OVR
Practical guide for the protection against surges

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Protection against surges
Damages caused by surges

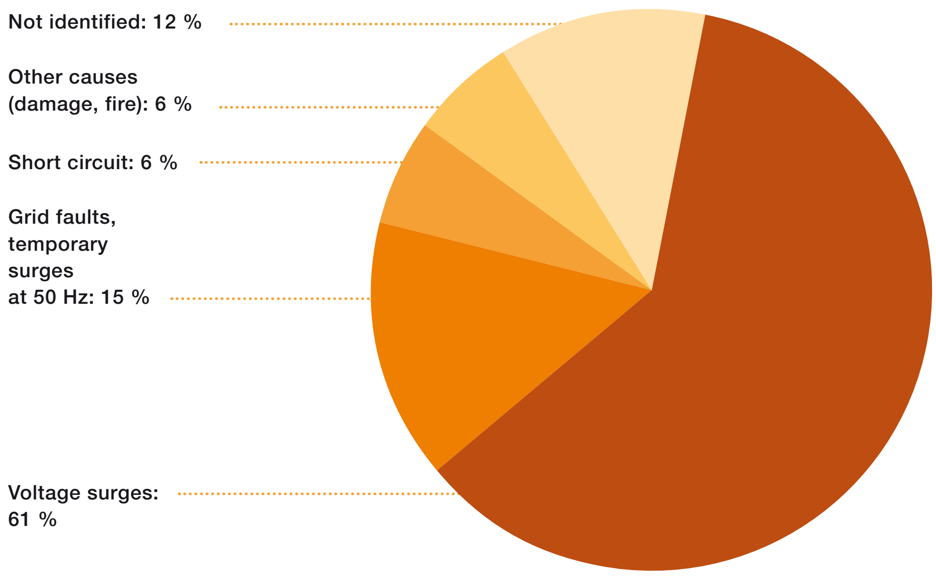
Surges represent the main cause of electrical devices failure and loss of productivity. The most dangerous surges are caused by lightning strikes, electrical operations on the distribution network and industrial parasitic interference.

Today, electronic equipment, IT systems and automation and control systems are used in all applications (residential, commercial and industrial).

A fault in one of these systems originating from a surge can have catastrophic consequences.

Loss of operational capacity, services, data and productivity generally result in enormous costs, many times greater than the costs of surge protective devices.

Ever more common electronic systems, increasingly sensitive electronic equipment, growing interconnection and network complexity all increase the probability of damages caused by overvoltage surges



Damage to electronic equipment. Analysis conducted in France for the residential segment by AVIVA, the sixth largest insurance company in the world (www.aviva.com)

At the same time, it is appropriate to highlight the following trends:

Electronic systems are ever more common, even in domestic environments: computers, domestic appliances IT networks, telecommunications equipment etc. The effects of and damage due to overvoltage surges are fundamentally important in a world which has drastically increased the applications entrusted to electrical grids and IT and telecoms networks.

Electronic equipment is increasingly sensitive.
With miniaturisation of circuits and components, modern equipment is more likely to be damaged by voltage surges than in the past, mainly because of the very low input voltage 3 V and networks interconnected equipment. Higher frequency networks are more sensitive than low frequency ones.

Electrical grids and telecommunications networks are ever more interconnected and complex. In highly populated cities, the effects caused by the electrical discharges from lightning are devastating, as they can propagate for several miles.

Surge protection therefore represents a fundamentally important factor.

Effects of overvoltage surges on electronic equipment

Protection against surges
Origins of surges
Atmospheric discharges

Atmospheric discharges are a powerful natural phenomenon. Lightning can reach a power of several hundred gigawatts and can have a destructive or disturbing effect on electrical systems located miles away from the point where the lightning strikes.

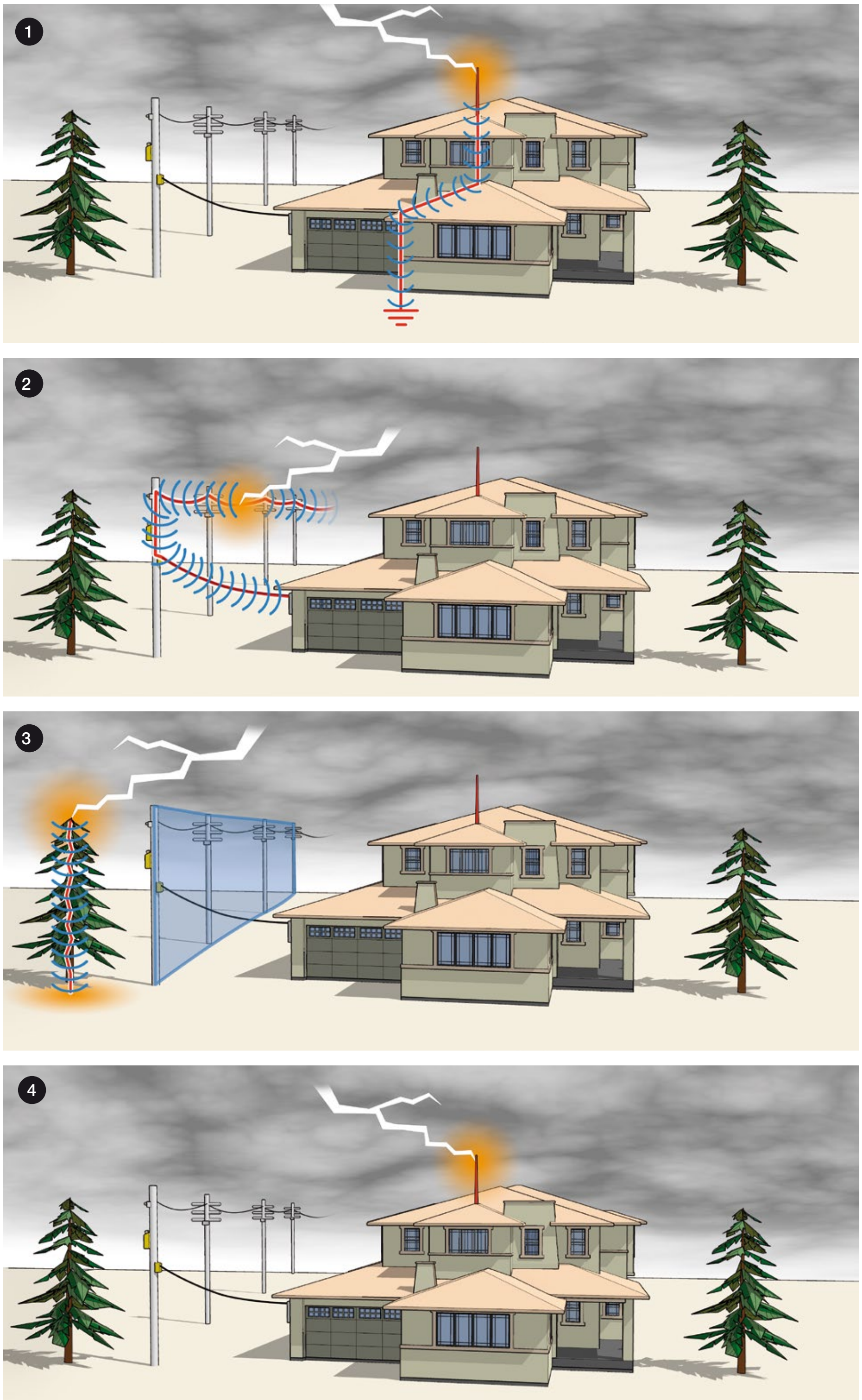
Damage caused by direct lightning strikes is generally serious, with large economic consequences. As an example, the electrical switchboard can catch fire, causing devastation of industrial equipment and even the building. The best and only way to avoid this is the installation of an ELP.

Atmospheric discharges can determine various phenomena in an electrical system, resulting both from direct and indirect lightning strikes.

Direct lightning strikes on lightning rods/conductors (LPS, Lightning Protection System) or external conductive elements (antennas, metallic pipes/guttering etc.).
Galvanic coupling
When lightning strikes the lightning conductor or roof of an earthed building directly, the current flows to earth and through the power supply lines. The resistance of the PE system, when dispersing the lightning current, causes an increase in the PE conductor up to several thousand volts (ohmic effect). On the other hand, the potential of the active conductors remains at 230 V for the phases and zero for the neutral (remote potential of the transformer). The electrical equipment connected between the power supply network and earth can break their isolation and some of the lightning current flows through them, resulting in damage.

Direct lightning strike on aerial power lines.
Conductive coupling
When lightning strikes a low voltage aerial power line, very strong currents flow through it, entering the buildings it supplies and giving rise to large overvoltage surges. The large amount of energy entering directly into the system causes faults and failures of electrical or electronic equipment connected to the power supply.

Indirect lightning strikes.
Electromagnetic coupling
The electromagnetic field created by atmospheric discharges in the vicinity of aerial electricity lines or electrical systems generates an overvoltage surge in each loop of the circuit.
The electricity lines incorporate loops since the neutral or PE is connected repeatedly to earth (every two or three poles).
Even lightning striking the external protection system (LPS) creates a surge in the loops formed by the electrical system wiring.
With a range of hundreds of yards or even miles, the electromagnetic field generated in cloud lightning can create sudden voltage increases.
In these cases the damage, less spectacular than in the previous cases, can still have a permanent effect on the most sensitive electronic equipment such as computers, photocopiers and security and communications systems.



1 - Direct lightning strike on external lightning protection system (lightning rod)

2 - Direct lightning strike on aerial electricity lines

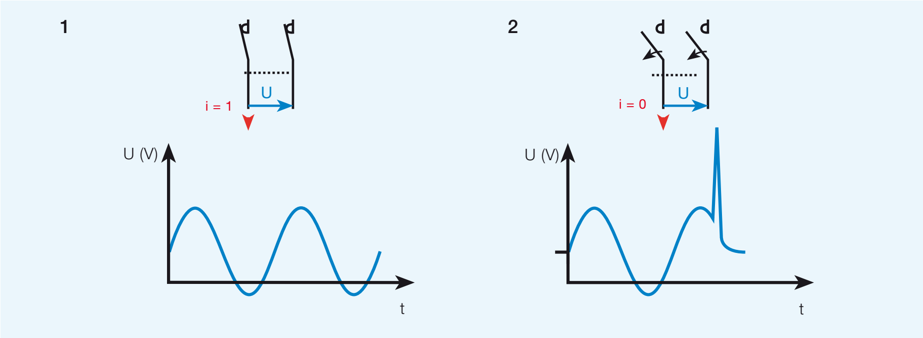
3 - Electromagnetic coupling: lightning striking a tree near the building and near an aerial electricity line

4 - Electromagnetic coupling: effect of the passage of current in the ELP down conductors (indirect lightning strike resulting from case 1)

Protection against surges
Origins of surges
Electrical operations on the distribution grid

The switching of breakers, transformers, motors and inductive loads in general or the sudden modification of loads causes sudden current variations (di/dt), generating transitory voltage surges.

Switching of breakers
1- closed circuit
2- opening of circuit

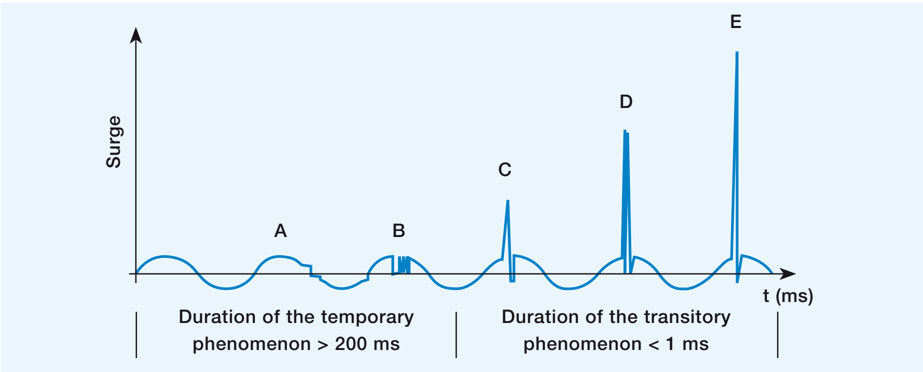


They are less energetic than surges caused by lightning, but they are much more frequent and are damaging as they are generated directly in the power supply network. Their brief duration, the sharp rising edge and the peak value (which can reach several kV) leads to premature wear of electronic equipment.

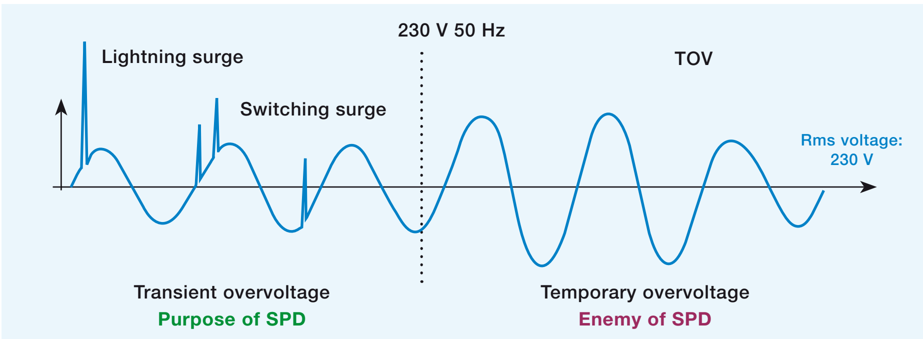
Order of magnitude of the disturbances.

Representation of the different disturbances on the electricity supply grid in AC

A - Harmonics
B - Micro-interruptions
C - Surges from switching
D - Indirect lightning strikes
E - Direct lightning strikes



From the point of view of overvoltage surges, direct lightning strikes carry the highest risk.



The stress caused by a lightning strike on the network almost always represents the most important parameter when selecting a SPD (Surge Protective Device).

Intensity of direct lightning strikes

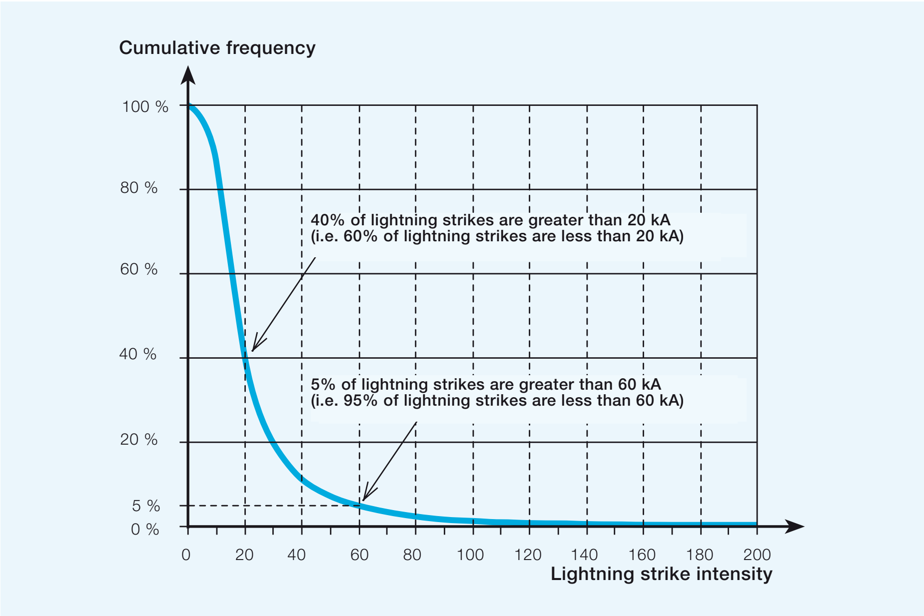
The French institute Meteorage conducted a series of measurements of the intensity of over 5.4 million lightning strikes in France over the ten years from 1995 to 2004. The following curve summarizes the cumulative frequency of the lightning strikes with respect to their intensity, according to the results of this enormous measuring campaign:

– 1.27% of the lightning strikes are greater than 100 kA
– 0.33% of the lightning strikes are greater than 150 kA
– 0.1% of the lightning strikes are greater than 200 kA
– 0.03% of the lightning strikes are greater than 250 kA

These are values measured in France, however the intensity of lightning has no correlation with the geographical position, and equivalent results would be obtained by performing the same analysis in other countries. What does, however, characterize each geographical area is the density value by geographical area Ng (described on the following page)

Cumulative frequency of lightning strikes - positive and negative - with respect to their intensity.

Data supplied by Meteorage (www.meteorage.fr)



Protection against surges
General information on lightning

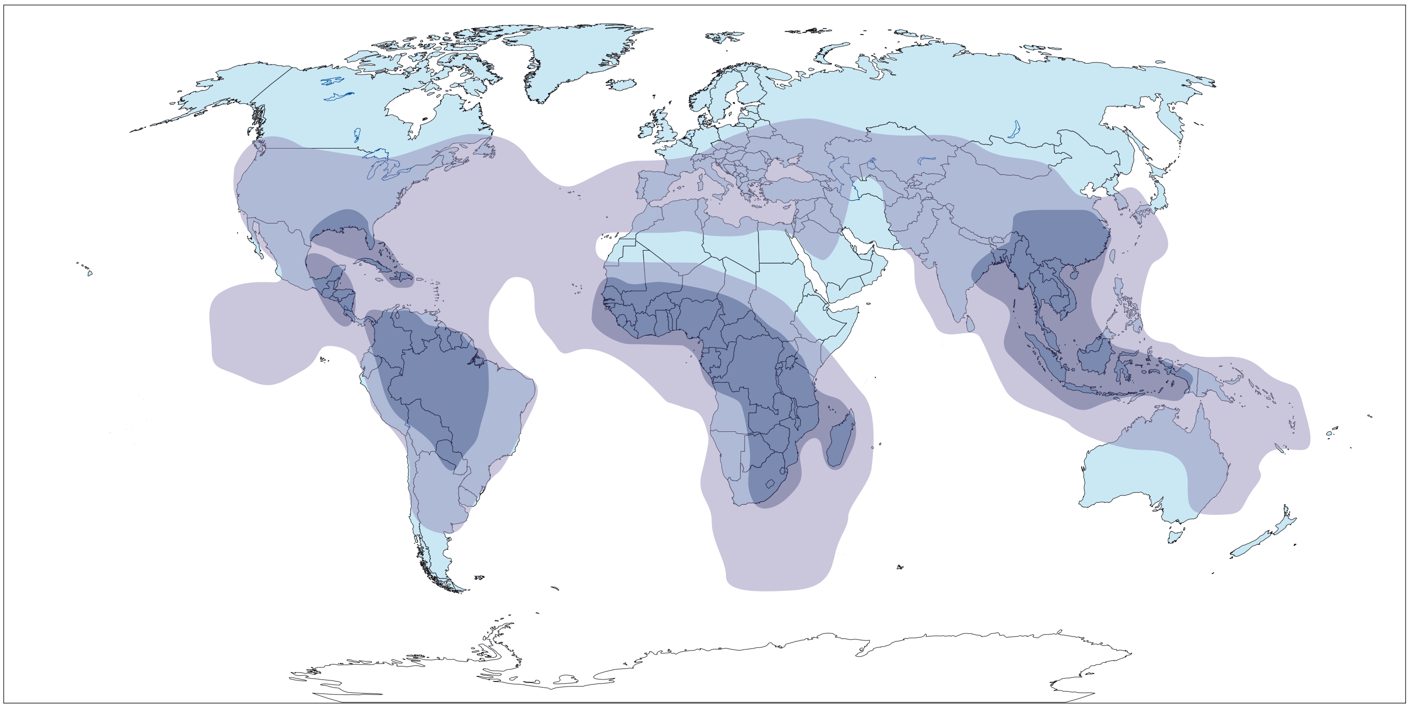
Lightning density by geographical area Ng

At any moment in time there are between 2 000 and 5 000 storms active in the world. At a local level, the estimation of the risk of lightning strikes is performed by consulting Ng charts, a parameter which indicates the density of electrical discharges from lightning by geographical area. Obtained experimentally or with lightning localization system (LLS), this gives the number of lightning strikes per square kilometer and per year.
For example, the IEC 81-3 supplies the Ng values for all municipalities in Italy. If the Ng value should not be available, it can be estimated with the following formula:

$$Ng \approx 0.1\ Td$$

where Td represents the days of storms per year (a value which can be obtained from isokeraunic maps).

Lightning flash density map (flashes per km² per year)



2 < Ng ≤ 8

8 < Ng < 18

Ng charts are available in many countries; consult local regulations for more information on the density of lightning strikes.

OVR PV.
Excellent performances with maximum safety. Always.

Born from the experience of ABB, the first company to launch them on a market which continues to choose them, OVR PV photovoltaic SPDs ensure absolute protection in photovoltaic installations. OVR PV SPDs are equipped with a patented thermal disconnector, with DC short circuit interruption performance, specially designed in order to prevent the risks of overheating and fires in photovoltaic installations up to 1000 V. Thanks to this innovative technology, OVR PV SPDs are self-protected from end-of-life short circuits up to 100 A DC without the necessity for back-up protection. This performance is ensured by conformity to the guide UTE EN 50539-11 and C61-740-51.

Protection against surges
Risk assessment

Risk assessment, according to lightning protection standard IEC 62305-2.

The international regulation IEC 62305, in force since April 2006, supplies all elements for evaluating the risk a building is subject to and for the selection of suitable protective measures against lightning for buildings, systems and people inside them and services connected to them.

The risk assessment is the first step towards protecting the electrical system from voltage surges and must be performed by an electrical project manager for each building and systems connected.

The assessment process starts with the analysis of the structure to be protected: type and dimensions of the building, its use, the number and type of services entering it, the characteristics of the surrounding environment and local lightning density.
The losses that a building can face are then defined, with reference to four different types of loss:

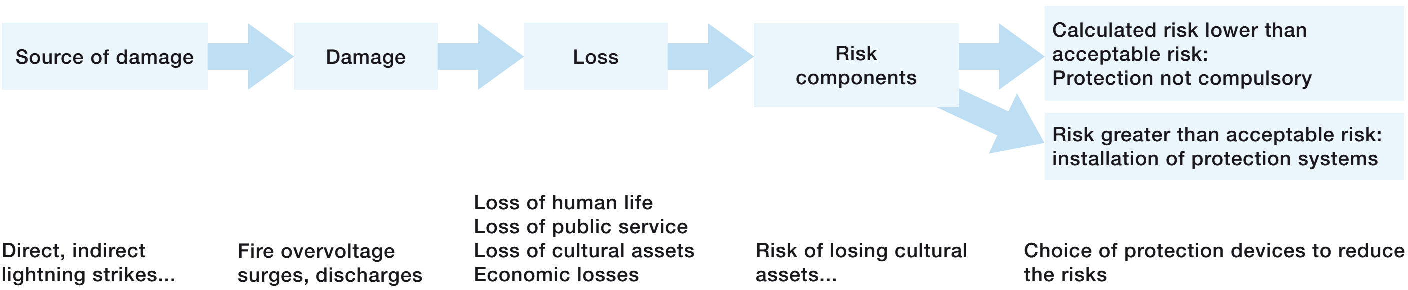
- **L1:** loss of human life
  Number of deaths per year, related to the total number of people exposed to the risk
- **L2:** Loss of essential public services
  Product of the number of users not serviced by the annual duration of the down time, related to the total number of users served in a year
- **L3:** Loss of irreplaceable cultural heritage
  Annual value of lost heritage, related to the total value of the heritage exposed to the risk
- **L4:** Loss of purely economic value
  The analysis of acceptable damage is a pure cost/benefit comparison

For example, the installation of a Type 1 SPD with I_{imp} = 25 kA per pole at the origin of a three-phase + neutral system allows the risk component R_B (risk of fire due to direct lightning strike on structure) to be reduced, as a Type 2 SPD with I_n = 20 kA reduces the R_M risk component (risk linked to induced overvoltages from lightning striking near the building).

