## Overview

### *Introduction to lightning and overvoltage protection*

Overvoltage destroys a considerable number of electrical and electronic devices and units. And the damage is not limited to just industrial and commercial facilities. Building management systems as well as household appliances for daily use are also affected.

Without effective protection against overvoltage there is a real risk of costly repairs or replacement purchases due to the damage done to equipment.

Listed below are units from various sectors which have sensitive electronic circuitry and are frequently destroyed by overvoltage. Clearly, protective measures for preventing overvoltage-related damage are just as important to private households as for the commercial and industrial sectors. An effective overvoltage protection concept for building management systems covers power supply, telephone, aerial/reception, data processing and control systems. What is important is that all the cables connected to a device are linked to a suitable surge arrester. Nearly all devices have a power supply. A television set, for example, also needs a reception signal which is supplied over an aerial cable. And regardless of whether the signal comes from an aerial or a wide band cable, both the aerial input and power supply to the television set should be protected. The need for such consistent all-round protection applies equally to all other devices and units.

### *Building management systems and industry*

- Heating controls
- Outdoor lighting
- Shutter controls
- Garage door actuators
- Central I&C
- Air conditioning
- Alarm systems
- Fire alarms
- Video surveillance
- Process computers

### *Office equipment*

- Computers
- Printers
- Telecommunication systems
- Fax machines
- Copying machines

### *Private households*

- Dishwashers
- Automatic washing machines
- Clothes dryers
- Coffee-makers
- Radio alarm clocks
- Refrigerators
- Deep-freezers
- Microwave ovens
- Electric cookers
- Telephone systems

### *Hobbies and leisure*

- Television sets
- Aerial amplifiers
- Video recorders
- DVD players
- Hifi systems
- Computers
- Electrical musical instruments
- CB radio systems

In relation to the total value of the equipment concerned, the cost of installing suitable protective devices usually pays for itself when just a single unit of electrical equipment is saved just once from destruction . Provided the performance parameters are not exceeded, surge suppressors work many times, thus increasing the benefits for the user several-fold.

### *The comprehensive surge protection concept*

Fundamentals

Transient overvoltage results from lightning discharges, switching operations in electrical circuits and electrostatic discharges. Without the protection provided by lightning arresters and overvoltage protection equipment, even the robustly constructed low-voltage supply systems of buildings or industrial plants are unable to cope with a lightning discharge. The overvoltage occurs only very briefly for millionths of a second. Nevertheless, the mostly very high voltages involved are capable of destroying electronic circuitry or the insulation between the conductors on printed circuit-boards. And even if an electrical or electronic device has passed the voltage withstand test according to IEC 100045, as required for being awarded the CE symbol, it is still not in a position to withstand unscathed all environmental influences with regard to electromagnetic compatibility (EMC). To prevent the destruction of electrical equipment by overvoltage, all endangered interfaces such as signal inputs and power supplies must be connected to overvoltage protection equipment. What is needed, depending on the case of application, are components such as spark gaps, gas-filled surge arresters, varistors and suppressor diodes, which because of the differences in their arresting and limiting specifications are arranged singly or as combinations in a protection circuit.

### *The following damage can be caused by overvoltage*

Overvoltage endangers and destroys a considerable number of electrical and electronic installations. In the last few years there has been a sharp increase in the frequency of incidents and the total costs of the damage incurred. The statistics published by property insurance companies have a clear tale to tell. Damage to devices and their destruction occur all the more often when devices need to be in permanent standby.

Repairs and replacement purchases are not the only expense factor, however. Costs also arise through not being able to use the affected system components and possibly even through loss of software and data. The damage profiles generally cover everything from destroyed cables, printed circuit-boards and switching devices to substantial mechanical destruction of the building installations. This damage can be reliably prevented by lightning arresters, surge suppressors and arrester combinations.

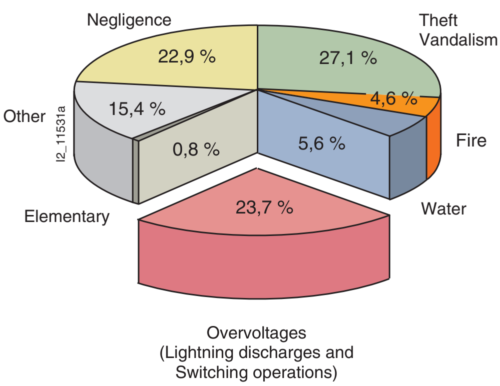
## Introduction

### *Lightning and overvoltage protection – WHY?*

Powerful information systems form the backbone of our modern industrial society. A fault or the failure of these types of systems can have far-reaching consequences. These can even cause service and industry companies to go bankrupt.

