRD 12	5098 60 3	Combined protection
	Spring terminal	2	Hat rail			MDP-2 D-24-T	5098 42 2	Combined protection
	SUB-D-9	9	Connector			SD09-V24 9	5080 05 3	Fine protection
	SUB-D-15	15	Connector			SD15-V24 15	5080 15 0	Fine protection

[1] Remote signalling, [2] leakage current-free

Selection aid for bus systems

Interface		Connection	Protected wires	Mounting	Ex	Test-able	FS[1]	Type	Item no.	Protection rating
ADVANT		Spring terminal	4	Hat rail		✓		MDP-4 D-24-T	5098 43 1	Combined protection
ARCNET		RJ45	8	Hat rail				ND-CAT6A/EA	5081 80 0	Fine protection
AS-I	Data cable	Spring terminal	2	Hat rail		✓		MDP-2 D-24-T-10	5098 42 5	Combined protection
	Supply voltage	Spring terminal	2	Hat rail		✓		VF24-AC/DC	5097 60 7	Fine protection
		Spring terminal	2	Hat rail		✓	✓	VF24-AC/DC-FS	5097 82 0	Fine protection
BITBUS		Spring terminal	4	Hat rail		✓		MDP-4 D-24-T	5098 43 1	Combined protection
BLN		Spring terminal	2	Hat rail		✓		MDP-2 D-24-T	5098 42 2	Combined protection
		Spring terminal	2	Hat rail				FRD 24 HF	5098 57 5	Fine protection
CAN bus	Data cable	Spring terminal	3	Hat rail		✓		MDP-3 D-5-T	5098 40 7	Combined protection
	Power supply	Spring terminal	2	Hat rail		✓		VF24-AC/DC	5097 60 7	Fine protection
		Spring terminal	2	Hat rail		✓	✓	VF24-AC/DC-FS	5097 82 0	Fine protection
CAN open	Data cable	Spring terminal	4	Hat rail		✓		MDP-4 D-24-T	5098 43 1	Combined protection
	Supply voltage	Spring terminal	2	Hat rail		✓		VF24-AC/DC	5097 60 7	Fine protection
		Spring terminal	2	Hat rail		✓	✓	VF24-AC/DC-FS	5097 82 0	Fine protection
C-BUS		Spring terminal	2	Hat rail				MDP-2 D-24-T	5098 42 2	Combined protection
		Spring terminal	2	Hat rail				FRD 24 HF	5098 57 5	Combined protection
CC-Link	Data cable	Spring terminal	4	Hat rail		✓		MDP-4-D-24-T	5098 43 1	Combined protection
	Supply voltage	Spring terminal	2	Hat rail		✓		VF24-AC/DC	5097 60 7	Fine protection
		Spring terminal	2	Hat rail		✓	✓	VF24-AC/DC-FS	5097 82 0	Fine protection
Data Highway Plus		Spring terminal	4	Hat rail		✓		MDP-4 D-24-T	5098 43 1	Combined protection
Device Net	Data cable	Spring terminal	4	Hat rail		✓		MDP-4 D-24-T	5098 43 1	Combined protection
	Supply voltage	Spring terminal	2	Hat rail		✓		VF24-AC/DC	5097 60 7	Fine protection
		Spring terminal	2	Hat rail		✓	✓	VF24-AC/DC-FS	5097 82 0	Fine protection
Dupline		Spring terminal	2	Hat rail		✓		MDP-2 D-24-T	5098 42 2	Combined protection
		Spring terminal	2	Hat rail				FRD 24 HF	5098 57 5	Combined protection
eBUS		Spring terminal	2	Hat rail		✓		MDP-2 D-48-T	5098 44 2	Combined protection
		Spring terminal	2	Hat rail				FRD 48	5098 52 2	Fine protection
EIB		Spring terminal	2	Hat rail		✓		MDP-2 D-24-T-10	5098 42 5	Combined protection
		Spring terminal	4	Hat rail		✓		MDP-4 D-24-T-10	5098 43 3	Combined protection
		Spring terminal	2	Hat rail				TKS-B	5097 97 6	Basic protection
ET 200		Spring terminal	2	Hat rail				FRD 5	5098 49 2	Fine protection
		Spring terminal	2	Hat rail		✓		MDP-2 D-5-T	5098 40 4	Combined protection
		Spring terminal	4	Hat rail		✓		MDP-4 D-24-T	5098 43 1	Combined protection
FIPIO / FIPWAY		Spring terminal	4	Hat rail		✓		MDP-4 D-5-T	5098 41 1	Combined protection
Foundation Fieldbus		Spring terminal	2	Hat rail		✓		MDP-2 D-48-T	5098 45 0	Combined protection
		Spring terminal	2	Hat rail	✓	✓		MDP-4 D-48-EX	5098 45 2	Combined protection
		Spring terminal	2	Thread – metric	✓			FDB-2 24-M	5098 38 0	Combined protection
		Spring terminal	2	Thread – NPT	✓			FDB-2 24-N	5098 39 0	Combined protection