A specific risk R is associated with each type of loss: $\mathbf{R_1}$ is the risk of loss of human life; $\mathbf{R_2}$ is the risk of losing essential public services; $\mathbf{R_3}$ is the risk of losing cultural heritage; $\mathbf{R_4}$ is the risk of economic loss.

Each type of risk can be expressed on the basis of its different components relative to the cause of the damage (damage to persons by step and touch potentials; material damage due to fire, explosion etc.; damage to electrical systems by voltage surges) and the source of the damage (direct lightning strikes on buildings or external electricity lines, indirect lightning strikes near buildings or lines).
For each of the three risks (R1, R2, R3), a maximum admissible value RT is defined: if the value is greater than that admissible, suitable measures must be taken to protect the building (LPS, equipotential bonding, SPDs). For the fourth risk component (R4), protection is always optional – it is recommended if the cost/benefit analysis is favorable.

Whenever the risk analysis requires the structure to be protected, the regulations also supply selection criteria for the appropriate SPDs to reduce the specific risk components below the acceptable risk values.



Protection against surges
Surge protection solutions

ABB is putting its experience gained in the last few decades to work in developing devices for the protection against surges and lightning strikes in the Bagnères-de-Bigorre plant, located in the Hautes Pyrénées region in South-west France

ABB completed a new laboratory in 2003, equipped with generators allowing to recreate the shape image of a direct lightning strike (10/350 µs waveform) and indirect lightning strike (8/20 µs waveform), this allows to best our SPD range.

Thanks to a wide range of products, ABB is able to offer network protection solutions for low-voltage and telecommunications networks.
Seminars held in ABB's training centers are organized so as to meet the requirements of all professionals: project managers, architects, distributors, installers and sales staff.
The courses combine theoretical and practical aspects, dealing with a wide range of subjects such as, for example, protection against direct lightning strikes, protection against overvoltage surges and electromagnetic compatibility.

The ABB Lab, with over 450 m² of floor area, is equipped to perform testing as per IEC 61643-1/EN 61643-11 and the UTE C 61-740-51 guide

High power generator	Normalized 8/20 µs and 10/350 µs waveforms Maximum test voltage 100 kA for both waveforms, in addition to the mains voltage. 800 kJ stored energy
200 kV generator	1.2/50 µs normalised wave Maximum voltage 200 kV 10 kJ stored energy PV power generator 200 to 1500 VDC
Combined waveform generator	"Biwave" 8/20 µs - 1/2-50 µs normalized wave Max. voltage 30 kV Max. current 30 kA 5 kJ stored energy
Electrical tests	Short circuit test at 440 V and 5 000 A
Mechanical tests	Operational tests under socket and multi-socket loads
Fast camera	Up to 120 000 frames per seconds

View of the ABB laboratory in Bagnères-de-Bigorre, France

General information on SPDs
How do they work

SPDs, or Surge Protective Devices, are designed to prevent electrical systems and equipment against transitory surges and impulses such as, for example, those caused by lightning and operations on the electrical grid.

Transient overvoltage surges consist of a small voltage peak of a short duration (less than a millisecond) which can reach tens of times the standard mains voltage.
The resistance to transitory surges – known as "impulse withstand voltage" – is of great importance in electrical and electronic equipment, and for this reason equipment is fitted with systems isolating the parts connected to the phases from earth or neutral. This isolation can vary from a few hundred volts, for sensitive electronic equipment, to several kilovolts for a breaker.
SPDs contain at least one non-linear component (a varistor or spark gap). Their function is to divert the discharge or impulse current and to limit the overvoltage at the downstream equipment.

Operation of a SPD:

- During normal operation (e.g. in the absence of surges), the SPD has no influence on the system where it's installed. It acts like an open circuit and maintains the isolation between the active conductors and earth.
- When a voltage surge occurs, the SPD reduces its impedance within a few nanoseconds and diverts the impulse current. The SPD behaves like a closed circuit, the overvoltage is short-circuited and limited to an acceptable value for the electrical equipment connected downstream.
- Once the impulse surge has stopped, the SPD will return to its original impedance and return to the open circuit condition.

Example of operation

Without a SPD (figure 1), the surge reaches the electrical equipment. If the surge exceeds the electrical equipment's impulse withstand voltage, the isolation is reduced and the impulse current flows freely through the device, damaging it.
With the use of a SPD (figure 2) between the active conductors and earth (TT network), the overvoltage is limited and the discharge current is safely diverted, establishing an equipotential connection between phase and earth.

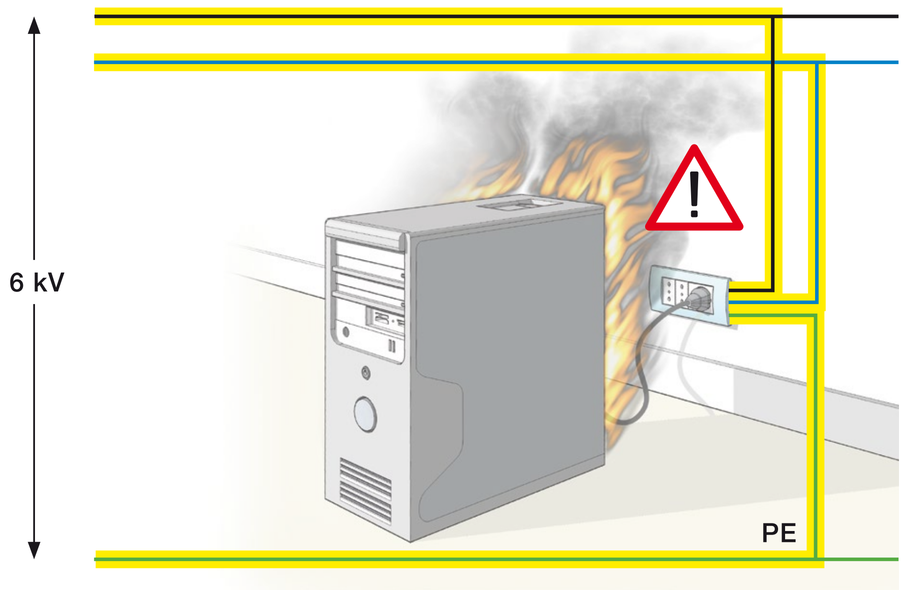


Figure 1

Without SPD:
- A 6 kV surge strikes the server power supply
- The electrical isolation between the circuits is irreparably damaged
- A discharge to earth is generated
- When the surge ends, the server is out of service and there is a fire risk present

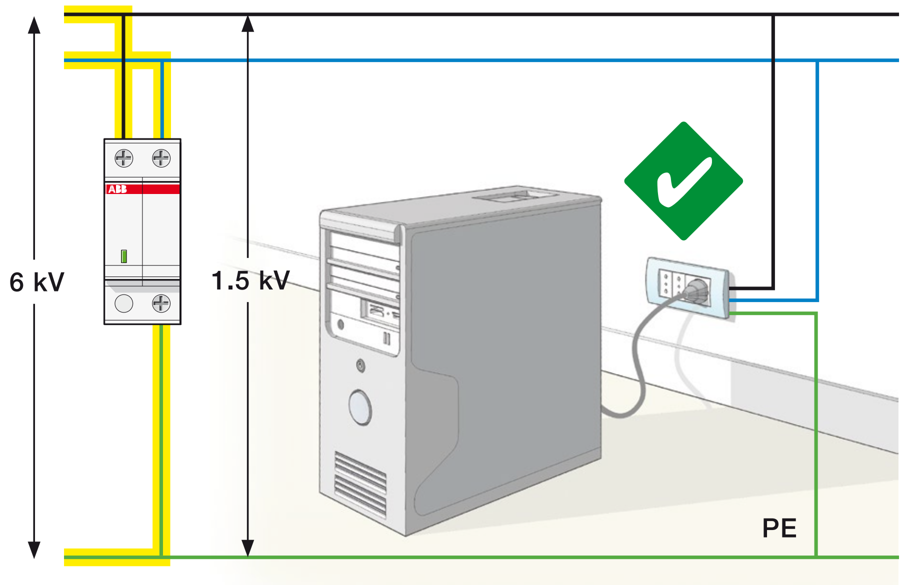


Figure 2

With SPD:
- A 6 kV surge strikes the SPD
- The SPD connects the active conductors (phase and neutral) to earth
- The discharge current is diverted to earth
- The server "sees" an overvoltage of 1.5 kV across the SPD
- The server continues to operate normally
- The effect of the surge has been limited by the SPD, preserving the server's integrity.

General information on SPDs
Test waveforms

Based on decades of research, recordings and measurement of lightning and overvoltage surge phenomena, the Standards introduced two waveforms to simulate direct and indirect lightning strikes and the effects of operations on the electrical grid.

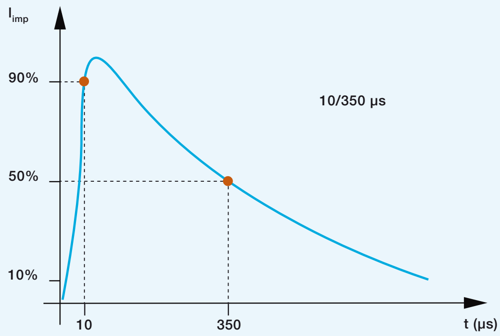
The waveform (10/350 µs) simulates a direct lightning strike, with a sudden and intense increase of the current with a very high associated energy level. The lightning can, indeed, be considered the ideal current generator, injecting a 10/350 µs wave of current into the network with a very high peak value.

The waveform (8/20 µs) with reduced energy represents an indirect lightning strike, as well as the effects of electrical grid operations and parasitic interference.

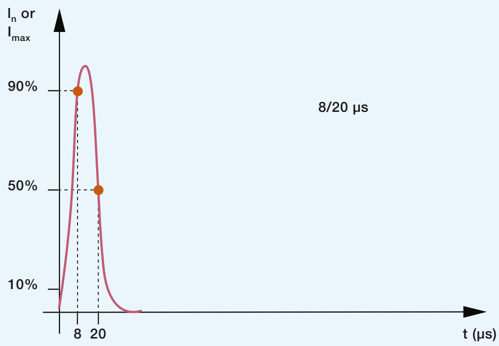
The energy associated with this waveform depends on the area under the curve: **Energy** $\approx \int_0^T i^2 dt$. The energy associated with the 10/350 µs waveform is therefore significantly greater than that of the 8/20 µs one (approximately 10 times greater).

	Duration of rising edge T_1 (from 10 % to 90 % of maximum value)	Duration of semivalue T_2	I (peak current)
10/350 µs wave	10 µs	350 µs	I_{imp}
8/20 µs wave	8 µs	20 µs	I_n or I_{max}

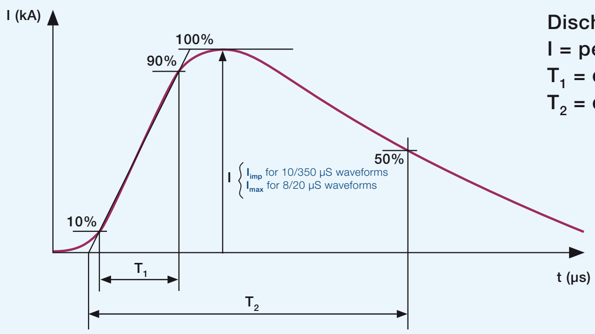
Over 75 % of lightning strikes have secondary discharges, which follow the initial one by 30-200 milliseconds. On average, the main discharge is followed by three secondary ones, but in some cases up to 34 discharges have been recorded in quick succession. The initial discharge ionizes a channel between the cloud and the ground, which then becomes a preferential path for successive discharges.
The rising edge of the lightning's current can reach 100 kA/µs for the primary discharge, a value which can be even greater for the discharges which follow. Rising edges have been recorded for voltages up to 12 000 V/µs, more than enough to damage even the more robust circuits.
In order to characterize lightning, international standards define a 10/350 microsecond standard waveform for the first positive discharge and one of 0.25/100 microseconds for subsequent negative discharges (IEC 62305-1, Annex B).
Only the first discharge is taken into consideration, both when designing and choosing a SPD, as it represents the most important stress on the device.



10/350 µs waveform for direct lightning strike tests. Current impulse with 10 µs rising edge and semi value duration of 350 µs.



8/20 µs waveform for tests on indirect lightning strikes and surges caused by operations on the electrical grid. Current impulse with 8 µs rising edge and semi value duration of 20 µs.

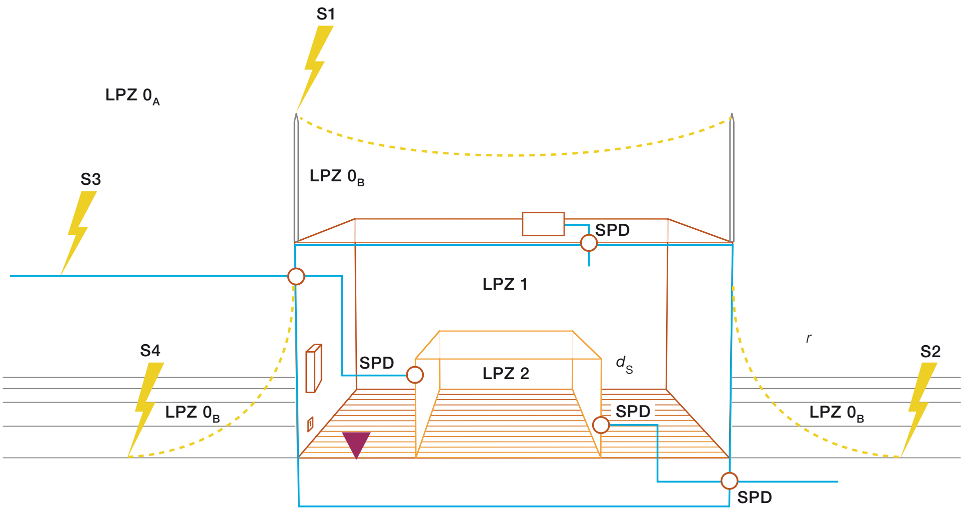


Discharge wave parameters
I = peak current
T_1 = duration of rising edge
T_2 = duration of semi value

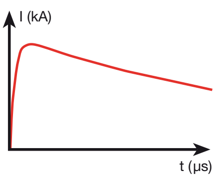
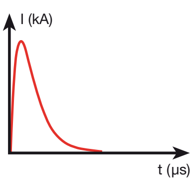
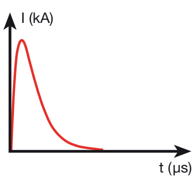
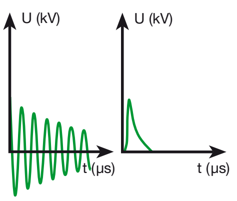
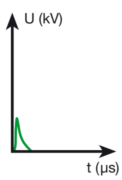
General information on SPDs
Protection zones LPZ (Lightning Protection Zones)

Surge protection starts at the origin of the electrical system and finishes near the most sensitive equipment. The discharge energy is reduced in various stages, first with the more robust SPDs (Class 1), then with finer protection (Class 2 devices). This protection co-ordination is represented with the LPZs, which divide up the structure on the basis of the effects of the lightning strike.

A structure for protecting equipment and systems against the electromagnetic effects of lightning currents (LEMP, Lightning electromagnetic impulse), can be divided into LPZs (Lightning Protection Zones), meaning homogeneous electromagnetic environments, not necessarily delimited by walls, floors and ceilings, but rather ideal, with homogeneous protection measures represented by LPS, shielding and SPDs. The type of electric and electronic systems and their vulnerability to LEMP also contribute to the identification of the various zones.
Electromagnetic conditions of different severity are associated with the protection zones, with a reduction in LEMP going downstream, in relation to the impulse withstand voltage level of the equipment's isolation.
The zones are defined as follows in the IEC 62905-1 standard:
- LPZ 0_A: open zone, not protected by external LPS protection area, in which the component elements are directly exposed to atmospheric discharges and must support the total current generated by them and are exposed to the complete magnetic field;
- LPZ 0_B: zone contained within the external LPS, and for which protection against direct lightning strikes is ensured, but the danger is coming from total exposure to the magnetic field;
- LPZ 1: interior zone, in which objects are not exposed to direct lightning strikes and the induced currents are less than zone 0_A. It is characterized by the presence of shielding and the installation of appropriate SPDs on the lines coming in;
- LPZ 2, LPZ n: zones with further shielding and SPDs, both at the limits of the different zones and protecting the terminal equipment, allowing a reduction of the induced current in relation to the requirements of the equipment to be protected.



1 Structure (shield of LPZ 1)
2 Air-termination system
3 Down-conductor system
4 Earth- termination system
5 Room (shield of LPZ 2)
6 Lines connected to the structure
S1 Flash to the structure
S2 Flash near to the structure
S3 Flash to a line connected to the structure
S4 Flash near to a line connected to the structure
r Rolling sphere radius
d_S Safety distance against too high magnetic field
LPZ 0_A Direct flash, full lightning current, full magnetic field
LPZ 0_B No direct flash, partial lightning or induced current, full magnetic field
LPZ 1 No direct flash, limited lightning or induced current, damped magnetic field
LPZ 2 No direct flash, induced currents, further damped magnetic field
Protected volumes inside LPZ 1 and LPZ 2 must respect safety distances d_S
Ground level
Lightning equipotential bonding by means of SPD

	LPZ 0_A	LPZ 0_B	LPZ 1	LPZ 2	LPZ 3
Location	Zone outside the building and outside the catchment area of the external LPS.	Area outside the building and inside the catchment area of the external LPS.	Area inside the building.	Area inside the building.	Area inside the building for highly sensitive equipment.
Possibility of direct lightning strikes	Yes	No	No	No	No
Electromagnetic field	Not attenuated		Attenuated		Additional shielding to reduce the effects of the magnetic fields (for example, metal cages for equipment) Very attenuated
Current waveforms carried by the power lines	10/350 µs and 8/20 µs – Partial lightning currents from direct lightning strikes (10/350 µs). – Electromagnetic field coupling coming from direct lightning strikes (8/20 µs). – Surges from operations on the grid (8/20 µs). 	8/20 µs – Electromagnetic field coupling deriving from a direct lightning strike (the electromagnetic field is not attenuated in LPZ 0_B) – Voltage surges from operations on the grid. 	8/20 µs Residual effects of: – Electromagnetic field coupling attenuated. – Impulse current of the lightning (low energy). – Voltage surges from operations on the grid. 	1.2/50 µs (Voltage impulse) – Resonance effects / amplification phenomena). – Electromagnetic field coupling attenuated. – Voltage surges from operations on the internal wiring. 	1.2/50 µs – Voltage impulse with very low energy. – Electromagnetic field very attenuated. 
SPD at the entrance of the zone		Type 1	Type 1 + 2 Type 2 (Class C) Type L	Type 2	Type 3

Type 1 products divert the impulse current from the lightning (10/350 wave), stopping it entering the installation.

Type 2 products handle a reduced energy level, coming from direct lightning strikes, surges due to electrical operations on the grid and electromagnetic field coupling.

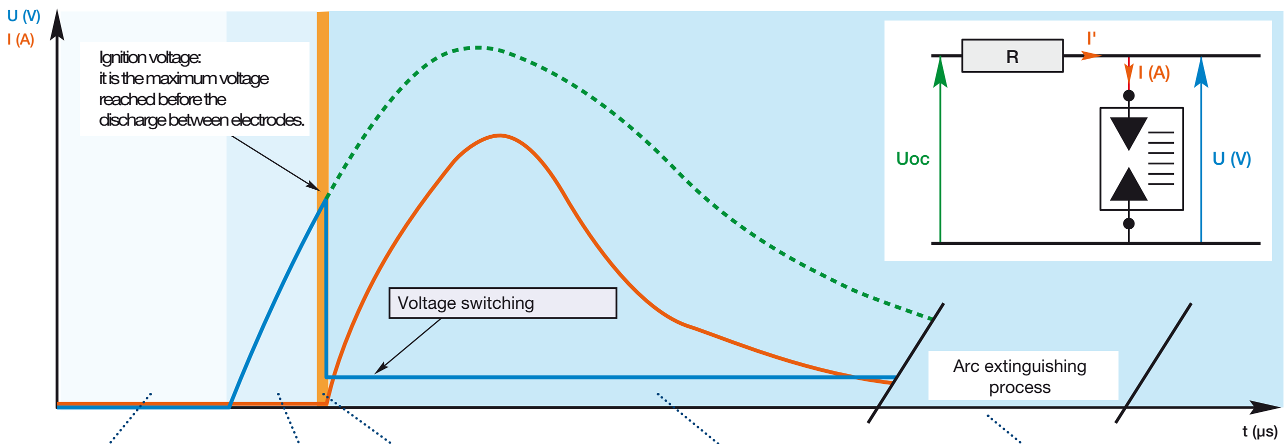
General information on SPDs
Technologies used

A SPD contains at least one non-linear component, its electrical resistance varying in function of the voltage which is applied to it.

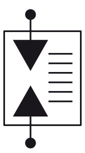
SPDs based on spark gaps

They are called switching SPDs. The spark gap is a component composed of two electrodes in close proximity which isolate one part of the circuit from the other up to a certain voltage level. These electrodes can be in air or encapsulated with a gaz. During normal operation of the system (at rated voltage), the spark gap does not conduct current between the two electrodes. In the presence of a voltage surge, the impedance of the spark gap rapidly decreases to 0.1-1 Ω with the formation of an electric arc between the electrodes, typically in 100 ns. The electric arc is extinguished when the surge finishes, restoring the isolation.

Operational principle of spark gaps



1. Without surge, the spark gap has a high impedance (typically 100 MΩ). The SPD behaves like an open circuit.



2. As soon as a surge occurs, the voltage between the electrodes increase in just a few microseconds.

3. When the voltage reaches thousands of volts, air or gas ionization takes place between the electrodes igniting the electric arc (ignition voltage). Thank to the active operation of the electronic device producing a spark, the electric arc ignites in advance (description on the following page).

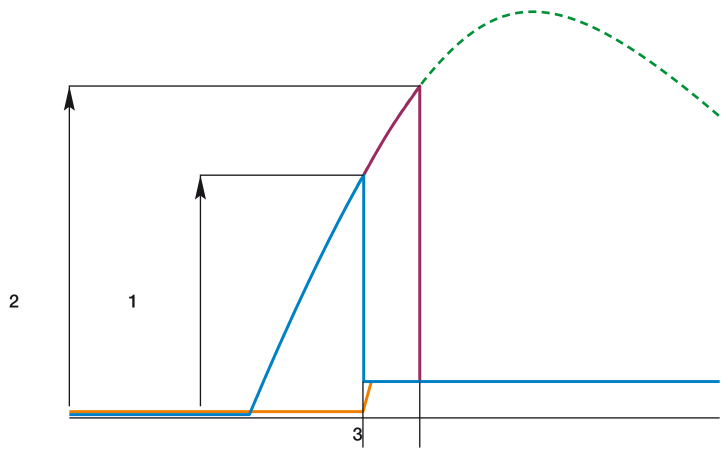
4. The discharge current owes through the electrodes. The electrodes are short circuited and energy flows through the SPD.

