Technical documentation

VARITECTOR GUIDE

Lightning and surge protection for power applications



Weidmüller

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*SPD = Surge protection device

The importance of lightning and surge protection

The 1x1 of surge protection

WHERE

should the lightning and surge protection be installed?

The power feed-in and distribution area is an important part of surge protection. Protecting the supply lines is the basis for protecting all electrical and electronic components, even down to the smallest and most sensitive parts.
In general, SPDs must always be installed where cables feed into the control cabinet – parallel to the power feed-in and with the shortest cable path possible.

WHO

is authorised to install lightning and surge protection?

Lightning and surge protection may only be installed, put into operation and maintained by qualified electricians who are familiar with national and international laws, regulations and standards.

WHAT

are typical damages caused by lightning and surges?

Typical damages following a lightning strike or surge pulse include, for instance, outlets or cables popping out of the wall, charred or burned SMD components, or even fires in the worst case scenario.

HOW

can I protect myself against lightning and surges?

Complete protection can be achieved only if both power lines and data and signal lines are protected using a surge protection device (SPD). In addition, it is important to have a uniform reference potential.

WHEN

do I need to maintain or replace surge protection devices?

If surge protection equipment is damaged or exhibits other faults, it must not be installed. If there is a red status indicator, the device must be replaced by a specialist. Opening the surge protection device is not permitted. To complete the insulation test, the SPDs must be disconnected from the system for the duration of the measurement, for instance by pulling out the plug-in arrester, or the product must be completely disconnected from the network.

WHY

do I need to use surge protection devices?

Because the use of SPDs is required by applicable standards!
In addition to the general lightning protection standard DIN EN 62305, (VDE 0185-305), the two parts of IEC 60364-4-44 (VDE 0100-443) and IEC 60364-5-53 (VDE 0100-534) apply. These standards explicitly describe WHEN surge protection must be used, WHERE it should be installed, and HOW to correctly install it.

WHAT

is the purpose of a surge protection arrester?

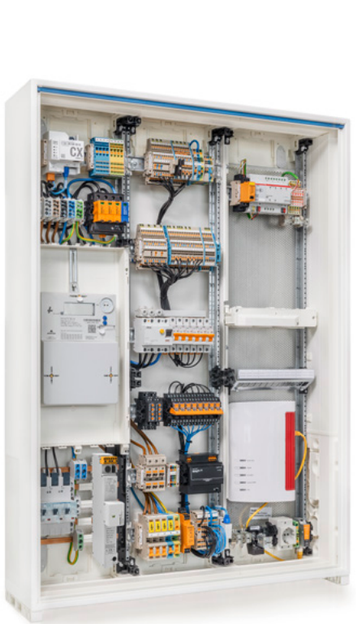
A surge protection arrester is a device that protects electrical power systems from damage caused by lightning and surge voltage. In normal operation, surge protection is a passive component and has very high impedance. The arrester only becomes conductive in the case of surge voltage, so that power from the surge pulse can flow to the ground.

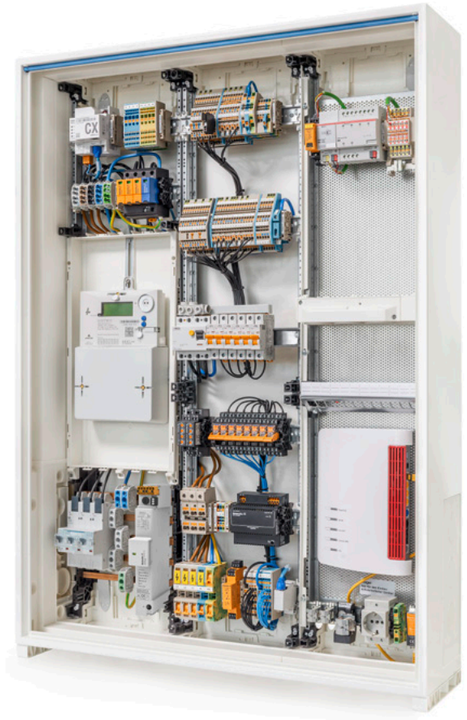
The importance of lightning and surge protection
Introduction

This document describes the technical and normative conditions for correct installation of the VARITECTOR PU (VPU) surge protection for power applications.

In addition to technical explanations, it also lists normative standards and application-specific requirements, for instance for line cross-section, line length or with respect to energy coordination.

However, since it is not possible to cover all application-specific conditions, this document only explains the basic principles for using surge protection. If you have further questions, you are welcome to contact our surge protection experts.





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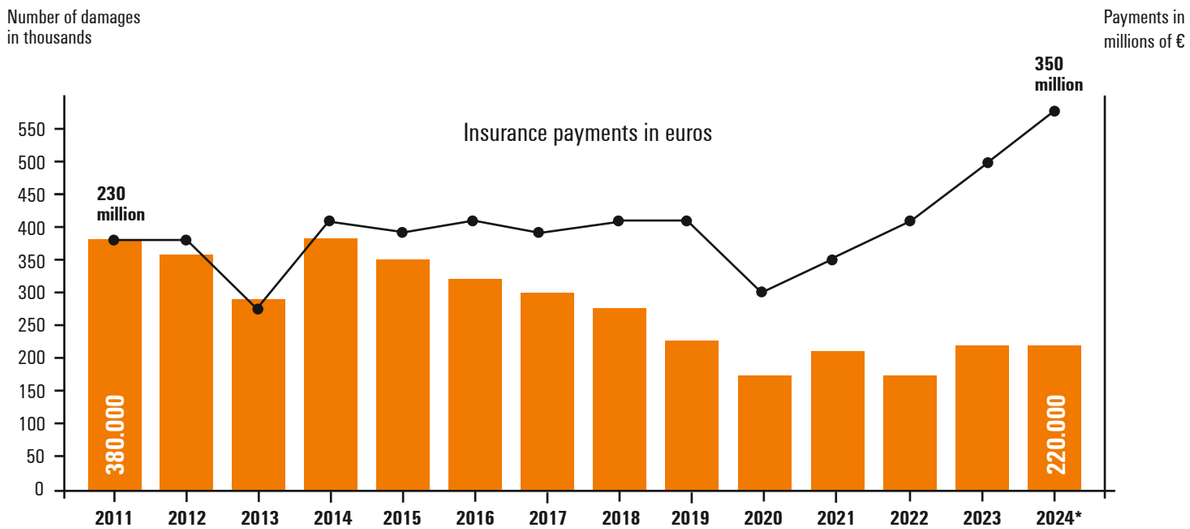
One of the primary causes of critical voltage surges are lightning strikes on or near power and signal lines. Capacitive and inductive effects of the lightning (LEMP - lightning electromagnetic pulse) induce prohibited voltage levels in conductor loops within a range of approx. 200 metres. Ohmic effects (ground resistance) can cause dangerously high potential differences to occur up to approx. 2 km. Switching processes in the medium or low-voltage networks in buildings can also cause voltage surges (SEMP - switching electromagnetic pulse). Switching electromagnetic pulses up to multiple kilovolts occur in cables beside fluorescent lamps with a conventional ballast (throttle), or when switching off an engine.

The GDV (Gesamtverband der Deutschen Versicherungswirtschaft e.V. - German Insurance Association) publishes a german lighting incident summary annually listing the number of damages and resulting insurance benefit payouts for the year. Similar statistics are also collected in several other countries.

The fluctuating number of lightning incidents has an influence on this. However, the general decline in the number of loss events is due to the change in standards since 1st October 2016. After this date, IEC 60364-5-53 (VDE 0100-534) and IEC 60364-4-44 (VDE 0100-443) require the installation of surge protection in all applications. According to GDV, the reason for the rising and high average number of claims is that buildings and houses are better equipped technically.

A correctly designed protective concept includes not only protection for power systems, but for all data and signal lines as well. This document only deals with the protection of the power infrastructure.

Insurers paid out around 350 million euros for lightning damage in 2024
Number of lightning and surge damage incidents and benefit payouts for personal property and residential building insurance

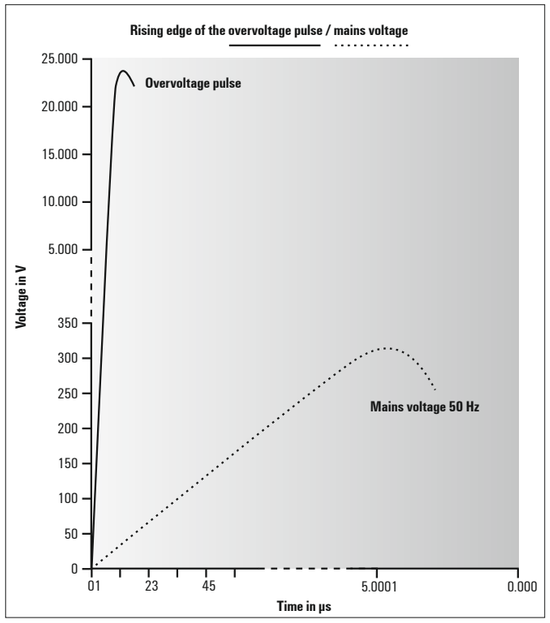


*Preliminary, as of June 2025
Source: www.gdv.de

What are surge voltages?
Basics

Surge voltages are extremely high voltages with very sharp rises in the µs range that can interfere with or even destroy the insulation and function of electrical and electronic components.
Every electrical component is fitted with insulation to isolate the electrical voltage from the earth or other live 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 over a defined time period with the specified voltages.
If this test voltage is exceeded in operation, the safety of the insulation is no longer guaranteed. The component can be damaged or completely destroyed. Surge voltages are voltage pulses above the permitted test voltage that can have damaging effects on the respective electrical operating material. This means that it is possible for components with a high rated voltage to tolerate a voltage surge, while components with a lower rated voltage are greatly endangered by it. A voltage surge that is not harmful to an electric motor can destroy an “electronic circuit”.
Continuously high voltages (permanent surge voltage) with a 50/60 Hz mains frequency also occur. These voltages can be coupled or may occur due to faulty switching. However, continuous interference voltages generated by them can also be handled with surge protection. Individual surge pulses (temporary voltage surges) that are high-frequency due to their physical formation have a current rise that is approx. 10,000 times steeper compared to 50 Hz voltage. While the current rise time in the 50/60 Hz range is 5 ms, it is in the 1 µs range for a voltage surge.

