## The basics of lightning and surge protection

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Prevention is better than cure

This is true, not only for people, but also for the “health” of your electrical and electronic components and equipment. Cost-effective strategies demand an investment in surge protection. Such an investment would only be a fraction of the amount of possible damage. The shut down of a manufacturing plant because of the failure of a controller or the collapse of industrial data transmission can be very costly. But the significant overhead in repairing the problem is not the only factor. You must also take into account the system down times. The lifespan of your components (mean time between failure) will also be shortened. Surge voltages present a significant danger and this can be demonstrated in many other ways than the examples given in damage statistics from property insurers.

All electrical equipment is potentially threatened by surge voltages: this includes free-standing high-voltage switching facilities and also electronic micro-components. For low voltages, this risk is predominant in the fields of power supply, measure and control technology, telecommunications, and data transmission. We therefore work with protective strategies and systems when designing lightning and surge protection. Only an entire system can provide effective protection for all areas of power, signals and data and we offer an ideal form of surge protection for all these applications fields.

Surge protection has become an area of increasing significance. On the one hand, electrical and electronic components continue to get smaller. On the other hand, the levels of automation in the industrial and consumer electronics sectors are continuing to rise. The safety clearances for insulation decrease as do the tolerance limits. Electronic circuits function at low voltage levels of only several hundred volts. Thus surge voltages can present a significant danger.

The German “Law on electromagnetic compatibility in devices” establishes the proper EMC-compliant design and layout for electrical and electronic devices. Surge protection is an element of these EMC measures and implementation of this protection is described in a variety of IEC/VDE standards. Such measures can also help in obtaining the CE mark of approval.

To guarantee the safety of consumers, different product standards offer a method for ensuring a global product standard.
For energy protection, these are IEC 61643-1 and IEC 61643-11. For protection of measurement and control systems, IEC 61643-21 is relevant. These standards provide the rules which are globally valid for all manufacturers of surge protection components.

The standards also provide helpful support for users. IEC 61643-12 is valid for the installation of energy-protection components and IEC 61643-22 is valid when protecting measurement and control systems. IEC 62305 is the overall guideline for all applications when dealing with lightning and surge protection. This standard covers all the parameters: risk analysis, external and internal lightning protection.

The subject of surge protection is rather complicated and requires special knowledge. Therefore, this catalogue provides you with some helpful information. And if you want to know more, simply contact us. We are happy to help and advise you.
What are overvoltages?

Surges are extremely high voltages that damage or even completely destroy insulation and hence impair or completely disrupt the function of electrical and electronic components of all kinds. Every electrical component is provided with insulation to isolate the electrical voltage from earth or other voltage-carrying parts. The insulation strength is dependent on the rated voltage and the type of electrical component, as stipulated by the IEC/VDE regulations. It is tested by applying the prescribed voltages for a defined period of time. If the test voltage is exceeded in operation, the safety effect of the insulation is no longer guaranteed. The component can be damaged or completely ruined. Surges are voltage pulses that are higher than the test voltage, and these could detrimentally affect an electrical component or system. This means that components with a high rated voltage may be capable of withstanding a surge voltage. But components with a lower rated voltage would be very much at risk from the same surge. An overvoltage allowable in an electric motor can spell disaster for an electronic circuit!

Permanently higher voltages also occur with the 50/60 Hz mains frequency. These voltage can be coupled and can also occur as a result of faulty switching operations. The resulting continuous interference voltages are another reason for installing overvoltage protection.

Individual surge pulses, which have a high frequency because of their physical formation, have a current rise that is about ten thousand times steeper compared with 50 Hz voltage. If the current rise time in the 50/60 Hz range is 5 ms, then for an overvoltage it is around 1 µs.

These surges are designated as “transient” voltages. This means that they are short-lived, temporary oscillations. Their shape and frequency depends on the impedance of the circuit.

![Edge behaviour between a 50 Hz sine wave and surge pulse](image-url)
How do overvoltages occur?

Surges are primarily caused by:
• Transient switching operations
• Lightning due to atmospheric discharges
• Electrostatic discharges
• Faulty switching operations

Lightning

Bolts of lightning comprise extremely high currents. They can cause a large voltage drop and a large rise in potential, even in well-earthed buildings or systems, despite low earthing resistances. This can then result in a galvanic, inductive or capacitive coupling of surge voltages within the circuits of electrical or electronic facilities. Any insulation will also be penetrated. So, in reality, there are no electrical isolation methods which provide reliable protection against surge voltages. Analogue converters, relays or opto modules are important for separating potentials, but they are definitely not surge protection components.

A natural lightning strike consists of a main discharge and a time-shifted post discharge. The strength of this second discharge is usually far below the energy level of the main discharge. Both discharges, however, have enough power to cause significant damage. Our table below shows results from a natural lightning strike and a lightning current generator which simulates a lightning pulse.

The various forms of coupling must be considered in order to understand the effects of lightning.

Conductive coupling

Surges are transferred directly into circuits via common earthing impedances. The magnitude of the overvoltage depends on the amperage of the lightning and the earthing conditions. The frequency and the wave behaviour are mainly determined by the inductance and the speed of the current rise. Even distant lightning strikes can lead to overvoltages in the form of travelling waves, which affect different parts of electrical systems by way of conductive coupling.

Inductive coupling

A high-amperage lightning strike generates a strong magnetic field. Starting from here, overvoltages reach nearby circuits by means of an induction effect (e.g. directly earthed conductor, power supply lines, data lines, etc.). According to the transformer principle, the coupling of induced voltages is considerable owing to the high-frequency current \( \frac{di}{dt} \) – even when primary and secondary windings consist of only a single winding each, i.e. the inductance is low.

Capacitive coupling

A capacitive coupling of overvoltages is also possible. The high voltage of the lightning generates an electric field with a high field strength. The transport of electrons can cause a capacitive decay to circuits with lower potentials and raise the potential concerned to an overvoltage level.

The basics of lightning and surge protection

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Radiation coupling

Electromagnetic wave fields (E/H field), that also ensue during lightning (distant field condition, E/H field vectors perpendicular to each other), affect conductor structures in such a way that coupled overvoltages must be expected even without direct lightning strikes. Permanent wave fields from strong transmitters are also able to cause coupled interference voltages in lines and circuits.

Switching operations – transients

More often, it is switching operations that cause interference rather than lightning. High-amperage shutdowns in the mains in particular can generate considerable overvoltages (e. g. welding equipment). Switching operations generate overvoltages because, due to their construction, switching contacts that switch the current on or off do not operate in synchronisation with the current zero of an alternating current. This means that in the majority of cases there is a very rapid change of current, from a high value to zero (di/dt). Owing to the impedances in the circuit concerned, this leads to transient overvoltages with high-frequency oscillations and high voltage peaks. These can reach electrical components by conductive, inductive or capacitive means and endanger or damage them. The situation is similar in the case of short-circuits in the mains because these also represent a rapid switching operation.

Electrostatic discharges – ESD

Electrostatic discharges (ESD) caused by frictional charges are well known. You can experience them when getting out of a car or walking across a carpet. These discharges can be over 10,000 volts in strength. We speak of ESD when these discharge to a lower potential. If such a charge strikes, for example, electronic components, then these can be completely ruined. Special care is taken, for example, with ESD issues when manufacturing electronic circuit boards.

Faulty switching operations

Again and again, we experience faulty switching operations in the 50/60 Hz mains. These can be caused by a failed power supply unit controller or incorrect wiring in a panel. The relatively high voltages that can occur as a result also represent dangerous overvoltages. Protection against these is vital.

Description of interference voltages

Surge voltages that occur between live conductors, or between a live conductor and the neutral conductor, are called transverse voltage or symmetric interference [UQ].

Surge voltages that occur between a live conductor and the PE conductor are called longitudinal voltage or asymmetric interference [UL].

The forms of interference voltage

Coupled transient surge voltages are basically either symmetric (differential-mode interference) or asymmetric (common-mode) interferences, which are measured as longitudinal or transverse voltages.

Normal-mode interference (symmetrical interference)

A voltage between supply and return conductor, differential mode voltage/current. Occurs mainly at low interference frequencies in the existing lines. The interference current causes an interference voltage $U_{Q}$ directly at the interference sink (between the input terminals). With galvanic or inductive coupling, both the effective sources and the interference sources are connected serially. The load and interference sources are connected in series as an inductive (magnetic field) or conductive coupling (common impedance). In symmetrical circuits (non-earthed or virtual potential earthed), the normal-mode interference occurs as symmetrical voltages. In unsymmetrical circuits (earthed one side), the normal-mode interference occurs as unsymmetrical voltages.
Transverse voltage $U_0$ (normal-mode voltage)

This is a transient coupled interference between two active conductors. For asymmetric circuits with ground potential, the transverse voltage is equal to the longitudinal voltage ($U_0 = U_L$).

A remedy or limitation may be achieved by twisting the corresponding wires together and shielding or multiple shielding with cable sheath. This reduces the induction of transverse voltages.

Common-mode interference
(unsymmetrical interference)

Voltage between conductor and reference potential (earth), common-mode voltage/current. Mainly caused by a capacitive coupling (electrical field).

Therefore, significant common-mode interference currents only flow at higher interference frequencies. The interference voltage at the potentially susceptible device is caused by different voltage drops at the supply and return conductors (in each case between input terminal and reference earth).

The source of interference can be between a signal wire and reference conductor increase in reference potential between separate earths.

In symmetrical circuits, common-mode interference occurs as asymmetrical voltages between the d.c. offset of the circuit and the reference earth. The forward and return conductors have the same interference voltages compared to the reference ground. In unsymmetrical circuits, common-mode interference occurs as unsymmetrical voltages between the individual conductors and the reference earth.

Longitudinal voltage $U_L$ (common-mode voltage)

A coupled transient interference voltage between an active conductor and the earth potential. As a rule, the longitudinal voltage is higher than the transverse voltage (transverse voltage is lower owing to cable shielding and twisting).

Longitudinal voltages caused by lightning currents on cable shielding can assume quite high values, especially in the case of long lines entering a building from the outside.

Consequences

The impedances and stray capacitances are equal in ideal circuits. This means that the currents in the supply and return conductors generated by coupled overvoltages are also equal and so do not generate any interference voltage.