5. The electric arc is kept in the installation point by the short circuit current of the power supply has to be extinguished as soon as possible (description on the following pages).

Advanced ignition of the electric arc

The ignition voltage is the maximum voltage reached during the overvoltage discharge operation. An electronic device cuts in so as to obtain a reduced protection level, igniting the arc with a spark before the surge reaches high voltage levels. The low protection level ensures protection of the downstream equipment.

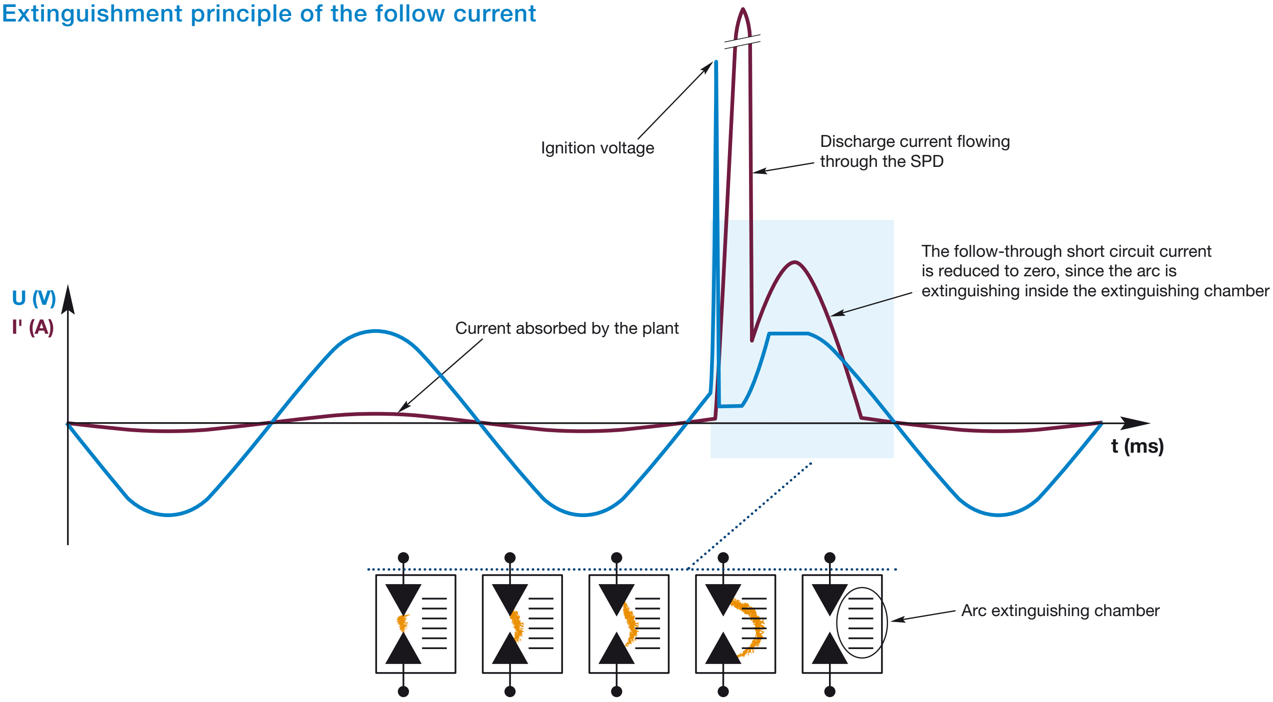
1 - Level of protection with the intervention of the electronic device
2 - Level of protection without the intervention of the electronic device
3 - Advanced ignition of the electric arc



Extinguishing of the electric arc (follow current) in the arc extinguishing chamber

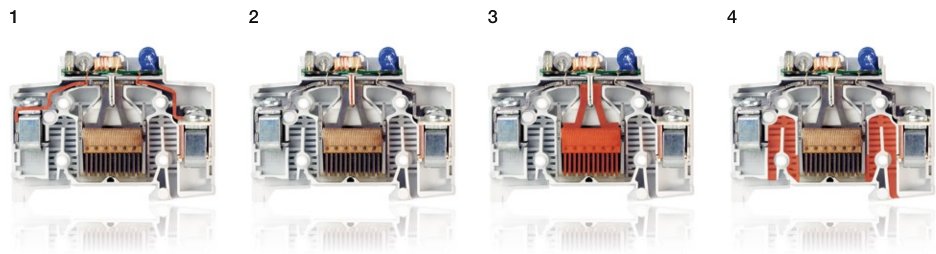
After that the voltage surge has been discharged by the SPD, the mains voltage persists at the electrodes; in the absence of suitable extinguishing systems, the arc would tend to remain (follow-through short circuit). The follow-through current tends to reach the short-circuit current at the installation point of the SPD, generally high at the origin of the system. The arc extinguishing chamber has the function of extinguishing the arc and interrupting the follow-through short circuit, even for high values.
The maximum short circuit current that a SPD is able to interrupt without the operation of a disconnector is known as follow current interrupting rating, I_{fi}.
If the SPD is not able to extinguish the arc itself, the current reaches the system short-circuit current intensity I_{sc} and the upstream back-up fuse cuts in.

Extinguishment principle of the follow current



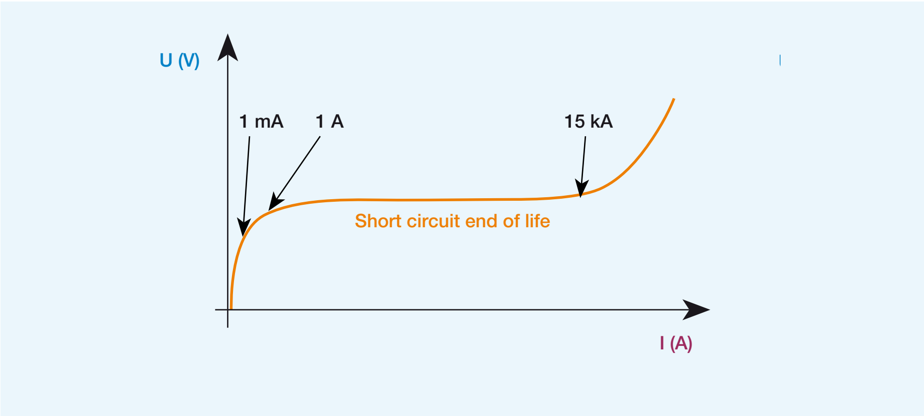
How does a Class 1 OVR T1 SPD work?

1 The discharge reaches the terminals of the SPD and is detected by the electronic device.
2 Thanks to the active intervention of the electronic device, the electric arc is ignited in advance.
3 The electric arc flows through the electrodes and is directed into the arc chamber to be extinguished.
4 The hot ionized gas flows in the special cooling conduits, preventing the risk of fire.

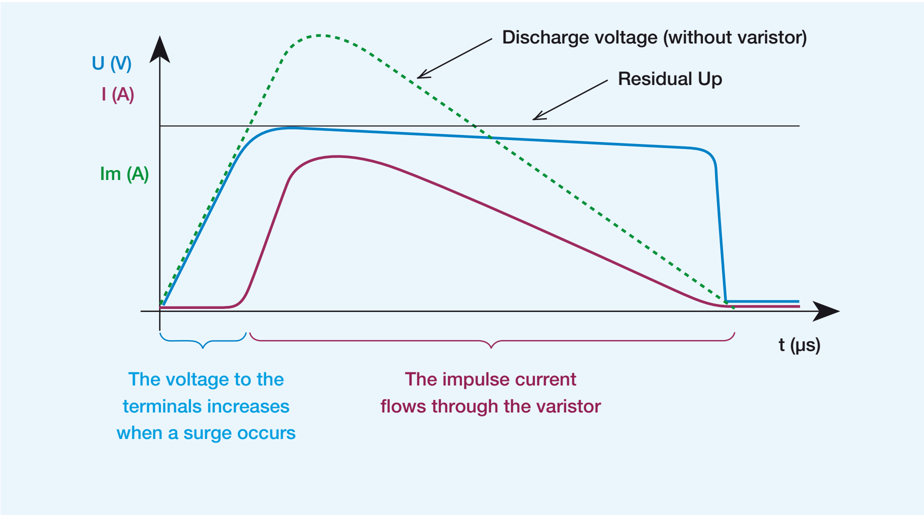


Varistor SPDs

Varistors are components which have their impedance controlled by the voltage, with a characteristic continuous but not linear "U in function of I". SPDs based on varistors, also known as voltage limiting, are characterized by a high impedance when there is no surge present (normally above 1 MΩ). When a surge occurs, the varistor's impedance falls rapidly below 1 Ω within a few nanoseconds, allowing the current to flow. The varistor regains its isolation properties after discharging the surge. A peculiarity of varistors is that a negligible current is always flowing through them, know as residual current, I_{PE} (100 to 200 µA).



Characteristic continuous U as a function of I for a varistor 1 kA.



Operation of a varistor SPD in case of voltage surge.

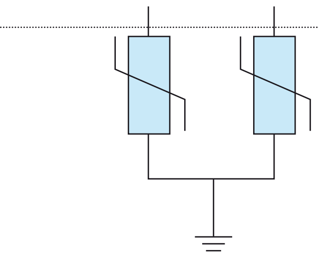
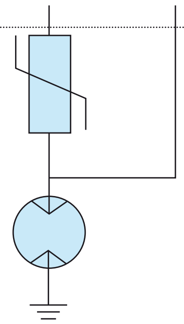
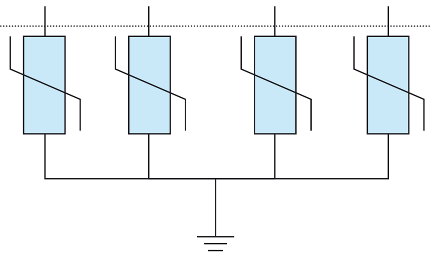
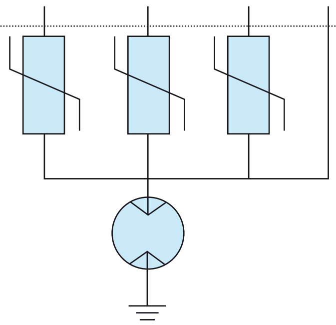
General information on SPDs
Comparison between spark gaps and varistors

The main characteristic of spark gaps is their capacity to manage large quantities of energy from direct lightning strikes, while varistors have a very low level of protection (therefore high-performance) and are fast acting. We will now examine the difference between the two technologies.

	Varistor	Spark Gap
Isolation properties	A varistor, although it presents a very high impedance at rest, always has a minimal continuous current, I_c, flowing through it (e.g. 0.5 NA). This current tends to increase as the varistor wears, until it reaches high levels. For this reason, Varistor SPDs must always be protected against short circuit and cannot be used for N-PE connection upstream of the RCDs. + include an internal protection that guarantees a safe end of life	A spark gap is a true open circuit when at rest, ensuring that there is no current flow at all either in normal operating conditions or when it reaches the end of its life; for this reason a SPD may be installed upstream of an RCD (therefore protecting it from the flow of impulse or discharge current) only if the connection between the active conductors and earth provides for a spark element.
Resistance when conducting	Even in the discharge phase, the resistance remains appreciably greater than zero, limiting the possibility to reduce the surge overvoltage to 3-4 times the rated mains voltage.	When the arc is ignited, the resistance becomes negligible.
Response time	Very rapid, a few nanoseconds	Generally slow, but accelerated by the electronic device.
Ignition / limiting voltage	Low, thanks to the fast response time	Generally high, thanks to the excellent insulating properties of the air, but reduced with the aid of the electronic device.
Extinction of the short-circuit	Varistors are not characterized by a follow-through short circuit current, as their impedance returns to very hight values as soon as the surge ceases.	SPDs with spark gap technology must necessarily be designed in a way that enables the interruption of the follow current (such as an arc extinguishing chamber).
End-of-life	A varistor progressively loses its isolating performance; at the end of its life it can therefore become a low impedance short-circuit.	A spark gap is no longer able to ignite the arc at the end of its life, due to the wear of its electrodes or because the electronic ignition circuit has faded. It therefore becomes a permanently open circuit.
Need for back-up protection	Back up protection is necessary in order to ensure short circuit end of life safety. In case of short circuit end of life of the varistor the thermal disconnector is generally not able to open the circuit.	Back-up protection is to be provided for in all cases to ensure safety in the case of a fault with the SPD and to interrupt the electrical arc if the short-circuit current in the installation point is greater than the SPD's performance for interrupting the short-circuit follow-through current ($I_{sc}>I_f$).

From the comparison between varistors and spark gaps it emerges that each has its own benefits and disadvantages. As a consequence, the best results are obtained, where possible, by combining the benefits of both technologies using "combined technology" SPDs.

The Class 2 OVR T2 SPDs are available with combined technology to obtain maximum performance from both types of component.

Poles	Varistor technology, classic set-up	Combined varistor + spark gaps-to-earth technology, optimum solution
1P+N		
3+N		
	Layouts only possible in TN-S Systems. Common Protection.	Layouts obligatory for TT systems and recommended in TN-S systems. Thanks to the insertion of a spark-gap to earth, the SPDs can be installed upstream of the RCD to protect it and prevent unwanted tripping.

The combined varistor + spark gap solutions are suitable for protecting TT and TN-S networks against indirect lightning strikes; ABB therefore offers multi-pole versions for each use.

General information on SPDs
SPD classes and uses

The effects and consequences of direct and indirect lightning strikes are different, and so two different devices are necessary to completely protect the system.

All SPDs are tested by subjecting them repeatedly to current and voltage impulses. A SPD tested with a 10/350 μs waveform takes the name of Type or Class 1, while a SPD tested with 8/20 μs waveform takes the name Type or Class 2.

Type or Class	Class 1	Class 2	Class 1 and Class 2
Tests	Tested with 10/350 μs impulses.	Tested with 8/20 μs impulses.	Tested both with impulse currents of 10/350 μs waves and discharges of 8/20 μs waves.
Use	Protect against impulse currents from lightning which enter the system directly, for example through the lightning rod or the aerial electricity lines.	Protect against surges induced by lightning hitting the building or surrounding area and from surges resulting from operations on the electricity grid.	Protect against both direct and indirect lightning strikes. Used in small systems containing sensitive equipment (e.g. telecommunications).
Composition	Usually with spark-gaps or power varistor.	Usually with varistors, combined versions (varistor + spark gap) may be installed upstream of the RCD.	Usually combined technology (varistor + spark gap)
Installation point	Installed at the origin of the system.	Installed in all electrical switchboard of the plant, near sensitive equipment.	Installed in a reduced space at the origin of the plant, near delicate equipment.

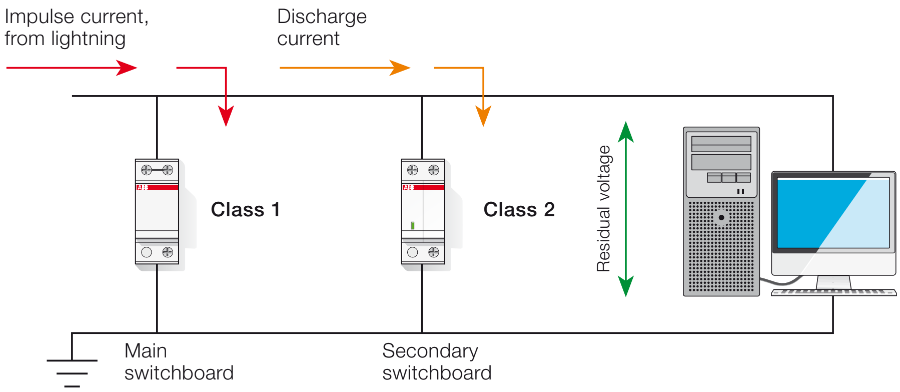
Class 1 and Class 2 SPDs are complementary, ensuring protection from the origin point of the plant right up to the terminal devices.

Class 1 SPDs protect from direct lightning strikes, with the ability to divert a large quantity of energy. They allow only a small part of the impulse current into the system, which must be managed by finer (Class 2) protection devices. A Class 2 SPD must be installed downstream of the Class 1 SPDs to protect sensitive equipment.

The Class 2 SPDs protect against indirect lightning strikes, designed to protect from a large number of discharges, quickly and with a high level of protection. They must be installed near the equipment to be protected.

Example of protecting a system with Class 1 and and Class 2 SPDs

Level of protection
<
Equipment impulse withstand voltage
=
Ensured protection



General information on SPDs
SPD terminology

Surge Protective Device (SPD)
A device designed to limit transitory overvoltage surges and to divert impulse currents away. Also known as limiters, they include at least one non-linear (non ohmic) component.
The international reference standards are IEC EN 61643-11 e IEC 61643-1.

10/350 μs waveform:
Standardized current waveform; it flows through the equipment at the moment it is summited to a direct lightning strike.

8/20 μs waveform:
Standardized current waveform; it flows through the equipment at the moment it is subjected to an indirect lightning strike.

1.2/50 μs impulse voltage
Standardized voltage waveform, it is added to the rated mains voltage.

Type 1 surge protective device (SPD)
Surge protective device designed to divert the energy associated to a direct lightning strike or an operation on the electricity grid. The test parameter is the discharge current represented by a 10/350 μs waveform (test class I).

Type 2 surge protective device (SPD)
Surge protective device designed to discharge the energy associated with an indirect lightning strike or an operation on the electricity grid. The test parameter is the discharge current idem 8/20 μs waveform (test class II).

I_{imp}: impulse current for test class I
This is the discharge current with 10/350 μs waveform that the device is able to divert towards earth or the network at least one time, without deterioration. It is used to classify the surge protection devices in test class 1 (the 10/350 μs waveform corresponds to this definition).

Why is I_{imp} important?

IEC 62305 standard requires a maximum impulse current value per pole of 25 kA. To ensure protection in any installation, the SPD must be correctly sized for the maximum current provided for. Be careful not to confuse the current per pole (25 kA) with the total current (100 kA for a 3P+N network).

General information on SPDs
SPD terminology

I_n: rated discharge current for test class II

This is the discharge current with 8/20 μs waveform that the Class 2 SPD is able to divert (towards earth) at least 20 consecutive times, without deteriorating.
It is used to determine the SPD's level of protection, U_p. It is at this I_n value the level of protection value (U_p) is measured.

Why is I_n important?

By law, a SPD with I_n of at least 5 kA may be installed in any system, even in areas with high frequency of lightning strikes.
In any case, it is better not to scrimp on the I_n: the higher it is, indeed, the longer the life of the SPD will be.

I_{max}: maximum discharge current for test class II

Peak value of the maximum discharge current with 8/20 μs waveform that a Class 2 SPD is able to withstand at least once.
I_{max} is, in general, much greater than I_n .

Why is I_{max} important?

The difference between I_{max} and I_n indicates when the SPD is working, in nominal conditions, near its limits.
The higher the I_{max} is, for the same I_n, the safer the SPD is working, far away from its performance limits.

U_n: rated voltage

Rated voltage of the mains network between phase and neutral (RMS AC value).

U_c: maximum continuous voltage (IEC 61643-1)

Maximum voltage to earth that the SPD is able to permanently support without either cutting in or deteriorating.

U_T: resistance to TOV (Temporary Overvoltage)

Maximum RMS or DC voltage which the SPD can be subjected to which exceeds the maximum voltage for continuous operation U_c for a specific and limited time (generally 5 s).

Ng: lightning density

Expressed as number of times lightning strikes the ground per km^2 per year.

Protection mode

Common mode (MC): protection between the active conductors (phase and neutral) and earth.
Differential mode (MD): protection between the active conductors.

I_{fi}: follow-through current

Current, supplied by the electrical supply grid, which flows through the SPD following an impulse current.

I_{fi}: rated interruption value of the follow-through current

Presumed short-circuit current that a SPD is able to interrupt on its own.

U_p: voltage protection level

It characterizes the ability of the SPD to limit the voltage between its terminals in the presence of a surge; the value of the protection level, selected from a list of preferential values, is greater than the most elevated residual voltages measured in the Test Class I or II.

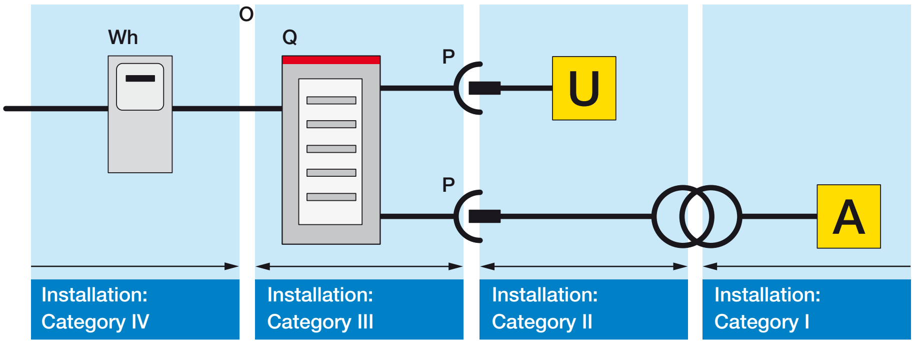
Protection level U_p and residual voltage U_{res}

The residual voltage U_{res} is the value of the voltage at the terminals of the SPD when it is subject to the passage of an electric discharge. There is a U_{res} value for each impulse or discharge current value. The only valid value, both from the point of view of design and of the choice of SPD is U_p, the level of protection. The U_p value is obtained by discharging a current of I_{imp} (for Class 1) or I_n (for Class 2). Other residual voltage values have no value in planning and cannot be used as a parameter for choosing the SPD.

The protection voltage U_{prot} is the sum of the level of protection U_p of the SPD and the voltage drops across the connections (see further information on page 85).

U_W: equipment impulse withstand voltage

The tolerance of equipment to overvoltage surges is classified according to 4 categories (as indicated in the following table), pursuant to IEC 60364-4-44, IEC 60664-1 and IEC 60730-1.



O = origin of the installation; Wh = electricity meter; Q = main electrical switchboard;
P = electric socket; U = end-user electrical equipment; A = electronic equipment

Category	U_n				Examples
	120-220 V	230-400 V	400-690 V	1 000 V	
I	800 V	1 500 V	2 500 V	4 000 V	Equipment containing particularly sensitive electronic circuits: – Servers, computers, TVs, HiFis, videos, alarms etc. – Household appliances with electronic programs etc.
II	1 500 V	2 500 V	4 000 V	6 000 V	Non-electronic household appliances, devices etc.
III	2 500 V	4 000 V	6 000 V	8 000 V	Distribution switchboards, switching devices (switches and circuit breakers, sockets, insulators etc.), conduits and accessories (wires, bars, junction boxes etc.)
IV	4 000 V	6 000 V	8 000 V	12 000 V	Industrial equipment and equipment such as, for example, fixed motors connected permanently to fixed systems, electricity meters, transformers etc.

The golden rule

The SPD's level of protection U_{prot} must always be less than the impulse withstand voltage U_w of the equipment to be protected.

For example, in a main switchboard (400 V three-phase), protection of category III equipment is ensured if the U_{prot} value is less than 4 kV. An OVR T1 SPD protects the equipment thanks to its low protection level (2.5 kV),

In the secondary switchboards, protection of the category II equipment requires the installation of a Class 2 SPD, or eventually a Class 1, with low U_p protection level (1.5 kV).