[1] *Remote signalling*

Selection aid for bus systems

Interface	Connection	Protected wires	Mounting	Ex	Test-able	Surge voltage protection	Item number	Protection rating
FSK	Spring terminal	2	Hat rail			FRD 5	5098 49 2	Fine protection
	Spring terminal	2	Hat rail	✓		MDP-2 D-5-T	5098 40 4	Combined protection
Genius	Spring terminal	4	Hat rail	✓		MDP-4 D-24-T	5098 43 1	Combined protection
HARD	Spring terminal	2	Hat rail			FRD 24	5098 51 4	Combined protection
	Spring terminal	2	Hat rail		✓	MDP-2 D-24-T	5098 42 2	Combined protection
	Spring terminal	4	Hat rail		✓	MDP-4 D-24-T	5098 43 1	Combined protection
	Spring terminal	4	Hat rail	✓		MDP-4 D-24-EX	5098 43 2	Combined protection
	Wire-to-terminal connection	4	Thread – metric	✓		FDB-2 24-M	5098 38 0	Fine protection
	Wire-to-terminal connection	4	Thread – NPT	✓		FDB-2 24-N	5098 39 0	Fine protection
IEC bus	Spring terminal	4	Hat rail		✓	MDP-4 D-5-T	5098 41 1	Combined protection
Interbus Inline (I/O)s	Spring terminal	4	Hat rail		✓	MDP-4 D-24-T	5098 42 2	Combined protection
Interbus (Loop)	Spring terminal	2	Hat rail		✓	MDP-4 D-24-T-10	5098 43 3	Combined protection
KNX	Spring terminal	2	Hat rail		✓	MDP-2 D-24-T-10	5098 42 5	Combined protection
	Spring terminal	4	Hat rail		✓	MDP-4 D-24-T-10	5098 43 3	Combined protection
	Spring terminal	2	Hat rail			TKS-B	5097 97 6	Basc protection
LON	Spring terminal	2	Hat rail			FRD 48	5098 52 2	Combined protection
	Spring terminal	2	Hat rail		✓	MDP-2 D-48-T	5098 44 2	Combined protection
LRE	Spring terminal	2	Hat rail			FRD 5	5098 49 2	Combined protection
	Spring terminal	2	Hat rail		✓	MDP-2 D-5-T	5098 40 4	Combined protection
LUXMATE	Spring terminal	4	Hat rail			MDP-4 D-5-T	5098 41 1	Combined protection
M-BUS	Spring terminal	2	Hat rail			FRD 24	5098 51 4	Combined protection
	Spring terminal	2	Hat rail		✓	MDP-2 D-24-T	5098 42 2	Combined protection
Melsec Net 2	BNC	1	Miscellaneous			DS-BNC m/f	5093 25 2	Basic protection
	BNC	1	Miscellaneous			DS-BNC f/f	5093 23 6	Basic protection
	BNC	1	Miscellaneous			DS-BNC f/m	5093 26 0	Basic protection
MODBUS	Spring terminal	4	Hat rail		✓	MDP-4 D-24-T	5098 43 1	Combined protection
MPI bus	Spring terminal	2	Hat rail			FRD 5	5098 49 2	Combined protection
	Spring terminal	2	Hat rail		✓	MDP-2 D-5-T	5098 40 4	Combined protection
	Spring terminal	4	Hat rail		✓	MDP-4 D-5-T	5098 41 1	Combined protection
N1 LAN	Spring terminal	2	Hat rail			FRD 5	5098 49 2	Combined protection
	Spring terminal	2	Hat rail		✓	MDP-2 D-5-T	5098 40 4	Combined protection
	Spring terminal	20	Hat rail			LSA-B-MAG	5084 02 0	Basic protection
	Spring terminal	2	Hat rail			LSA-BF-24	5084 02 8	Combined protection
N2 bus	Spring terminal	2	Hat rail			FRD 2-5	5098 79 4	Combined protection
	Spring terminal	2	Hat rail		✓	MDP-2 D-5-T	5098 40 4	Combined protection
novaNet	Spring terminal	2	Hat rail			FRD 12	5098 60 3	Combined protection
	Spring terminal	2	Hat rail		✓	MDP-2 D-24-T	5098 42 2	Combined protection