However, in practice the impedances and stray capacitances in the supply and return conductors are different. This results in unequal currents which cause different voltages to earth in the supply and return conductors.

This means that the unequal impedances lead to the common-mode voltage becoming, for the most part, a normal-mode voltage because of the dissimilarity in the voltages to earth of the supply and return conductors.
How do we achieve surge protection?

We have to consider surge protection from two points of view:

- General protective measures during the planning and construction of buildings and electrical installations.
- Special protective measures realised by the installation of additional surge protection components.

Planning buildings and electrical installations

Some primary measures to prevent or limit surge voltage damages can be incorporated into buildings and electrical/electronic facilities right from the start. Although such measures can achieve only basic protection, they can save some of the costs involved when it comes to planning an effective, complete protection concept. Beginning with the first phase of construction, it is very important to set up an earthing or equipotential bonding facility of sufficient size. Only this will ensure full equipotential bonding in the event of a malfunction.

Thus when speaking of lightning protection, we only refer to lightning protection equipotential bonding. All cables are connected to the lightning protection equipotential bonding: including the power supply, measurement and control signals, telephone lines, and even the water and gas lines. When planning the electrical installation, care must be taken to ensure that electrical systems with dissimilar rated voltages are kept separate. Corresponding protection zones can then be set up and this leads to cost-savings in the surge protection.

Furthermore, the physical separation or shielding of lines that can influence each other is a good way to achieve maximum electrical isolation. Another good option is to split up the individual phases of three-phase systems corresponding to their functions, e.g. one phase only for the supply to instrumentation and control systems.

Of course, all these primary measures do not achieve complete protection. To do this, you must install additional protective components.

Surge protection components

Surge voltages are kept away from at-risk electrical components by first reducing them to a harmless dimension before they reach the components. The quick reaction times of surge arresters are used to provide this protection. They must respond during the high-frequency rising phase of the overvoltage, i.e. before a dangerous value has been reached, and quench the overvoltage. The response time lies in the nanoseconds range.

Naturally the surge protection components must be able to withstand very high currents, since a surge can, under certain circumstances, deliver several thousand amperes. At the same time, no excessive (i.e., dangerous) residual voltages should remain, even if the operating current is very high. So surge protection components must exhibit a very low resistance discharge behaviour.

In addition, it is absolutely essential that the surge protection component is very quickly available again in electrical terms after the surge has been quenched by earthing it. This is necessary to ensure that the function of the circuit is guaranteed.

Good surge protection is characterised by:
- Fast response behaviour
- High current-carrying capacity
- Low residual voltage
- Good reactivation time

Weidmüller can supply protective components that fulfil these criteria. Depending on the application, these usually consist of a combination of individual components, as described in the chapter on surge components. Which combination of protective components is available for the respective application is described in the chapters B, C and D.

It will become clearer, from the set-up of the protective elements, how and where a product is used. The first protection mechanism is always installed at the building entrance, so that the initial coupling interference can be directly “intercepted” before the sensitive end devices.
A fundamental requirement for effective surge protection is the presence of properly functioning equipotential bonding to DIN VDE 0100 part 540 in a series, or better still, star or grid arrangement. DIN VDE 0110 (insulation coordination) divides overvoltage protection for power supplies and power distribution into the following three areas:

1. **Power supply**

   The surge voltage strength of the insulation is 6 kV from the incoming supply to the building – by means of underground cables or overhead lines – right up to the main distribution board (backup fuse and meter cupboard). Owing to the lightning protection zoning concept and the physical circumstances, high-energy overvoltages have to be discharged here.

   Surge currents exceeding 200 kA can be generated by cloud-to-ground but also cloud-to-cloud lightning discharges.

   As a rule, 50 % of the current is discharged via the lightning protection system and the remaining 50 % is coupled into the conductors and conductive parts in the building and distributed uniformly. The closer a conductor is to the lightning protection system, the greater is the launched voltage (which can exceed 100 kV). The pulse duration can be up to 0.5 ms. These powerful interference pulses are discharged to earth directly at the incoming supply or main distribution board by Type I lightning arresters and limited to voltages below 6 kV. Power follow currents and backup fuse values are just some of the aspects that need to be taken into account here.

   Depending on the local circumstances and the discharge currents to be expected, sparkover gaps or varistor surge arresters are used, taking into account the type of network.
Surge protection concept

If a lightning protection system has been installed, or the power supply is via overhead lines, or buildings or plants are spread over a wide area and individual buildings are sited on elevated ground or open areas, high-capacity Type I arresters should always be employed.

2. Subdistribution

The surge voltage strength of the insulation is 4 kV from the main distribution board up to and including subdistribution boards. Owing to the co-ordinated use of arresters, Type II surge arresters are used here and, if necessary, decoupled from Type I arresters by means of coils. The use of decoupling coils is only necessary when the Type I arresters consist of one sparkover gap and the length of the line between the Type I and Type II arresters is less than 10 m. It is not necessary to decouple Weidmüller Type I and Type II arresters. The pulse currents that occur here are no longer that high because most of the energy has already been absorbed by the Type I arresters. Nevertheless, the line impedances give rise to high interference voltages which must be limited to less than 4 kV by the Type II arresters.

Type II arresters based on varistors are normally installed in the subdistribution board before the residual-current circuit-breakers.

3. Terminals, consumers, sockets

The surge voltage strength of the insulation is 2.5 kV from the subdistribution board to the electrical consumer. Surge arresters in Type III are used for this purpose. Depending on the application, they can be used as protective components or in composite switching together with gas discharge tubes, varistors, suppressor diodes and decoupling elements. These arresters are best installed directly before the device to be protected. This can be in a socket or trailing socket (on extension lead) but also in the terminal or junction box of the device itself.

To protect against permanent interference such as “ripples” or “noise” caused by other systems, additional filter circuits are available for the voltage supplies to devices. The insulation of the electrical consumer itself has a surge voltage strength of 1.5 kV.

Principle for selecting arresters according to IEC 664 DIN VDE 0110 part 1

- Lightning arrester Type I (B)
- Overvoltage arrester Type II (C)
- Arrester Type III (D)

Design surge voltage 300 V conductor-to-earth voltage
Classification and protective zones

The requirements placed on surge protection and the necessary tests for surge protection components are stipulated by national and international standards. A product can only be considered safe after the product has been fully tested.

For rated voltages up to 1000 V AC, the standards are valid for the manufacturers of surge protection devices and the installers of the surge protection within the facility or system. This catalogue contains a list of valid standards for your reference.

The insulation coordination for electrical equipment in low-voltage systems to IIIV EN 60664-1 (IEC 60664-1) is critical for the design of a surge protection solution. This specifies different dielectric strengths within electrical systems. Based on this, individual lightning protection zones can be set up according to IEC/EN 62305-3.

Lightning protection zones

A protective zone is characterised by a fully earthed envelope. In other words, it has an enclosing shield which enables full equipotential bonding. This shielding can be formed by building materials such as metal facades or metal reinforcements. Lines that pass through this shield must be protected with arresters in such a way that a prescribed protection level is achieved. Further protective zones can be set up inside such a protective zone. The protection level of these zones can be lower than that of the enclosing protective zone. This leads to a co-ordinated protection level for the objects to be protected. Not every individual section has to be protected with the maximum protection level (e.g. against lightning). Instead, the individual protective zones guarantee that a certain overvoltage level is not exceeded and hence cannot infiltrate that zone. This leads to economic protection concepts with respect to the capital outlay for protective components.

Classification

Originally, protective zones were classified according to coarse, medium and fine protection. These protective zones were designated classes B, C and D in IEC 60099 (VDE 0675-1). There was also a class A for external arresters (e.g. for low-voltage overhead lines); however, this class has now been abolished. IEC 61643-11 classifies the protective zones as Types I, II and III.

Comparison of surge protection classifications.
Many national standards, e.g. in Austria, are derived from the aforementioned VDE or IEC standards.

<table>
<thead>
<tr>
<th>Formerly DIN VDE 0875 Part 8 / A1</th>
<th>New IEC 61 643-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arresters of requirements class B, lightning protection equipotential bonding to DIN VDE 0166 part 1 (“B arresters”)</td>
<td>“Type I” arresters</td>
</tr>
<tr>
<td>Arresters of requirements class C, surge protection in permanent installations, surge withstand voltage category (surge cat.) III (“C arresters”)</td>
<td>“Type II” arresters</td>
</tr>
<tr>
<td>Arresters of requirements class D, surge protection in mobile/permanent installations, surge withstand voltage category (surge cat.) II (“D arresters”)</td>
<td>“Type III” arresters</td>
</tr>
</tbody>
</table>

At Weidmüller, we make sure that all our surge protection products are tested by an independent testing lab for compliance with the relevant product standards. This is documented by test reports and corresponding test certificates.
Lightning protection levels

The lightning protection level applies only to the pulse current 10/350 or to Type I.

**Lightning protection level I**

Lightning protection level I covers a pulse of 200 kA. This is the worst-case scenario of a direct strike. This pertains to external lightning protection facilities. Half of this pulse is conducted to the earth and the other half is conducted to the section of the facility that is conductive. If only a four-wire system is available, then a current of 25 kA is distributed to each wire. For a five-wire system, that would correspond to 20 kA. This lightning protection class covers multiple areas, including: petrochemical facilities (Ex-zones) and explosive material depots.

**Lightning protection level II**

Lightning protection level II covers a pulse of 150 kA. This pertains to external lightning protection facilities. Half of this pulse is conducted to the earth and the other half is conducted to that section of the facility that is conductive. If only a four-wire system is available, then a current of 19 kA is distributed to each wire. For a five-wire system, that would correspond to 15 kA. This lightning protection class covers multiple areas, including: parts of hospitals, shipping warehouses with fire alarm systems and telecommunication towers.