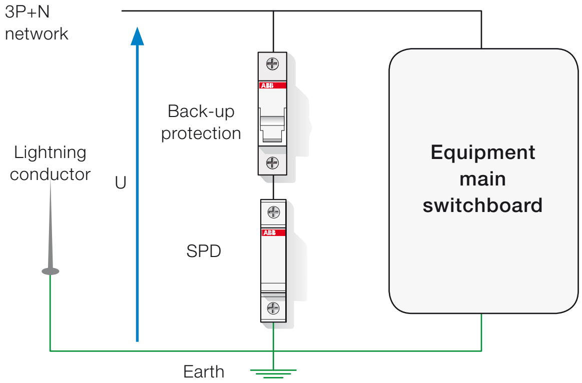
For example, for a Type 2 SPD installed near terminal equipment (Category II) in a 230 V single-phase network, the level of protection (U_{prot}) must be chosen so that the sum of the U_p and inductive voltage drops on the connections is less than 2.5 kV.

SPD terminology

The technical terminology outlined above is referenced in the following designs which illustrate the different stages of operation of Class 1 and 2 SPDs in a standard installation.

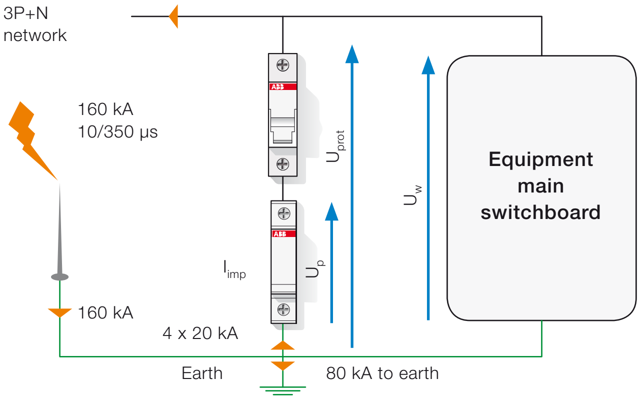
Class 1 SPDs: Standard operation

U: U_n rated network voltage (230 V between phase and earth)
U_C maximum continuous operating voltage of SPD (255 V between phase and earth)
U_T resistance to temporary overvoltage (TOV) of the SPD



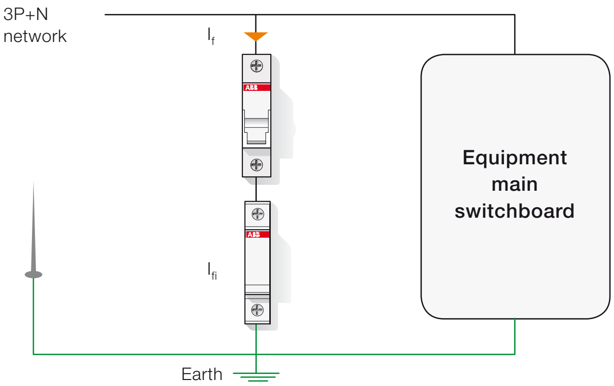
Direct lightning strike on external LPS

I_{imp}: lightning current per pole of the SPD (25 kA).
I_{imp} > discharge current per pole, 20 kA
U_p: level of protection of the SPD, 2.5 kV
U_{prot}: level of protection of the SPD + voltage drops on the connections U_{prot} = 3 kV with short connections
U_w: Impulse withstand voltage of the equipment, 4 kV (category III)
$U_w > U_{prot}$, the equipment is protected



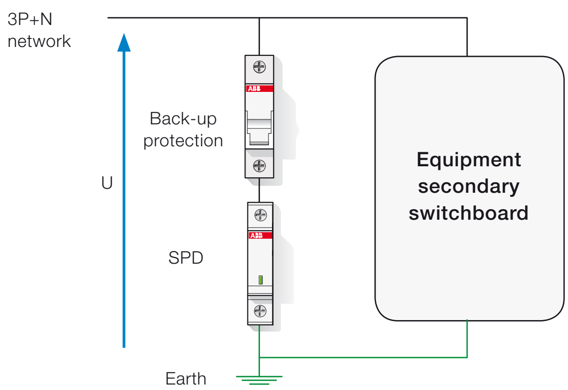
Extinguishment of discharge follow-through current

I_f: Follow-through short-circuit current
I_{fi}: Rated follow-through current interruption value of the SPD
$I_{fi} > I_f$, the electric arc is safely extinguished inside the SPD. Protection against direct lightning strikes has been ensured.
The passage of the lightning current creates an indirect lightning strike in the surrounding area, dealt with below.



Class 2 SPDs:
Standard operation

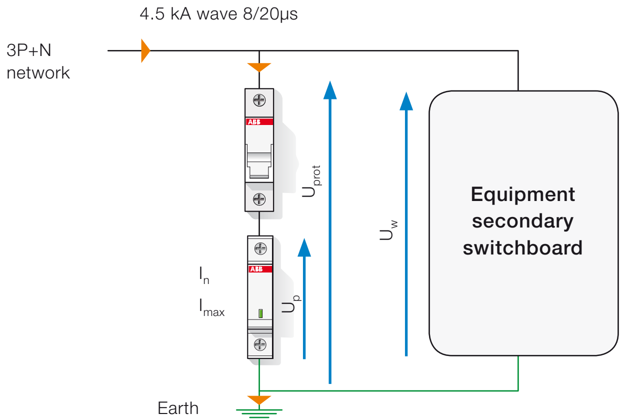
U: U_n rated network voltage (230 V between phase and earth)
U_C maximum continuous voltage of SPD (255 V between phase and earth)
U_T resistance to temporary overvoltage (TOV) of the SPD



Indirect lightning

I_n: nominal discharge current of the SPD (20 kA).
I_{max}: maximum discharge current of the SPD (40 kA).
I_n > discharge current, 4.5 kA
U_p: level of protection of the SPD, 1.4 kV
U_{prot}: level of protection of the SPD + voltage drops on the connections
U_{prot} = 1.9 kV with short connections
U_w: Impulse withstand voltage of the equipment, 2.5 kV (category II)
$U_w > U_{prot}$, the equipment is protected

The SPD's insulation properties are automatically restored after the passage of the discharge.



The product designs are simplified in these two pages. In the case of a 3P+N network the SPD and fuse holder are multi-pole.

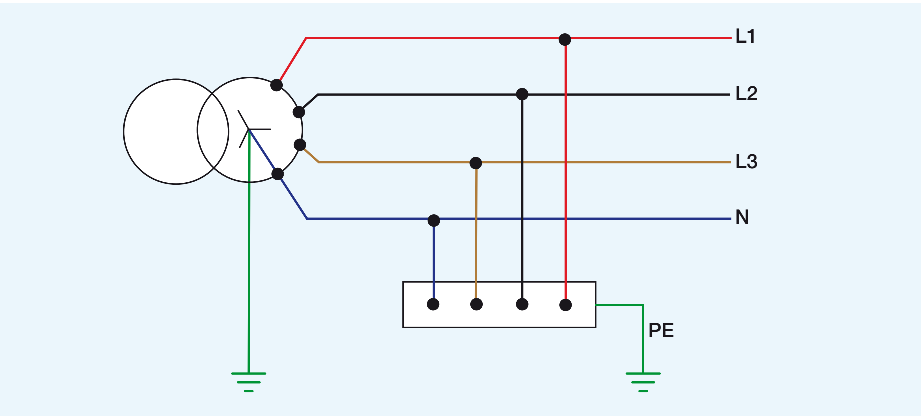
General information on SPDs
Earthing systems

The earthing system describes the connection to earth of the electrical system and its equipment earths.

All devices installed in an electrical supply system must ensure protection of people and equipment.

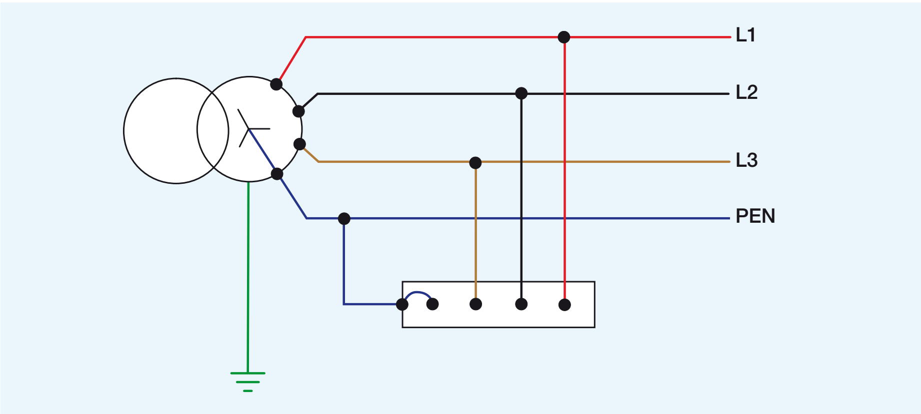
Four earthing systems exist, differentiated by:
– Connection of the neutral to ground
– Connection of the exposed conductive parts (equipment earthing) to earth or neutral.

Earthing system	Neutral connection	Connection of earths
TT	Neutral connected to earth	Earths connected to an earth collector
TN-C	Neutral connected to earth	Earths connected to neutral
TN-S	Neutral connected to earth	Earths connected to protective conductor
IT	Neutral isolated from earth or connected to earth via an impedance	Earths connected to an earth collector



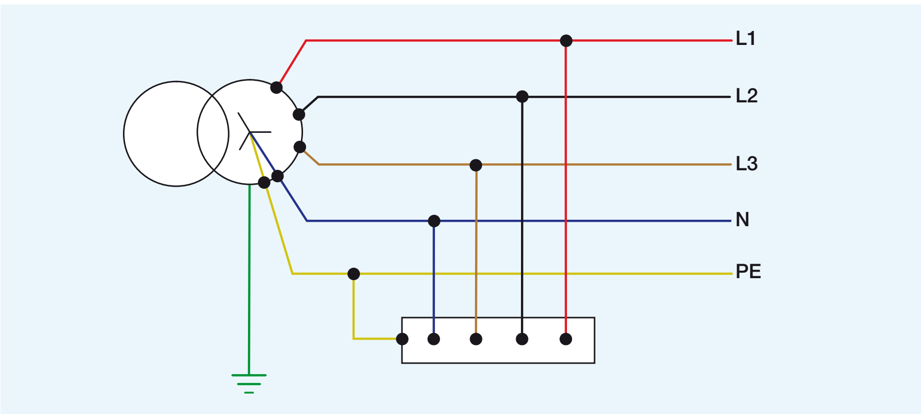
TT System

The electrical supply neutral is connected to earth. The exposed conductive parts of the system are connected to an earth bar (this can be a separate earth bar, or else the bar which the neutral is earthed to).



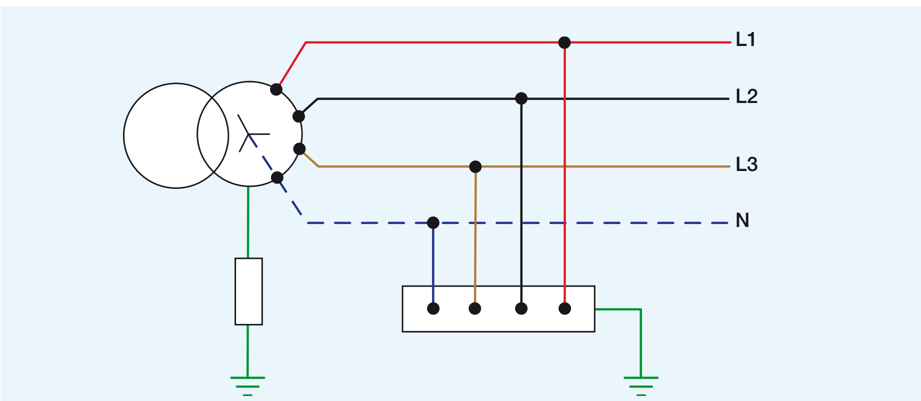
TN-C system

The electrical supply neutral is connected to earth. The neutral conductor and the protective conductor are the same conductor: PEN.



TN-S system

The neutral and the protective conductor are separate and connected to the same earthing system.



IT System
(isolated neutral or else earthed via an impedance).

The neutral may be isolated from earth, or else connected to it via an impedance
(from 1 000 to 2 000 ohms)

General information on SPDs
Earthing systems

The choice of the earthing system depends on:
– Operational conditions
– Maintenance methods and requirements

Is continuity of service a priority?	
Yes	**No**
Isolated neutral (IT)	Isolated neutral (IT) Neutral connected to earth (TT) Distributed neutral (TN)
This is the safest system for avoiding interruptions to the power supply. Some examples are industrial environments and hospitals.	The choice of system depends on a careful exam of: – Characteristics of the system and complexity of implementing each type of earthing system – Operational and installation costs of each type of earthing system

The earthing system may be imposed by the electricity company:
– TT, for residential customers, small offices and small tertiary service plants
– IT, used in the case where continuity of service is required: hospitals, public buildings.

Earthing systems	
System type	**Recommended**
Large network with few equipment earths	TT
Network located in an area subject to thunderstorms	TN
Grid supply from aerial electricity lines	TT
Backup or emergency generator	IT
Loads with reduced insulation (ovens, kitchens, welding equipment)	TN
Portable single-phase loads (drills, grinders)	TT or TN-S
Machines for handling, hoisting, conveyor belts	TN
Large amount of auxiliary equipment, machine tools	TN-S
Buildings at risk of fire	IT or TT
Construction sites (unreliable earthing)	TT
Electronic/computer equipment	TN-S

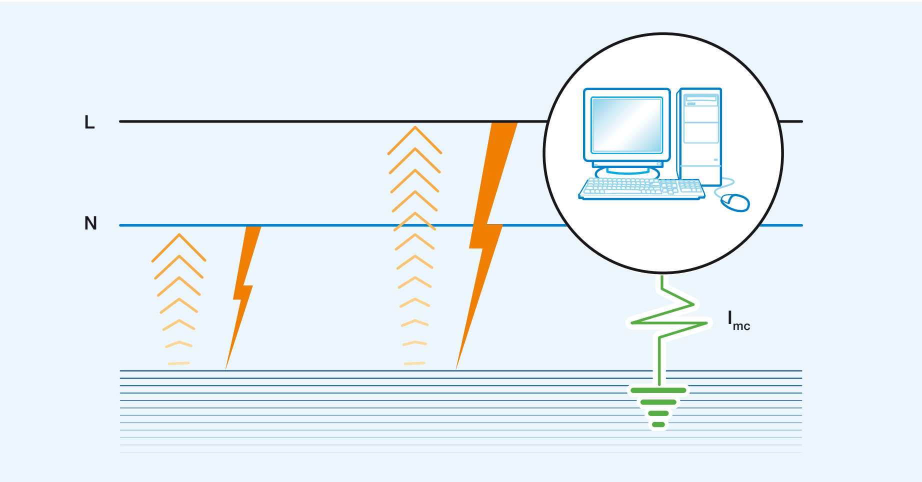
ABB's range of SPDs covers all requirements, for all earthing systems.

General information on SPDs
Protection methods

Surges in electrical systems are classified by category, may be common, differential, or a combination of both.

Common mode

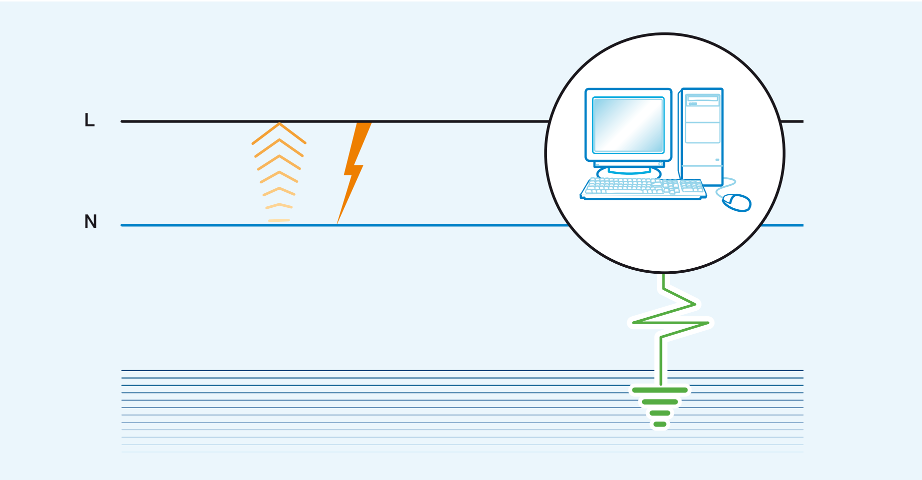
Common mode overvoltages occur between the active conductors and earth, for example phase-earth or neutral-earth.
Active conductor here means both the phase conductors and the neutral conductor. This overvoltage mode destroys equipment connected to earth (class I equipment), but also equipment not connected to earth (class II equipment) located near an earth and with insufficient electrical insulation (few kV). Class II equipment not positioned near an earth is, in theory, protected against this type of aggression attack.



Note:
Common mode overvoltages have an effect on all earthing systems.

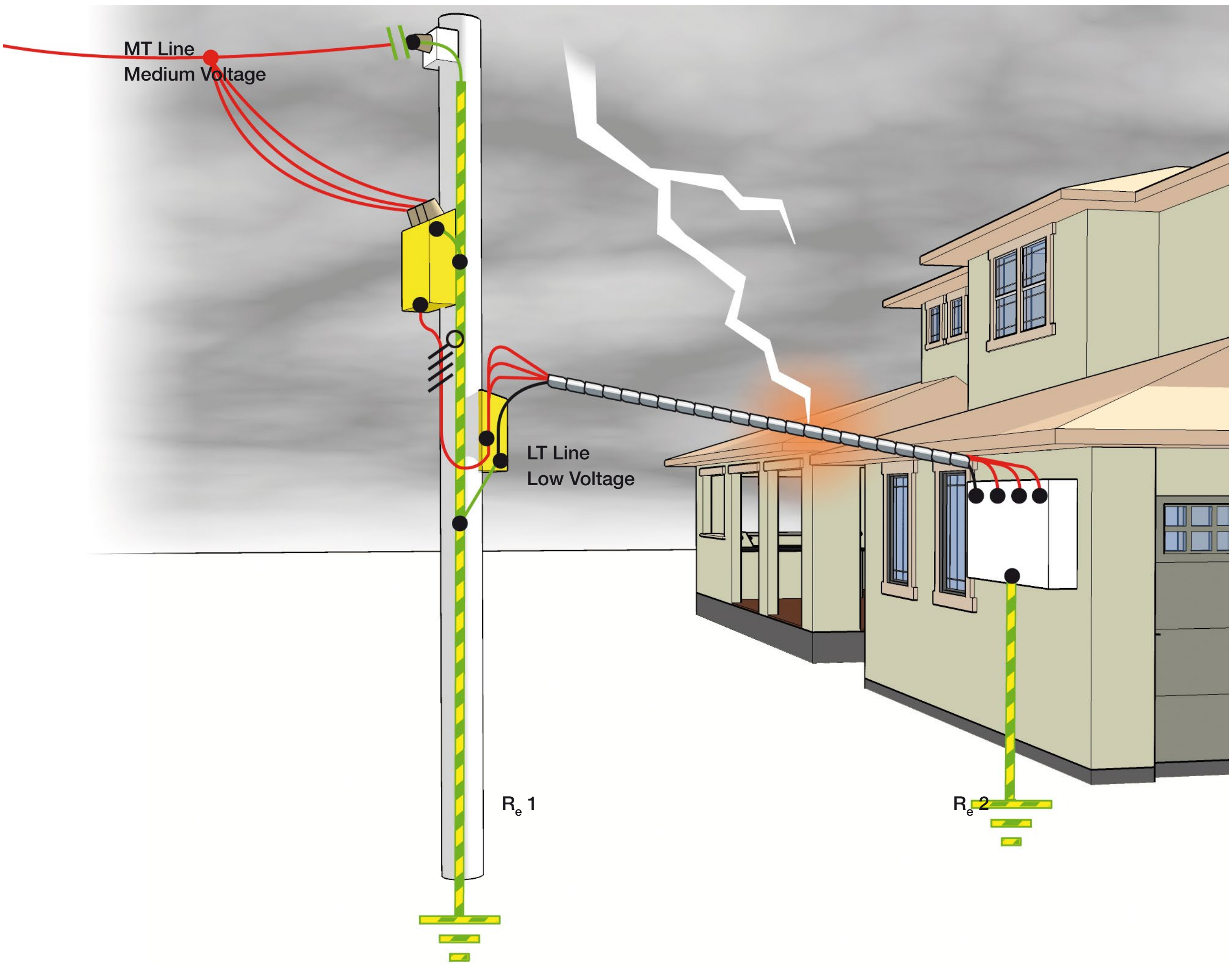
Differential mode

Differential mode overvoltages occur between the active conductors: phase-phase or phase-neutral. These overvoltages have a potentially damaging effect on all electrical equipment connected to the electrical network, above all sensitive equipment.



Note:
Differential mode overvoltages occur in TT earth systems because the cables follow different paths.
They can also occur in TN-S earthing systems whenever there is a noticeable difference between the length of the neutral and the protective (PE) cables.

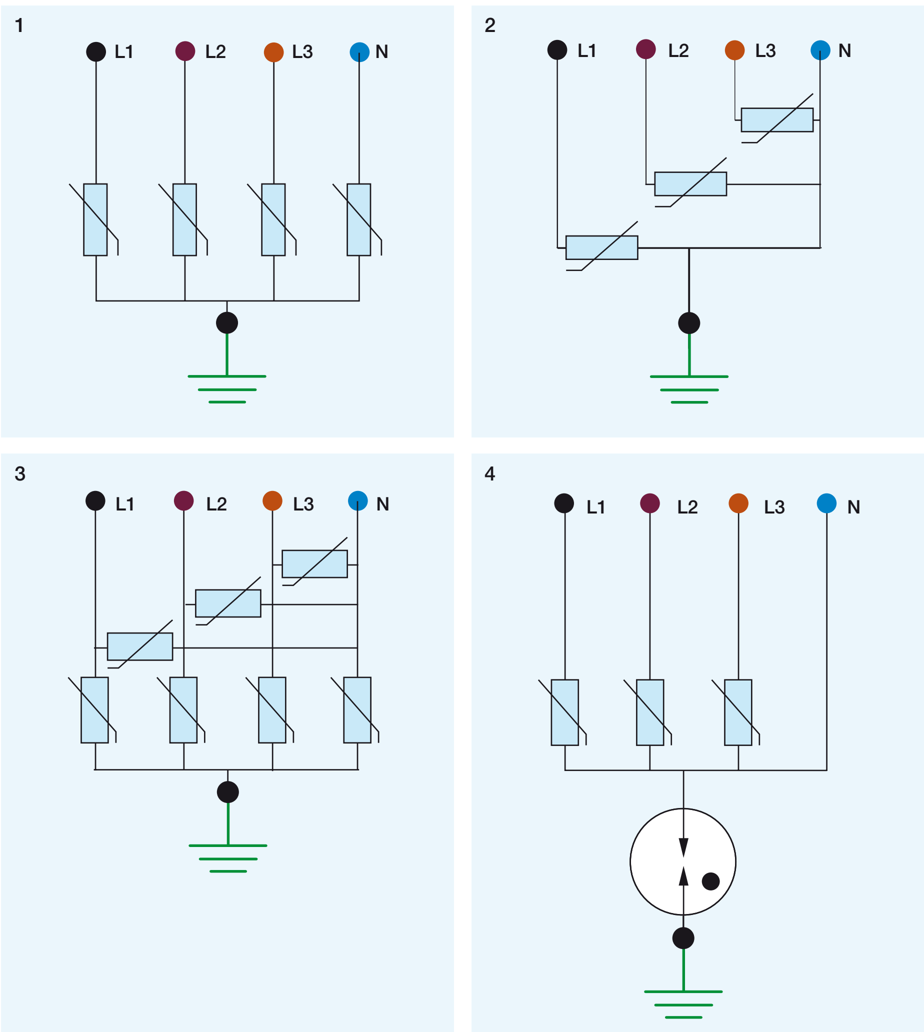
"Surges caused by a lightning strike inevitably generate common mode voltages" and may also generate differential mode voltages. The solution ensuring maximum safety consists of using protective devices which allow a combination of common and differential mode; most SPDs developed by ABB are made this way.