These surges are designated as "transient" voltages. This means that they are short-lived, temporary transient waves. Their development and frequency are dependent on the impedance of the electric circuit.



Edge ratio between a 50 Hz sine and an overvoltage pulse

VARITECTOR surge protection
Portfolio overview

Power systems



- Suitable for universal use in all lightning protection classes
- IEC/EN 61643-11 and UL 1449 tested
- Installation according to IEC/EN 61643-12, IEC 62305-4
- Fuseless operation up to 315 A

Instrumentation & Control (I&C)



- Protection of analogue and digital measurement and control signals with monitoring
- VSPC and VSSC tested to IEC/EN 61643-21
- VSPC and VSSC can be installed in systems according to IEC/EN 61643-22
- Available with visual and electrical signalling function

Data interfaces



- Protects your standard signals such as RS 485 and RS 232
- Ethernet CAT.6 Protection with PoE+ function
- Direct or floating earthing via the outlet

Accessories



- EMC filter and pulse counter
- Test device for testing the protective function for all VARITECTOR PU AC & PV products

Visit our website for more information
www.weidmueller.com/varitector

VARITECTOR PU AC Series

Your benefits at a glance



The VARITECTOR PU AC series offers sophisticated advantages that make operation safer and easier:

5 year warranty
for all VARITECTOR PU and VSPC products! The identification can be found in the product catalogue.

Integrated fuse
The integrated fuse allows a faster and more efficient installation. No additional circuit breaker or fuse holder for auxiliary applications is required.

Safe operation up to 4,000 m
Systems in high-elevation regions are reliably protected. An additional risk analysis of deratings is not required for extraordinary locations.

Space saving
The reduction in installed width for the VPU AC I S-line from 2 subunits to 1 subunit per pole with 25 kA discharge current means they require 50 % less space.

Plug-in inserts
Plug-in modules simplify arrester replacements. The optimised mounting rail clip enables easy and quick assembly and removal, without tools.

HAD technology
The innovative HAD technology is extremely compact, and uses a voltage switching technology with a very low residual voltage.

Worldwide usage
Certifications according to international IEC/EN standards, as well as the latest UL 1449 standard, guarantee they can be used for every application in conformity with applicable regulations.

Full status control
Products in the VPU AC series feature a clearly visible optical display and, optionally, a pluggable remote signaling contact for error reporting to external monitoring systems.

Vibration-resistant
Thanks to the use of a locking clip, the VARITECTOR PU series fulfils high vibration requirements. A tool is required to disconnect the base and the arrester.

Busbars
Quick installation without tools on 40 mm busbars in the pre-counter area according to application rule VDE-AR-N 4100.

Safe disconnection in case of an overload

High-performance shutdown functions

All products in the VPU series fulfil product standard IEC/EN 61643-11, and have a visual status indicator that indicates the function of the SPD. In addition, the function can also be transmitted to a central controller via a remote signalling contact (for product variants with “R” in the name).

In general, when the status indicator is green this indicates that the SPD is fully functional.
If the status indicator is red, the SPD's protective function is no longer ensured, and the arrester must be replaced by an electrician.



1. Status signalling for remote signalling contact (via a switch in the base)
2. High-precision spring for quick disconnection
3. Thermal cut-off point
4. Visual signal of the status



Components for surge protection
Varistor and HAD technology

There is no perfect component that can effectively and consistently fulfil all surge protection requirements. Instead, different components are used with different and complementary physical mechanisms.They have different specific protective effects. The VARITECTOR PU series uses a well-established varistor technology or highly innovative HAD technology.





Varistor technology
The VARITECTOR PU series is based on varistor technology. The resistance of a varistor depends on the voltage applied to them, and they heat up in case of an overload.
The thermal cutoff used in the VPU series consists of the following components:

The varistor is connected to the thermal cutoff via a specialised soldered connection. Once the varistor reaches a certain temperature, the solder liquefies and the pretensioned springs activate the mechanical lever. This opens the soldered connection and safely disconnects the varistor from the network. At the same time, the mechanical lever switches the status indicator from green to red, and the remote signalling contact transmits the status change to the higher-level controller (if installed).

HAD technology
The innovative HAD technology is extremely compact, and uses a voltage switching technology with a very low residual voltage. This enables the products to achieve a low follow current strength, which means that even a 16 A fuses will not trip.

Both technologies are equipped with a safe cutoff device in order to safely disconnect the product from the network in case of an overload. Both protective technologies are available with or without an integrated backup fuse.

Optimal protection for type I+II and type II+III
Integrated fuse

The proven surge protection devices of the VPU series are now also available in variants with integrated back-up fuses. This eliminates the need for an additional fuse before the SPD.
The combined type I+II and II+III surge protection devices have one back-up fuse per protective path and can be used universally in power distribution systems. The application-oriented pluggable product configurations allow flexible use in different network types.



Maximum protection
The surge protection devices with integrated fuse offer optimum protection thanks to 20 kA rated discharge current and 40 kA maximum discharge current.

Universal use
Dimensioning is independent of the main fuse rating – no additional pre-fuse is required, even above 315 A. The wiring can therefore be minimised for all power distributions.

Compact design
The pluggable and thus particularly maintenance-friendly arresters have an extra narrow design. This allows them to be used flexibly in all power distribution systems.

VPU AC I with integrated fuse



- Perfect protection due to integrated fuse and high discharge currents
- More efficient wiring by omission of back-up fuses
- Flexible use in all power distribution systems
- Convenient installation and maintenance due to pluggable modules
- Particularly compact with space-saving design
- Innovative leakage current-free protection technology

VPU AC II with integrated fuse



- Perfect protection due to integrated fuse and high discharge currents
- More efficient wiring by omission of back-up fuses
- Flexible use in all power distribution systems
- Convenient installation and maintenance due to pluggable modules
- Particularly compact with space-saving design

VARITECTOR PU AC S-Line
HAD technology



The new VPU AC S-Line is the latest development in surge protection from Weidmüller. With a lightning impulse current (10/350 µs) of 25 kA in a 1 subunit (17.5 mm) DIN housing, it is the most compact pluggable surge protection device (SPD) on the market that fulfils the requirements of test class I in accordance with IEC 61643-11. For many years, manufacturers of protective devices have worked to develop a surge protection device with 25 kA 10/350 µs test class I in a DIN housing smaller than 2 subunits. The VPU AC S-Line is the first device on the market to achieve this goal, while at the same time offering the required level of voltage protection with follow current regulation, and being designed for intensive lighting protection environments.

To better understand what designers achieved with the VPU AC S-Line, we first need to consider the advantages and disadvantages of conventional SPDs. In general, surge protection device technology can be divided into two categories – voltage switching and voltage limiting surge protection devices.

Voltage switching SPDs
Voltage switching SPDs are designed so that they transition to a conductive state once a surge exceeds a certain threshold. They have a relatively simple design and can achieve a high surge voltage resistance in a compact housing, however they suffer from poor voltage protection values and difficulties in eliminating follow current. Encapsulated triggered spark gap technology can improve residual forward voltage, however the problem of eliminating follow current still exists. The follow current check determines the capability of an SPD to deactivate itself once the surge voltage condition (voltage surge) is over. An SPD with poor (low) follow current regulation can only be installed in a power supply system where the expected residual current is lower than the follow current capacity of the device. If an SPD were installed in a power supply system for which the expected residual current were greater than its follow current rating, it could experience catastrophic failure once it was switched into the electric circuit by a voltage surge or a voltage transient.

To put it simply, SPDs based on voltage switching technology can be designed to be compact and have a high surge voltage resistance, however these advantages come at the cost of poor follow current regulation that limits the maximum power for which they can be installed.

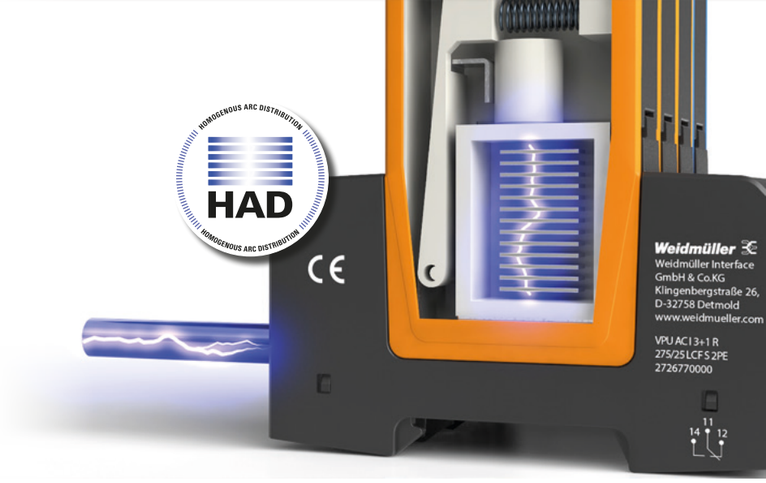
Voltage limiting SPDs
Voltage limiters such as metal oxide varistors (MOVs) are designed to limit voltage surges by transitioning to a lower impedance state in order to dissipate the surge current from the devices to be protected.

In contrast to voltage switching devices, they return to their low ohm state once the voltage surge is over, which means they do not have the problem of being unable to eliminate follow current. They can be installed in any power network, regardless of the expected residual current. They also offer a good (low) level of protection.

In summary, SPDs based on voltage limiting technology offer the advantages of a good level of protection (low residual or terminal voltage) without the problem of follow current regulation.