**Lightning protection level III/IV**

Lightning protection level III covers a pulse of 100 kA. This pertains to external lightning protection facilities. Half of this pulse is conducted to the earth and the other half is conducted to that section of the facility that is conductive. If only a four-wire system is available, then a current of 12.5 kA is distributed to each wire. For a five-wire system, that calculates to 10 kA. The 12.5 kA value is also used here. About 80% of all applications are covered by lightning protection Type III. This includes houses, homes, administrative buildings and industrial facilities.
Table 2.2.1
Buildings requiring lightning protection, lightning protection levels, control intervals

<table>
<thead>
<tr>
<th>Building, facility, zone, areas</th>
<th>Lightning protection level</th>
<th>Control intervals (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Buildings that have rooms with a large number of occupants (e.g. theatres, concert halls, dance halls, cinemas, multi-purpose sporting/exhibition arenas, retail stores, restaurants, churches, schools, transportation facilities such as railway stations and similar sites of public assembly, including the associated buildings, which can be adversely affected by a lightning strike);</td>
<td>II</td>
<td>10</td>
</tr>
<tr>
<td><strong>Note</strong> Especially multi-purpose sports/exhibition arenas, theatres, cinemas, restaurants and similar sites with rooms where there could be 100 or more persons; sales sites with a total sales area of less than 1,200 m², if the calculated number exceeds 100 persons, sales sites with a total sales area of more than 1,200 m².</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b Accommodation facilities (e.g. hotels, nursing homes, institutions, hospitals, prisons, military barracks);</td>
<td>II</td>
<td>10</td>
</tr>
<tr>
<td><strong>Note</strong> Especially hospitals, nursing homes where there are permanently or temporarily 10 or more persons who depend on outside help; especially hotels, inns and boarding houses where there are permanently or temporarily 15 or more persons that do not depend on outside help.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c Particularly tall buildings, including the adjoining buildings of normal height; high-rise buildings used as residential and commercial buildings, high chimneys and towers (church steeples).</td>
<td>III</td>
<td>10</td>
</tr>
<tr>
<td><strong>Note</strong> Buildings which are considered tall according to building legislation or where the top floor is more than 22 metres above the surrounding terrain serviced by firemen or where the eaves have a height of more than 25 metres.</td>
<td>II</td>
<td>10</td>
</tr>
<tr>
<td>d Buildings made from combustible materials with a total volume of more than 3,000 m³;</td>
<td>III</td>
<td>10</td>
</tr>
<tr>
<td>e Large agricultural and operational buildings (more than 3,000 m³) including the adjoining silos and adjacent residential buildings which could be adversely affected by a lightning strike; fermenting facilities or biogas plants;</td>
<td>III</td>
<td>10</td>
</tr>
<tr>
<td>f Industrial and commercial buildings in high-risk areas (such as plants and equipment where flammable or explosive materials are handled or stored), wood processing factories, mills, chemical plants, textile and plastics factories, explosives and ammunition depots, pipelines, gas stations; – Areas at risk of fire – Explosion-risk zones under a roof</td>
<td>II – I</td>
<td>10 – 3</td>
</tr>
<tr>
<td>g Containers for flammable or explosive substances (such as flammable liquids or gases), warehouses for solid or liquid fuels and associated buildings and facilities (e.g. machine buildings, gas stations, storage buildings with filling equipment);</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h Buildings and facilities which house content with special value items (e.g. archives, museums, collections);</td>
<td>II</td>
<td>10</td>
</tr>
<tr>
<td>i Buildings and facilities which house sensitive technical equipment (e.g. IT and telecommunications facilities); Data centres;</td>
<td>II</td>
<td>10</td>
</tr>
<tr>
<td>j Buildings and installations in exposed topographic positions (e.g. free-standing building [alpine huts] in the mountains)</td>
<td>III – I</td>
<td>10 – 3</td>
</tr>
</tbody>
</table>

Extract from the guidelines of the SEV 4022 Lightning Protection Systems 2008; please follow the installation regulations and standards in the individual countries.
Network forms to DIN VDE 0100 part 300 (DIN 57100 part 310)

The letters in this table describe the earthing conditions:

<table>
<thead>
<tr>
<th>1st letter</th>
<th>2nd letter</th>
<th>3rd letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthing at current source</td>
<td>Earthing of exposed conductive parts of electrical installation</td>
<td>Routing of N and PE conductor (only applies to TN systems)</td>
</tr>
<tr>
<td>T-</td>
<td>T-</td>
<td>C-</td>
</tr>
<tr>
<td>Direct earthing of current source (of transformer)</td>
<td>Exposed conductive parts of electrical installation are earthed directly</td>
<td>“Combined” N conductor and PE conductor are routed together as PEN conductor from current source into electrical installation</td>
</tr>
<tr>
<td>I-</td>
<td>N-</td>
<td>S-</td>
</tr>
<tr>
<td>Insulated structure of current source</td>
<td>Exposed conductive parts of electrical installation are connected to earth of current source</td>
<td>“Separate” N conductor and PE conductor are routed separately from current source to exposed conductive parts of electrical installation</td>
</tr>
</tbody>
</table>

Four-conductor systems:

Still valid according to VDE but unfavourable for information technology systems from the point of view of EMC (VDE 0100 pt 444 / pt 540 pt 2).

TN-C systems (“classic earthing”)

Neutral conductor and protective earth conductor functions are combined throughout the network in a single conductor, the PEN conductor.

TN-C systems (“modern earthing”)

Neutral conductor, PEN conductor and equipotential bonding system are connected once at the main distribution board or after the incoming supply to the building. Therefore, a TN-C system becomes a TN-S system (TN-C-S system) from this point onwards.
**Five-conductor systems:**

The neutral point of the supply source is earthed (N and PE). Both conductors must be laid separately and insulated from the incoming supply onwards. In these systems the PE (protective earth conductor) does not carry any operating current but instead only discharge currents.

**TN-S systems**

Neutral conductor and protective earth conductor are separated throughout the network.

**TT systems**

One point is earthed directly (operational earth). The exposed conductive parts of the electrical installation are connected to earth lines separate from the operational earth.

**Special system:**

Used, for example, in medical applications

**IT systems**

There is no direct connection between active conductors and earthed parts. The exposed conductive parts of the electrical installation are earthed.
Surge protection with 3+1 circuitry in consumer loads with TT power systems

3+1 does not always equal 4! At least not in the case of protective circuits with arresters in a TT system. In a TT system the supply is via the three phase conductors L1, L2 and L3 and the neutral conductor N, i.e. without an additional integral PE conductor. The equipotential bonding is then made separately within the consumer installation through the earthing. The outcome of this is that the neutral conductor can accommodate a higher voltage compared to the earth potential. Therefore, to protect against overvoltages between neutral conductor and earth potential, an arrester must be incorporated here as well.

The “four-arrester circuit” does not satisfy all safety aspects. Up to now, four arresters, i.e. one each between earth potential and L1, L2, L3 and N, were installed in consumer installations with TT systems. However, this “four-arrester circuit” is no longer regarded as the optimum solution because the physical characteristics of the varistors used may lead to unacceptably high touch voltages at the PE conductor in the consumer installation. Depending on the age of the system, leakage currents can flow through varistors and cause overvoltages via the earthing resistance.

The downstream RCD-(Fi) circuit breaker found in TT systems cannot detect such leakage currents. Therefore it cannot trigger. Furthermore, a failed, i.e. low-resistance, varistor would create a connection between N and PE. One remedy is to install an arrester disconnector in sequence with the varistors. But an arrester disconnector that monitors the varistors takes up space and costs extra.

If instead of varistors, sparkover gaps were to be arranged between the conductors and the equipotential bonding, then that, too, would not be an ideal solution. The longer time to sparkover and the characteristics of the sparkover gaps result in higher residual voltages.

The 3+1 circuit includes varistors with the three L conductors and the N conductor, and a sparkover gap between the base of the three varistors at the N conductor and the equipotential bonding rail (PE). The size of the sparkover gap must be such that it can accommodate the total current of the three phase conductors and the neutral conductor. The sparkover voltage of the sparkover gap in 230 V systems should be 1.5…2 kV.
The sparkover gap isolates the three varistors electrically from the PE so that leakage currents through the varistors cannot cause voltage increases at the PE. The residual-current circuit-breaker behind the 3+1 circuit then provides reliable protection against hazardous touch voltages in all situations.

In terms of its relevance for safety aspects, the 3+1 circuit described in VDE 0100 part 534 (section 534.2.2) can therefore be regarded as a solution for surge protection in TT systems.

Note: Although the “four-arrester circuit”, i.e. with one varistor each between earth potential and L1, L2, L3 and N, is prescribed in VDE 0100 part 534 (section 524.2.1) for consumer installations in TN-S systems, the 3+1 circuit would also be possible here without increasing the risk. In ÖVE/ÖNORM E 8001-1/A2:2003-11-01, the 3+1 circuit is already expressly listed for use in TN-S and TT systems.
General installation advice

Many details have to be taken into account during the installation of surge protection and the electrical system in order to achieve optimum protection.

Arrangement and subdivision of electrical panel

Steel cabinets possess good magnetic shielding properties. The following points should be taken into consideration during the installation:

• Avoid unnecessarily long lines (particularly lines with a high volume of data traffic).
• Route sensitive signalling lines separately from lines with a high interference potential.
• Route shielded lines directly to the equipment and connect the shielding there (do not connect via additional terminal in switching cabinet).
• Classify equipment in groups with different sensitivities and place these together.

Place of installation

The surge protection devices should be mounted where the lines and cables enter the cabinet. This is the lowest mounting rail directly above the cable entries. This prevents interference being coupled within the cabinet; interference is discharged right at the entry to the cabinet. When using shielded lines, these can be connected at this point by using Weidmüller clamp straps.

Routing the lines

Signalling lines should be laid within the system/cabinet over the shortest route to the surge protection and then continue to the connected equipment. Protected and unprotected lines should be routed separately. The earth line should be regarded as an unprotected line. Metal partitions can be used along cable routes or in cable ducts to achieve this separation. If signalling lines are laid parallel to power lines, a clearance of min. 500 mm must be maintained. The best shielding offers metallic cable conduits along with a metal cover.