Protection from overvoltages in common and differential mode (MC/MD)

Non-linear components, such as varistors and spark gaps, are used to stop overvoltage surges reaching equipment.

The combination of one or more non-linear components allows common mode protection, differential mode, or a combination of both, of the internal electrical scheme or the wiring of the equipment.
Diagrams of electrical connections are given below based on the protection mode.



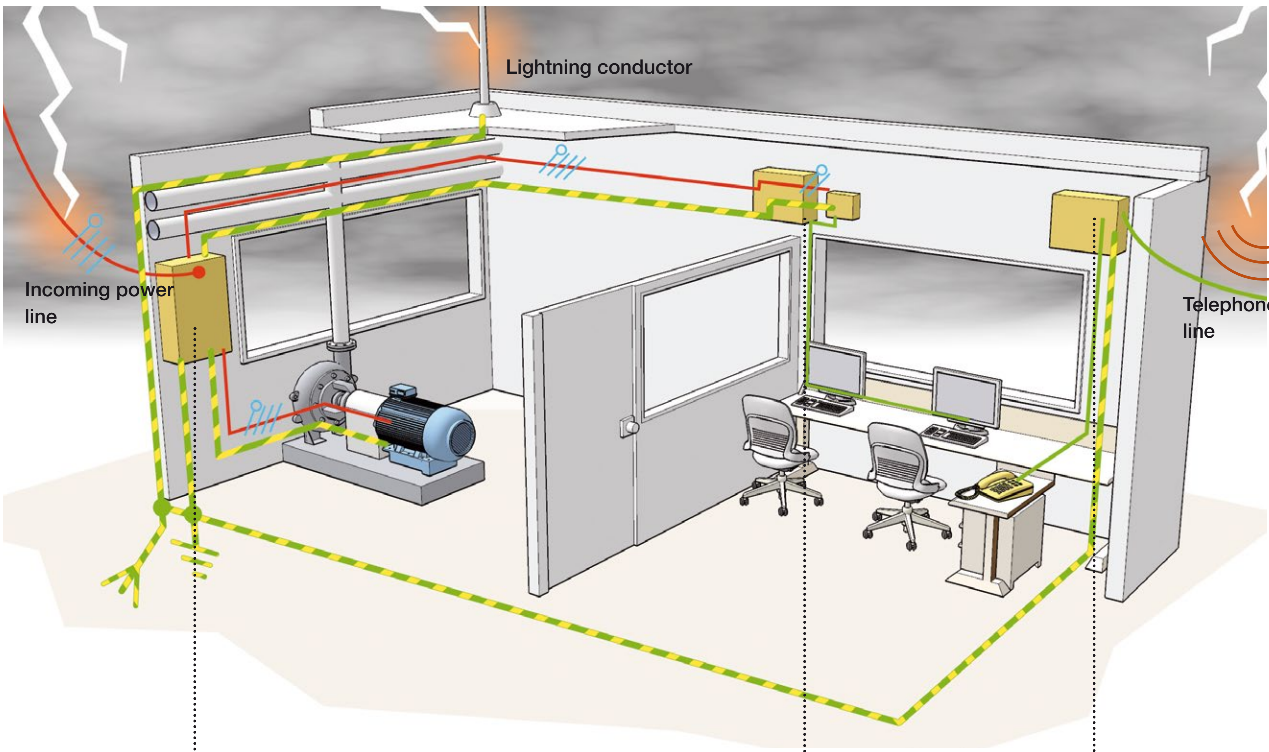
1. Protection from surges in common mode (MC)
2. Protection from surges in differential mode (MD) (Schematic not applicable, phase and earth are in contact).
3. Protection from surges in common and differential mode (MC/MD)
4. Protection from surges in common and differential mode (MC/MD), with gas spark gap to earth. No current flows to earth at the rated voltage.

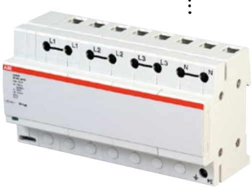
Only 1 and 4 schematics are used.

Surge protective devices
General diagram of an installation protected against direct and indirect lightning strikes

Global protection of this installation fitted with a lightning conductor is performed with a Class 1 SPD to protect against direct lightning strikes (OVR T1), by a Class 2 SPD (OVR T2) to protect against indirect lightning strikes and by a dedicated SPD on the data lines (OVR TC)

The Type 1 SPD (OVR T1), installed in the main electrical switchboard at the origin of the system, is able to direct the current of a direct lightning strike to earth or to the network. This is the first level of protection for the electrical supply network. The behavior of the wiring in the presence of an impulsive phenomenon limits the effectiveness of the upstream SPD to 10 m. It is therefore necessary to use one or more protective devices downstream in order to obtain the required level of protection for the terminal equipment.
As such, it is appropriate to use a Type 2 SPD (OVR T2) co-ordinated with the protective device at the system origin. This is the second level of protection. Finally, whenever there is a risk of overvoltages on the electrical network, this risk also exists for the auxiliary and data networks. Appropriate protection consists of a SPD designed to protect the telephone or data lines (OVR TC).





Main electrical switchboard
Protection of equipment (machinery)
OVR T1 Type 1 SPD
3N 25 255 TS

Secondary distribution switchboard
Protection of terminal equipment (power supply for computers, etc.)
OVR T2 Type 2 SPD
3N 40 275 s P TS

Protection of the telephone network
OVR TC

Surge protective devices
How to choose a SPD

The choice of the SPD depends on a series of criteria defined in the phase of assessing the risk of lightning strikes, allowing the surge protection requirements to be identified.

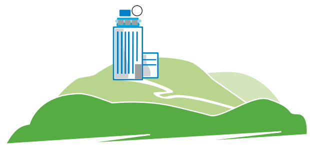
When is it necessary to provide for protection?
First of all, the requirements of the standards must be considered; to the analysis of these we can add recommendations based on ABB's industrial experience.
The criteria taken into consideration in this section consist of assessing the risk of a direct lightning strike on or near a building, including the financial aspect caused by equipment which may be damaged and temporary loss of operational capacity. Even in the case that protection is not indispensable, it is as well to note that, considering that a zero risk does not exist, it is always a good idea to provide a protection.

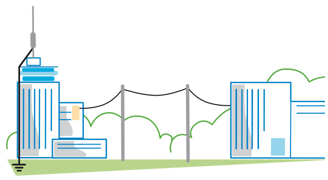
In the case that protection against lightning strikes is recommended, it is sufficient to choose the appropriate product and install it.
The choice of the SPD is based
on different elements:
– The type of lightning strike, direct or indirect
– protection level U_p;
– The discharge capacity: I_{imp} or I_n (10/350 µs or 8/20 µs impulse wave);
– The network's earthing system;
– The operating voltages (U_c and U_T).
– Options and accessories (end-of-life indicator, pluggable cartridges, safety reserve, remote signaling).

Surge protective devices
How to choose a SPD

Recommendations for the use of SPDs

Environmental criteria

			
Context	**The building has a LPS**	**Ng > 2.5 and aerial electricity lines**	**Building located in a mountainous area**
ABB's installation recommendations	SPD strongly recommended	SPD strongly recommended	SPD recommended
Type of SPD	Type 1	Type 1 or Type 2	Type 1 or Type 2 (70 kA)

			
Context	**Element greater than 20 m height less than 50 m from the building to protect**	**Less than 500 m in a straight line separate the LPS and the main electrical switchboard of the building to be protected**	**Less than 50 m of distance separate the lightning rod from the building to be protected**
ABB's installation recommendations	SPD recommended	SPD recommended	SPD recommended
Type of SPD	T1 or T2	T1 or T2	T1 or T2 (70 kA)

Operational criteria

Selection criteria	**Recommended**	**Particularly recommended**	**Absolutely recommended**
Priority to operational continuity (for cost reasons to avoid operational losses, safety reasons etc.):			
- Industrial plants, offices, banks, airports, police stations, pharmacies, surveillance systems etc.;			●
- Hospitals, old-people's homes, dialysis centers.			●
Protection priority of the equipment			
- High value > 150 000 euros			●
- Medium value > 15 000 euros		●	
- Low value > 150 euros	●		
Frequency of lightning strikes in the region			
- Ng ≤ 2.5		●	
- Ng > 2.5			●
Isolated area			●
Type of electricity supply lines powering the building			
- Aerial lines		●	
- Underground lines	●		

Frequent and repeated overvoltage surges due to lightning strikes cause large economic losses greater than the cost of installing the system to protect against overvoltage surges.

The cost of the protection is often low compared to the cost of the equipment to protect.

Choosing the type of protection according to the supply network

Overvoltages occur in common and differential mode, or only in common mode, depending on the type of earthing system.

	TT	TN-S	TN-C	IT with N	IT without N
Common mode	Yes	Yes	Yes	Yes	Yes
Differential mode	Yes	Yes(1)	No	No	No

Note:
For each network configuration it is easy to identify the suitable multi-pole protection.

1) In the case that there is a considerable difference between the length of the neutral cable and that of the protective cable (PE).

The choice of the operating voltage is fundamental when selecting a SPD

Two voltage characteristics exist for a SPD: U_c and U_T.
It is essential that SPDs, in combination with their switching devices, are able to resist a temporary overvoltage at 50 Hz without any change of their characteristics or operation. For an electrical network (phase/neutral) at 230 V, this overvoltage is defined as follows:

U_C: Maximum continuous voltage
U_T: Resistance to temporary overvoltages (TOV)

U_T for 5 seconds (+ 0/–5%).

It is fundamental that the U_T values are chosen in conformity with the table given below, according to the type of earthing system.

Connection of the SPD	Earthing system of the network conform to IEC 60364-4-442									
	TT		TN-C		TN-S		IT (distributed neutral)		IT (non-distributed neutral)	
	U_c	U_T	U_c	U_T	U_c	U_T	U_c	U_T	U_c	U_T
Between phase and neutral	253 V	334 V	N.A.	N.A.	253 V	334 V	253 V	334 V	N.A.	N.A.
Between phase and PE	253 V	400 V	N.A.	N.A.	253 V	334 V	400 V	N.A.	400 V	400 V
Between neutral and PE	230 V	N.A.	N.A.	N.A.	230 V	N.A.	230 V	N.A.	N.A.	N.A.
Between phase and PEN	N.A.	N.A.	253 V	334 V	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

These represent minimum voltages
N.A.: not applicable.

The table also supplies the U_c values corresponding to the maximum continuous operating voltage which the SPDs must be able to manage in a network at a rated voltage of 230/400 V.

Surge protective devices
Choice of I_{imp} and I_n for a SPD

The protection performance of a SPD depends on its technical characteristics and rated specifications on its data plate.
The choice is therefore made on the basis of the accepted level of risk.

Over 99% of lightning strikes are less than 200 kA (IEC 62305-1, Annex A, base values of lightning currents); in the case of a lightning bolt of 200 kA, we can consider that the impulse current on each conductor of a three-phase plus neutral network is 25 kA.

Impulse current I_{imp} for Type 1 SPDs

ABB therefore recommends a minimum I_{imp} of 25 kA per pole for Type 1 SPDs, based on the following calculation:

– Maximum direct lightning current I: 200 kA
(only 1% of lightning discharges are over 200 kA)
– Distribution of the current inside the building:
50% to earth and 50% to the electrical network (according to International Standard IEC 62305-1, Annex D).
– Equal distribution of the current across each of the conductors (3 L + N):

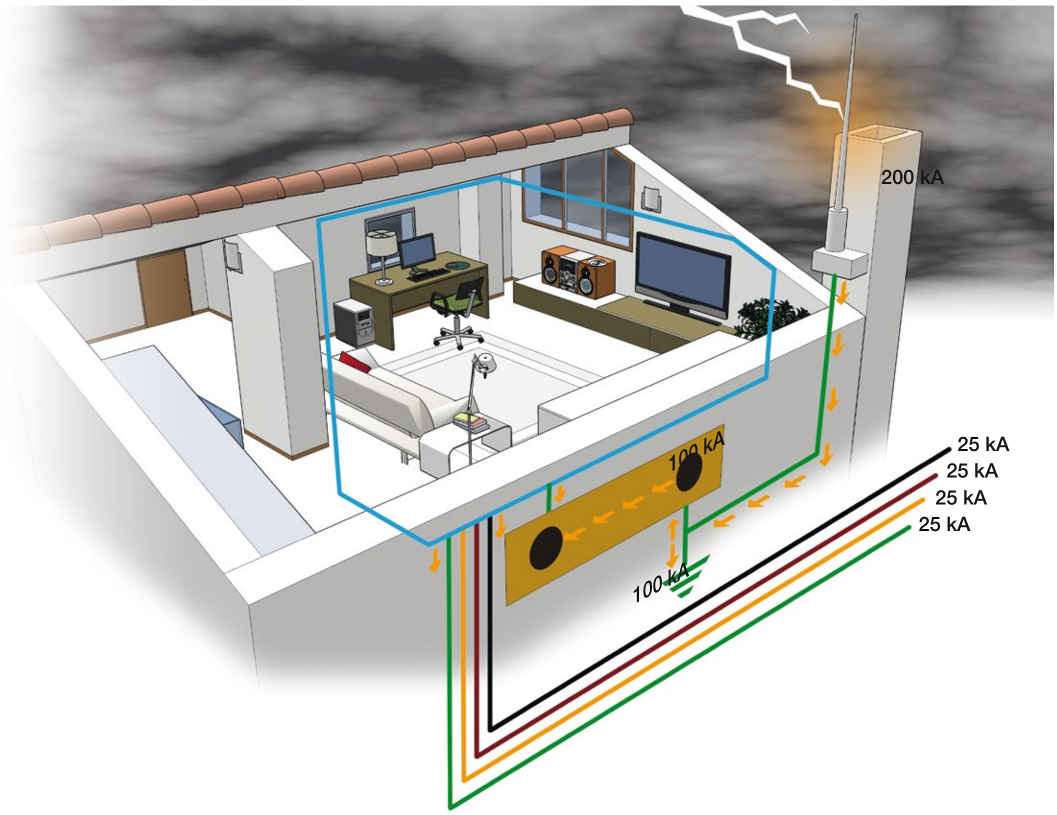
$$I_{imp} = \frac{100 \text{ kA}}{4} = 25 \text{ kA}$$

Rated discharge current I_n for Type 2 SPDs

Note:
ABB defines its Type 2 SPDs on the basis of their maximum discharge current (I_{max}). For a determined value of I_{max} there is a corresponding rated discharge current value (I_n).

	Optimization of I_n for Type 2 SPDs, according to ABB recommendations, on the basis of lightning density data.		
Ng	< 2	2 ≤ Ng < 3	3 ≤ Ng
I_n (kA)	5	20	30
I_{max} (kA)	15	40	70

Note: The lightning current can bring the earth collector to a much higher potential. For example, if the earth resistance is 10 ohms, a discharge current of 50 kA to earth will cause an increase in potential up to 500 kV.



Lifetime of Class 2 SPDs

The duration of a Class 2 SPD, that is to say its capability to operate correctly over time, essentially depends on its resilience

(characterized by its rated discharge current I_n), but also by the quantity of lightning strikes in the vicinity of the system each year.

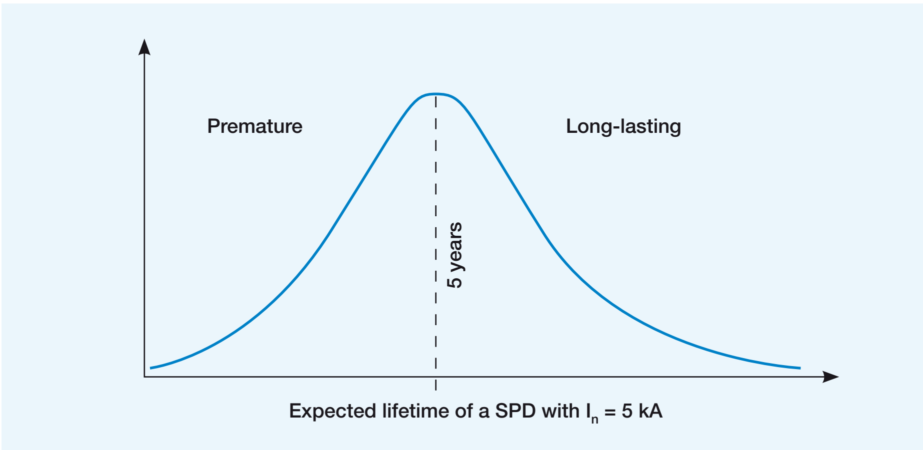
IEC EN 61643-11 provides for a rather complicated functional test for Type 2 SPDs. To summarize, we can state that a SPD is made to survive at least 20 8/20 µs waveform surges at its rated discharge current I_n undamaged.

If the collection area for indirect lightning for a building is, let us assume for simplicity, Am = 1 km^2 and, in the district in which this is installed, the number of lightning strikes per year per km^2 is Ng = 4 lightning strikes/km^2/year and the maximum discharge current expected on the system is 5 kA, a SPD with I_n = 5 kA will have a duration of approximately:

$$\frac{\text{20 discharges}}{\text{Am x Ng}} = \frac{20}{1 \times 4} = \text{5 years}$$

It is obvious that a SPD with I_n = 5 kA, while fully complying with regulations, would have a very short duration, if compared to the expected life of the installation to which it is connected. If several SPDs are installed in the network, given that 5 years is an average lifespan, some SPDs (premature) could already reach the end of their lives in the first few years of the system's operation.
If several SPDs are to be installed, in order to avoid changing cartridges after less than five years, it is advisable to choose a SPD with a safety margin, that is with a higher rated discharge current. Choosing a SPD with a high rated discharge current I_n saves on maintenance and ensures protection for a longer period.

End-of-life probability of a SPD with rated discharge current of 5 kA.



Do not scrimp on I_n

By law, a SPD with I_n of at least 5 kA may be installed in any plant, even in areas with high frequency of lightning strikes. In any case, it is better not to save money by using SPDs with low I_n values; indeed, the higher the I_n, the longer the lifetime of the SPD will be.

The I_n value which gives the best compromise between the cost of the SPD and the cost of subsequent maintenance of the product lies between 15 kA and 20 kA.

Tests in ABB laboratories have determined an average lifespan of at least 20 years for a SPD with I_n 20 kA.

Lifespan of a 20 kA SPD

	I_{max} test		In I_n		Real case		
Overcurrent expected in the system [kA]	**40**	30	**20**	10	**5**	2	1
Number of discharges before end-of-life	**1**	5	**20**	40	**200**	1 000	3 000

The table allows us to see that, in practice, a 20 kA SPD, under the most serious overcurrent conditions at 5 kA, will have an average lifetime of 200 discharges, presumably lasting longer than the average lifetime of the system it is installed in.

ABB also offers Class 2 SPDs with a rated discharge current I_n of 30 kA (with I_{max}=70 kA), with the benefit of doubling the average life and protecting zones with serious risk of lightning strikes (building located in mountainous region, lightning conductor at less than 50 m from the building to protect...)

Solutions for all uses

Protection from direct lightning strikes in electrical networks

Class 1 SPDs - OVR T1

Type 1 SPDs provide input protection for plants in areas with high levels of lightning strikes, and are typically installed in main distribution switchboards to protect against direct lightning strikes.

Benefits of the ABB OVR T1 range:

Wide range
OVR T1 SPDs are available in multi-pole versions to be used in all applications. There are also single-pole versions to be assembled for maximum flexibility.

High impulse current
The impulse current of 25 kA per pole (10/350 µs wave) satisfies all requirements for overvoltage surge protection.

Signaling contact
It is possible to monitor the operational status of the SPD remotely via a 1 A dry exchange contact.

Co-ordination
OVR T1 SPDs are co-ordinated at zero distance from OVR Class 2 SPDs; they can therefore be installed next to each other without decoupling coils, for combined protection against direct and indirect lightning strikes.

Electronic arc ignition device
The early creation of the electric arc by this electronic device reduces the protection level U_p to an optimum value, 2.5 kV.

Extinguishment of the follow-through current
OVR T1 SPDs contain a dedicated arc chamber for extinguishing the electric arcs following through from discharges. Thanks to this the SPD can open short-circuits up to 50 kA without the back-up fuse having to cut in.

Multi-pole versions with "1+1" and "3+1" schemes
Thanks to the "1+1" and "3+1" designs providing for a spark gap to earth, OVR T1 can be installed upstream of the RCD to protect against and prevent unwanted tripping. Combined-mode protection is provided, both common and differential.

Double terminals
OVR T1 allows an input and output cable to be connected for each pole, with a current up to 125 A. They allow connection distances to be reduced to a minimum and avoid bridges.

Combined Type 1 + Type 2 SPDs
These are very compact SPDs which protect both against direct and indirect lightning strikes. They are dedicated to applications where space is very limited (telecoms).

Solutions for all uses
Protection from indirect lightning strikes in electrical networks
Class 2 SPDs - OVR T2

Type 2 SPDs are suitable for installation at the origin of the network, in intermediate panels and by the terminal equipment, protecting from indirect lightning strikes.

Benefits of the ABB OVR T2 range:

Wide range
OVR T2 SPDs are available in specific multi-pole versions for all distribution systems. There are also single-pole versions to be assembled in the field for maximum flexibility. With OVR T2 you can choose between three different rated discharge currents to ensure the maximum lifespan of the installation in all conditions and co-ordinate protection in extended installations.

Multi-pole versions with "1+1" and "3+1" schemes
Thanks to the "1+1" and "3+1" designs providing for a spark gap to earth, OVR T2 can be installed upstream of the RCD to protect against and prevent unwanted tripping. Combined-mode protection is provided, both common and differential.

Reduced protection level, for better protection
For all versions the maximum protection level U_p is 1.5 kV, a value suitable for the protection of all terminal equipment, even the most sensitive.

Back-up protection with fuse or MCB
Fuses or ABB circuit breakers may be chosen as back-up protection for all versions.

Co-ordination
The Class 2 SPDs are co-ordinated starting from a distance of one meter.