The cause of faults are many and electromagnetic influences play a major role. In a highly technical, electromagnetic environment, it is not advisable to simply wait for the mutual influencing of electrical and electronic devices and systems and then pay good money to eliminate the resulting problems. Rather it is essential to plan and take preventative measures that reduce the risk of influences, faults and destruction.

In spite of all this, the damage and loss statistics of electronic insurance companies are extremely worrying: More than a quarter of all claims are as a result of overvoltages due to electromagnetic influences.




Source: The causes of damage to electronics in 2001, analysis of 7370 claims Württembergische Versicherungs AG.

### *Causes of overvoltage*

Depending on their cause, overvoltages are divided into two categories:

- **LEMP** (**L**ightning **E**lectro**M**agnetic **P**ulse) – overvoltages, caused by atmospheric influences (e.g. direct lightning strikes, electromagnetic lightning fields).
- **SEMP** (**S**witching **E**lectro**M**agnetic **P**ulse) – overvoltages caused by switching operations (e.g. disconnection of short-circuits, normal switching of loads).

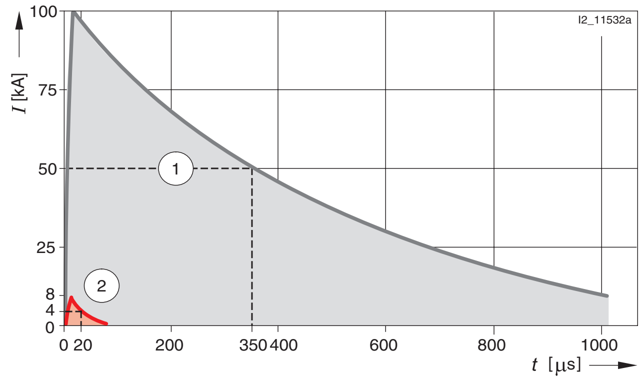
Overvoltages that are the result of thunderstorms are caused by **direct/close-up** or **remote strikes** (see diagram on page 5/5).

**Direct or close-up strikes** are lightning strikes to the lightning protection system of a building, its immediate proximity or to the electrical conductive systems of a building (e.g. l.v. power supply, TC and control lines). The resulting surge currents and voltages are a particular threat to the system to be protected due to their amplitude and power.

In the case of direct or close-up lightning strikes, the overvoltages (see diagram on page 5/5) are caused by the voltage drop at the surge grounding resistance and the resulting increase in potential of the building, compared to the distant environment. This represents the greatest possible loading of an electrical plant in buildings.

The characteristic parameters of the surge current (peak value, rate of current rise, charge content, specific energy) can be described using the surge current waveform 10/350 µs (see diagram: examples of impulse test currents). These are defined in the international, European and national standards as test current for components and devices for protection in the event of direct strikes.

In addition to the voltage drop at the surge grounding resistance, overvoltages also occur in electrical building installations and the connected systems and devices, due to the induction effect of the electromagnetic lightning field (see diagram on page 5/5: Example 1b).
The energy of these induced overvoltages and the resulting pulse currents is considerably less than that of a direct lightning impulse current and is therefore only described with surge current wave 8/20 µs (see diagram: Examples of impulse test currents). Components and devices that do not carry currents from direct lightning strikes are therefore checked using surge currents 8/20 µs.




| | $I_{max}$ [kA] | Waveform [µs] | Q [As] | W/R [J/Ω] |
|---|---|---|---|---|
| 1 Impulse test current for lightning arresters | 100 | 10/350 | 50 | $2{,}5 \times 10^6$ |
| 2 Impulse test current for surge arresters | 8 | 8/20 | 0,1 | $0{,}4 \times 10^3$ |

Examples of impulse test currents

### *The protection concept*

Remote strikes are lightning strikes at a greater distance from the objects to be protected, lightning strikes in the medium-voltage overhead system or the immediate proximity thereof, or lightning discharges from cloud to cloud (see diagram on page 5/5: Cases 2a, 2b and 2c). At the same time as these induced overvoltages, the effects of remote strikes on the electrical system of a building are controlled through devices and components, the dimensions of which correspond to surge current wave 8/20 µs.