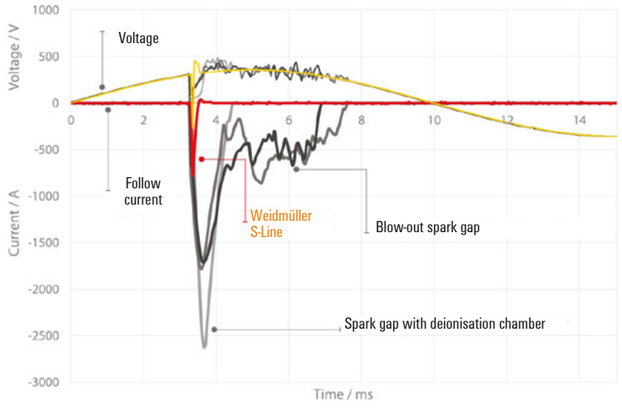


Get to know our VARITECTOR PU S-Line in the video.



HAD technology
Weidmüllers innovative HAD technology (**H**omogenous **A**rc **D**istribution) was developed to combine these two technologies, thereby creating the ideal class I surge protection device. It allows for a compact housing with voltage switching technology, without the disadvantages of a high residual voltage or poor follow current.
The VPU AC S-Line uses a multi-cell, encapsulated HAD technology to achieve a residual voltage like that of a MOV-based SPD, but with a footprint just half the size of its competitors, without any restrictions regarding where it can be installed in a network. Weidmüller has a long tradition of using materials that guarantee robust and durable products. The combination of this expertise with a newly patented multi-cell HAD technology offers customers a solution that can be used in lightning-intensive environments where voltage surges can occur repeatedly, even in intervals of just a few minutes. At the same time, VPU AC S-Line devices can protect against lightning strikes under challenging network conditions, such as in the case of mains errors and extremely high prospective currents, without being damaged and without any influence on the network itself.

Features and advantages
The features and advantages of the new HAD technology can be summarised as follows:
- Fulfils IEC test for Class I in accordance with IEC 61643-11, meaning it is suitable for use in locations where direct or partially direct lightning currents in accordance with IEC 62305-4 are expected.
- VDE mark - certified in accordance with applicable IEC and European standards of the Low Voltage Directive.
- High surge voltage resistance, but without the problem of eliminating follow current - can be installed in networks with high expected short circuit current ratings (SCCR).



Network follow current and voltage at U_{ref} = 255 V and 25 kArms

- Network follow current is reduced significantly in comparison to conventional spark gaps
- Network follow current does **not** trip a 16 A fuse!
- Significantly longer service life for the arrester

Surge protection concept
Installation locations

Effective surge protection requires the availability of functional equipotential bonding in accordance with DIN VDE 0100-540 in linear, or better yet star or mesh circuits. Surge protection for the power feed-in and power distribution is divided into the following three areas by DIN VDE 0110 (insulation coordination):

1. Feed-in
From the feed-in through the underground cable or overhead line into the building to the main distribution (back-up fuse and meter area), the impulse withstand voltage of the insulation is 6 kV. Based on the lighting protection concept and physical conditions the high-energy voltage surges must be dissipated here.

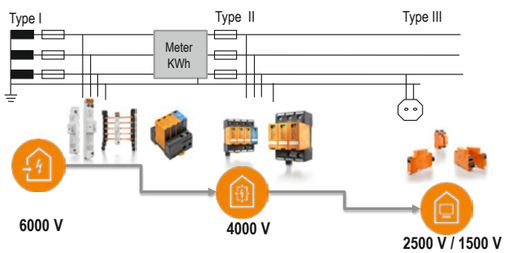
Generally, 50 % of the current is dissipated via an external existing lighting protection system, and the other 50 % is coupled to the conductors and conductive components in the building and distributed evenly. The closer the conductor is to the lightning protection system, the greater the coupled voltage, up to over 100 kV. The pulse duration can be up to 0.5 ms. These powerful interference pulses are dissipated to the earth via type I lightning current arresters directly on the feed-in or the main distribution and limited to voltages below 6 kV.

The network follow currents and back-up fuse values, in particular, must be taken into consideration here. Depending on the set up on site and expected discharge currents, spark gaps or varistor arresters are used in consideration of the mains system type. In the case of an installed external lightning protection system, overhead line feed-in, building or factory site covering a wide area and with individual elevated buildings or open areas, type I arresters should generally be used.

2. Sub-distribution
The impulse withstand voltage of the insulation is 4 kV from the main distribution up to and including the sub-distribution. Due to the coordinated use of arresters, type II surge voltage arresters are used here. It is only necessary to use decoupling coils if the type I arrester consists of a basic spark gap and the line length between the type I and II arresters is less than 10 m. Decoupling the Weidmüller type I to type II arresters is not required. The pulse currents that occur here are no longer as high, since most of the power was already absorbed by the type I arresters.

Nevertheless, line impedances still result in high interfering voltages that must be limited to below 4 kV with type II arresters. Type II arresters based on varistors are normally installed in the sub-distribution upstream of the fault-current circuit breaker.

3. Devices/outlets
The impulse withstand voltage of the insulation is 2.5 kV from the sub-distribution to the device. Type III surge voltage arresters are used here, which consist of individual protective components or combined circuits with gas tube arresters, varistors, suppression diodes and decoupling elements, depending on the specific use case.
Ideally, these arresters are installed directly upstream of the device to be protected. This can be in the outlet or outlet strip, or in the connection or junction box for the device. In addition, filter circuits are available for the device power supply to protect against permanently coupled interferences like “ripple” or “noise” caused by other systems. The device itself typically has an insulation impulse withstand voltage of 1.5 kV.



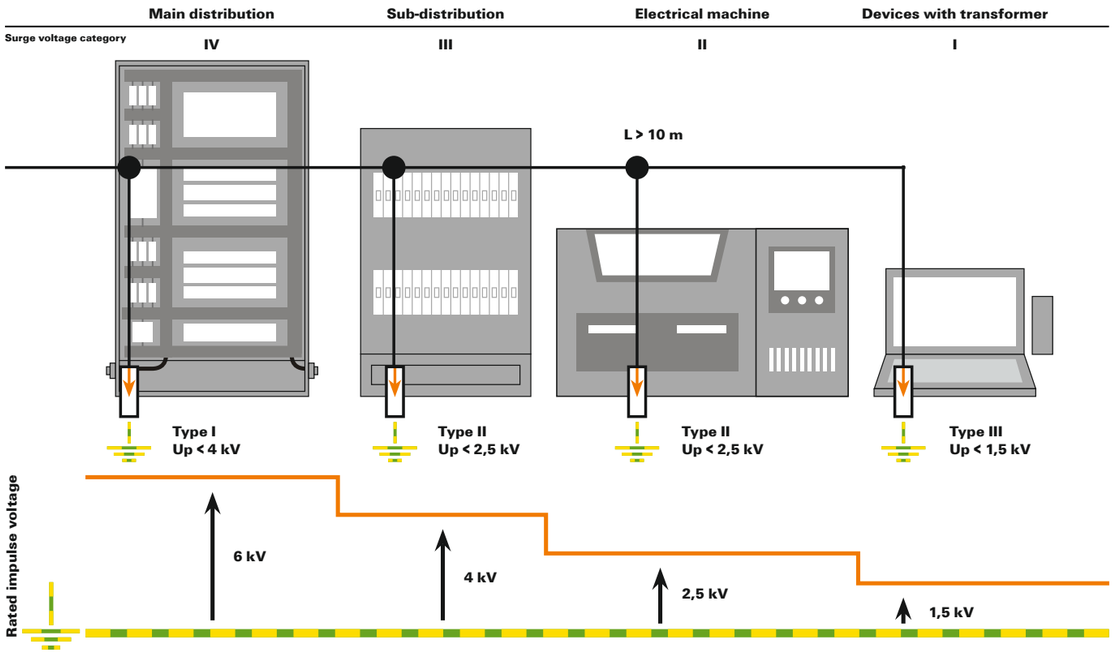
Rated surge voltage
Equipment

Every electrical product available on the market and every electrical machine (referred to in the following simply as “devices”) must bear a CE mark and pass an EMC test. The emitted interference as well as the interference immunity are tested during the EMC test, among other parameters. Devices are assigned to four different overvoltage categories depending on their interference immunity.

These overvoltage categories provide information on the impulse withstand voltage (resistance to voltage surges) of the devices. The table shows that household appliances and electrical machines fall under overvoltage category II. Accordingly, it is necessary to ensure the voltage surges that occur on the device are limited to a value < 2,500 volts.

Rated surge voltage of operating equipment

Rated voltage in V	Voltage exterior to neutral conductor in V	Required rated surge voltage in kV			
		Overvoltage category IV	Overvoltage category III	Overvoltage category II	Overvoltage category I
		e.g. electrical meters, ripple control receivers	e.g. distribution panels, switches, outlets	e.g. household appliances, electrical machines	e.g. sensitive electronic devices
230/400 277/480	300	6	4	2,5	1,5
1500 DC	1500 DC	15	10	8	6



Installation standards for SPDs

IEC 60364-4-44 (VDE 0100-443) and IEC 60364-5-53 (VDE 0100-534)

The new regulations of the installation and surge protection standard have applied since 1 October 2016. These new standards must be taken into consideration for ongoing plans for buildings to be completed after January 2019 and new electrical plans. The following is an extract of the new regulations. The new regulations affect the following standards:

IEC 60364-4-44 (VDE 0100-443)
(Protection against voltage disturbances and electromagnetic disturbances - Clause 443: Protection against voltage surges of atmospheric origin or due to switching)
This standard describes the necessity:
When are SPDs required?

IEC 60364-5-53 (VDE 0100-534)
(Selection and erection of electrical equipment
- Devices for protection against transient surge voltage)
This standard describes the installation:
Where and **how** are SPDs used?