Selection aid for bus systems

Interface		Connection	Protected wires	Mounting	Ex	Testable	FS[1]	Surge protection	Item number	Protection rating
P bus, process Bus, Panel Bus	Data cable	Spring terminal	2	Hat rail				FRD 24 HF	5098 57 5	Combined protection
		Spring terminal	2	Hat rail		✓		MDP-2 D-24-T	5098 42 2	Combined protection
	Supply voltage	Spring terminal	2	Hat rail		✓		VF24-AC/DC	5097 60 7	Fine protection
		Spring terminal	2	Hat rail		✓	✓	VF24-AC/DC-FS	5097 82 0	Fine protection
P-NET		Spring terminal	4	Hat rail		✓		MDP-4 D-24-T	5098 43 1	Combined protection
Procontic CS31		Spring terminal	2	Hat rail				FRD 12	5098 60 3	Combined protection
		Spring terminal	2	Hat rail		✓		MDP-2 D-24-T	5098 42 2	Combined protection
Procontic T200		Spring terminal	4	Hat rail		✓		MDP-4 D-24-T	5098 43 1	Combined protection
Profibus DP		Spring terminal	2	Hat rail		✓		MDP-2 D-5-T	5098 40 4	Combined protection
		Screw terminal	2	Hat rail				FRD 5 HF	5098 57 1	Combined protection
		SUB-D-9	9	Connector				SD09-V24 9	5080 05 3	Fine protection
Profibus PA		Spring terminal	2	Hat rail		✓		MDP-2 D-48-T	5098 44 2	Combined protection
		Spring terminal	4	Hat rail	✓			MDP-4 D-48-EX	5098 45 2	Combined protection
		Wire-to-terminal connection	2	Thread – metric	✓			FDB-2 24-M	5098 38 0	Fine protection
		Wire-to-terminal connection	2	Thread – NPT	✓			FDB-2 24-N	5098 39 0	Fine protection
Profinet		Spring terminal	8	Hat rail				ND-CAT6A/EA	5081 80 0	Fine protection
SafetyBUS p		Spring terminal	4	Hat rail		✓		MDP-4 D-24-T	5098 43 1	Combined protection
SDLC		Spring terminal	4	Hat rail		✓		MDP-4 D-24-T	5098 43 1	Combined protection
SIGMALOOP (SIGMASYS)		Spring terminal	2	Hat rail				FRD 24	5098 51 4	Combined protection
		Spring terminal	2	Hat rail		✓		MDP-4 D-24-T	5098 43 1	Combined protection
SIGMANET (SIGMASYS)		Spring terminal	2	Hat rail				FRD 24	5098 51 4	Combined protection
		Spring terminal	2	Hat rail		✓		MDP-4 D-24-T	5098 43 1	Combined protection
SINEC L1		Spring terminal	4	Hat rail		✓		MDP-4 D-5-T	5098 41 1	Combined protection