The causes of overvoltages due to **switching operations** include the following:

- Switching off of inductive loads (e.g. transformers, reactors, motors),
- Ignition and interruption of electric arcs (e.g. arc-welding device),
- Tripping of fuses.

The effects of switching operations in the electrical installation of a building are simulated for testing purposes with surge currents of waveform 8/20 µs.

To ensure the continuous availability of complex power and information systems, even in the event of direct lightning strikes, further measures for overvoltage protection of electrical and electronic systems are required as well as a building lightning protection system. It is important to take all the causes of overvoltages into account. For this purpose, the lightning protection zone concept is used as described in IEC 62305-4 (DIN V VDE V 0185-4) (see diagram on page 5/6). The building is divided into zones of different danger levels. Using these zones, it is possible to determine the devices and components required for the lightning and overvoltage protection.

## Introduction

An EMC-oriented lightning protection zone concept should also include external lightning protection (with air terminals, arresters, grounding), equipotential bonding, room insulation and overvoltage protection for power and information systems.
For the definition of lightning protection zones (LPZ), please use the specifications made in the table "Definition of lightning protection zones".

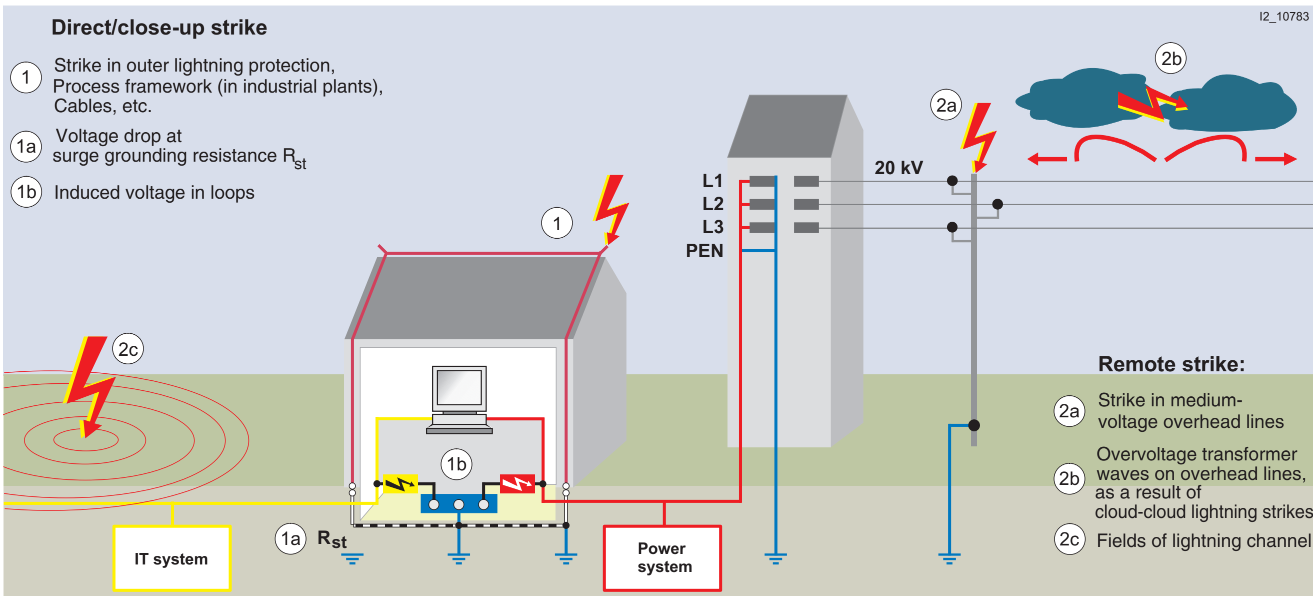
***Definition of lightning protection zones***

| Lightning protection zones | Description |
|---|---|
| **LPZ $0_A$** | Zone where objects are exposed to direct lightning strikes and must therefore carry the whole lightning current. The undamped electromagnetic field occurs in this case. |
| **LPZ $0_B$** | Zone where objects are not exposed to direct lightning strikes but where the undamped electromagnetic field still occurs. |
| **LPZ 1** | Zone where objects are not exposed to direct lightning strikes and in which the currents are reduced compared to Zone $0_A$. In this zone, the electromagnetic field may be damped, depending on the insulation measures implemented. |
| **LPZ 2, LPZ 3** | If a significant reduction in the conducted currents and/ or the electromagnetic field is required, subsequent zones must be set up. The demand on these zones must be geared towards the required environment zones of the system to be protected. |

According to the demands and loads made on overvoltage protection devices with regard to their installation site, these are divided into lightning arresters, surge arresters and arrester combinations.