IEC 60364-4-44 (VDE 0100-443)

1) Surge protection is obligatory in all newly planned buildings
The new regulations now require the installation of surge protection equipment to protect against transient surge voltages which have implications on:

- gatherings of people, for example in large (residential) buildings, churches, schools and offices
- individuals, for example in residential buildings and small offices, if these buildings contain equipment in overvoltage category I or II (e.g. household appliances, portable tools and sensitive electrical devices)

Because of the new regulations, standard-compliant surge protection must now be installed in all new building plans. This affects both private residential building, housing cooperatives, functional buildings and all other building projects which meet the above criteria.

2) Surge protection for intrinsic switching surge voltage becomes mandatory
Until now, the installation of surge protection was only required if there is interference from the network side. But now, even intrinsic switching surge voltages have been included in the standard for the first time. Intrinsic switching surge voltages can be generated in the following ways and by the following devices, for example:

- Switching of highly inductive, capacitive loads by air-conditioning systems, converters, lifts, etc.
- Switching of high load currents by flow heaters, corridor lighting, crane systems, charging stations for electric vehicles
- Switching a generator feed, CHP unit, etc.

3) Surge protection becomes mandatory for overhead line supply
As soon as there is a network of overhead cables on a building or nearby, the new regulations stipulate that newly planned buildings now have to incorporate standard-compliant surge protection.



Lightning Protection Zones (LPZ)

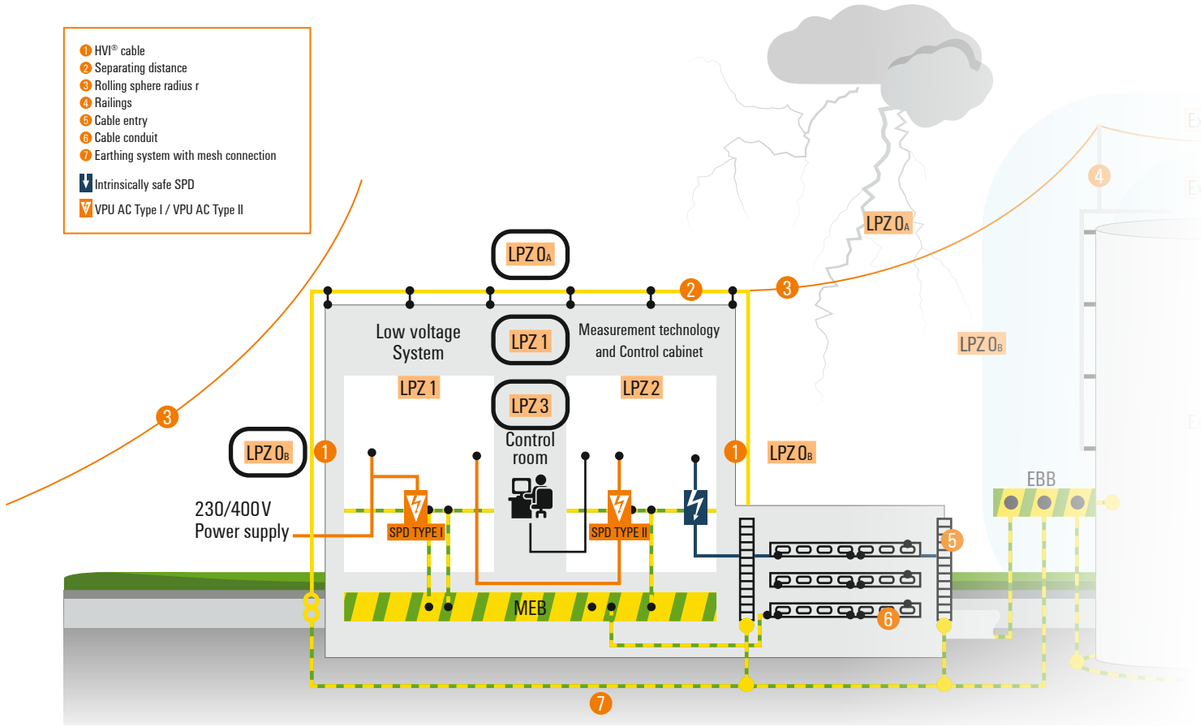
Lightning protection zones in accordance with IEC 62305-4

LPZ 0_A
Direct strike is possible and full electromagnetic field.

LPZ 0_B
No direct strike is possible but full electromagnetic field.

LPZ 1
Pulse currents are further limited by current distribution; the lightning field is attenuated by room shielding.

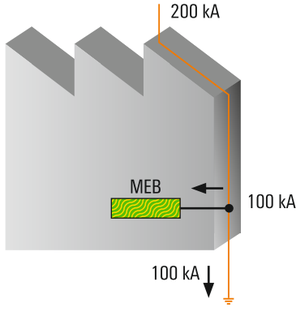
LPZ 2...n
Pulse currents further limited; reduction of the field by room shielding.



Lightning Protection Level (LPL)
Lightning protection classes

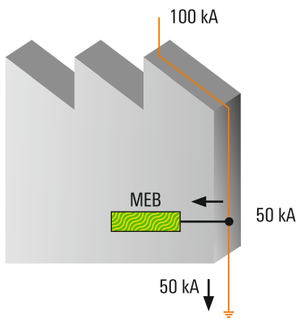
The lighting protection level applies only to the pulse current 10/350 µs or to type I.

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 level I 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 level II 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/IV 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 level III/IV. This includes houses, homes, administrative buildings, industrial facilities, ...



Building, facility, zone, areas	Lightning protection level	Control intervals (years)
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) **Note** 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 m^2, if the calculated number exceeds 100 persons, sales sites with a total sales area of more than 1,200 m^2.	II	10
b Accommodation facilities (e.g. hotels, nursing homes, institutions, hospitals, prisons, military barracks) **Note** 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.	II	10
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) **Note** 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.	III II	10 10
d Buildings made from combustible materials with a total volume of more than 3,000 m^3	III	10
e Large agricultural and operational buildings (more than 3,000 m^3) including the adjoining silos and adjacent residential buildings which could be adversely affected by a lightning strike; fermenting facilities or biogas plants	III	10
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	II – I II I	10 – 3 10 3
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)		
h Buildings and facilities which house content with special value items (e.g. archives, museums, collections)	II	10
i Buildings and facilities which house sensitive technical equipment (e.g. IT and telecommunications facilities); Data centres	II	10
j Buildings and installations in exposed topographic positions (e.g. free-standing building [alpine huts] in the mountains	III – I	10 – 3

Extract from the guidelines of the SEV 4022 Lightning Protection Systems 2008; please follow the installation regulations and standards in the individual countries.

Determining the lightning impulse current I_{imp} (10/350 µs) of an SPDs
Example calculation

This example calculation shows how to select the right type I arrester.

Assumption:
We have an application with exterior lightning protection

Lightning protection class = LPL III: 100 kA
Mains voltage: 230 / 400 V AC
Mains system type: TN-C-S (L1, L2, L3, N, PE)

Calculation:
100 kA from direct lightning strike
50 % (50 kA) is conducted directly to the earth
50 % (50 kA) will go into the building

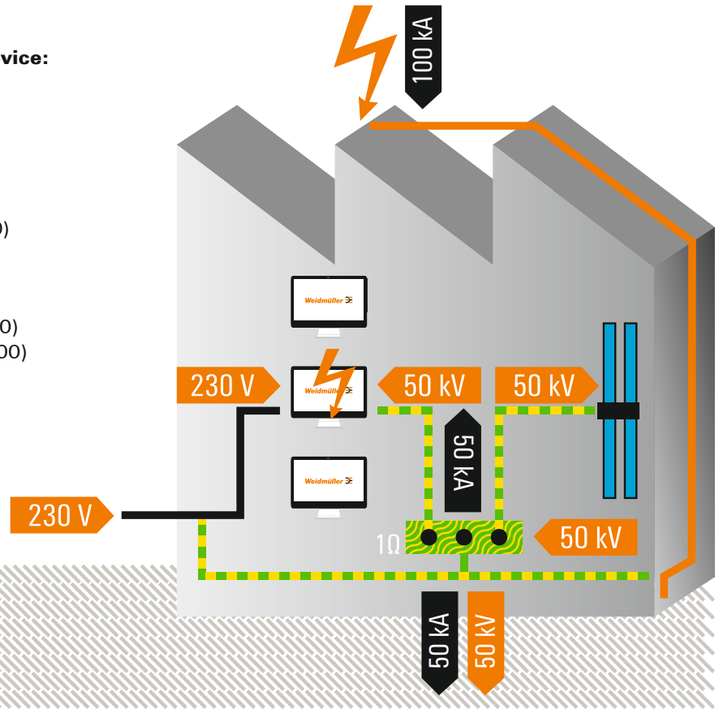
Lightning protection class	Lightning pulse current [I_{imp}]
I	200 kA
II	150 kA
III – IV	100 kA

$$\text{Lightning impulse current of SPD} = \frac{\text{Current inside the building}}{\text{Number of active cables}}$$

Parameters for the surge protection device:
I_{imp} = 50 kA / 4 = 12.5 kA
U_n = 230 V =>U_c = 300 V

Without remote signalling contact:
VPU AC I 4 300/12.5 LH (2983600000)
VPU AC I 3+1 300/12.5 LH (2983580000)
VPU AC I 3+1 300/12.5 LCF (2636910000)

With remote signalling contact:
VPU AC I 4 R 300/12.5 LH (2983610000)
VPU AC I 3+1 R 300/12.5 LH (2983590000)
VPU AC I 3+1 R 300/12.5 LCF (2636920000)



Risk-oriented lightning protection
VdS

Download



The VdS publication helps in assessing the risk of damages as a result of lightning and voltage surges.