[1] Remote signalling

Selection aid for bus systems

Interface	Connection	Protected wires	Mounting	EX	Test-able	Type	Item no.	Protection rating
SINEC L2	Spring terminal	2	Hat rail			FRD 5 HF	5098 57 1	Combined protection
	Spring terminal	2	Hat rail		✓	MDP-4 D-5-T	5098 41 1	Combined protection
	SUB-D-9	9	Connector			SD09-V24 9	5080 05 3	Fine protection
SS97 SINIX	Spring terminal	4	Hat rail		✓	MDP-4 D-24-T	5098 43 1	Combined protection
SUCONET	Spring terminal	4	Hat rail		✓	MDP-4 D-24-T	5098 43 1	Combined protection
	Crimp clamp	20	LSA			LSA-B-MAG	5084 02 0	Basic protection
	Crimp clamp	2	LSA			LSA-BF-24	5084 02 8	Fine protection
TTL	Spring terminal	2	Hat rail			FRD 24	5098 51 4	Combined protection
	Spring terminal	2	Hat rail		✓	MDP-2 D-24-T	5098 42 2	Combined protection
	SUB-D-9	9	Connector			SD09-V24 9	5080 05 3	Fine protection
	SUB-D-15	15	Connector			SD15-V24 15	5080 15 0	Fine protection
U bus	Spring terminal	4	Hat rail			2x TKS-B	5097 97 6	Basic protection

4

Every lightning protection system must undergo an acceptance test following installation. Regular tests must also be carried out to ensure correct functioning. In addition, the entire system must be checked following any lightning or surge voltage event. According to the current lightning protection standard, IEC 62305 (VDE 0185-305), the interception cables and down-conductors, the earthing system and the equipotential bonding must be tested.

In addition to a visual inspection of the system and its compliance with the relevant documentation, volume resistance must also be measured. The documentation should be updated following each test or service.

Chapter 4: Testing, maintenance and documentation

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4. Testing, maintenance and documentation

Lightning protection systems must, even after the acceptance test, be checked at regular intervals to ensure correct functioning, establish any faults and carry out any necessary repairs. The test involves checking the technical documentation and inspecting and measuring of the lightning protection system.
The testing and servicing activities should be carried out on the basis of the standard and the technical principles of IEC 62305-3 (VDE 0185-305 Part 3).

The tests also comprise checking the internal lightning protection system. This includes checking the lightning protection equipotential bonding and the connected lightning and surge arresters. A test report or test log is used to record the testing and servicing of lightning protection systems and must be updated or recreated at each test/service.

The operator or owner of a building structure is responsible for maintaining safety and ensuring immediate rectification of any faults.

Testing must be carried out by specialist personnel.

Figure 4.1: Separation point on a metal facade

4.1 External lightning protection system

Testing criteria

- Checking all records and documentation, including compliance with the standards.
- Checking general condition of interception and arrester systems and all connection components (no loose connections), and volume resistances.
- Checking the earthing system and earthing resistances including transitions and connections.
- Checking internal lightning protection, incl. surge arresters and fuses.
- General corrosion status.
- Reliability of fastening the lines of the LPS and its components.
- Documenting all changes and additions to the LPS and changes to the building structure.

Critical systems (e.g. installations at risk from explosion) must be checked annually.

Lightning protection class	Visual inspection (year)	Comprehensive visual inspection (year)	Comprehensive visual inspection in critical situations (year)
I and II	1	2	1
III and IV	2	4	1

Table 4.1: Critical situations include structures containing sensitive systems, or office and commercial buildings or places in which a large number of people meet.

Components for lightning protection systems are tested according to IEC 62561-1 (VDE 0185-561-1).

Figure 4.2: BET lightning current generator

Components for lightning protection systems are tested for functionality according to IEC 62561-1 (VDE 0185-561-1) – Requirements for connection components. After a conditioning phase lasting 10 days, the components are impacted with three lightning strikes. The lightning protection components for air-termination systems are tested with 3 x I_{imp} 100 kA (10/350). This corresponds to test class H.

Components for down-conductor along which the lightning current can spread (at least two down-conductors) and connections in the earthing system are tested with 3 x Iimp 50 kA (10/350). This corresponds to test class N.