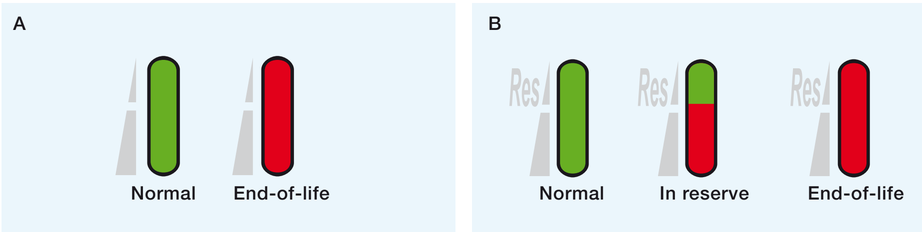
Protection from indirect lightning strikes in electrical networks
Class 2 SPDs - OVR T2

End-of-life indicator on the SPD (present on all versions)

Indicates the status of the SPD via a mechanical indicator which changes colour from green to red when the device reaches the end of its life.

Safety reserve versions ("s" versions)

Thanks to the back-up function which allows it to continue operating with reduced current capacity, even when approaching the end of its life-cycle, the SPD gives advanced warning that it is approaching the end of its life, allowing its replacement to be planned ahead of time.



A - End-of-life indicator for a SPD without safety reserve
B - End-of-life indicator for a SPD equipped with safety reserve

Pluggable cartridges, on all versions

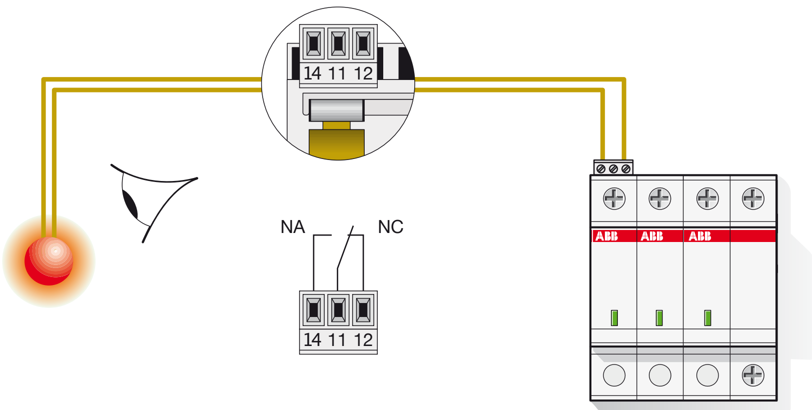
ABB SPDs with pluggable cartridges facilitate maintenance operations. If one or more used cartridges need replacing, it is not necessary to disconnect the device. A cartridge at the end of its life can be replaced without having to change either the SPD or all the whole set of cartridges.

Note:
OVR pluggable cartridges contain a device which ensures an incorrect version cannot be inserted when replacing them: phase and neutral cartridges cannot be mixed up.

Signaling contact ("TS" versions)

Allows the operational status of the SPD to be monitored remotely via a 1 A dry auxiliary contact. The monitoring contact is integrated and does not require extra space on the DIN rail. This allows a connection to a Centralized Technical Management (CTM) system.

Technical specifications of the integrated auxiliary contact:
- Changeover contact: 1 NO, 1 NC
- Minimum load: 12 V DC - 10 mA
- Maximum load: 250 V AC - 1 A
- Maximum cable section: 1.5 mm^2



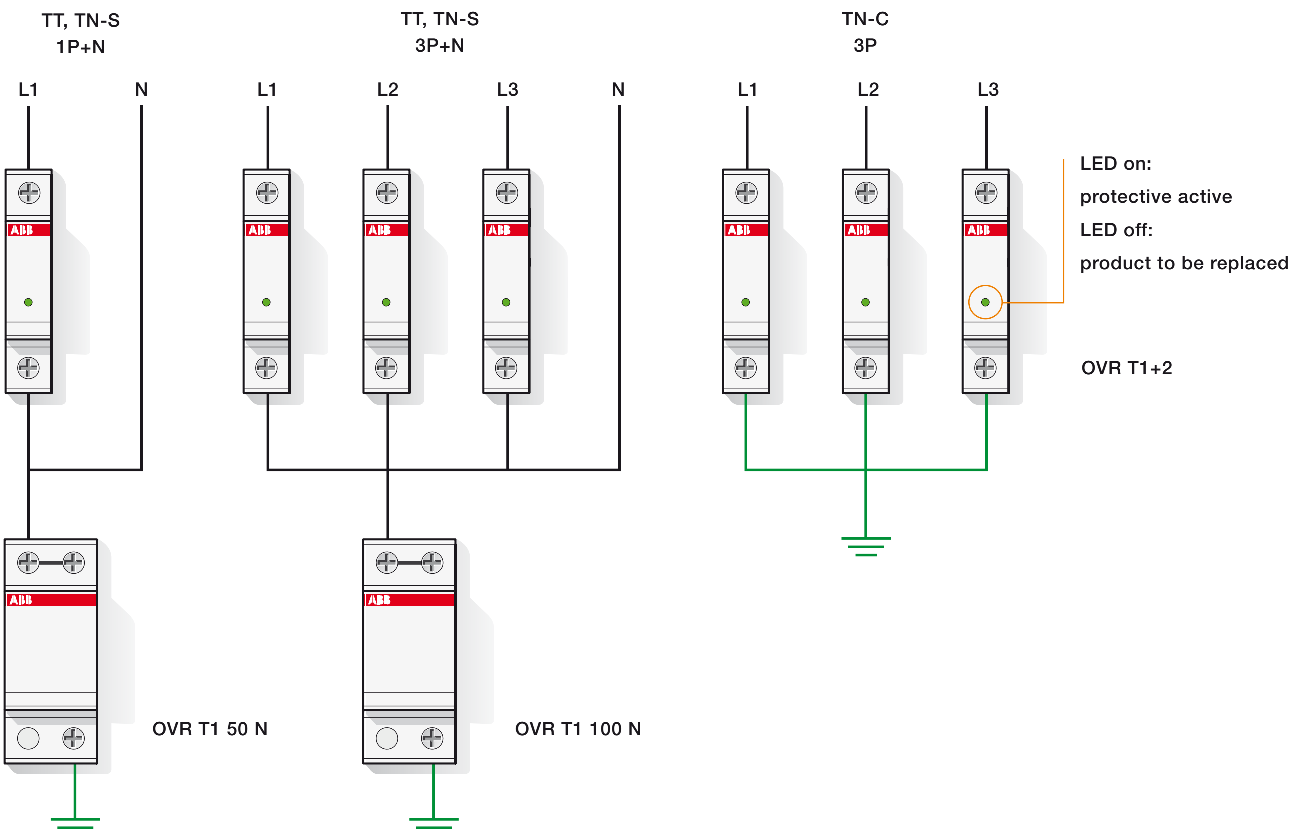
Solutions for all uses
Protection in smaller plants
OVR T1+2: when space is a determining factor

How does it work?
- OVR T1+2 is an integrated solution, equivalent to an automatically co-ordinated Type 1 and Type 2 SPD
- The single-pole module must be combined with the neutral module OVR T1 50 N for single-phase and OVR T1 100 N for three-phase

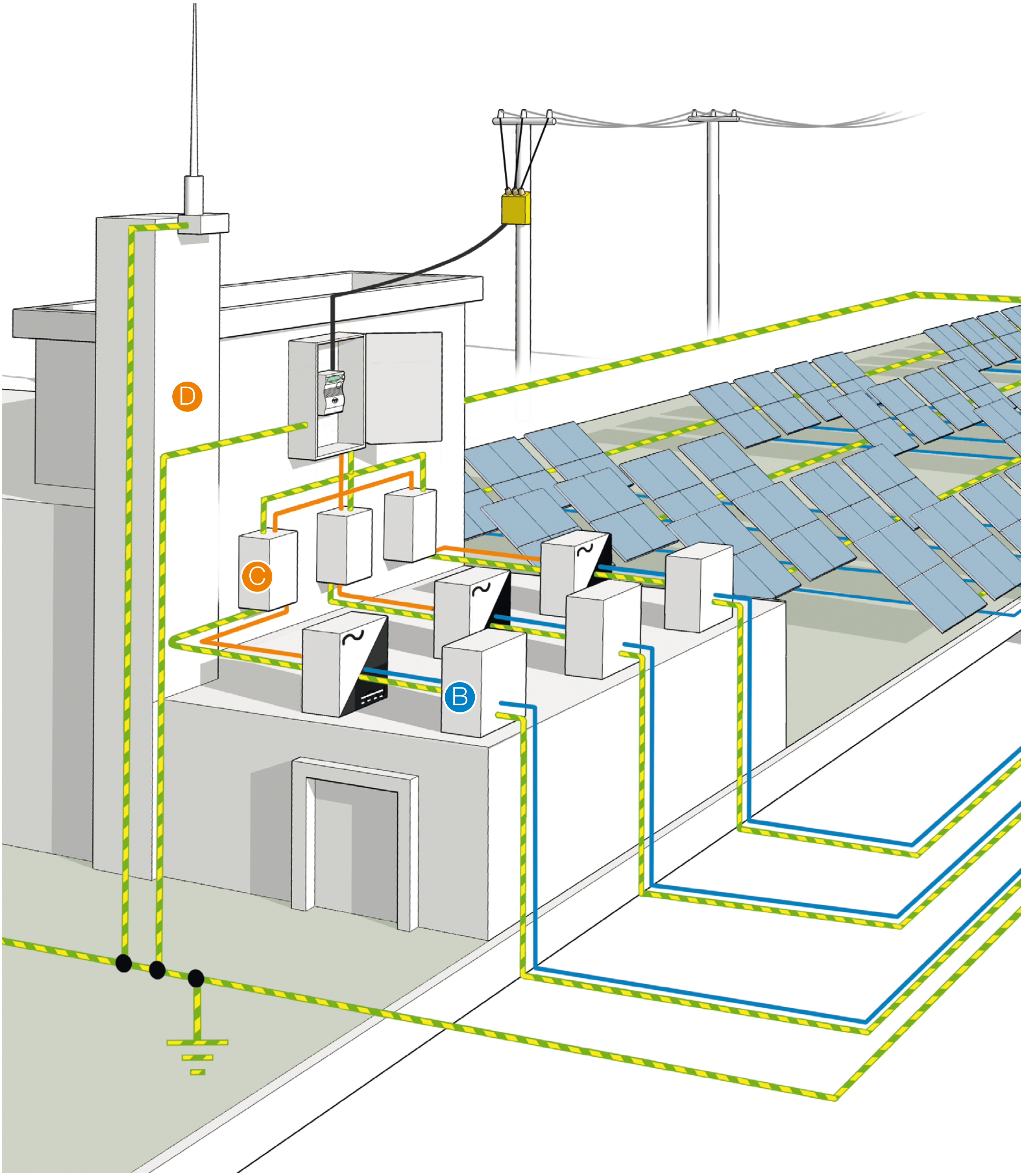
Where are they installed ?
- Ideal for all smaller plants to obtain simultaneous protection from the main switch to the terminal equipment
- In all distribution systems (TT, TN-C, TN-S)
- Upstream of the RCD, thanks to the spark gap to earth (1+1 or 3+1).

Benefits
- Ideal in all reduced-size plants
- Dual protection: currents from lightning strikes and induced voltage surges
- Optimum level of protection (1.5 kV), high impulse and discharge current per pole
- High operational continuity and low maintenance costs thanks to extinguishment of follow-through currents up to 7-15 kA depending on the version
- Tested in test Class 1 and test Class 2
- Status indicator on the front
- Integrated remote monitoring contact for OVR T1+2 25 255 TS
- Rapid maintenance thanks to the pluggable cartridge format for OVR T1+2 25 255 TS

Recommended connection schemes for OVR T1+2, for both versions:

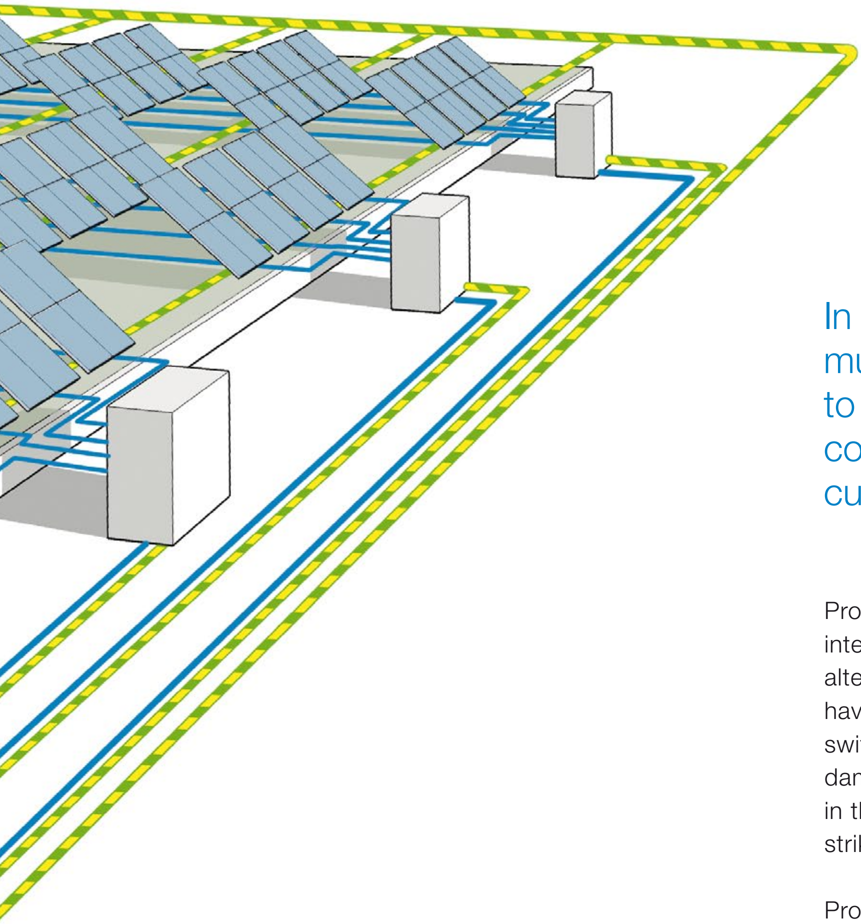


Surge protection in photovoltaic installations
Production plant



Installed outside, almost always in wide-open areas, photovoltaic installations are particularly subject to atmospheric phenomena and can face damage from surges caused by lightning strikes. For this reason, and given the high value of the components and the high cost of any down time, it is always best practice to fit PV installations with suitable surge protection.

Production plant
- DC side: zones A, B
- AC side: zones C, D



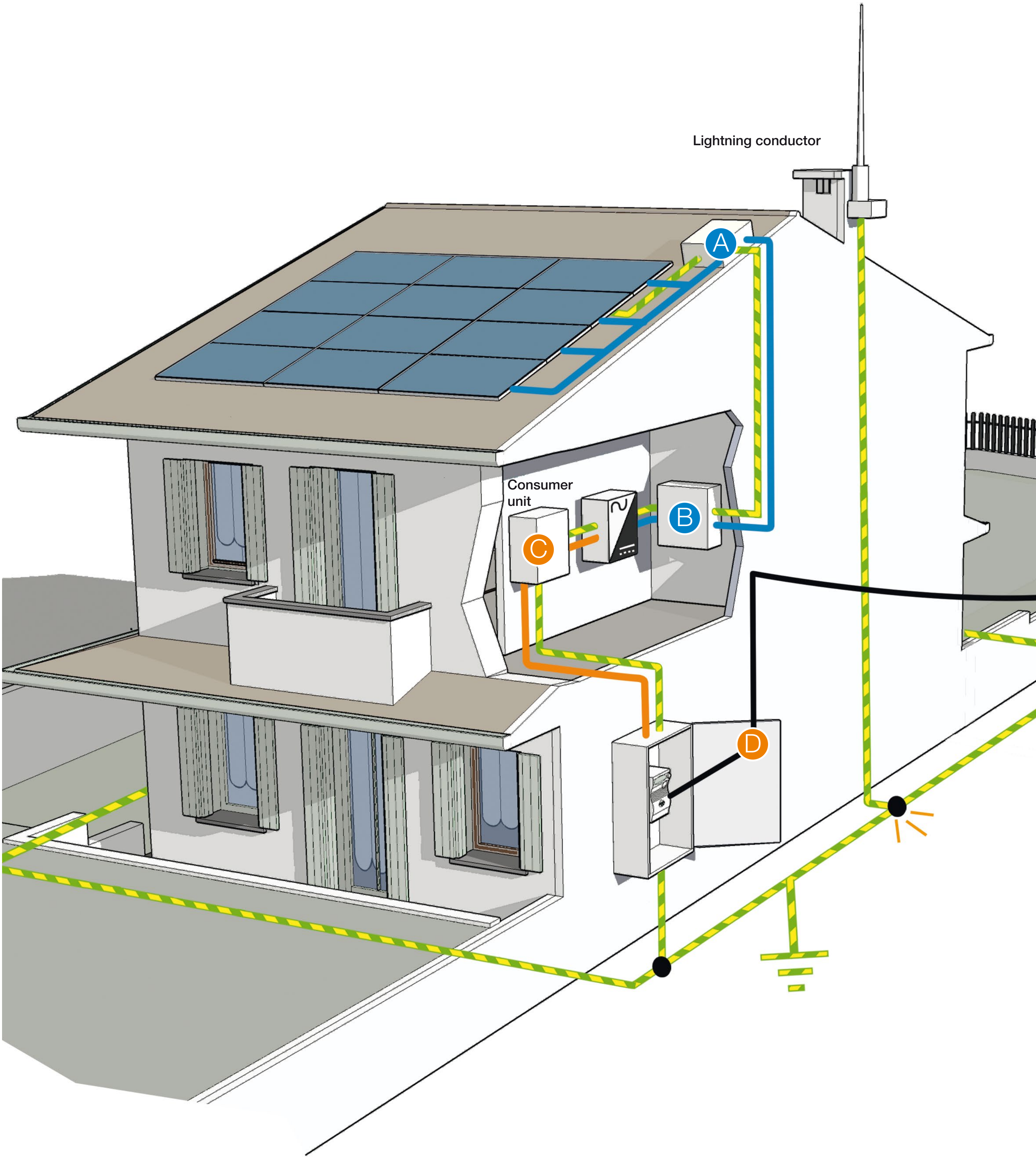
In this example, the plant is composed of multiple strings in parallel and connected to three inverters. The inverters are in turn connected in parallel on the alternating current side.

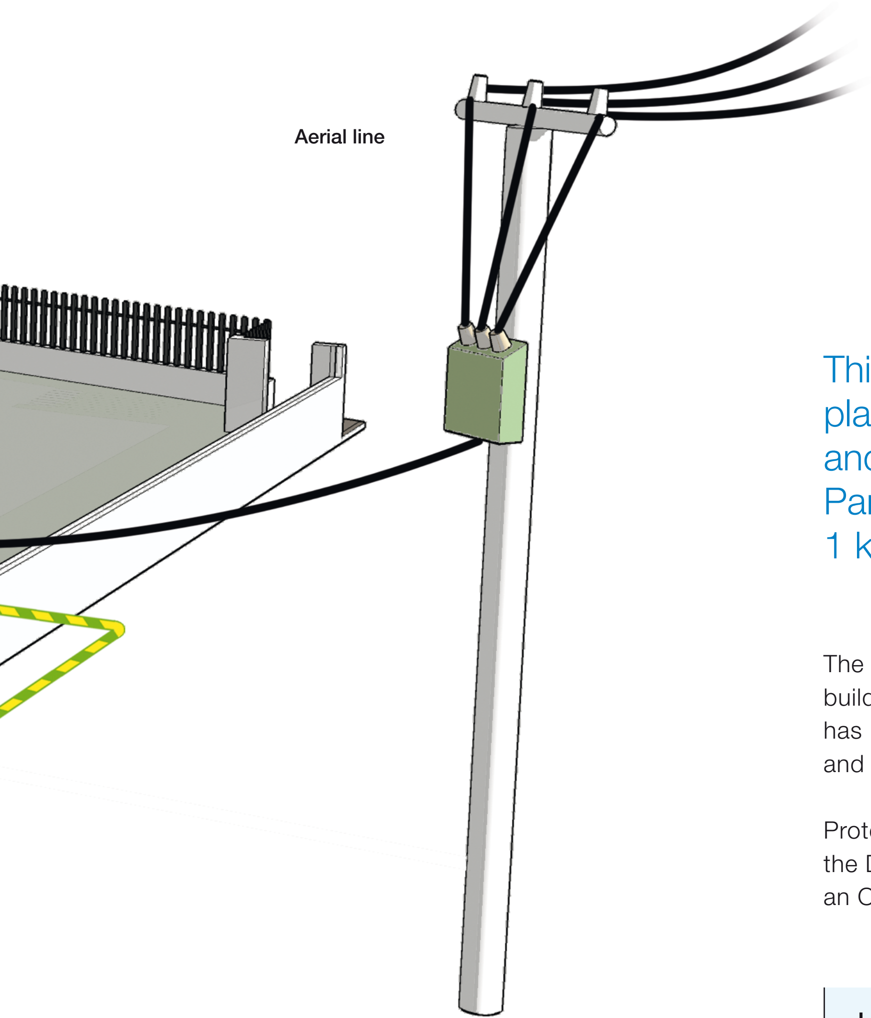
Protection against direct lightning strikes is ensured by integration of a lightning conductor, connected on the alternating current side. This LPS is selected in order to have a protection area (radius of protection) that covers the switchboard as well as the PV panel, preventing them from damage from direct lightning strikes. A Type 1 SPD is installed in the main switchboard (D) for protection from direct lightning strikes.

Protection against indirect lightning strikes, on the direct current side, is ensured by using OVR PV SPDs for photovoltaic installations. OVR T2 SPDs are used on the alternative current side.

It is necessary to protect both the direct current and alternative current circuits from surges: lightning is not interested in what type of current is flowing in the cables!

Solutions for all uses
Protecting photovoltaic installations
Domestic plant





Domestic installation - On-site exchange
- DC side: zones A, B
- AC side: zones C, D

This example shows a small domestic plant in a suburban area with one string and a single inverter.
Panels with a combined output power of 1 kW are installed on the roof.

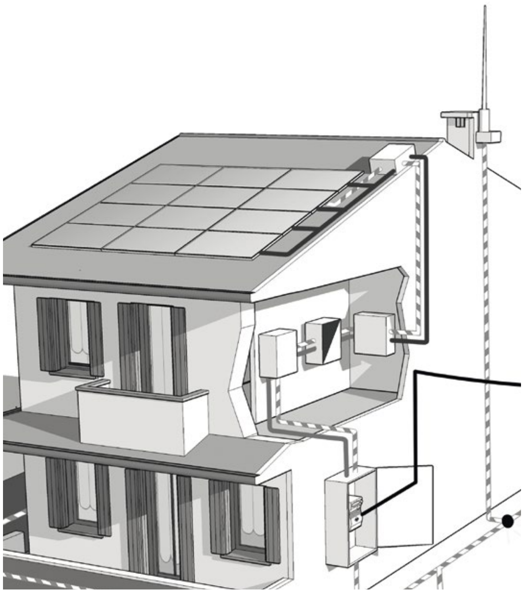
The house is subject both to the risk of lightning striking the building and the aerial LV line. For that reason, a Type 1 SPD has been installed in the main switchboard (D) on the AC side and an ESEAT on the roof.

Protection against direct lightning strikes is ensured both on the DC side by using an OVR PV SPD and on the AC side with an OVR T2 SPD.

> In this case, too, it is necessary to protect both the direct current and alternating current circuits from surges: lightning is not interested in what type of current is flowing in the cables!