A variety of objects and their lightning protection classes are described starting on page 7. Normally, a complex calculation is required to determine this classification. This document helps classify objects quickly (valid only in Germany), and serves only as a recommendation. This does not release the user from completing a risk assessment.

Example excerpt from the VdS recommendation:

Objekt Mehrfachnennungen möglich	Gebäude[1] (-teile, -bereiche, -einrichtungen sowie -kenndaten)	Äußerer Blitzschutz		Überspannungsschutz (innerer Blitzschutz), Potentialausgleich	
		Blitzschutzklasse	Prüfintervalle in Jahren	erforderlich	Ausführung nach DIN VDE 0100-534, DIN EN 62305 (VDE 0185-305), DIN VDE 0845 sowie VdS 2031 und zusätzlich
Anlagen für brennbare Gase und Flüssigkeiten	Druck-, Regelanlagen, Verdichterstationen	II	3	X	Online-Überwachung[2]
	Lager > 1000 kg	II	3	X	
	Ex-Bereiche	I	1	X	
Antennen				X	DIN VDE 0855
Archive		III	5	X	
Bäder	Hallenbad	III	5	X	
	Freibad	III	5	X	
	Kombi-(Spaß-)bad[3]	II	5	X	
Bahnhöfe		III	3	X	
Banken				X	
	Nutzfläche > 2000 m²	III	3	X	
Bauliche Anlagen der chemische, petrochemische Industrie		II	3	X	Online-Überwachung[2]
	Explosionsgefahr	I	1	X	Online-Überwachung[2]
Bauliche Anlagen der Landwirtschaft	Stall			X	VdS 2017
	Wohnhaus			X	VdS 2017/2019
	Silo			X	
	Mit Heu-/Strohlagerung	III	5		

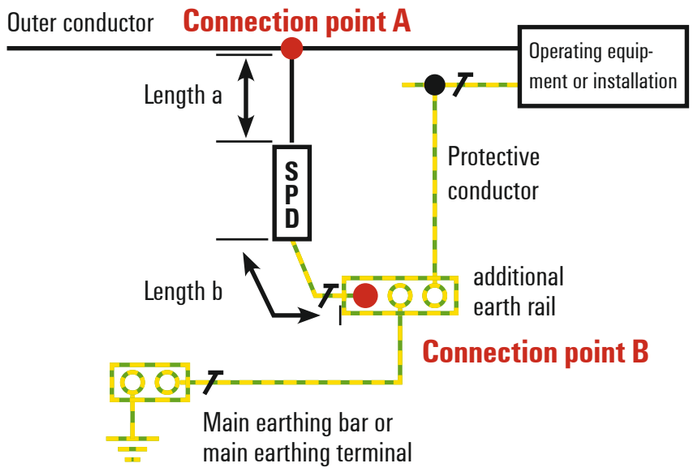
Earthing and equipotential bonding
Line connection and installation

All SPDs have an earth-connection terminal point.
The earthing wire for the associated equipotential bonding rail must be connected to this point. The earthing wire must be as short as possible with the largest possible cross-section, since each centimetre of line length increases the residual voltage of the SPD:

- Rule of thumb: 1 m cable = 1 kV voltage drop

In type I arresters, both earth-connection terminals must be connected. One cable leads to the equipotential bonding connection on the building and the second cable is connected to the PE conductor on the installation.

Remote Signalling
Product variants with an "R" in the product name include a remote signalling contact for external status monitoring. The status information is designed as a changeover contact and is connected to connection terminals 11 and 14. In normal operation (green status indicator), connecting terminals 11/12 are closed and terminals 11/14 are open. In the event of an error (red status indicator), connecting terminals 11/14 are closed and 11/12 are open.

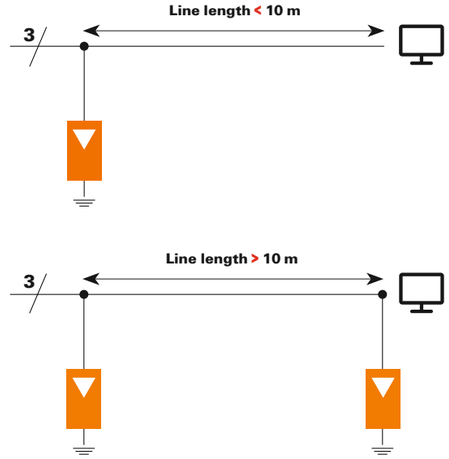


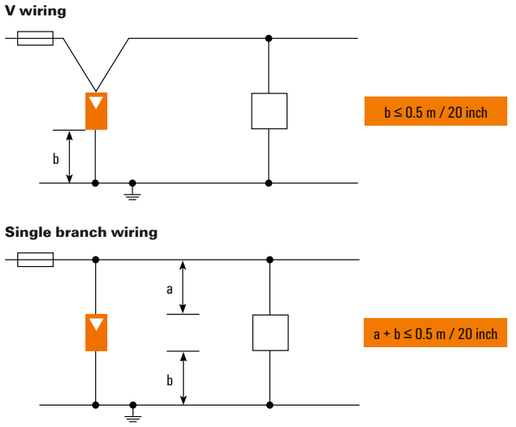
Installation information and requirements
Protected area and line lengths

IEC 60364-5-53 (DIN VDE 0100-534)

Specifications for the installation location
To ensure effective protection, the surge protection must be installed as close as possible to the feed point for the electrical system. For a residential building, for example, this is directly at the mains infeed in the bottom connection area of the meter cabinet. Potential intrinsic sources of interference within the building must also be taken into consideration. In these cases, the surge protection also needs to be installed as close as possible to the triggering device.

Specifications for the protected area
The standard (IEC 60364-5-53) regulates the maximum distance between a surge protection device and the devices to be protected (effective protection range).
The length of the cables should be **≤ 10 m**. If this distance cannot be maintained, an additional surge protection device must be installed as close as possible to the device to be protected.





Line lengths
The length of the connecting leads of an SPD are an essential and important factor for correct installation and functionality of the SPD. Due to the inductive conductor resistance, a voltage drop of several 1,000 V can quickly occur in the event of a transient overvoltage. This would degrade the effective protection level of the SPD to such an extent that the dielectric strength of the installation or the device to be protected would probably be exceeded despite the use of an SPD.

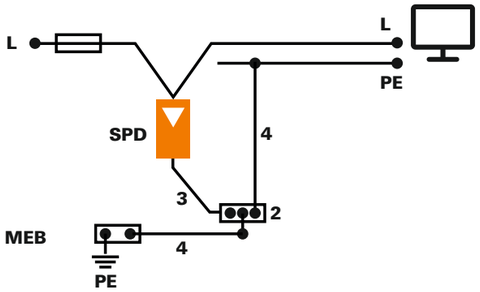
In the worst case, the device could be damaged, destroyed or even a fire could be generated. For this reason, the standard requires a maximum cable length of the connecting lines of an SPD of **≤ 0.5 m**. The installation can be realised using the so-called V-connection or a single branch wiring.

IEC 60364-5-53 (VDE 0100-534) sets forth requirements for the protective range of an SPD (<10m) and the permitted line length (<0.5 m)

Installation information and requirements
Protected area and line lengths

Installation according to IEC 60364-5-53 (VDE 0100-534)
SPD Surge protection device
PE PE conductor
MEB Main earthing terminal
2 Additional earthing rail
3 Considerd lead length
4 Lead lenght has not to be taken into calculation

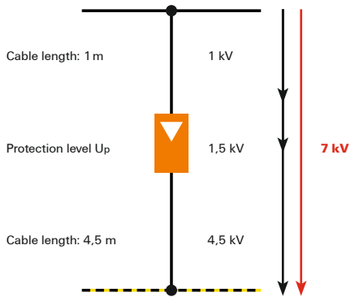
The protection level of the surge protection device must be equal to or less than the rated electric strength of the operating equipment.



Voltage drop on the cable
The total length of the connecting line must not exceed 0.5 m. IEC 60364-5-53 (VDE 0100-534) stipulates a reference value that a voltage drop of approx. 1000 V is generated on a 1 m long connecting line (approx. 1 µH inductance) at a surge current of 10 kA (8/20).

Formula:
u = L · di/dt = 1 µH x 10 kA/8 µs = 1250 V (approx. 1000 V/m)

Note: in larger systems, if necessary the induced surge voltage must also be taken into consideration according to VDE 0185-305-4.

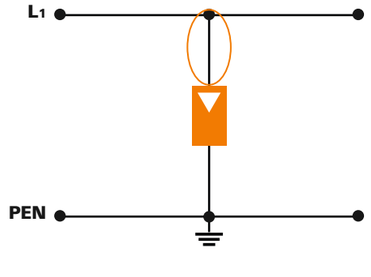


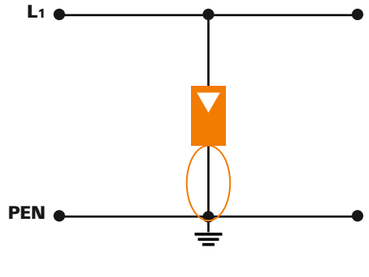
Installation information and requirements
Line cross-sections for type I and type II

As a rule, the same cable cross-section is selected for the connecting cables to the SPD as for the outer conductor (L1, L2, L3) and the neutral conductor (N).

The standards IEC 60364-5-53 (VDE 0100-534) require the minimum cable cross-sections shown in the table for type I and type II SPDs. The remote signalling contact (for variants with an "R" in the product name) is connected with a maximum cable cross-section of 1.5 mm².

Type	Connection lines between SPD and line conductor	Connection lines between SPD and main grounding busbar or protective earth (PE or PEN)
I	6 mm² Cu	16 mm² Cu
II	2.5 mm² Cu	6 mm² Cu

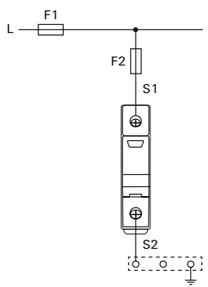




Fuse protection
For safety reasons, SPDs are protected against short circuits or overloads by means of an overcurrent protection element (F2) designed for the type of installation and the cross-section of the connected cable.