Earthing of products and connected products

All surge protection devices have an earth-connection terminal point. The earthing wire for the associated equipotential bonding rail must be connected to this point. The earthing wire should have as large a cross-section as possible and also be as short as possible. Every centimetre of extra cable length increases the residual voltage of the surge protection device (1 metre / 39 inch of cable = 1 kV voltage drop). In addition to the earthing terminal, the surge protection products for measurement control systems also offer the option of earthing via a DIN rail contact on a TS 35. In order to achieve the best earth contact, the rail should be mounted to an earthed metal back wall. In order to obtain a lower protection level, the earthing terminal on the surge protection products (for measurement and control systems) also offers the option of earthing via a DIN rail contact on a TS 35. In order to achieve the best earth contact, the rail should be mounted to an earthed metal back wall. In order to obtain a lower protection level, the earthing terminal on the surge protection products (for measurement and control systems) should be connected to the equipotential bonding every 60 cm / 24 inch. According to IEC 62305, the PE connection and the SPD spur may only be 0.5 m / 20 inch to the lightning protection equipotential bonding. It is possible to make the path as short as possible by using a so-called V-connection or by connecting to the accompanying PE.

Cable lengths

It is valid:

\[ a + b \leq 0.5 \text{ m / 20 inch} \]

\[ a + c \leq 0.5 \text{ m / 20 inch}, \text{ then } b \text{ is not relevant} \]
**Fuse protection**

Surge protection devices for instrumentation and control systems frequently operate with a decoupling between the components. This decoupling is carried out using inductors or resistors. The decoupling dictates the cable type, cable routing and also a fusing for the maximum nominal current of the surge protection devices. The fusing for the VPU series on the power supply side must be installed in accordance with DIN VDE 0298 part 4 (cross section, quantity, type of conductor and the type of installation). This information is documented in the package insert and on the products for the corresponding VPU modules. In the event of overloads caused by partial lightning currents or transformer short circuits, the lightning arrester and surge arrester (SPD) must be protected by a back-up fuse if F1 is greater than the value specified by the manufacturer. In compliance with the ratio 1:1.6, the maximum nominal value should be configured for the SPD. Depending on the installation of the connecting cables, F1 can be increased during the lifespan of the facility. If a circuit breaker or a main circuit breaker is used instead of the safety fuse required in the installation instructions, then the triggering characteristics must be followed.

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**Lightning current strength of NH fuses**

**for surge currents 10/350 μs**

<table>
<thead>
<tr>
<th>Fuse nominal currents in A</th>
<th>Imax in kA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3…3.7 kA</td>
<td>6…10.3 kA</td>
</tr>
<tr>
<td>4.4…6.1 kA</td>
<td>8.8…10.3 kA</td>
</tr>
<tr>
<td>6.8…10.3 kA</td>
<td>13.2…16.4 kA</td>
</tr>
<tr>
<td>15.6…29.8 kA</td>
<td>50</td>
</tr>
</tbody>
</table>

**Values from the 1 ms melting integral**

**for surge currents 8/20 μs**

<table>
<thead>
<tr>
<th>Fuse nominal currents in A</th>
<th>Imax in kA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.7…4.3 kA</td>
<td>2.3…3.7 kA</td>
</tr>
<tr>
<td>4.4…6.1 kA</td>
<td>6.8…10.3 kA</td>
</tr>
<tr>
<td>6.8…10.3 kA</td>
<td>8.8…10.3 kA</td>
</tr>
<tr>
<td>13.2…16.4 kA</td>
<td>28…34 kA</td>
</tr>
<tr>
<td>28…34 kA</td>
<td>43…55 kA</td>
</tr>
</tbody>
</table>

**Values from the 1 ms melting integral**
General installation advice

Behaviour of NH fuses for lightning surge current (10/350 µs)

It is important to understand that the question is not how small the SPD fusing should be; rather the maximum back-up fuse that should be used, as the capacity of the small fuses to carry lightning current is very limited. Unrestricted SPD protection is only available when the installation accommodates the maximum value.
Installation instructions for Weidmüller’s VPU I, VPU-II and VPU-III lightning/surge protection in power grids

Surge protection should only be installed by trained personnel. Please follow all local regulations concerning connection methods during the installation.

1 Application

Type I VPU I lightning protection and the Type II VPU II surge protection are used to protect low-voltage consumer installations and electronic devices against surge voltages that may arise as a result of atmospheric discharges (thunderstorms) or switching operations. The VPU I is a Type I/II lightning arrester according to IEC 61643-11, ENV 61024-1 and IEC 1312-1. In the event of a lightning strike, the required equipotential bonding (lightning protection equipotential bonding according to IEC 62305 part 1) between the building lightning protection and the earthing system for the power supply is provided by built-in varistors. The VPU II complies with Type II of IEC 61643-11 and ÖVE SN60 part 4 and part 1. Metal-oxide varistors are used as voltage-limiting components. The VPU III and VPO-DS Type III surge protection for end devices protect low-voltage consumer installations and electronic devices against surges and switching operations. The VPU III or VPO DS is installed in addition to the VPU II in the small distributor, floor distributor, cable conduit, or directly behind the outlet. They meet the requirements of IEC 61643-11 and EN 61643-11.

2 Installation location

The VPU II needs to be installed in the meter cabinet or in the distributor so that the space for connection terminals is not accessible to unauthorised persons. The VPU I is installed near the power feed so that there is the required lightning current equipotential bonding between the lightning protection facility and the power distribution system. All arresters must be installed by a qualified electrician.

The VPU I LCF can be installed upstream of the meter. VDE 0100 part 534 “Selection and installation of equipment” describes the construction of facilities with surge protection equipment. This is related to the following standards:

a. IEC 60364-4-43: “Protection for surge voltages from atmospheric origins and from switching operations”

b. IEC 60364-5-53: “Selection and installation of electrical equipment”

c. IEC 61024-1: “Protection of buildings against lightning strikes”

d. IEC 61312-1: “Protection against lightning electromagnetic pulses”

3 Electrical connection

The shortest possible cables should be used to connect the VPU I lightning arrester and the VPU II surge protector with the phase conductors (L1, L2, L3) or the neutral wire (N) and the earth (PE) on the consumer installation. Unprotected cables should never run in parallel with protected cables (connection examples can be found on the last page).
Surge protection installation instructions

3.1 Connection to the phase conductor and the neutral wire

When connecting cables to the VPU I/VPU II arresters, normally the same wire cross-section is used both for the phase conductors (L1, L2, L3) and the neutral wire (N). If you need to reduce the cross-sections, then a protective device (e.g. a main port fuse) should be used to protect the connecting cables from short circuits. The terminals of the arrester must not be used as branch terminals. The back-up fuse for the VPU II can be be up to 200 A gL. For the VPU I, a max. of 315 A gL can be selected for the back-up fuse.

Notes:
In the TN-CS power grid, 3-pole VPU IIs are used (on the TN-C side). If the PEN conductor uses a separate PE and N, then a 4-pole VPU II should be used (on the TN-S side). According to DIN VDE 0100-534/A1 10/96, a VPU II 3+1-280 V protector can be installed in a TT-type power grid. For an IT grid with a 400 V phase-wire voltage, the VPU II 3+1 385 V should be installed for 385 V.

3.2 Connection to the earth

The earthing wire of the arrester is connected via the shortest path to the earthing system of the consumer installation. Longer connecting cables reduce the effectiveness of the surge protection. They should not be routed in parallel to other cables. An equipotential bonding rail is available as a connection point in electrical consumer systems with equipotential bonding. You must be certain that the earthing for the arrester is connected to the earthing system of the consumer installation.

In TN power grids, the PEN conductor and the earthing line of the arrester should be connected to each other. The PEN conductor from the electrical utility may not be used as the earth.

If the PE or PEN rail on a distributor is used as the earthing terminal, then the rail must be connected via a separate earth wire to the earthing system of the consumer installation.

Two ground terminals are provided in the VPU I. Both terminal points must be connected. One leads to the equipotential bonding connection on the building and the other leads to the PE conductor on the installation. For Type I lightning arresters, a conductor for carrying lightning current must be used that is at least 16 mm². A minimum cross-section of 4 mm² is required with Type II surge protection.

4 Installation of surge protection for end devices (Type III arresters)

The VPU III or VPO-DS arrester is installed together with and after the VPU II. The VPU III or VPO DS is built into the cable that is to be protected. It can then protect a circuit up to 16 A. The VPU III can be installed in small distribution boards for one circuit (e.g. for protecting monitors). The VPO DS can be installed in devices or in cable conduits on-site.

5 Functional check

It is important to visually inspect VPU lightning arresters and surge protectors, especially during stormy weather. If the colour of the viewing window changes or if the LED is red, then the SPD must be replaced. As the varistors get older, the temperature of the varistors may increase. In low-voltage networks this can lead to fire. Therefore all SPDs have a built-in temperature monitoring mechanism that isolates the varistor automatically from the power supply in the event of danger. A signal or LED indicates that it has been switched off. An additional switching contact (remote signalling contact) reports this separation (this is labelled with R in all product designs). The functionality of all VPU modules can be tested using testing equipment (such as the V-TEST), which is available separately.
5.1 Replacements

When an arrester has a red window (as described by point 5) or a red LED, then the arrester should be replaced by a qualified electrician. The individual Type I-II arresters are pluggable and coded for voltage.

For the insulation resistance test, the SPD must be disconnected from the facility during the duration of the measurement (e.g. by pulling out the upper sections) or the arresters are disconnected from the power network. Weidmüller provides special notice stickers for the electrical cabinet (order number 1287670000) for this purpose. A proper arrester that matches the nominal voltage must be re-installed.

6 Connecting the remote signalling (R)

The signal contact is designed as a change-over (CO) contact. It is connected to terminals 11 and 14. Terminals 11/12 are in normal operation (window is green) closed and terminals 11/14 are open. In the event of an error (red box), the connecting terminals 11/14 are closed and 11/12 are open.

For the VPU III, the response of the isolating mechanism is signalled when a non-reversible thermal fuse opens.

The alert circuit is connected using cables with a maximum cross-section of 1.5 mm². The connecting cables must not be run parallel to the earthing cable. A protective circuit using fine surge protection (Type III) according to the voltage level can reduce interference on and in the evaluation device.

7 Back-up fuse

The lightning and surge protection devices in the VPU I and VPU II series behave passively during normal operation. No current is drawn. This provides the necessary protection against short circuits and overloads by using a fuse that is designed for the installation method and the cross-section of the connected cable. The VPU product series is also tested with a maximum back-up fuse. This back-up fuse is listed in the technical specifications or the side label on the product.