Solutions for all uses

Protecting photovoltaic installations
Surge protection is effective only when done globally. Protect the four zones.



In the table and the drawings, the direct current parts are indicated in blue, while the alternating current parts are indicated in orange

Zone A
– Field or parallel switchboard
– Protection of panels and strings from surges of atmospheric origin
– Required if distance between A and B is greater than 10 m

Zone B
– Direct current side inverter
– Protection of the inverter from surges of atmospheric origin
– SPD always required

Side	Zone	Description	Protection function	When to protect	Presence of external LPS or aerial supply	
Direct current	A	Field or parallel switchboard	Protection of panels and strings from surges of atmospheric origin	Required if distance between A and B is greater than 10 m		
	B	Direct current side inverter	Protection of the inverter from surges of atmospheric origin	Always required		
Alternative current	C	Alternative current side inverter	Protection of the inverter from surges of atmospheric and grid origin	Required if distance between C and D is greater than 10 m		
	D	Delivery point, alternative current-side plant origin	Protection of the electrical installation from surges of atmospheric and grid origin and from direct lightning strikes	Always required	No	
					Yes	

Zone C
– Alternating current side inverter
– Protection of the inverter from surges of atmospheric and grid origin
– Required if distance between C and D is greater than 10 m

Zone D – No lightning conductor
– Delivery point, alternative current side plant origin
– Protection of the electrical system from surges of atmospheric and grid origin
– SPD always required

Zone D – With lightning conductor
– Delivery point, alternating current side plant origin
– Protection of the electrical system from direct lightning strikes and from surges of atmospheric and grid origin
– SPD always required

SPD				Back-up protection			
Version	**Remote contact**	**Type**	**Code**	**When to install it**	**Rating**	Fuse or MCB disconnector	
						Type	**Code**
670 V	-	OVR PV 40 600 P	2CTB803953R5300	Required only if	10 A gPV	E 92/32 PV	
	1 NO/NC	OVR PV 40 600 P TS	2CTB803953R5400	the prospective	Note: for		
	1 NO/NC	OVR PV T1 6.25 600 P TS	2CTB803953R5700	short-circuit current at	670 V and	S802PV-S10	
1000 V	-	OVR PV 40 1000 P	2CTB803953R6400	the installation point of	100 V.		
	1 NO/NC	OVR PV 40 1000 P TS	2CTB803953R6500	the SPD is greater	Fuses for	or	
	1 NO/NC	OVR PV T1 6.25 1000 P TS	2CTB803953R6700	than 300 A DC (for	1500 V	S804PV-S10	
	1 NO/NC	OVR PV 40 1000 P TS BW	2CTB804153R1900	600 and 1000 V DC)	being		
1500 V	- NEW	OVR PV 40 1500 P BW	2CTB804153R2200	and 235 A (for	tested		
	1 NO/NC NEW	OVR PV 40 1500 P TS BW	2CTB804153R2100	1500 V DC)			
670 V	-	OVR PV 40 600 P	2CTB803953R5300				
	1 NO/NC	OVR PV 40 600 P TS	2CTB803953R5400				
	1 NO/NC	OVR PV T1 6.25 600 P TS	2CTB803953R5700				
1000 V	-	OVR PV 40 1000 P	2CTB803953R6400				
	1 NO/NC	OVR PV 40 1000 P TS	2CTB803953R6500				
	1 NO/NC	OVR PV T1 6.25 1000 P TS	2CTB803953R6700				
	1 NO/NC	OVR PV 40 1000 P TS BW	2CTB804153R1900				
1500 V	- NEW	OVR PV 40 1500 P BW	2CTB804153R2200				
	1 NO/NC NEW	OVR PV 40 1500 P TS BW	2CTB804153R2100				
3P+N	If required, see "TS" ver-	OVR T2 3N 40 275s P	2CTB803953R0800	Always required	50A gG	E 93hN/32	
3P	sions in the System pro *M*	OVR T2 3L 40 275s P	2CTB803853R2200			E 93/32	
1P+N	compact® catalogue	OVR T2 1N 40 275s P	2CTB803952R0800		(M277543)	E 91hN/32	
3P+N	If required, see "TS" ver-	OVR T2 3N 40 275s P	2CTB803953R0800			E 93hN/32	
3P	sions in the System pro *M*	OVR T2 3L 40 275s P	2CTB803853R2200			E 93/32	
1P+N	compact® catalogue	OVR T2 1N 40 275s P	2CTB803952R0800			E 91hN/32	
3P+N		OVR T1 3N 25 255	2CTB815101R1600		125 A gG	E 933N/125	
3P		OVR T1 3L 25 255	2CTB815101R1300			E 933/125	
1P+N		OVR T1 1N 25 255	2CTB815101R1500		(M258343)	E 931N/125	

Solutions for all uses
Protecting photovoltaic installations
Surge protection in PV installations
EN 50539-11 standard

Many indications regarding protection from surges due to direct lightning strikes have been taken from point 9.2.3 of the EN 50539-11 standard. "Guide to the development of photovoltaic power generation systems connected to networks of medium and low voltage".

The protection must be:
- specific
- complete
- safe
- permanent

The protection must be...	Principles of overvoltage surge protection [9.2.3]	ABB's response
Specific	The installation of a SPD protecting the panels and the sensitive electronic equipment (inverter) must be evaluated	OVR PV is the ABB range specifically designed to protect equipment in photovoltaic installations
Complete	SPDs must, in general, provide both differential (+/-) and common mode (+/PE, -/PE) protection	OVR PV is a multi-pole (L, L, PE) module ideal for providing both common and differential mode protection
Safe	The installation of suitable fuse protection upstream of the SPDs is recommended	OVR PV is self-protected up to a short-circuit current of 300 A for 600 V DC and 1000 V DC, and 235 A for 1500 V DC and, for higher values, must be protected with suitable fuses
Permanent	Since the end-of-life of the SPD is difficult or impossible to detect, it is recommended to install a SPD with integrated remote signaling contact	The TS versions of OVR PV incorporate an end-of-life remote signaling contact The dimensions of the versions with and without contacts are the same.

Varistors and spark gaps are non-linear components: at rated voltages they behave like an open circuit, while in the presence of a surges they close the circuit.
In the example below we will try to explain intuitively how a varistor SPD works with a concept borrowed from plumbing: the safety valve.

A safety relief valve

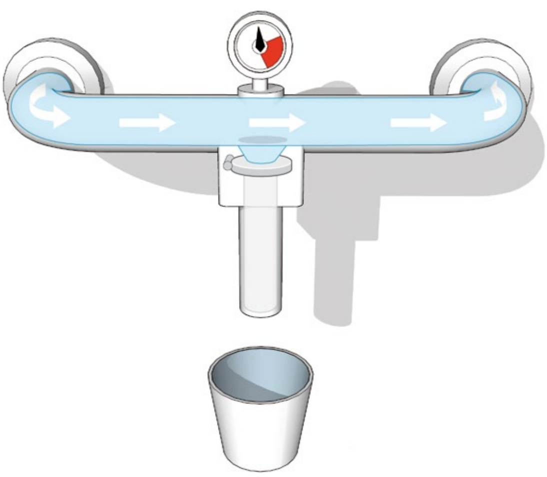
– The varistor behaves like a safety valve. When the pressure in the pipe (the voltage) is normal, the valve is closed

– When the pressure suddenly increases, this could cause the pipes (the electrical wires) or the equipment connected to them to break

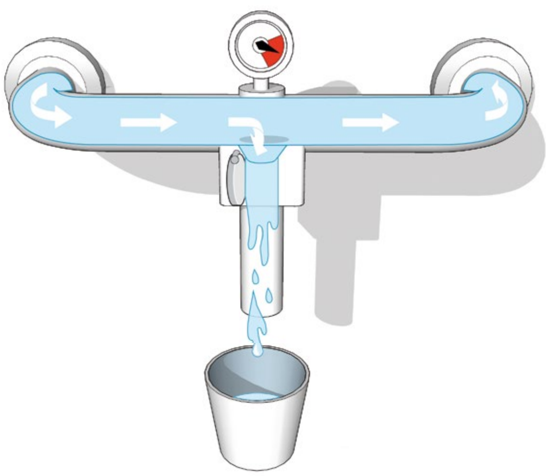
– The safety relief valve uses the pressure in the pipe to open the safety bleed outlet, letting a little of the liquid (the discharge current) flow out

– When the pressure has returned to normal, the valve re-closes by itself

Normal water pressure



Sudden increase in pressure



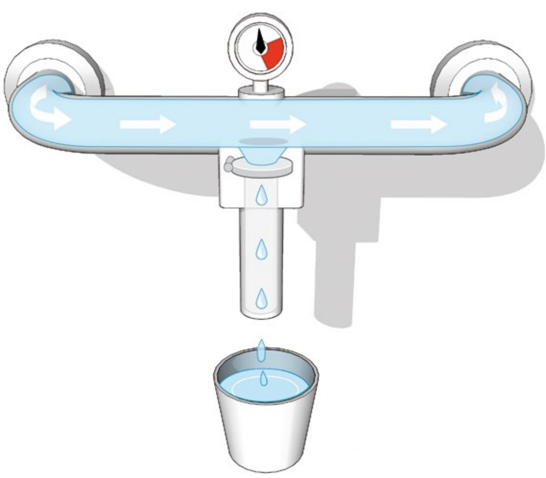
End-of-life, safety begins. Let's discover what it is

After many sudden changes, even with normal pressure … The safety valve starts to leak!

Back to electricity…
- The varistor is no longer able to isolate the network
- Even under normal voltages it conducts a current, to earth or between two phases
- This current is ever as small as the lower the short-circuit current of the system is at the installation point: for PV it can be just a few amps
- In any case the varistor does not have zero resistance
- According to Joule's law: Loss in Watts = Resistance x Current ^{2} therefore…

$$R \text{ (large)} \times I^2 \text{ (small)} \times T \text{ (minutes)} = \textbf{heat!}$$

The passage of this current through the varistor is problematic, provoking dangerous overheating!

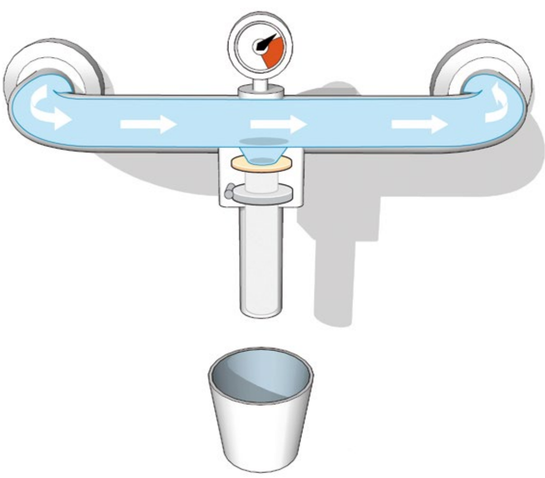


The heat generated by a varistor in end-of-life conditions can be sufficient to cause dangerous overheating of the SPD case and even cause the component to catch fire. To keep the system safe, each varistor is accompanied by a thermal disconnector and, if necessary, back-up protection is installed upstream.

The back-up fuse

- The SPD manufacturer must ensure adequate protection and prevent overheating of the varistor at the end of its life. If necessary, additional back-up protection must be provided: in general, fuses are used for PV
- If fitted, the fuse must be quite fast-acting in order to disconnect the varistor from the network at the end of its life before the heat generated has negative consequences
- Since the short-circuit currents are small in PV installations, the fuses must be able to cut in after a few seconds at low currents, so in general they will have a small rating compared to alternating current systems

This is why ABB has developed the specific OVR PV range, which does not require any back-up protection up to 300 A (for 600 V DC and 1000 V DC) and 235 A (for 1500 V DC) short-circuit current (self-protected) while for values above those just indicated it must be protected by a 10 A gR fuse (for 600 V DC and 1000 V DC, tests for 1500 V DC on going).

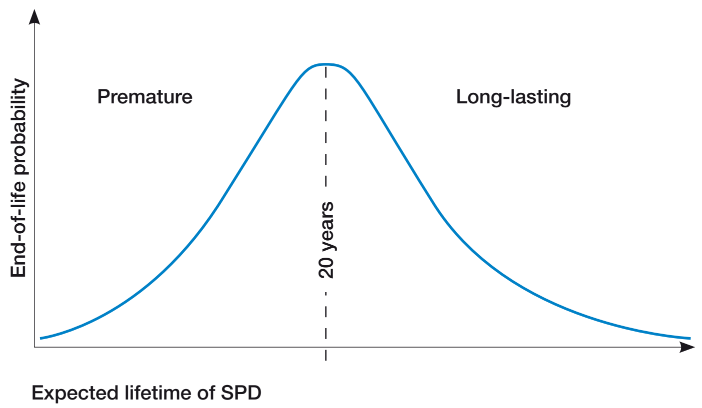


Solutions for all uses
Protecting photovoltaic installations
End-of-life safety... And when it occurs

On average, a 20 kA Type 2 SPD has a lifespan of twenty years, but some may last thirty, and others only five! The data refer to the frequency of lightning strikes according to IEC 62305 standards, to SPD lifespan tests according to IEC 61643-11 and to basic statistics.

A statistical question

- The lifespan of a SPD depends on its resilience connected to its rated discharge current I_n, but also to the number of times lightning strikes near the system each year
- On average, a 20 kA SPD worldwide will reach the end of its life after twenty years
- Given the long functional life of a PV plant and the large number of SPDs installed, statistics tell us that a SPD reaching the end of its life is far from an improbable occurrence; some SPDs (premature) could reach the end of their lives in the first few years of the system's operation...



What happens to each of the SPDs I've installed in the PV system over the years?

The replacement cartridges allow surge protection to be renewed when one of the SPDs reaches the end of its life-cycle.

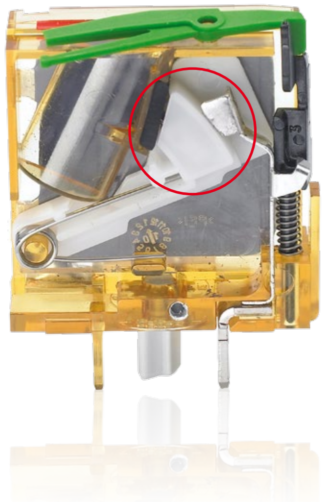
Solutions for all uses
Protecting photovoltaic installations
OVR PV thermal disconnector. Safety through-and-through

OVR PV SPDs contain varistors which are subject to slight wear at each electric discharge.

After approximately twenty years of use the electrical resistance diminishes appreciably and the SPDs allow current to flow which becomes dangerous, overheating the product to the point where it is damaged. This stage is called the end of life, and the SPD must be disconnected from the network supply to prevent the risk of fire. Given the difficulty in opening an electric arc in direct current, ABB has developed and patented a thermal disconnector able to disconnect the end of life SPD in safety. The operation of the thermal disconnector on the OVR PV is explained in these three drawings:

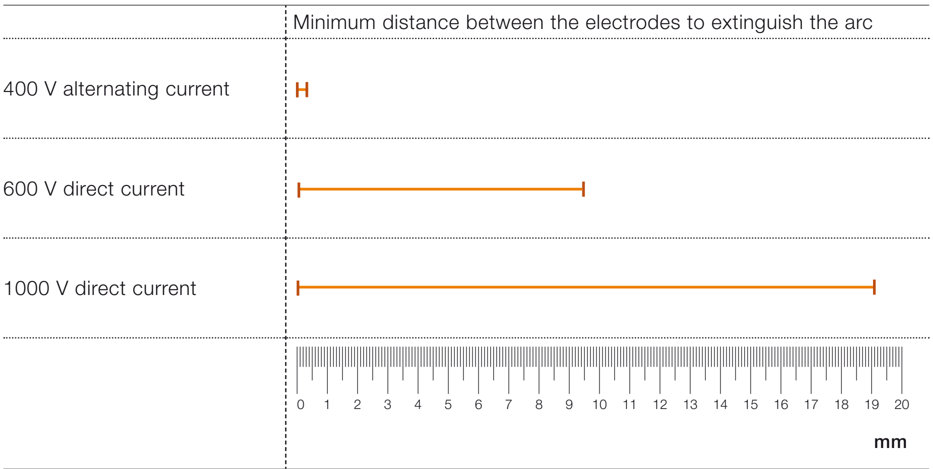
Operating principle of the SPD when it has not reached the end of life

At the end of life, the opening of the thermal disconnector and ignition of an electric arc in direct current



Extinguishing of the electric arc when the patented device opens

Size of an electric arc: difference between alternating and direct current, indicative values for a current of 10 A



An electric arc can be ignited between two electrodes because of the voltage present at their heads.
The extinguishment of the arc is more complex in direct current than in alternating current because the current never passes through zero.
- **Switching off may take place at lesser distances, for example by quickly separating the two electrodes.**
- **The thermal disconnector contained in OVR PV photovoltaic SPDs is able to extinguish the electric arc thanks to the fast opening of the contact and the isolation of the parts with insertion of an obstacle in the path of the arc.**

Solutions for all uses
Protecting photovoltaic installations
Expert's corner: What criteria are used to choose the SPDs for PV installations?

Are there international standards?

Since 2010, only the French UTE C 61740-51 was the reference to certify safety in SPDs for PV applications. In 2014 an European regulation shall come out with the EN 50539-11. In agreement with the UTE C, it does introduce the idea of testing the behavior of the SPD in end of life for the safety of the equipment.

If the SPD is rated for alternating current performance, is it ok to use?

Since in theory, but only in theory a SPD can support a peak voltage of $\sqrt{2}$ x V AC, we might be tempted to use a product designed and certified for AC systems in a PV environment for example adapting a 440 V AC SPD for a 600 V DC installation.

This calculation does not take into account the SPD's end of life, a particularly critical case since the SPD must extinguish a DC arc, which is much more difficult compared to an AC arc.
ABB's OVR PV SPDs are specifically designed for direct current and their performance is specified on the product documentation as well as being clearly printed on the product.
On the previous page you can find further information about DC electric arcs and the patented ABB solution to make PV systems safer than ever.

Is it enough for the SPD to be fitted with an integrated thermal disconnector?

The thermal disconnector is a component required by law in all varistor SPDs; it is necessary in any case to be sure that the disconnector has been designed and tested to interrupt a DC short circuit.
The disconnector is the component which ensures SPDs at the end of their lives do not cause fires. ABB knows this very well and so designed a specific one for the OVR PV range.

How can I be sure that the back-up protection is correct?

The IEC guide states that SPD back-up must be co-ordinated. The co-ordination is ensured by special tests carried out by the manufacturer and must be consistent with the maximum short-circuit current of the system, almost always very low.

The tests performed by ABB on the OVR PV range in our laboratory ensure that back-up protection is not required up to 300 A (for 600 V DC and 1000 V DC) and 235 A (for 1500 V DC) above this value, a 10 A gR fuse must be installed to ensure end-of-life protection (for 600 and 1000 V DC, tests for 1500 V DC on going).

What guarantees does ABB give on the safety of its SPDs for PV systems?

Today, the EN 50539-11 guide is the only protocol in the world to supply clear and unambiguous indications on the tests to be performed to ensure that a SPD is safe for PV applications. EN 50539-11 conformity is today an additional guarantee of the quality and safety of OVR PV.

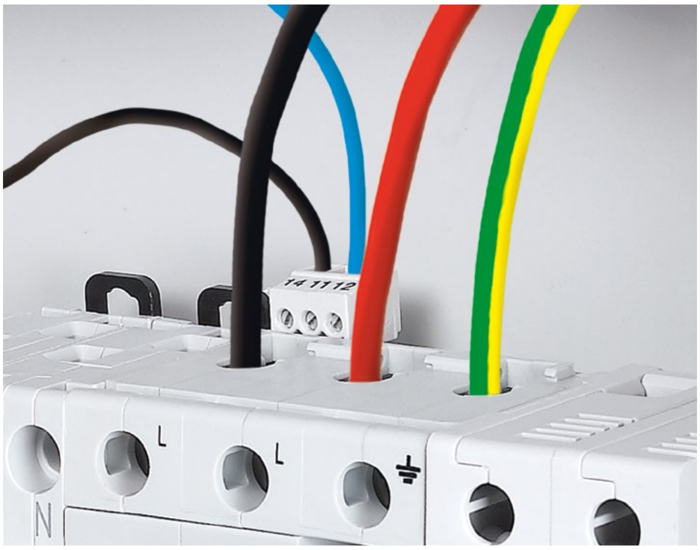
Solutions for all uses
Protecting photovoltaic installations
Designed for PV. Designed to always be effective.
The benefits of OVR PV

ABB's OVR PV SPDs are 100% safe and compatible with all types of PV installations.

The OVR PV SPDs are fitted with a patented thermal disconnector which ensures a safe end-of-life for the SPD in points of the plant with short-circuit current up to 300 A (for 600 V DC and 1000 V DC) and 235 A (for 1500 V DC) in DC. Where the short-circuit current is less than 300 A (for 600 V DC and 1000 V DC) and 235 A (for 1500 V DC), OVR PV can be installed without any back-up protection, while if it is above this value then it must be protected with a 10 A gR fuse (for 600 and 1000 V DC, tests for 1500 V DC on going).

Experience
– The OVR PV range has been designed and tested by ABB specifically for PV applications.

Practicality
– All OVR PV models are multi-pole and have terminals for the two poles and PE
– The wiring system is fast and foolproof, since bars or other accessories are not required.



Solutions for all uses
Protecting photovoltaic installations
Designed for PV. Designed to always be effective.
The benefits of OVR PV

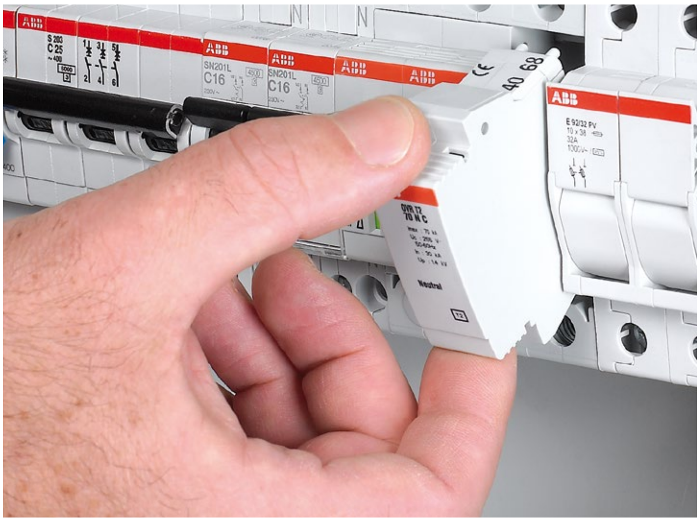
A spark gap normally behaves like an open circuit, and conducts only when discharging. The nature of the spark gap therefore prevents permanent flow of current to earth.