The cable cross-sections and backup protection for surge protection devices with a short-circuit resistance (I_{SCCR}) of 50 kA and 25 kA are shown in the table as examples.

	I_{sccr} = 50 kA			I_{sccr} = 25 kA		
F1	F1 ≤ 250 A gG		F1 > 250 A gG	F1 ≤ 315 A gG	F1 > 315 A gG	
F2	F2 not needed		F2 ≤ 250 A gG	F2 not needed	F2 ≤ 315 A gG	
F1	≤ 40 A	63 A - 80 A	100 A - 125 A	160 A - 200 A	> 250 A	> 315 A
F2	-	-	-	-	≤ 250 A	≤ 315 A
S1	6 mm²	10 mm²	25 mm²	25 mm²	25 mm²	25 / 35 mm²
S2	6 mm²	10 mm²	16 mm²	16 mm²	16 mm²	25 mm²

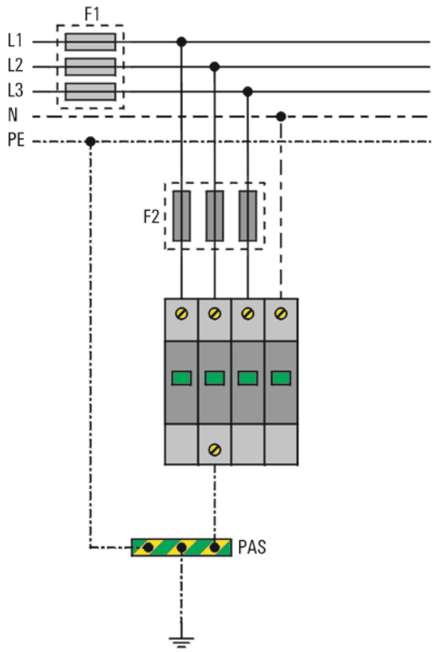


Installation information and requirements
Fuse protection for SPDs

SPDs behave like passive, non-conductive components in normal operation. Only in the event of an overvoltage or at the end of the life of the protective components does a current flow occur. SPDs must be protected against short circuit or overload by means of a fuse (F2) designed for the type of installation and the cross-section of the connected line.

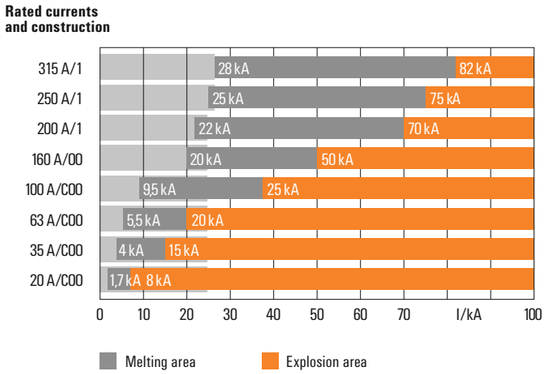
An additional fuse (F2) is required if the nominal value of the system-side fuse F1 is greater than the maximum rating of the fuse, specified by SPD manufacturer.

Fuses for protecting an SPD
The fuses must be chosen taking into account the rated currents specified for the SPD. It must be ensured that the line protection (F2) is actually capable of carrying lightning currents and that the maximum back-up fuse is selected for the dimensioning.



Protection of SPDs using an overcurrent protection element (F2)

The figure shows the behaviour of fuses with a lightning impulse current of 10/350 µs. The lightning current carrying capacity is severely limited, especially with small fuses. Only the design according to the maximum value also offers the unrestricted protection by an SPD.



Behavior of NH fuses under lightning impulse current (10/350 µs)

Fuses have a melting device that unbinds the connection and interrupts the electric circuit in the event of overload. They are single-use components and must be replaced after tripping.

Circuit breaker for protecting an SPD
Circuit breakers (LS switches for short) provide overload protection through a thermal initiator and protection against short circuits through electromagnetic tripping. They can be switched on again after initiation and are therefore reusable.

If circuit breakers are used as protective components, they should comply with IEC/EN 60947-2, DIN EN 60947-2 (VDE 0660-101). The rated short-circuit breaking capacity (I_{cu}) and rated short-circuit breaking capacity (I_{cn}) must be taken into account. I_{cu} or I_{cn} correspond to the maximum short-circuit current that a circuit breaker can interrupt without damage.

If circuit breakers are used, the values (I_{cu}) or (I_{cn}) must be large enough to carry the lightning / leakage current (like gG fuses), i.e. greater than I_{imp}!

Recommendation
The basic recommendation is to use a fuse gG. It guarantees absolutely safe disconnection by destroying the fuse, even if the power is too high. Nevertheless, the use of MCBs is an alternative, taking into account the parameters described above.

Surge protection device with integrated fuse
An additional fuse (F2) needs space and longer connecting lines. A reliable alternative is surge protection with an integrated fuse.

Planning and installation are simplified because no additional back-up fuse (F2) is required upstream of the surge protection device, regardless of the main fuse rating F1 (even greater than 315 A). Both the condition of the fuse and the condition of the SPD are monitored. The VPU AC F series is available in all multipole variants.

Nominal values of the NH fuses		Trigger value for surge current (8/20µs) calculated kA
In A	I²t A²s	
35	3.030	14,7
63	9.000	25,4
100	21.200	38,9
125	36.000	50,7
160	64.000	67,6
200	104.000	86,2
250	185.000	115,0

Trigger values for NH fuses for application of 8/20µs surge current



Installation information and requirements
Wire cross-section in case of a short circuit

It is valid: $k^2 \cdot S^2 \geq I^2 \cdot t$

S	Wire cross-section in mm²
I	Current during complete short- circuit in A
t	Permissible switch-off time in the event of a short circuit in s
k	Material coefficient in $(A\sqrt{s})/(mm^2)$

VDE 0675-6-11 states:
b) Low short circuit current test
A mains-frequency voltage source U_{REF} whose prospective short-circuit current is 5 times the value of the specified maximum overcurrent protection (if designated by the manufacturer) and whose power factor meets the requirements of Table 8 shall be applied for a time of 5 s ± 0,5 s. If no external overcurrent protection is specified by the manufacturer, a prospective short-circuit of 300 A is used.

This results in:

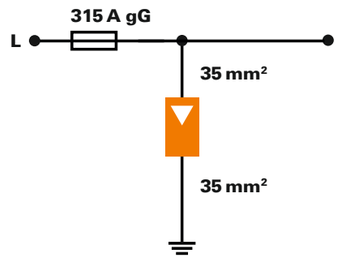
I	5·315 A=1.575 A
t	5 s
k	115 $(A\sqrt{s})/(mm^2)$ (copper conductor with PVC insulation)

The required wire cross-section in the event of a short-circuit is calculated as follows:

$$S \geq \sqrt{\frac{I^2 \cdot t}{k^2}} \geq \frac{\sqrt{(1.575\ A)^2 \cdot 5s}}{115\ \frac{A\sqrt{s}}{mm^2}} \geq$$

Products of the VARITECTOR PU AC series can clamp cables up to 35 mm², thus fulfilling the normative requirement.

The VPU AC series can be operated up to a (main) fuse F1 of 315 A gG in the active conductor without an additional back-up fuse F2. With this dimensioning, we recommend a conductor cross-section of 35 mm² for a short-circuit-proof installation.



SPD wiring with 315 A main fuse

- When using the VPU AC products in DC applications, please use the fuse from SIBA Type NH2XL aR/aSF DC 1500 V.
- Instead of the fuse, an equivalent circuit breaker (MCB – Main Circuit Breaker) can also be used. If a circuit breaker or a main circuit breaker is used, the tripping characteristics must be taken into account. Normatively, however, only one test is performed in combination of SPD and fuse.

Installation information and requirements
Coordination

Could products from different manufacturers be used in the same application?
IEC 60364-5-53 (VDE 0100-534) notes multiple times that protective devices that are connected in series in the application in the direction of energy flow (typically: Type I in the main distribution board, Type II in the sub-distribution boards and Type III near the end device), must be coordinated with each other. The main aim of the coordination is to ensure that a downstream protective device does not have the same energy as the upstream one protective device is loaded. Due to overloading or destruction of the protective device systems and devices would be at risk.

Example
A type I arrester is installed at the feed-in point for the building (1), and a type II arrester is installed in the sub-distribution board on the floors (2). Coordinated arresters ensure that the high energy of a lightning pulse on the type I device is (1) discharged, only a weakened surge pulse reaches the type II arrester, (2) and this does not destroy it.



DIN CLC/TS 61643-12 (VDE 0675-6-12) describes the coordination, applications, and potential problem areas and coordination studies to verify properly functioning coordination between different devices in section 6.2.6. Paragraph 6.2.6.3 states: “The coordination study can be complex. If all SPDs are provided by the same manufacturer, the simplest option is to ask the manufacturer for the requirements on distance or impedance between the selected SPDs in order to achieve suitable coordination. “This formulation should not seriously be interpreted to mean that the use of products from different manufacturers in one application is prohibited by the standard.

Paragraph 6.2.6.3 then describes four ways to create a coordination study. According to the standard, a coordination test can be carried out by the manufacturer, the installer or the user. We use the measurement technology variant, and test the interactions between different manufacturers (such as Dehn and Phoenix Contact) as well as different technologies (spark gaps, varistors).

Conclusion
Even with line lengths of well below one metre, arresters constructed according to current standards coordinate safely with one another. The conditions defined in Annex J.4, coordination test, are fulfilled and coordination is ensured.

For new generation type I lightning current arresters or type I/II combination arresters, no inductive decoupling (long cable length, line coil) between the products is required. This also applies to type I arresters based on spark gap technology.