If the fuse used in the system has a smaller or equal value, then it can be used for cable protection on the power feed. If the power-feed fuse has a value greater than the fuse specified in the technical specifications, additional fuses must be integrated depending on the connecting cable in the wiring harness of the VPU module. Remember that the fuse for the wiring harness is also capable of carrying a lightning current. This fuse should not be too small which would make the SPD ineffective during an actual power surge.

8 Application

The VPU I LCF and VPU I establish the required lightning protection equipotential bonding for existing lightning protection systems and power feeds. The encapsulated VPU I LCF and VPU I are preferably used in the distributors in building installations. The blow-out PU I TSG is often installed for industrial applications (such as wind power facilities) with voltages of 330 V or 440 V.

The VPU I LCF and VPU I TSG+ products can be used before the meter, since this does not cause leakage current during operation. The VPU I LCF and the VPU I have been certified as lightning protection as well as surge protection. This means that they are permitted for Type I and Type II (whereby the VPU II surge protector is permitted for Type II and III) – surge protection and end-device surge protection. VPU III and VPO DS are Type III surge protectors for end devices.

9 Approvals

The VPU I and VPU-II series have a CB report and can thus be rewritten for country-specific approvals. All products bear the CE mark.

10 A brief overview of the installation standard for lightning and surge protection

Based on VDE 0100-534, derived from the IEC 60364-5-53 standard. This standard specifies the surge protection (Type I or II) that should be installed.

The IEC 60364-5-534 standard may not be the same as the adopted standards from each country. The country-specific standards and application-based standards or rules must be observed during the installation. The installation must be carried out by locally licensed professionals.

The VDE 0100-534 distinguishes between the connection diagrams A, B and C.

The following is derived in actual practice:

A = 3+0 circuitry (VPU I 3 or VPU II 3 in the TN-C system)
B = 4+0 circuitry (VPU I 4 or VPU II 4 in the TN-S system)
C = 3+1 circuitry (VPU I 3 +1 or VPU II 3+1 in the PU II TN-S/TT or IT system with N).
Surge protection installation instructions

VDE 0100-534 now states that there should be a gap of \( \leq 0.5 \text{ m} \) between the SPD in the vicinity of the installation location and the direct connection to N or PE.

IEC 60364-5-534 specifies that the earth must be established from the SPD to the equipotential bonding rail or to PE – whichever is the shortest connection. Both cables are specified in the VDE.

During the insulation test, the SPD must be isolated from the facility for the duration of the measurement. Establishing SPDs after an RCD is only permitted under special preconditions.

Protection against surge currents

The F2 fuse ensures protection against SPD short circuits. These fuses should be chosen based on the rated currents listed in the installation instructions from the SPD manufacturer. The F2 fuse does not need to be used when the characteristics of the F1 fuse (which is part of the electrical facility) correspond to a combination of the rated currents specified by the SPD manufacturer.
The basics of lightning and surge protection

Standard texts for surge protection tenders

You will find standard, up-to-date texts for tender documents at our Internet site www.weidmueller.com – select language: English. These will help you draw up the specification to suit your installation. The advantage of this is that you can download the correct, up-to-date technical information from our Internet site at any time.

Please visit our online catalogue on our homepage for more product information. www.weidmueller.com
Applications, installation positions:
Application Office building

Power (low-voltage supply)
1 Type I  Arresters with sparkover gaps with/without high-power varistors, VPU I LCF
2 Type I  Arresters with high-power varistors, VPU I series
3 Type II Arresters with high-power varistors, VPU II series
4 Type III Arresters for installing in subdistribution boards, VPU III series
5 Type III Arresters in the form of plug-in surge protectors, VPO DS

Data
8 Surge protection for data lines, e.g. Ethernet CAT.5

Power and data
6 Type III Arrester VSPC
7 Type III Arrester VSPC

Instrumentation and control equipment
9 Surge protection for measurement and control circuits, e.g. VSPC or VSSC
Applications, installation positions:
Application Industrial building

Standards
IEC 61643-11. SPDs connected to low-voltage power distribution systems. Type I, Type II and Type III products are tested in accordance with this standard.

IEC/EN 62305-1 until 4 - Protection against lightning. This lightning protection standard defines everything to do with internal and external lightning protection. It includes four sections:
• “Protection against Lightning – Part 1: General principles”
• “Protection against Lightning – Part 2: Risk management; assessing the damage risk for buildings and structures”
• “Protection against Lightning – Part 3: Physical damage to structures and life hazard”
• “Protection against Lightning – Part 4: Electrical and electronic systems within structures”

Regulations for installation
(Content in VDE 0100-534). Standard for the installation of low-voltage facilities.
VDE 0800, VDE 0843-T5, VDE 0845 describe the selection and installation for communication electronics.

Guidelines for the SEV lightning protection system SN 4022:2004 and the SEV 4113 foundation earth

LPZ OA
Unprotected area outside of the building. Direct lightning strike; no shielding against electromagnetic interference.

LPZ OB
Area protected by lightning protection system. No shielding against LEMP.
Components for Surge protection

Surge protection devices (SPDs)

There is no ideal component that can fulfil all the technical requirements of surge protection equally effectively. Instead, we use a variety of components with different physical methods of operation that complement each other; these possess distinct protective effects. Super-fast reaction time, high current-carrying capacity, low residual voltage and long service life cannot be found in one single component.

In practice we use three principal components:
1. spark gaps
2. varistors
3. suppression diodes

Therefore, to optimise the surge protection solution, carefully matched groups of these components are often combined in one protective module.

The basics of lightning and surge protection

W.28

1368910000 – 2013
The varistors used with surge protection (MOV-Metal Oxide Varistors) have resistance which depends on the voltage. This is implemented with metal-oxide (zinc-oxide) discs. There is a low-ohm resistance in the range above the rated voltage. The surge voltage is limited since a current flows through the varistor. The varistor works bi-directionally. Depending on the type, varistors have either a middle or high discharging capacity. It is in the range from 40 kA to 80 kA. The response time is less than 25 ns. However there are also disadvantages when using varistors. Two factors that must be taken into account are the relatively high capacitance and the aging characteristics. Leakage currents occur over time, depending on the frequency of the triggering, because individual resistance elements break down. This can cause temperature rise or even destroy them completely. This is one reason for thermal fuses being built into Weidmüller products. The high capacity of the varistors is problematic for circuits with high frequencies. Some signal attenuation should be expected at frequencies above 100 kHz. We therefore recommend that they are not used in data transmission systems.

Suppressor diodes function in a similar fashion as Zener diodes. There are uni-directional and bi-directional versions. Uni-directional suppressor diodes are often used in DC circuits. Compared to standard Zener diodes, suppressor diodes have a higher current-carrying capacity and are significantly quicker. At a certain breakdown voltage level, they become conductive very quickly. They therefore discharge the surge voltage. However their current-carrying capacity is not very high. It is only a few hundred amps. Instead, they feature a very quick reaction time which lies in the picosecond range. Unfortunately, suppression diodes possess a significant inherent capacitance. Therefore, like with varistors, their possible attenuation effect on high frequencies must be taken into account.

1. Varistors / MOV
2. Suppression diodes / TAZ
4. Combination circuits

Combining the components described above results in surge protection products that can match individual requirements. If a voltage pulse reaches the input of such a combination circuit, then the gas discharge tube is fired and discharges high current. The residual pulse is attenuated by a downstream inductance and subsequently received and limited by the varistor and/or suppression diode. If the gas discharge tube is not triggered, i.e. in the case of a slower voltage rise, then the pulse is discharged by the varistor or the suppression diode alone.

The sequence of the individual components results in an increasing response sensitivity towards the output. An interference voltage with a rise of 1 kV/µs and a peak value of 10 kV at the input is limited by a gas-filled surge arrester to approx. 600-700 V. The second stage, decoupled from the first by means of an inductance, suppresses this value to approx. 100 V. This voltage pulse is then reduced to approx. 35 V (in a 24 V protective combination) by the suppression diode. Therefore, the downstream electronics need only be able to cope with a voltage pulse of approx. 1.5 x \( U_b \).
Test criteria

The classification is based on the experience that “B arresters” can become overloaded in extreme situations, and also on more recent investigations into lightning discharges. This resulted in the standardised 10/350 µs current curves for the testing of “Type I” arresters. The test parameters lie between 12.5 and 25 kA $I_{\text{peak}}$ or $I_{\text{imp}}$. The term “10/350 µs” means that the surge current reaches 90% of its maximum value after 10 µs and then decays to half that value after 350 µs. The area beneath this curve corresponds to the current energy used in the test. As in the past, “Type II” arresters (formerly “C arresters”) are tested with the 8/20 µs current curve. The rated discharge current for our arresters: for a 2-pole feed up to 75 kA; for a 4-pole feed up to 100 kA. “Type III” arresters (formerly “D arresters”) are used for protecting equipment. These are tested with a 2 W hybrid surge current generator delivering a maximum charging voltage of 0.1 to max. 20 kV.

Relationship between 10/350 µs and 8/20 µs

<table>
<thead>
<tr>
<th>Wave form</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>pulse (µs)</td>
<td>10/350</td>
<td>8/20</td>
</tr>
<tr>
<td>$I_{\text{peak}}$ (kA)</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td>Q (Ae)</td>
<td>50</td>
<td>0.1</td>
</tr>
<tr>
<td>W/R (J/Ω)</td>
<td>2.5 – 10ª</td>
<td>0.4 – 10ª</td>
</tr>
</tbody>
</table>

Norm

- DIN V DE V 0185-1
- DIN V DE V 0432 T.2

which during a short-circuit supplies between 0.05 and 10 kA, 8/20 µs.
EMC – electromagnetic compatibility – means the trouble-free interaction between electrical and electronic systems and devices without mutual interference. In this respect, any electrical item can act both as transmitter (source of interference) and receiver (potentially susceptible device) simultaneously.

Normally it is not sufficient to construct an EMC-compliant electrical or electronic system using EMC-compliant components and to then expect that everything will operate smoothly. Only when you use the proper surge protection devices in the proper places in the facility, can you operate without outages using coupled surge voltages. The method for using surge protection devices is also linked to the influence of interference sinks and interference sources. It integrates with the lightning protection zone strategy and insulation coordination to form a complete protection system.