Test class	Tested with	Application
H according to IEC 62561-1 (VDE 0185-561-1)	3 x I_{imp} 100 kA (10/350)	Interception system
N according to IEC 62561-1 (VDE 0185-561-1)	3 x I_{imp} 50 kA (10/350)	Multiple applications along which the lightning current can spread, at least two arresters

Table 4.2: Test classes of connecting components

Figure 4.3: PCS sensor on a down-conductor

Testing a lightning protection system with the PCS system

The peak current sensor (PCS) records and stores pulsed currents in the form of a magnetic card. This is a method of monitoring whether lightning has hit the lightning protection system and which maximum lightning current has occurred. If the PCS system is mounted between the interface from equipotential bonding to earthing system, the coupled lightning current in a building can also be measured. The results can provide information on potential damage in the electrical installation.

The PCS card is mounted by snapping a card holder onto the round conductor at a defined distance. The measuring range of the card is from 3–120 kA. The magnetic card reader offers the possibility of evaluating the peak current sensors. The corresponding peak current value is shown on the display.

Alternatively, OBO Bettermann can include the read-out of the data as an additional service. If this is desired, please contact your OBO Bettermann representative or subsidiary.

Figure 4.4: Life Control testing unit

This innovation from OBO Bettermann comes complete with a high-quality testing case for safe transportation and the documentation of test results.

4.2 Internal lightning protection system

Testing surge protection devices within data cables
It is often necessary to check the function of the surge protection devices within the data cable. It is particularly important to check that the actual test of the protection devices has no negative influence on the data signal.
The Life Control testing unit developed by OBO Bettermann allows protection devices to be tested in their installed state without this affecting the data signal. Contact is made with the lightning barrier in its installed state by using a narrow test prod. The integrated microprocessor shows the test result on the OLED display; acoustic signals supplement the information on the display. A further feature is an LED in the test prod that can be activated if desired to provide orientation in even the darkest switching cabinet.

Testing of the arrester upper parts V50, V25, V20 and V10
The ISOLAB testing unit allows the checking of the arrester upper parts V50, V25, V20 and V10. A rotary controller allows the selection of the appropriate OBO Bettermann arrester. Then, the upper part of the appropriate combination and/or surge arrester is placed in the appropriate opening in the device. The function of the varistor is then checked by pressing the test button. Besides arrester testing, the ISOLAB also allows insulation testing according to VDE 0100-610.

5

Chapter 5: Brief glossary of ssurge protection

Term	Standard text
Arrester (SPD= surge protective device)	Arresters are devices consisting primarily of voltage-dependent resistors and/or spark gaps. These elements can be connected either in series or in parallel, or used individually. Arresters protect other electrical equipment and systems from surge voltages.
Arrester measured voltage Uc	In arresters without a spark gap, the measured voltage is the maximum permissible effective value of network voltage at the arrester terminals. The measured voltage can be applied constantly to the arrester without changing its operating characteristics.
Cut-off unit	The cut-off unit cuts the arrester off from the mains/earthing system in case of overloading, to prevent a risk of fire while at the same time signalling that the protection device has been switched off.
100% response lightning impulse voltage	The 100% response lightning impulse voltage is the value of the lightning impulse voltage 1.2/50 µs, causing the arrester to switch. At this test voltage the surge voltage protection device must respond ten times when exposed to load ten times.
Response time (ta)	The response time essentially characterises the response behaviour of the individual protection elements used in arresters. Depending on the rate of rise of the surge voltage (du/dt) or surge current (di/dt), response times can vary within specific boundaries.
Lightning protection equipotential bonding system	The lightning protection system equipotential bonding system is an important element for reducing the risk of fire or explosion in the area/building to be protected. The lightning protection equipotential bonding system is produced using equipotential bonding cables or arresters that connect the external lightning protection system; metal components of the building or space; installations; extraneous conductive parts; and the electrical energy and telecommunication systems, with each other.
Lightning protection system (LPS)	The term lightning protection zone (LPS) refers to the entire system used to protect a room or building against the effects of a lightning strike. It refers to both external and internal lightning protection.
Lightning protection zone (LPZ)	The term Lightning Protection Zone (LPZ) describes an individual area in which the electromagnetic environment of the lightning is defined and brought under control. At transitions between zones, all cables and metal components must be incorporated into the equipotential bonding.
Lightning surge current (limp)	The lightning surge current (lightning current carrying capacity per path) is a standardised surge current curve with the waveform 10/350 µs. Through its parameters – peak value, charge and specific energy – it reproduces the load produced by a natural lightning current. Type 1 lightning current arresters (previously requirement class B) must be able to arrest such lightning currents without being destroyed.
Volume resistance per path, series resistance	The volume resistance per path is the ohmic resistance increase per wire produced by the use of the surge voltage protection device.
Residual current device (RCD)	Device to protect against electric shock and fires (e.g. FI protection switch).
Short circuit resistance	The surge protection device must be able to conduct the short circuit current, until it is either interrupted by the device itself or by an internal or external cut-off unit or by mains-side over-current protection (e.g. back-up fuse).
LPZ	See “Lightning protection zone”
Nominal discharge current (In)	Maximum value of the current flowing through the arrester with the waveform 8/20. Used for classification of the test of Type 2 surge arresters (formerly requirement class C).
Nominal frequency (fn)	The nominal frequency is the frequency for which a given resource is designed, after which it is named, and to which other nominal values refer.