Regardless of manufacturer, these products are subject to the current IEC 61643-11 and ensure a protection level of < 2 kV (type. 1.3...1.6 kV), which ensures that the system will work properly even with connection in direct series (type I beside type II arresters). If no data is known for the upstream arresters, we recommend a distance between type I (type I/II) and type II (type II/III) of ≥ 2 m.

Above a distance of 10 m, the effectiveness of a protective module, and therefore the possibility of influence in accordance with IEC 60364-5-53 (VDE 0100-534, 534.4.9), is no longer be given. In these applications, no coordination assessment is required.

Surge protection for electrical machines

Surge protection is required!

The following section provides two different explanations:

1. Overvoltage categories according to IEC 60664-1 (VDE 0110-1)
2. Surge protection requirement according to IEC 60204-1 (VDE 0113-1) and IEC 60364-5-53 (VDE 0100-534)

1. Overvoltage categories According to IEC 60664-1 (VDE 0110-1)

Every electrical product available on the market and every electrical machine (referred to in the following simply as “devices”) must bear a CE mark and pass an EMC test. The emitted interference as well as the interference immunity are tested during the EMC test, among other parameters. Devices are assigned to four different overvoltage categories depending on their interference immunity. These overvoltage categories provide information on the impulse withstand voltage (resistance to voltage surges) of the devices.

Table 1: Description of the overvoltage categories according to IEC 60664-1 (VDE 0110-1)

Surge voltage category	Rated surge voltage UW	Typical Installation location / Device classification
IV	6.000 Volt	Feed-in point of the electrical installation / devices in the main distribution
III	4.000 Volt	Sub-distribution / devices that do not have a plug but rather are directly connected
II	2.500 Volt	Household devices / devices with cold appliance plug / electrical machines
I	1.500 Volt	Devices with an external transformer / switched-mode power supply unit

Table 1 shows that household appliances and also electrical machines belong to overvoltage category II. Accordingly, it must be ensured that the overvoltage occurring on the device is limited to a value < 2,500 Volt.

Now it can happen that a Type II arrester is already installed in the sub-distribution board, which suggests sufficient protection. Normally, all devices in the sub-distribution board have a rated surge voltage of 4 kV (overvoltage category III). The Type II arrester installed in the sub-distribution board must limit the overvoltage to < 2,500 V (see Figure 1). In this case, theoretically all connected devices would be protected with an overvoltage category II (household appliances and electrical machines).

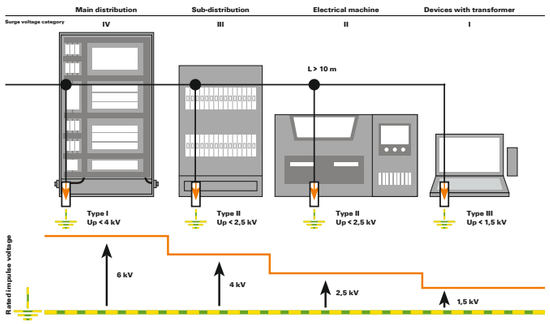


Figure 1: Overvoltage categories and their rated impulse voltages

Due to improvements in technical values for surge protection devices available on the market, it is reasonable to argue that a Type II arrester with a protection level < 1,500 Volt in the sub-distribution protects all devices and machines connected behind it.
However, this kind of blanket statement would be incorrect. The only way to evaluate whether surge protection is truly reliable is to consider the installation as a whole. This includes the effective protective area of an SPD, but also the length of the SPD's connecting cables. Both are defined according to IEC 60364-5-53 (VDE 0100-534).

The standard limits the effective protective range of surge protection devices to 10 m (IEC 60364-5-53, section 534.4.9 in DIN VDE 0100-534). Devices whose supply lines extend beyond this protected range (> 10 m) require an additional SPD in the supply line for safe operation.

Since electrical machines often operate at a distance of many times this 10 m from the sub-distribution board and the installation site and, associated with this, the cable lengths are not known during the design phase of the machines, only an additional SPD directly on the machine ensures protection in conformity with the standard. The protection level of this additional surge protection device must not exceed never exceed the rated impulse voltage U_W of the equipment.

The second, mandatory point to consider is the cable lengths of all installation cables used for the SPD. Here, the standard (IEC 60364-5-53, section 534.4.8 of DIN VDE 0100-534) requires that all connecting cables of the SPD, including phase, neutral and PE conductors, do not exceed a total length of 0.5 m, see figure 2. The standard explains that an additional cable length of 1 m increases the protection level of the SPD by 1 kV. As a result, the amount of an overvoltage can significantly exceed the rated impulse voltage (i.e. the insulation strength) of a device. The protection would be ineffective!

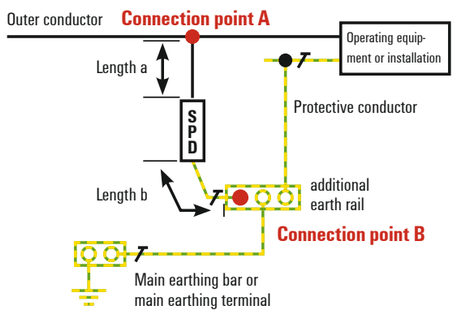


Figure 2: IEC 60364-5-53 (VDE 0100-534) requires a line length of a + b ≤ 0.5 m

2. Surge protection requirement according to IEC 60204-1 (VDE 0113-1) and IEC 60364-5-53 (VDE 0100-534)

IEC 60204-1 (VDE 0113-1) is a so-called installer standard, and is titled “Safety of machinery - Electrical equipment of machines - Part 1: General requirements”. This standard is valid for machine manufacturers and installers.
Chapter 7.9 describes the topic "Protection against overvoltages caused by lightning and switching operations". For correct selection and installation, please refer to the lightning protection standard IEC 62305 or the international standards of IEC 60364-4-44 (VDE 0100-443) and IEC 60364-5-53 (VDE 0100-534).

As presented in explanation 1, IEC 60364-5-53 (VDE 0100-534) describes the effective operation of an SPD. Here as well, if the cable length between the SPD and the device to be protected is > 10 m, an additional SPD is required in the power supply to reliably protect the device.

Conclusion

Both explanations presented refer to the valid lightning and surge protection approaches, and in particular to the installation regulations. When considering the effective protective range of a surge protector, it becomes clear that every electrical machine must be protected with an additional SPD. In addition to these required standards for surge protection in electrical machines, the Machinery Directive and SIL safety classes also apply, both of which can be used to formulate recommendations for surge protection.

Continuous protection for your building infrastructure

Surge protection is required!

Equipment and energy systems in buildings are becoming more complex and more sensitive. Therefore, surge protection is particularly important when constructing new building infrastructures. In addition to minimising the risk of damage, the choice of the best surge protection focuses on finding a future-proof design and improving efficiency. Since indirectly coupled surges can cause damage, the installation of surge protection devices (SPD) is subject to specific regulations. IEC 60364-5-53 (VDE 0100-534) defines where and how surge protection must be installed.

The goal is to ensure complete protection, from the power feed-in to the power distribution and the final device, and offer protection against dangerous surges of all kinds. Integrating surge protection has been mandatory since 2018. This applies to all new buildings and to modifications or expansions of existing electrical installations. Supplementary protective devices are recommended if the cable length between the surge protection and the device to be protected is over 10 metres. Ethernet and SAT cables are also required to be protected.

Surge protection is required!

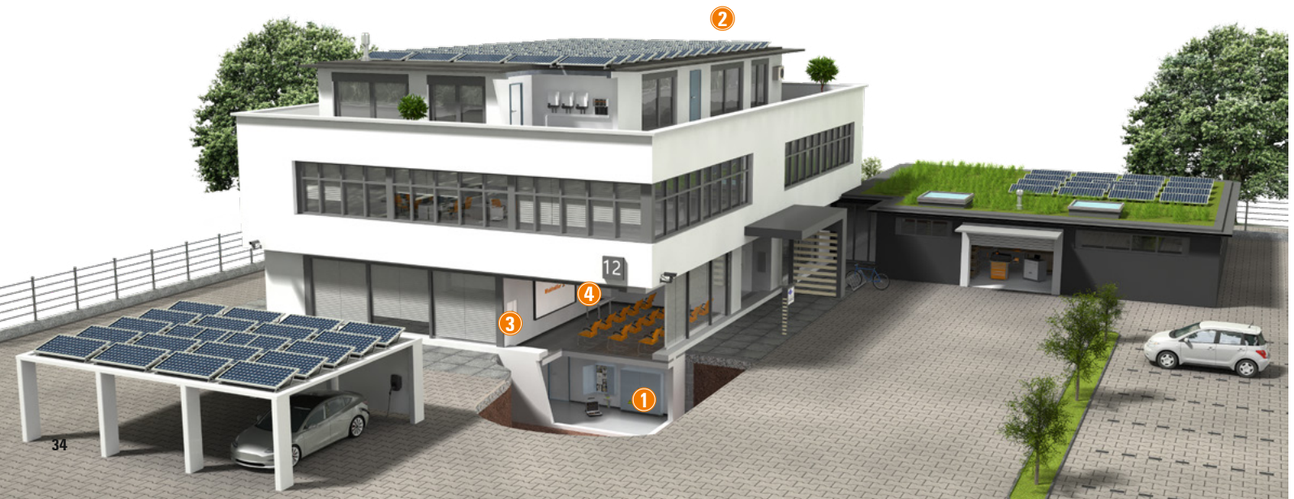
Indirectly coupled voltage surges also cause damage:
IEC 60364-5-53 (VDE 0100-534) describes where and how surge protection (SPDs) must be installed.

Mandatory:

1. The surge protection device must be installed near the power grid feed-in point. Both power and telephone lines must be protected.
2. Likewise, mandatory surge protection must be installed for the cables of photovoltaic systems.

Recommendation:

3. Above a cable length of > 10m, additional surge protection should be installed (such as in subdistributions).
4. Protection of Ethernet and SAT cables.