EMC laws and directives

There are a multitude of standards and statutory requirements aimed at controlling mutual interference-free operation. With the establishment of the unified European market in 1989, the EEC Directive (EN 50-370 part 1+2) on electromagnetic compatibility was adopted and then implemented into national law. In Germany, the law on the electromagnetic compatibility (EMVG) was endorsed in 1992. The current version of this law was passed in 2008 as was the international standard IEC 61000. Electromagnetic influences can be caused by natural processes, e.g. a lightning strike, and also technical processes, e.g. high-speed changes in the status of currents and voltages. We distinguish between periodic interference (system hum, RF irradiation), transient interference (brief, often high-energy pulses) and noise (broad distribution of interference energy across the frequency range).

The model used in EMC observations designates the transmitter as the source of interference emission and the receiver as the interference drain. The transmission of the interference takes place via line-bound and/or field-bound (H-field/E-field) coupling mechanisms. When considered as a source of interference, a device or a system may not exceed emissions thresholds specified in the EMC standards. When considered as a potentially susceptible device, the same system must exhibit the immunity to interference specified in the standards. However, the arrangement of various electrical systems within a complex plant or in a room and the many lines for power supplies, inputs and outputs to controls and bus systems give rise to diverse potential influences. Surges can be introduced by lightning, switching operations, etc. via the various coupling paths. This can lead to the following effects:

- Reduced functionality
- Malfunctions
- Failure of functions
- Damage
These last two functional interferences result in stoppages for entire production facilities and cause high breakdown costs.

The following points must be taken into account in order to achieve a system or plant that operates according to EMC guidelines:

- Lightning protection
- Earthing
- Routing of cables
- Cable shielding
- Panel construction
- Sensors and actuators
- Transmitters and receivers
- Frequency converters
- Bus and field devices
- ESD
FAQ list

When do I need a Type I arrester, when a Type II arrester?

In a lightning protection system set up on a building, the Type I arrester achieves the lightning protection equipotential bonding for the supply voltage. The Type I arrester is used when higher pulses are expected and is installed in the vicinity of the incoming supply.

The Type I arrester is intended for use in lightning protection equipotential bonding, in compliance with DIN VDE 0185 part 1 and IEC 62305. The Type I arrester meets the requirements of Type I (B) DIN VDE 0675 and IEC 61643-1 Type I.

The Type II arrester is used to protect low-voltage consumer installations and electronic equipment against surge voltages arising from atmospheric discharges (thunderstorms) or switching operations. The Type II arresters comply with VDE 0675 part 6, Type II (C). Draft and DIN VDE 0675 part 6, A2 and the IEC 61643-11 Type II.

When is a decoupling inductance needed?

When using Weidmüller arresters of Type I and II based on varistors, no decoupling inductance is needed. The PU1 TSG + operates with a triggered sparkover gap. The fast response and low protection level mean that no decoupling is required here either.

Why are there 3- and 4-pole versions?

Various arresters are used depending on the network structure. A widely used network structure is the TN system. In the TN-C system, the electricity supply company routes the potential of the operational earth of the low-voltage source (transformer) to the consumer installation via the integral PEN conductor. The PE conductor has the same potential as the N conductor in this case. A 3-pole arrester is used here. Every rule has an exception: in the TN-S system, PE and N are separate. This means there can be a potential shift between PE and N. A 4-pole PU is used in this case. In addition, a combination of 3- or 4-pole modules reduces the amount of wiring.

What other network structures are available?

**TT-System**

In the TT system, surge protection Type I/II arresters are not used between the active conductor and the earth potential like in TN systems. Instead they are used between phases L1, L2 and L3 and the neutral conductor.

In a “classic” arrangement of surge protection devices between the phases and the earth potential, the devices may not be capable of extinguishing mains follow currents at the end of their lifespan. They could even create a short circuit. Depending on the earth resistance that exists for the consumer installation, a fault current could flow back to the supply source. Usually, because of the relatively high loop resistances in TT systems, the fuses which conduct the operating current do not detect this fault current as a fault and thus do not isolate promptly. This can lead to increases in potential in the building’s entire equipotential bonding system. Dangerous parasitic voltages can be transferred if more distant buildings are being supplied from these consumer systems or if consumer loads are being operated via portable cables beyond the range of the building’s equipotential bonding system. The 3+1 circuitry can be used in such instances.

**IT-System**

An IT system is set up in some consumer installations for reasons of availability. A single-phase earth fault practically creates a TN system. The power supply is not interrupted but instead maintained. IT systems are used in medical applications, for example. A device for monitoring insulation provides information on the quality of the insulation of active conductors and connected consumers in relation to the earth potential. Surge protection devices are incorporated between the active conductors and the main equipotential bonding. The fuses, conductor cross-section and conductor routes are handled as for T systems. Likewise, all active conductors are protected against local earth potential in sub-circuit distribution boards. VPU surge protection devices in Type III surge protection for end devices are used (such as VPU III or VPO DS) to protect sensitive consumer loads. The arrester must be sized for the voltage of the phase conductor.
What does this have to do with the 3+1 circuitry?

If Type II arresters are now being led to a neutral conductor instead of a local earth in a TT system, then, for an arrester that has become low ohm, only the wire resistance of the neutral wire limits the incipient follow-on current. Immediately after the fault, this is isolated from the spur line fuses or from the main fuses that are carrying the operating current. A pure short-circuit current has emerged out of a fault current that was subject to an earthing facility and resistor. The connection between the neutral conductor and the main equipotential bonding is established using a spark gap. This conducts the total surge currents occurring at the installation site without overloading. This 3+1 circuitry is also implemented for the circuit distributors. The phase conductors L1, L2 and L3 are connected via the neutral conductor. From there, a spark gap link is established with the PE rail. The same information on the TN system applies when working with local equipotential bonding systems, when there is a separate discharge to the equipotential bonding, and when the surge protection components are being arranged ahead of the fault-current protective circuits.

How does monitoring work with VPU arresters?

Each individual element of the PU arrester is equipped with a thermal monitoring mechanism. This state-of-the-art design isolates the aged arrester from the power supply network. This helps to prevent fires. This thermal monitoring mechanism functions using a special solder which separates itself within 30 seconds when a current of about 0.2 A flows through the varistor. The functionality is indicated when the viewing window is green, or for the VPU series with arresters marked R, using a remote alert output with a CO contact.

Does a lightning/surge protection system continue to operate after a surge voltage?

Yes, if the leakage current on, for example, the VPU II remains below the nominal leakage current for each individual disk. However the varistor does age during each discharge. The ageing accumulates over its lifetime and then leads to the failure of the arrester after several years. This can be monitored using remote signalling. Another method, which is required by IEC 62305-3, is a periodic check of the lightning protection system. The V-TEST can help by allowing you to test the function of each individual module.

How are the VPU modules tested?

The VPU I and VPU II are tested in accordance with IEC 61643-11. The arresters from the VPU I series correspond with Type I and Type II. The VPU II series corresponds with Type II and Type III. The VPU III and VPO DS series are designed and tested in accordance with the requirements of IEC 61643-11. They are in Type III.

Where are the VPU modules installed?

The dimensions of the VPU modules for installation distributors, comply with DIN 43 880 A1 draft 6/81. The Type I arresters are installed in the vicinity of the power feed and main equipotential bonding. The Type II arresters are installed in the distributor and the VPU III are installed in the sub-distributions, closer to the object being protected. The insulation co-ordination in DIN VDE 0110 requires that facility components have certain insulation strengths. This can be achieved through the gradual application of arresters in Type I, II and III.

What must be considered when installing the VPU modules?

IEC 60364-5-53 describes the selection and installation of surge protection in buildings worldwide. The German draft standard VDE V 0100-534 describes the selection and set-up of surge protection systems.

What is the difference between a spark gap and a varistor?

A varistor is a voltage-dependent resistor which switches off the surge voltage “softly”. A spark gap is a mechanical component or an encapsulated, gas-filled ceramic unit whereby the spark gap switches through immediately, and after the spark, only the ignition voltage is present (80 – 120 V). Depending on the type of spark gap, the capability to suppress the 50-Hz mains follow-on current must also be considered. The varistors, however, do not draw any mains follow-on current.

What are triggered spark gaps?

These spark gaps have additional electronics. They “see” the interference pulse and ignite the spark gap. This means that the protection level is kept low and the time to spark is reduced. This saves on decoupling coils.
When should I use CL or SL circuits with surge protection components for measurement and control systems?

The difference between the switching in the CL (current loop) and SL (symmetrical loop) is the integration of the suppressor diodes. The CL circuit has a diode between the lines. This system is used for current loops and offers direct protection at the input or output of the analogue sensor. The SL circuit operates symmetrically to earth, i.e. two Transzorb diodes are connected to earth. If this is used in a current loop instead of the CL circuit, the residual voltage is twice as high because there are two diodes instead of just the one of the CL circuit.