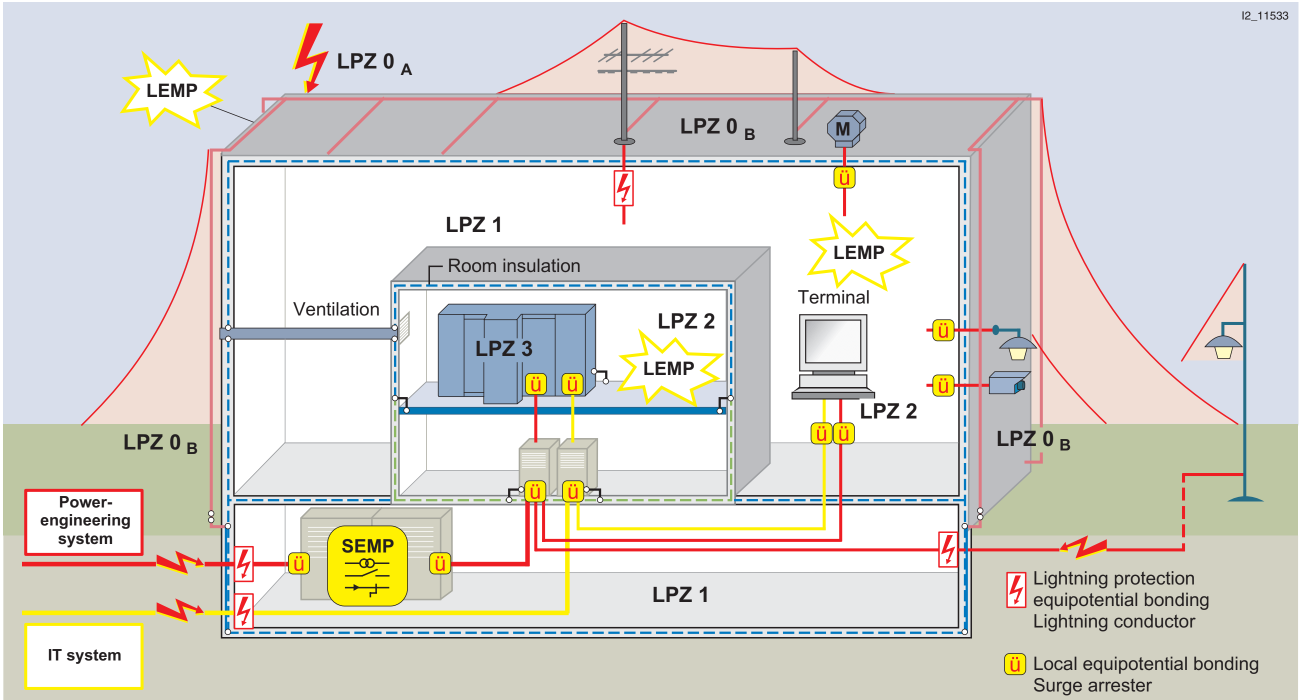
The highest demands with regard to discharge capacity are made on lightning current and arrester combinations, which implement the transition from lightning protection zone LPZ $0_A$ to LPZ 1 or LPZ $0_A$ to LPZ 2. These surge arresters must be able to carry lightning partial currents of waveform 10/350 µs several times and thus prevent these destructive currents from penetrating the electrical installation of a building. At the transition of lightning protection zone LPZ $0_B$ to LPZ 1 the downstream lightning arrester at the transition area of lightning protection zones LPZ 1 auf LPZ 2 and higher, surge arresters are installed to protect against overvoltages. It is their task to further attenuate the remaining extent of the upstream protection level and restrict the overvoltages in the system, whether they are induced or self-generated.

The lightning and overvoltage protective measures at the borders of the lightning protection zones apply in equal measure to the energy and information system. The holistic approach of the measures described in the EMC-oriented lightning protection zone concept means it is possible to achieve permanent plant availability of a modern infrastructure.




Causes for overvoltages during lightning discharges

## Introduction




EMC-oriented lightning protection zone concept