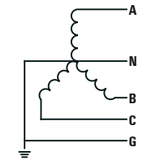
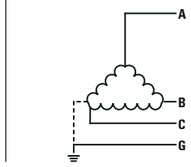
Surge protection for North American network types

VARITECTOR PU AC US Series

Worldwide usage
In the USA, electrical installations need to have surge protection. The current safety standard NFPA 79 defines the use of surge protection devices in machines with safety circuits.

This requirement is met by devices of the VARITECTOR PU US series. They are UL listed, which includes the requirements of NFPA 79. The product series has been specially adapted to the North American market. In addition to the requirements of UL 1449, it also meets the IEC/EN 61643-11 standard and can therefore be used worldwide.

The products have been adapted to the North American grounding networks such as WYE or DELTA. They are simultaneously approved to UL 1449 and VDE – for worldwide use in any application.

Rated voltage	277/480 V	347/600 V	480 V	600 V
	3-Phase star		Grounded corner/ungrounded delta	
Configuration				



Surge protection for photovoltaic systems

Choosing AC and DC protection in compliance with standards

PV systems with external lightning protection
A type II surge protection device can be used if the separation distance is complied with (generally > 0.7 m to 1 m). If the distance is not complied with, type I surge protection is required for DC cabling.

PV systems without external lightning protection
This is a common design for which type II surge protection should be in place for the DC cabling.

The figure shows the general PV system architecture. The table below can be used to help choose the right surge protection products according to the specifications of valid standards in a PV system.

L_1 describes the cable length between the main distribution board and PV inverter (AC side) and L_2 describes the cable length between the PV inverter and PV generator (DC side). At a cable length > 10 m, the standard requires an SPD on both sides.

Case A: PV systems without external lightning protection
In this case, the standard requires a type II arrester with $I_n \geq 5$ kA on both the AC and DC sides.

Case B: PV systems with external lightning protection
1: compliance with the separation distance (typical > 0.7m to 1m). In this case (which is fairly rare) a type II arrester on the DC side is sufficient. A type I arrester is required on the AC side.

2: non-compliance with the separation distance between the lightning protection system and PV generator. In this likely case, a type I arrester is required on both the AC and DC sides by the standard. Two arresters must be installed for line lengths L1 > 10 m (between the PV generator and inverter).

Case C: Outdoor systems
For outdoor systems, according to DIN EN 51643-32 there is only LPL III / IV. The standard requires a combined type I + II arrester with the following minimum leakage currents:

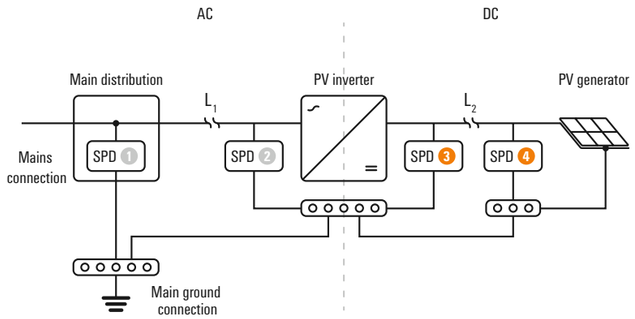
I_{imp} (10/350µs) ≥ 5 kA I_{total} (10/350µs) ≥ 10 kA
I_n (8/20µs) ≥ 15 kA I_{total} (8/20µs) ≥ 30 kA



Determining the surge protection required by applicable standards

Answer the questions in the table below from left to right to determine what surge protection is required for your installation on the AC and DC side. The figure shows the general PV system architecture:

1 In the main distribution, 2 on or in the inverter (AC side), 3 on or in the inverter (DC side), 4 on the generator field. At a cable length of over 10 m, you will need an additional surge protection according to the standard.



Question 1: Outdoor lightning protection system present?	Question 2: Separation distance observed?	Question 3: Line length L_1 less than 10 m?	Question 4: Line length L_2 less than 10 m?	Installation locations AC: SPD 1	Installation locations AC: SPD 2*	Installation locations DC: SPD 3	Installation locations DC: SPD 4
no	–	no	no	Type II AC	Type II AC	Type II PV	Type II PV
no	–	no	yes	Type II AC	Type II AC	Type II PV	–
no	–	yes	no	Type II AC	–	Type II PV	Type II PV
no	–	yes	yes	Type II AC	–	Type II PV	–
yes	yes	no	no	Type I AC	Type II AC	Type II PV	Type II PV
yes	yes	no	yes	Type I AC	Type II AC	Type II PV	–
yes	yes	yes	no	Type I AC	–	Type II PV	Type II PV
yes	yes	yes	yes	Type I AC	–	Type II PV	–
yes	no	no	no	Type I AC	Type I AC	Type I PV	Type I PV
yes	no	no	yes	Type I AC	Type I AC	Type I PV	–
yes	no	yes	no	Type I AC	–	Type I PV	Type I PV
yes	no	yes	yes	Type I AC	–	Type I PV	–

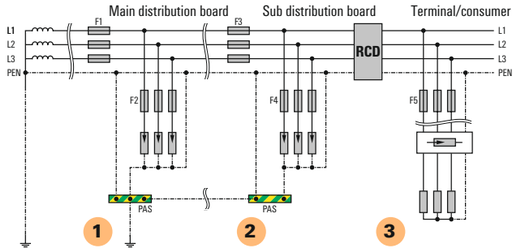
*If the inverter and the main distribution board are connected to the same earthing bar with a cable length of less than or equal to 0.5 m each, no SPD is required at installation location "2".

Example application
230 / 400-V networks

TN-C systems

Neutral conductor and protective earth conductor functions are combined throughout the network in a single conductor, the PEN conductor (4-conductor-system).

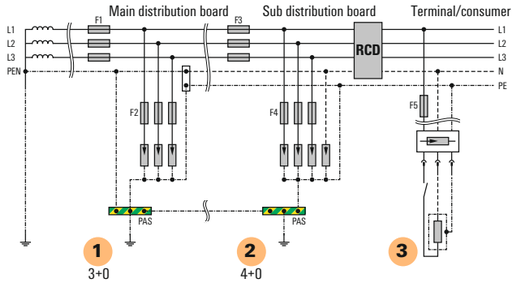
Position	LPL	Type	Order No.
1	I/II	VPU AC I 3 275/25 LCF S	2726740000
	III/IV	VPU AC I 3 300/12.5 LCF	2636970000
2		VPU AC II 3 300/50	2591160000
3		VPU AC II+III 3 275/20 S	2907870000



TN-C-S systems

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.

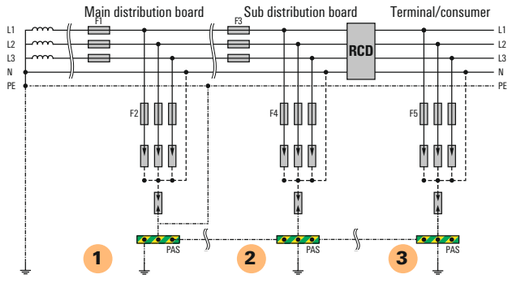
Position	LPL	Type	Order No.
1	I/II	VPU AC I 3 275/25 LCF S	2726740000
	III/IV	VPU AC I 3 300/12.5 LCF	2636970000
2		VPU AC II 4 300/50	2591140000
		VPU AC II 3+1 300/50	2591080000
3		VPU III R 230 V/6 KV AC	1351650000



TN-S systems

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

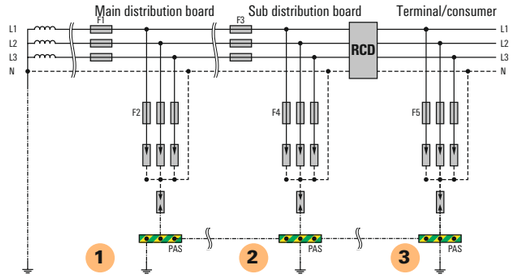
Position	LPL	Type	Order No.
1	I/II	VPU AC I 3+1 275/25 LCF S 2PE	2726760000
	III/IV	VPU AC I 3+1 300/12.5 LCF	2636910000
2		VPU AC II 3+1 300/50	2591080000
3		VPU AC II 3+1 300/50	2591080000
		VPU AC II 4 300/50	2591140000



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.

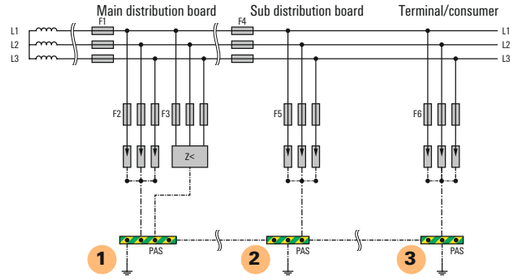
Position	LPL	Type	Order No.
1	I/II	VPU AC I 3+1 275/25 LCF S 2PE	2726760000
	III/IV	VPU AC I 3+1 300/12.5 LCF	2636910000
2		VPU AC II 3+1 300/50	2591080000
3		VPU AC II 3+1 300/50	2591080000



IT systems

There is no direct connection between active conductors and earthed parts. The exposed conductive parts of the electrical installation are earthed. The system is equipped with an insulation measuring device. Only for IT network systems in which the ground on the distribution transformer is connected to the ground on the customer side. (RE=RA in Figure 44 A1 of IEC 60634-4-44:2018)

Position	LPL	Type	Order No.
1	I/II	VPU AC I 3 440/25 LCF	2619160000
	III/IV	VPU AC I 3 480/10	2591530000
2		VPU AC II 3 480/50	2591250000
3		VPU AC II+III 3 440/20 S	2908460000



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Weidmüller Interface GmbH & Co. KG
Klingenbergstraße 26
32758 Detmold, Germany
T +49 5231 14-0
F +49 5231 14-292083
www.weidmueller.com

Personal support can
be found on our website:
www.weidmueller.com/contact

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