### 2 CL protective circuit

![Diagram of 2 CL protective circuit]

### 2 SL protective circuit

![Diagram of 2 SL protective circuit]
The basics of lightning and surge protection
### Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3 +1 circuit</strong></td>
<td>Surge protection for TT-/TNS power networks with 3 varistors and an N-PE spark gap. There are no parasitic voltages in the event of defective varistors.</td>
</tr>
<tr>
<td><strong>Ageing</strong></td>
<td>Change in the original power data caused by interference pulse due to operations or unfavourable environmental conditions.</td>
</tr>
<tr>
<td><strong>Arrester</strong></td>
<td>Protective device that the discharges the energy either symmetrically between the conductors or asymmetrically between the cables and the earth.</td>
</tr>
<tr>
<td><strong>Asymmetric interference voltage</strong></td>
<td>Voltage between the “electrical centre”, and common ground (earth). Voltage between conductor and signal ground (earth).</td>
</tr>
<tr>
<td><strong>Back-up fuse</strong></td>
<td>Dependent on the connection cross-section and/or maximum longitudinal decoupling of the proposed fuse.</td>
</tr>
<tr>
<td><strong>Binary signals</strong></td>
<td>Switching signals with on and off states.</td>
</tr>
<tr>
<td><strong>Burst</strong></td>
<td>For a surge pulse that reoccurs during a specific time interval.</td>
</tr>
<tr>
<td><strong>Cable lengths</strong></td>
<td>With a spur line connecting the lightning arrester, the length of the phase-side and earth-side cables should be kept as short as possible and should never be longer than 0.5 metres / 20 inch. The earth-side connection should be as short as possible. Installation site: At the feed point of the facility, for Type I and II. In the immediate vicinity of the end device being protected for Type III.</td>
</tr>
<tr>
<td><strong>Capacitive coupling</strong></td>
<td>Coupling of the interference circuit and the useful circuit because of a potential difference with coupling capacitances.</td>
</tr>
<tr>
<td><strong>Combination circuit</strong></td>
<td>Protective circuit (e.g. from gas discharge tube, varistor and/or suppressor diode)</td>
</tr>
<tr>
<td><strong>Combined pulse</strong></td>
<td>The hybrid generator, when idle, creates a 1.2/50 μs pulse and, when in short circuit, a 8/20 μs pulse. The ratio of peak open-circuit voltage (U0c) to peak short-circuit current (Isc) is 2 ohms.</td>
</tr>
<tr>
<td><strong>Common-mode interference</strong></td>
<td>The interference source is between a signal wire and a reference conductor (e.g. capacitive coupling, or increase in potential of spatially dispersed earths).</td>
</tr>
<tr>
<td><strong>Continuous operating current Ic</strong></td>
<td>Current per protective path for continuous voltage Uc.</td>
</tr>
<tr>
<td><strong>Cut-off mechanism</strong></td>
<td>Device which disconnects the arrester in case of a system malfunction and displays this.</td>
</tr>
<tr>
<td><strong>Degree of protection for housing (IP code)</strong></td>
<td>Degree of protection ensured by the housing against touch access to live parts and against the ingress of solid foreign objects or water. Testing in accordance with IEC 529 section 7.4.</td>
</tr>
<tr>
<td><strong>Differential-mode interference</strong></td>
<td>Interference source and useful source are in series (e.g. magnetic or galvanic coupling).</td>
</tr>
<tr>
<td><strong>EMC</strong></td>
<td>Electromagnetic compatibility.</td>
</tr>
<tr>
<td><strong>External lightning protection</strong></td>
<td>The external lightning protection consists primarily of an air-termination device, arresters and an earthing system. It is responsible for protecting the facility buildings from lightning strikes which could cause fire or mechanical destruction.</td>
</tr>
<tr>
<td><strong>Follow-on current If</strong></td>
<td>Current that flows through the surge protection device immediately following a discharge and is delivered from the power grid.</td>
</tr>
<tr>
<td><strong>Follow-on current extinguishing capability In</strong></td>
<td>The VPU I, II and III series do not generate any power follow current between L-PEN (follow current) and thus simplify the installation. Therefore, the strength of the short circuit current, or power follow current, from the generator or transformer, does not have to be taken into account.</td>
</tr>
</tbody>
</table>
### Fuse, back-up fuse
A back-up fuse is required if the upstream fuse F1 is greater than the maximum value specified by the manufacturer. Remember to select the largest nominal value in keeping with the ratio F1 to F2 (back-up fuse before SPD) = 1 : 1.6. Be sure to take the triggering characteristics into account if a circuit breaker is being used in the surge protection equipment instead of the fuse specified in the installation instructions.

### Galvanic coupling
The interference circuit and the useful circuit have a common impedance.

### Gas discharge tube
Voltage-dependent, encapsulated switch with high current-carrying capacity.

### HAK
House junction box.

### I&C
Measurement and control systems.

### IMAX
Maximum current that can be switched by an arrester.

### Inductive coupling
Coupling from two or more current-carrying conductor loops.

### Insertion loss (attenuation)
Attenuation in decibels that is added by inserting a four-pole.

### INSTA
Installation housing in accordance with DIN 43880, suitable for installation in distribution boards.

### Insulation co-ordination or rated impulse withstand voltage
Standing surge current strength of the insulation in parts of the facility, according to DIN VDE 0110 T.1.

### Internal lightning protection
Internal lightning protection refers to protecting electrical equipment from power surges.

### Intrinsically safe circuit
Intrinsically safe circuits are especially vulnerable because even a small amount of energy is sufficient to nullify their intrinsic safety. During the installation of intrinsically safe circuits (including cables and wires), be sure that you do not exceed the maximum allowable inductance, capacitance, or the L/R ratio and the surface temperature.

### Iₘₐₓ
Maximum nominal current via the internal cross-connection of an arrester with two connections for one phase.

### Iₚₑ𝐚ᵏ = Iₘₚₑᵃᵏ
Current peak value of a test pulse.

### Iₚₑₙ
Peak value of the nominal discharge current.

### IT power network
Power system with three phase conductors, constructed with insulation to the earth potential. The building’s PE is not connected to the power grid.

### Leakage current
Current that flows to PE at nominal voltage.

### LEMP
Lightning electromagnetic pulse = electromagnetic interference pulse.

### Lightning protection equipotential bonding
Equipotential bonding of separated metal parts with the LPS using a direct connection or connection via surge protection devices in order to reduce the lightning current caused by the potential difference.

### Lightning pulse current Iₘₚₑᵃᵏ
Defined by the peak value Ipeak and the charge Q, when tested in accordance with Type I with 10/350 µs pulse.

### Limiting frequency
Specifies the max. frequency at which a transfer will function. At higher frequencies, the protective circuit cushions so strongly that no transfer is possible.

### Longitudinal voltage
Interference voltage between the active conductor and the earth.
## Glossary

### LPL

- **Lightning protection level**
- **LPL I = 200 kA**
- **LPL II = 150 kA**
- **LPL III = 100 kA**

Maximum lightning current that can enter as a direct strike in the external lightning protection. Various applications and buildings are categorised according to these lightning protection levels.

- **10/350 µs**: test current for lightning arrester (Type I products), for simulating or reproducing a lightning bolt.
- **8/20 µs**: test current for lightning arrester (Type II products), for simulating or reproducing a surge voltage.

### LPS

- **Lightning protection system** – a complete system that is used to reduce the physical damage to a building or facility that could be caused by direct lightning strikes.

### LPZ

- **Lightning protection zone = lightning protection zone**

The lightning protection zones are divided into: external lightning protection LPZ 0 / 0A / 0B and internal lightning protection LPZ 1, 2, 3.

### Max. continuous voltage $U_{c}$

The highest RMS value of the AC voltage or the highest value of the DC voltage that is allowed continually on the protective path of the surge protection device. Continual voltage = rated voltage.

### Maximum discharge surge current $I_{\max}$

Peak value of the current 8/20 µs during duty test for Type II (type 40 kA).

### Measured limiting voltage

Max. voltage level while loading with pulses of a specific form and amplitude during the test.

### MOV

- **See varistor.**

### Nominal discharge surge current

At peak value of the surge current 8/20 µs, during test for Type II (type 20 kA)

### PAS main earth rail

Metal rail which is connected with the foundation, and which can be used to connect metal installations, external conductive parts, power supply cables, telecommunications cables, water pipes and gas pipes to the LPS.

### PE

- **Protective system and earth system to which energy is discharged.**

### Protection level, $U_{p}$

- **Specifies the residual voltage that can still be measured at the terminals during a surge voltage pulse (preferred value is greater than the largest measured limiting voltage). Important parameter that characterises the performance of the SPD.**

### Protective path

Component circuity in a SPD: conductor to conductor, conductor to earth, conductor to neutral, neutral to earth are designated as protective paths.

### Pulse current 10/350 µs

Pulse voltage with a front time of 10 µs and a half-value time of 350 µs.

### Pulse current 8/20 µs

Pulse voltage with a front time of 8 µs and a half-value time of 20 µs.

### Pulse voltage 1.2/50 µs

Pulse voltage with a front time of 1.2 µs and a half-value time of 50 µs.

### Radiation coupling

Electromagnetic field coupled to one or more conductive loops.

### Rated voltage UC

The maximum RMS value of the AC voltage which may continuously be applied to an arrester.

### RCD circuit breaker

If a fault current exceeds a certain threshold, then the RCD switches off within 0.2 seconds.

### Recommended fuse

The nominal value of the fuse recommended by the manufacturer and specified by the technical data sheet.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote alert contact (FM)</td>
<td>A volt-free contact for the power products for signalling triggered/defective arresters. For the measurement/control SPD/VSPC products, this connection with the VSPC CONTROL UNIT is required to produce a signal. The Weidmüller diagrams show this with the letter R which stands for “remote signal contact”.</td>
</tr>
<tr>
<td>Requirement class B / T 1 / Type I</td>
<td>For the purpose of lightning protection equipotential bonding according to DIN VDE 0185-1, also see Type I.</td>
</tr>
<tr>
<td>Requirement class C / T 2 / Type II</td>
<td>For the purpose of surge protection in the fixed facility, preferably for use in impulse withstand voltage category III, also see Type II.</td>
</tr>
<tr>
<td>Requirement class D / T 3 / Type III</td>
<td>For the purpose of surge protection in the fixed facility, preferably for use in impulse withstand voltage category II, also see Type III.</td>
</tr>
<tr>
<td>RSU</td>
<td>Surge protection on clip-on base with gas discharge tube, varistor and suppressor diode for 6-A and 10-A current loops</td>
</tr>
<tr>
<td>Short-circuit withstand rating</td>
<td>Maximum prospective short-circuit current that the surge protection device can withstand.</td>
</tr>
<tr>
<td>Sparkover time</td>
<td>Response times can vary between a few µs to ps, depending on the type and construction of the protective components.</td>
</tr>
<tr>
<td>SPD</td>
<td>Surge protection device (lightning and surge protection device).</td>
</tr>
<tr>
<td>Suppressor diode</td>
<td>Voltage-dependent, fast-switching semiconductor diode.</td>
</tr>
<tr>
<td>Surge protection (OVP/SPD)</td>
<td>Switching circuitry/wiring of a circuit used to limit the output voltage; and the sum of all lightning protection measures used to protect the technical equipment against lightning currents and surge voltages.</td>
</tr>
<tr>
<td>Surge protection device (SPD)</td>
<td>Device with at least one non-linear component, used to limit the surge voltages and to discharge the surge currents.</td>
</tr>
<tr>
<td>Surge protection equipment (SPE)</td>
<td>Surge protection devices and surge protection equipment for a facility, including the cables associated with the surge protection .</td>
</tr>
<tr>
<td>Surge voltage</td>
<td>Unwanted continuous or short-term differences in potential between the conductors or between conductor and earth which create interference or destruction.</td>
</tr>
<tr>
<td>Surge voltage protection classes</td>
<td>Classification of electrical equipment in accordance with their dielectric strength relative to the nominal voltage, EN 50178.</td>
</tr>
<tr>
<td>Symmetric interference voltage</td>
<td>Voltage between the outward and return conductors (differential-mode voltage).</td>
</tr>
<tr>
<td>TAZ</td>
<td>See suppressor diode.</td>
</tr>
<tr>
<td>TN power grid</td>
<td>Power grid as a 4- or 5-wire system; 3 phases and the PEN come into the building. PE from the building and PE from power system are connected to each other.</td>
</tr>
</tbody>
</table>
**TOV error mode**

TOV = arresters must be able to withstand persistent voltage increases with mains frequency, so-called “temporary overvoltages” or “TOVs”. Various error states inside and outside the low voltage consumer facility of a building can occur to cause TOVs. An example of one of the causes of TOVs described in VDE 0100, part 442, is an earth fault on the high voltage side of the local grid transformer.