Term	Standard text
Nominal voltage (U_n)	The nominal voltage is the voltage value for which a resource is designed. This can be a DC voltage value or the effective value of a sinusoidal AC voltage.
Nominal current (I_n)	The nominal current is the maximum permissible operating current which can be continuously passed through connection terminals marked with that value.
Line follow current quenching (I_f)	The follow current – also called network follow current – is the current which flows through the surge protection device after an arresting operation and is supplied by the network. The follow current differs considerably from the permanent operating current. The magnitude of the line follow current depends on the supply line from the transformer to the arrester.
Equipotential bonding	Electrical connection bringing the bodies of electrical equipment and extraneous conductive parts to the same or a similar potential.
Bonding rail (PAS)	A terminal or rail, intended to connect the protective conductor, the equipotential bonding cable and, if necessary, the conductor for function earthing with the earthing cable and the earthers.
Residual voltage (U_{res})	The peak value of the voltage across the terminals of the surge protection device during or immediately following the passage of the arrested surge current.
Protection level (U_p)	The protection level is the maximum instantaneous voltage at the terminals of the surge voltage protection device prior to response.
SPD	Surge protection device.
Temperature range	The operating temperature range specifies the upper and lower temperature limits between which the flawless functioning of a surge protection device is guaranteed.
Surge voltage	A surge voltage is a voltage occurring briefly between conductors or between a conductor and the earth, which exceeds the highest permissible operating voltage value by a long way, but does not have the operating frequency. It can arise due to thunderstorms, earth faults and short circuits.
Surge arrester, type 1	An arrester with a special structure that enables it to arrest lightning currents and partial lightning currents in the case of a direct lightning strike. (SPD= surge protective device)
Surge arrester, type 2	An arrester that can arrest surge voltages caused by remote or nearby strikes or switching operations. (SPD= surge protective device)
Surge arrester, type 3	An arrester used for the surge voltage protection of individual consumers or groups of consumers; this type of arrester is used directly at the socket. (SPD= surge protective device)
Transmission frequency (f_g)	The transmission frequency is the maximum frequency at which the insertion loss of a resource is still below 3 dB.
Surge protective device (SPD)	A device intended for the limitation of transient surge voltages and arresting of surge voltages. It contains at least one nonlinear component. Surge protective devices are also commonly referred to as “arresters”.
Back-up fuse before the arresters	A back-up fuse must be fitted before arresters. If the rating of the fuse before an arrester is higher than the maximum permissible back-up fuse rating for the arrester elements (see device technical data), the arrester must be fused selectively with the required value.
Transient surge voltage (TOV)	Transient surge voltages are short-lived (i.e. temporary) surge voltages that can occur due to errors in the medium and low-voltage networks.
	Legend: LPL = lightning protection level LPZ = lightning protection zone LPS = lightning protection system Important: use specialist terms/abbreviations consistently

Tightening torques	
M5	4 Nm
M6	6 Nm
M8	12 Nm
M10	20 Nm

Detailed information on tightening torques is available on request.

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