**Failure mode**

Mode 1: Surge protection has switched itself off, no protection is being provided.

Mode 2: Surge protection has short circuited with an internal connection, the terminal equipment is protected by the short. The supply or the signal is no longer operational.

---

<table>
<thead>
<tr>
<th><strong>Transverse voltage</strong></th>
<th>Interference voltage between two conductors in circuit.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Triggered sparkover gap</strong></td>
<td>A gas-filled sparkover gap which is ignited by a capacitive voltage divider with a pre-set voltage value.</td>
</tr>
<tr>
<td><strong>TT power grid</strong></td>
<td>Power system with 4 wires; 3-phase conductors and the neutral conductor come into the building. The building’s PE is not connected to the power grid.</td>
</tr>
<tr>
<td><strong>Type I</strong></td>
<td>For the purpose of lightning protection equipotential bonding according to IEC 37A/44/CDV; also refer to requirement class B.</td>
</tr>
<tr>
<td><strong>Type II</strong></td>
<td>For the purpose of surge protection in the fixed facility, preferably for use in impulse withstand voltage category III, also see requirements class B.</td>
</tr>
<tr>
<td><strong>Type III</strong></td>
<td>For the purpose of surge protection in the fixed facility, preferably for use in impulse withstand voltage category II, also see requirements class B.</td>
</tr>
<tr>
<td><strong>Varistor</strong></td>
<td>Voltage-dependent metal oxide resistor; the resistance decreases with increasing voltage.</td>
</tr>
</tbody>
</table>
The continued availability of electrical and electronic equipment and systems is critical. It is therefore important to prevent loss and faults that are frequently caused by overvoltage events. It is for this reason that there are standards and directives for lightning and surge protection that cover buildings, parts of buildings, structural and technical installations (objects).

The technical committee IEC TC 81 deals with lightning protection issues worldwide. The new IEC 62305 standard was introduced following a decision in October 2001. Since January 2006, IEC 62305 has been divided into four parts:
- IEC 62305-1: General principles
- IEC 62305-2: Risk management
- IEC 62305-3: Physical damage to structures and life hazard
- IEC 62305-4: Electrical and electronic systems within structures

The German committee responsible for German implementation decided to maintain the VDE classification of the new standard series DIN EN 62305 as VDE 0185-305 parts 1-4.

It is known that lighting protection equipotential bonding is not sufficient in itself to protect electrical equipment from voltage surges. On account of that, standards such as:
- DIN VDE 0100 part 410
- DIN VDE 0100 part 540
- DIN VDE 0100 part 443
- DIN VDE 0100 part 534
- DIN VDE 0800 part 1
- DIN VDE 0800 part 2
- DIN VDE 0800 part 10
- DIN VDE 0845 part 1
- DIN VDE 0845 part 2
explicitly require measures for protection against voltage surges. In DIN VDE 0100, the surge protection measures for low-voltage installations and, in the DIN VDE 0800 standard, the surge protection measures for communication engineering as a whole are described. Appendix A of DIN V VDE V 0100-534 shows the selectively graded use of surge arresters of Type I (B arresters) in the main power supply, Type II (C arresters) in the sub-circuit distribution board and Type III (D arresters) in the area of the final circuit. Appendix A of DIN V VDE V 0100 part 534.

IEC 61643-5-53 has been available since 2002. It is implemented in VDE 0100-534 and describes the selection and installation of surge protection for electrical facilities. This is intended as a replacement for DIN VDE 0100-534. The international equivalent is IEC 60364-5-53:2002-06. The chapter 534: “Devices for protection against overvoltages” contains the devices for protection against overvoltages, the selection of these and their use in the building installation. The rules that apply on the low voltage side are adapted to communication electronics as a whole and are described by the national series of standards 0800 parts 1, 2 and 10 and 0845 parts 1 and 2. DIN VDE 0800 describes general issues such as earthing, equipotential bonding, etc. and DIN VDE 0845 the measures for protecting against overvoltage events of all kinds.

Guidelines of the loss insurers

The guidelines apply to decisions on whether lightning and surge protection is to be provided for buildings, parts of buildings, structural and technical installations. The guidelines become, on agreement, a binding part of the insurance contract between insurer and policyholder. However, their application does not exempt the insured party from observance of legislation, statutory instruments, official requirements and generally accepted codes of practice such as that described in the DIN VDE standards. The building regulations of different countries and the relevant statutory and official regulations and codes of practice, call for lightning protection systems to be installed in certain buildings for reasons of public safety, e.g. in shops, hospitals, schools.
and children’s homes, etc. The generally acknowledged code of practice, in this case DIN EN 62305 (VDE 0185-305):2006-11 or DIN VDE V 0185, must be adhered to when installing technical systems. Issues relating to installation arise not only in connection with official requirements but also when the insurers call for lightning protection, e.g. for high-racking warehouses or plants with a high risk of explosion. Similar relationships apply to surge protection. For example, DIN VDE 0100 part 443 specifies risk factors which determine the installation of surge protection measures.

The Association of German Property Insurers (VdS) publishes a number of documents covering particular applications, e.g. electrical installations, IT systems, agricultural businesses and residential buildings:

- VdS 2192: Leaflet on surge protection for loss prevention
- VdS 2014: Determining causes of damage due to lightning and surge
- VdS 2258: Protection against surge
- VdS 2006: Lightning protection by means of lightning arresters
- VdS 2017: Lightning and surge protection for agricultural businesses
- VdS 2031: Lightning and surge protection in electrical installations
- VdS 2028: Foundation earth electrodes for equipotential bonding and lightning protection earth termination
- VdS 2019: surge protection in residential buildings
- VdS 2569: surge protection for electronic IT systems
- VdS 2010: Risk-based lightning and surge protection
- VdS 2007: IT installations
- VdS 3428: surge protection devices

Furthermore, in Germany lightning protection is also covered in the construction law requirements of the individual federal states and also in national regulations. In light of this situation, the Association of German Property Insurers has produced a table to simplify the assignment of lightning protection classes and surge protection requirements to buildings and installations (VdS guideline 2010). This takes into account the experience and findings of loss prevention experts as well as legislation, official regulations and standards.

**Legal basis**

Basically, lightning and surge protection is not a mandatory provision in the form of legislation, even though lightning and surge protection is covered in Germany’s EMC Act. However, it is important to know that there is indeed a legal basis. This comes into play when a loss event has occurred and, as a result, legal proceedings become relevant.

In Germany, the following legal aspects must be taken into account:

**Civil law:**

- **BGB (German Civil Code)**
  - cl. 633 Contractor’s duty of warranty; removal of defects
  - cl. 276 Responsibility for one’s own conduct
  - cl. 278 Responsibility for persons employed in performing an obligation
  - cl. 459 Liability for defect of quality
  - cl. 823b Unlawful actions
### Surge protection standards and regulations

In the case of national and international standards and specifications on the same subject, the document with the widest scope takes precedence (e.g. international "IEC", European "CENELEC" or "CNC", national (Germany) "DIN VDE" or Austria"ÖVE" (Similar to TÜV Germany, also valid in Austria)).

<table>
<thead>
<tr>
<th>IEC</th>
<th>EN</th>
<th>VDE</th>
<th>others</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 60364-5-53</td>
<td>HD 60364-5-53</td>
<td>VDE 0100-534</td>
<td>Cable distribution systems for television and sound signals – Part 1: Safety requirements</td>
</tr>
<tr>
<td>IEC 60364-5-64</td>
<td>HD 60364-5-64</td>
<td>VDE 0100-540</td>
<td>Electrical installations of buildings – Part 5-54: Selection and erection of electrical equipment – Isolation, switching and control – Part 534: Surge protection device</td>
</tr>
<tr>
<td>IEC 60664-1</td>
<td>EN 60664-1</td>
<td>VDE 0110-1</td>
<td>Electrical installations of buildings – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors</td>
</tr>
<tr>
<td>IEC 60079-11</td>
<td>EN 60079-14</td>
<td>VDE 0165 Part 1</td>
<td>Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests</td>
</tr>
<tr>
<td>IEC 60079-11</td>
<td>EN 60079-11</td>
<td>VDE 0170 Part 7</td>
<td>Electrical apparatus for use in the presence of combustible dust – Part 14: Selection and installation</td>
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| KTA 2208, 06.92 | Lightning protection standard for nuclear power plants |
| VDE publication 44 | Lightning protection systems, explanations to DIN 57185/VDE 01 85, published by VDE |
| DIN-VDE publication | Publication No. 919; Lightning protection systems 1, external lightning protection, published by VDE |
| DKE publication No. 520 | Publication No. 920; Lightning protection systems 2, internal lightning protection, published by VDE |
IEC EN VDE others

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Risk-based lightning and surge protection, guidelines for damage prevention; VdS damage prevention in the German General Association of Property Insurers Association (GDV)

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UL Approvals

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