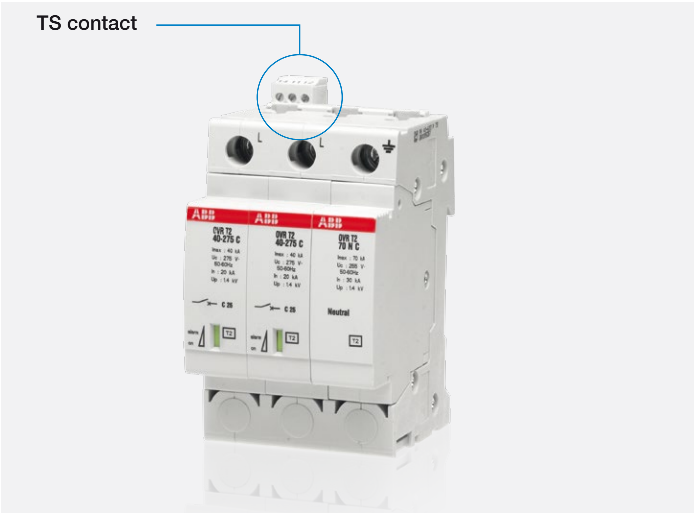
Insulation
- The spark gap to earth on the OVR PV 40 600 P stops current flowing to the PE
- The number of SPDs which can be installed is unlimited, even when insulation controls are present.

Maximum protection
- The OVR PV has an extremely low level of protection: 1.4-2.8 kV for the 600 V version and 3.8 kV for the 1000 V version and 4.5 K for the 1500 V version.

Pluggable cartridges
- The SPD socket on Base can always be reused
- If a single cartridge reaches the end of its life, it is not necessary to replace the entire product
- Replacements can be made without cutting the power to the switchboard.

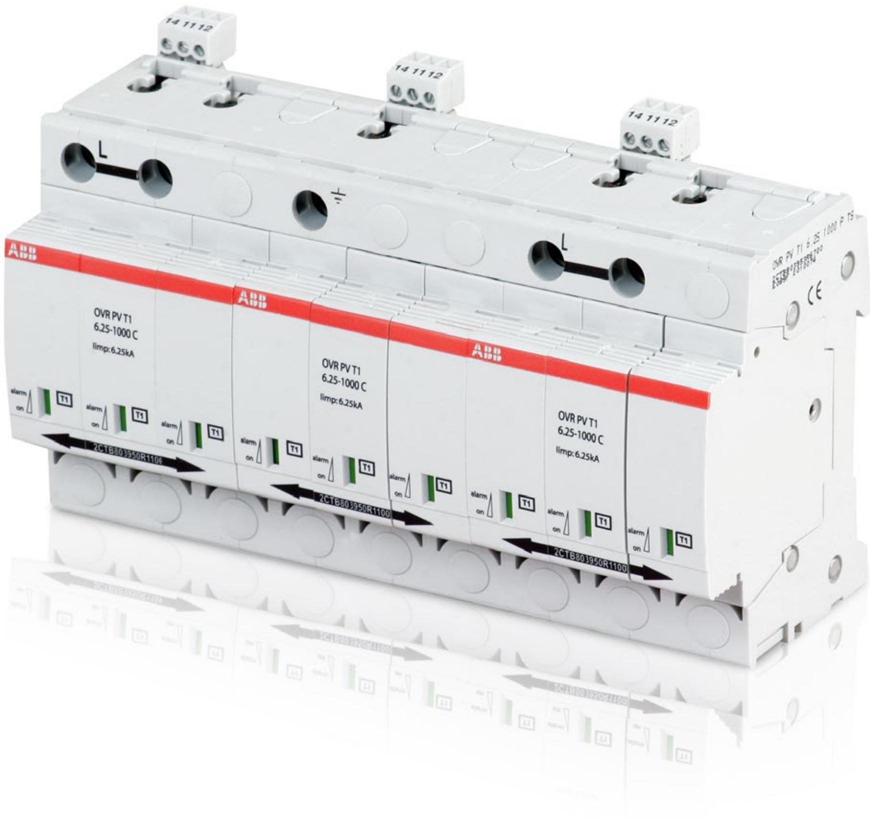
Integrated contact
- Available on all versions
- Does not take up extra modules
- Signals the SPD end of life to the remote supervision systems.





Solutions for all uses
Protecting photovoltaic installations
OVR PV SPDs for PV installations.
Main characteristics

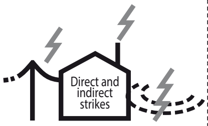
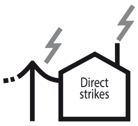
Features
- SPDs designed and manufactured by ABB specifically for the protection of photovoltaic installations
- Self-protected from end-of-life short circuit up to 300 A (for 600 V DC and 1000 V DC) and 235 A (for 1500 V DC) thanks to the integrated thermal protection with direct current breaking capacity
- Multi-pole 2P+E (L/L/PE) configuration on all models
- Pluggable cartridges
- Versions with and without end-of-life indication contact



Solutions for all uses
SPDs for electrical switchboards - or easy selection

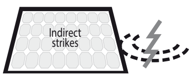
This table and the "OVR WIZARD" software application are available to make choosing SPDs even quicker and easier.

Alternating current protection

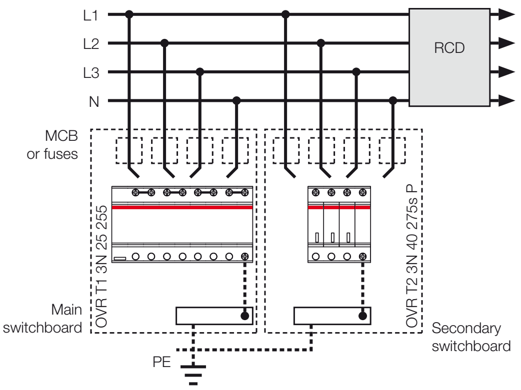
	System			SPD		Breakers or fuses		
	Class	System	Poles	Code	Type	Size	Code	Type
	In a main switchboard, if there is a lightning conductor or aerial supply and there is delicate equipment connected to the switchboard							
	1 + 2	TT, TN-S	3P+N	3 x 2CTB815101R0300 + 1 x 2CTB815101R0500	3 x OVR T1+2 25 255 TS + 1 x OVR T1 100 N	3 x 125A gG	EA 062 8	E 933N/125
			1P+N	1 x 2CTB815101R0300 + 1 x 2CTB815101R0400	1 x OVR T1+2 25 255 TS + 1 x OVR T1 50 N	1 x 125A gG	EA 059 4	E 931N/125
		TN-C	3P	3 x 2CTB815101R0300	3 x OVR T1+2 25 255 TS	3 x 125A gG	EA 061 0	E 933/125
	In a main switchboard, if there is a lightning conductor or when the electricity supply is from an aerial line							
	1	TT, TN-S	3P+N	2CTB815101R1600	OVR T1 3N 25 255	3 x 125A gG	EA 062 8	E 933N/125
			1P+N	2CTB815101R1500	OVR T1 1N 25 255	1 x 125A gG	EA 059 4	E 931N/125
		TN-C	3P	2CTB815101R1300	OVR T1 3L 25 255	3 x 125A gG	EA 061 0	E 933/125
	In all switchboards, to protect end-user equipment from the electro-magnetic impulse of lightning strikes							
	2	TT, TN-S	3P+N	2CTB803953R0800	OVR T2 3N 40 275s P	3P+N C25A	S529235[1]	S 204 - C25
			1P+N	2CTB803952R0800	OVR T2 1N 40 275s P	1P+N C25A	S531795[1]	S 201 Na - C25
		TN-C	3P	2CTB803853R2200	OVR T2 3L 40 275s P	3P+N C25A	S468206[1]	S 203 - C25

[1] 6 kA MCB. See the ABB System pro M compact® catalogue for other models.

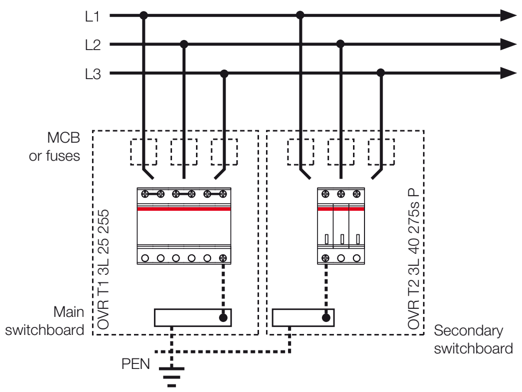
Direct current protection - PV installations

	Photovoltaic, DC side			SPD		Protection - Only if Isc > 100 A		
	Class	Maximum string U_{oc} voltage	Remote contact	Code	Type	Size	Code	Type
	In string panels for protection against induced overvoltages on the DC side.							
	2	670 V DC	-	2CTB803953R5300	OVR PV 40 600 P	2 x 10A gPV	M204703	E 92/32 PV
			Yes	2CTB803953R5400	OVR PV 40 600 P TS			
		1000 V DC	-	2CTB803953R6400	OVR PV 40 1000 P			
			Yes	2CTB803953R6500	OVR PV 40 1000 P TS			
			Yes	2CTB804153R1900	OVR PV 40 1000 P TS BW			
		1500 V DC	- NEW	2CTB804153R2200	OVR PV 40 1500 P BW	Fuse under test		
			Yes NEW	2CTB804153R2100	OVR PV 40 1500 P TS BW			

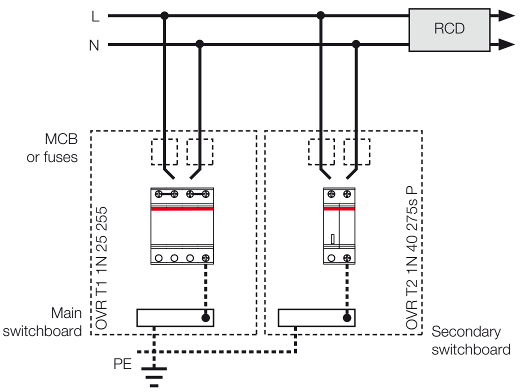
TT and TN-S 3P+N Systems



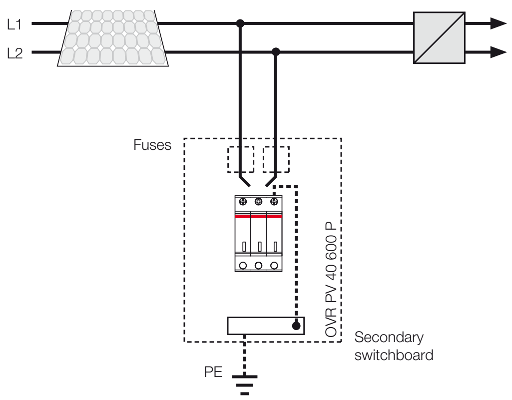
TNC 3P (230 V L-N) Systems



TT and TN-S, 1P+N Systems



Photovoltaic



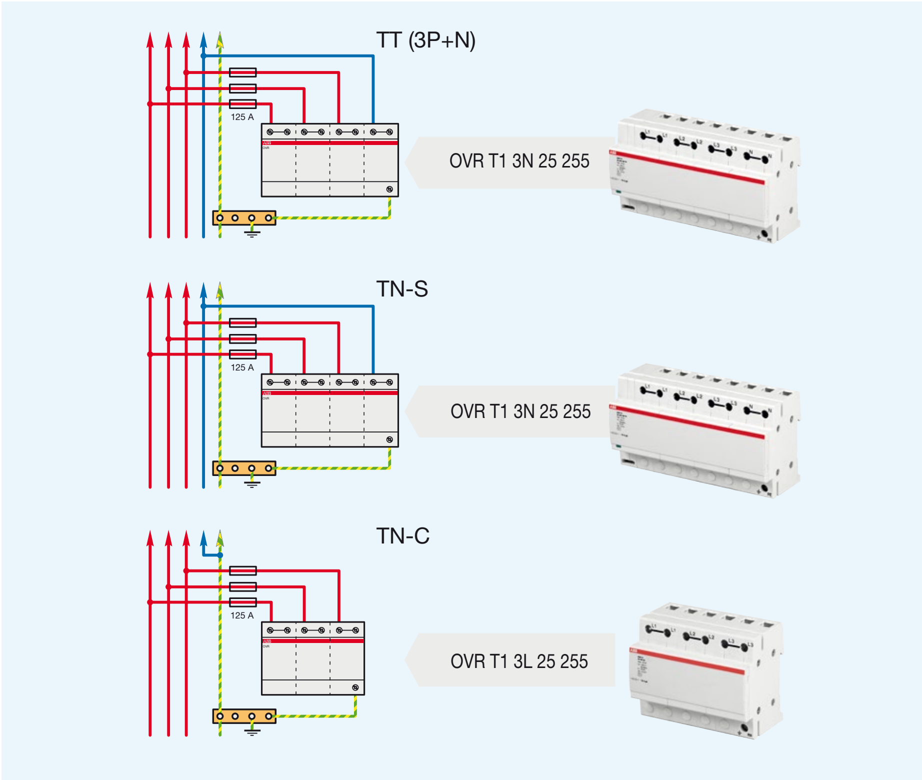
NOTE: In some countries, there is a deviation for the national standard and the IEC 60364-5-53 "Selection and erection of electrical equipment – Isolation, switching and control". In this case, both connections, to the main earthing terminal and to the protective conductor need to be done, and not just one as per the above pictures coming from the IEC. Please check your national standard before defining the electrical connections.

Solutions for all uses
SPDs for electrical switchboards - quick choice

Selection of protection on the basis of the panel, the presence of lightning rods and the earthing system

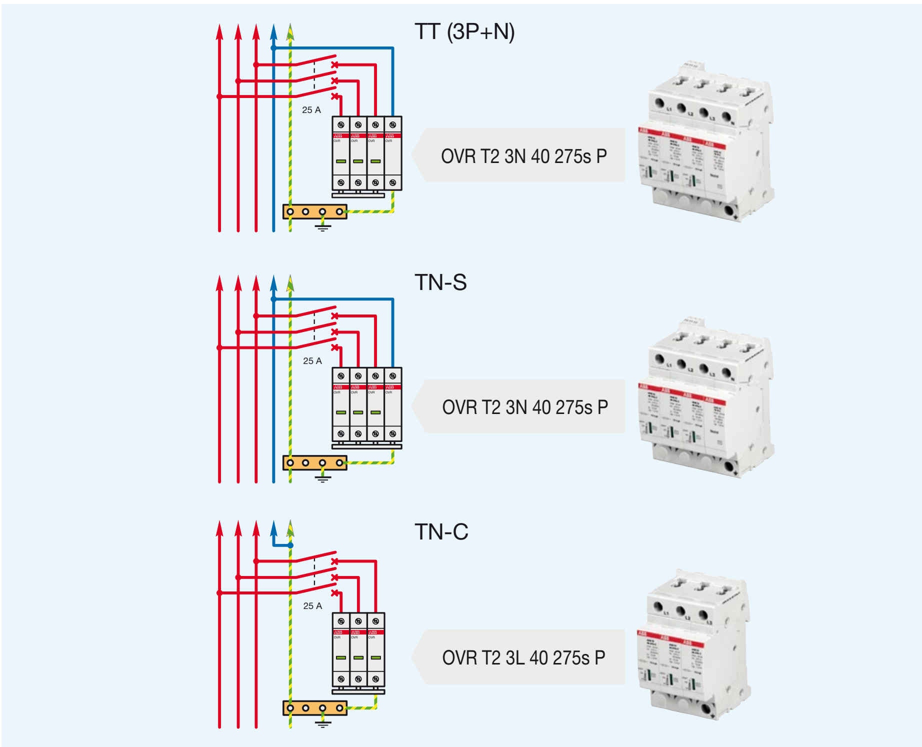
Main electrical switchboard
Presence of external LPS

OVR T1

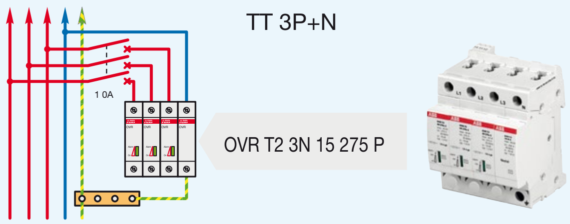


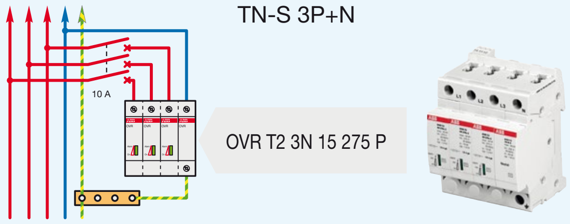
Main or secondary electrical switchboard
External LPS not present

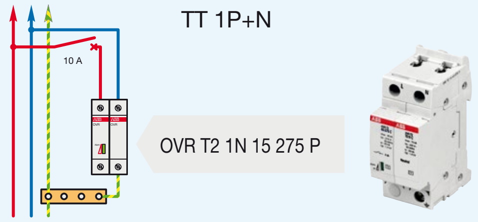
OVR T2

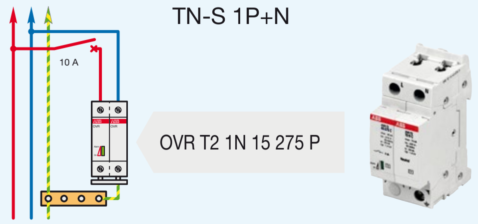


Protection of terminal equipment. Recommended if the terminal electrical switchboard is more than 10 meters from the upstream switchboard









Solutions for all uses
Protecting telecommunications networks

OVR TC...P with integrated RJ socket:
With RJ11 socket (15 mm width)
With RJ45 socket (24 mm width)

OVR TC SPDs are for fine protection of telephonic equipment, IT devices and BUS systems connected to low-voltage signal lines.

ABB offers a complete range of solutions for protecting telephone and internet through to management and control networks in industrial, service and residential environments.

Main characteristics of the range:
- Pluggable cartridges:
  cartridges can be removed and replaced at the end of their lives, while the base remains reusable. The telecoms line remains active while they are being replaced, thanks to a bypass.
- Reduced dimensions:
  When the cartridge is not plug in the modules with standard two-wire terminal protection are all 12.5 mm wide.
- Bases with integrated RJ11 and RJ45 connectors: these guarantee maximum speed of cabling in the telephone or data patch panel.

It is also wise to provide for the installation of Type 1 or Type 2 SPDs on the power lines to provide effective protection of the telecoms and data equipment.

Benefits of the OVR TC pluggable cartridges range

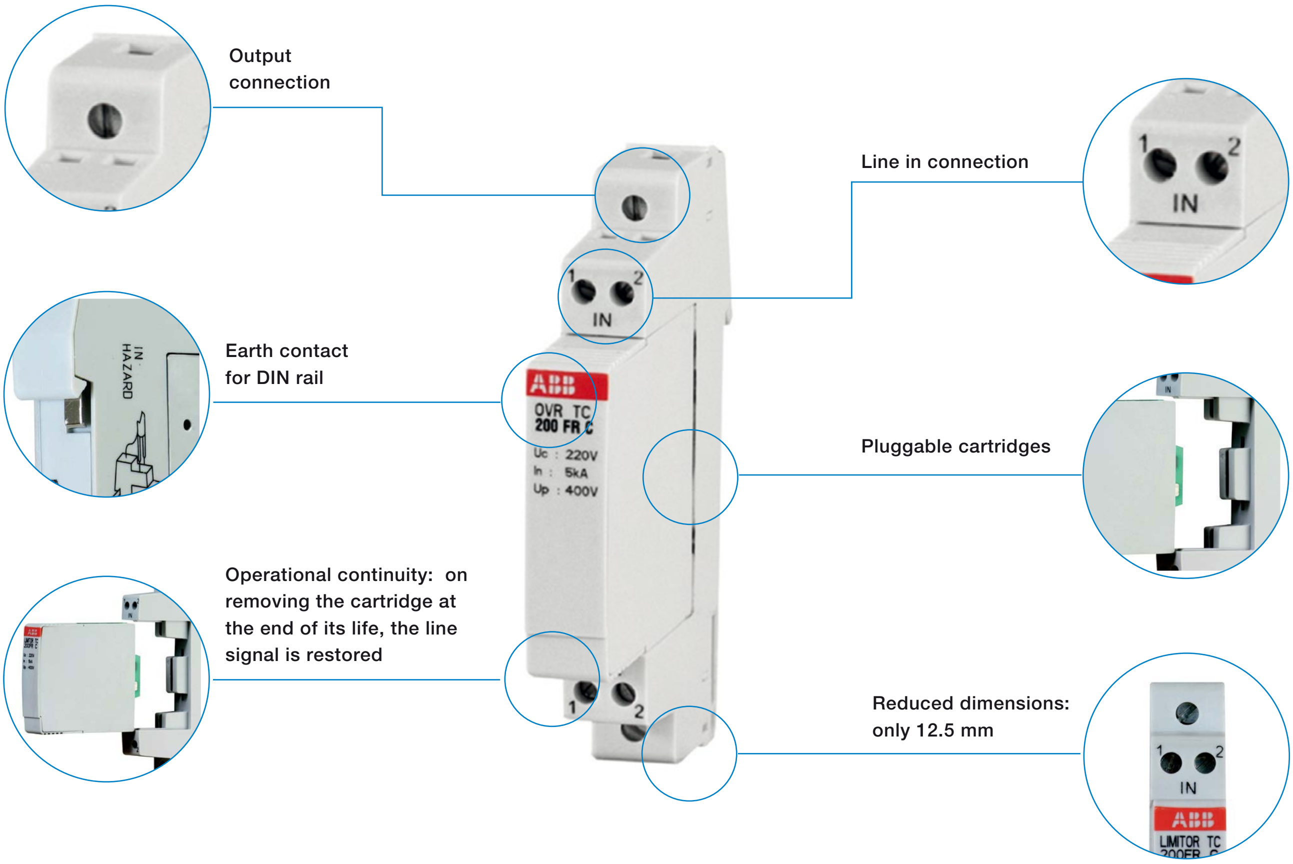


Table for choosing protection for Telephone, internet, broadband

Network	Type of connection / application		Type of signal	Max voltage of signal	Max. carrier frequency	Max. downstream speed	Standard connection	Physical medium	Type
PSTN	Traditional telephone		Analogic	180 V	3.4 kHz		RJ11	1 pair	OVR TC 200 FR P
	56 K Modem		Digital	180 V	3.8 kHz	56 kbps		1 pair	OVR TC 200 FR P
	xDSL	ADSL (Asymmetric DSL)	Digital	180 V	1.1 MHz	8 Mbps	RJ45	1 pair	OVR TC 200 FR P
		ADSL 2+			2.2 MHz	20 Mbps		1 or 2 pairs	1 or 2 x OVR TC 200 FR P
		HDSL			240 kHz	2 Mbps		1 or 2 pairs	1 or 2 x OVR TC 200 FR P
		VDSL			30 MHz	52 Mbps		1 pair	OVR TC 200V P
ISDN	Network-Network	U		100 V	120 kHz or 1 MHz	160 kbps or 1.9 Mbps	Terminals	1 or 2 pairs	See ISDN table (following page)
	Network-User	Basic rate (T0) (2B+D)		2.5 V (40 V between the pairs)	120 kHz	160 kbps	RJ45	2 pairs	
		2.5 V	Digital	2.5 V	1 MHz	1.9 Mbps			
	User-User	Basic rate (S0) (2B+D)		2.5 V (40 V between the pairs)	120 kHz	160 kbps			
		Primary rate (S2) (30B+D)		2.5 V	1 MHz	1.9 Mbps			
		Local ISDN / PSTN interface (R)	Analogic	180 V	3.4 kHz	56 kbps	RJ11	1 pair	

Note:
For weak signals, use OVR TC 200 V P (parallel connection)

Solutions for all uses
Protecting telecommunications networks

Choice of ISDN SPD

Equipment		Application	Access	Input connection	Type	Output connection	Type
NT1*	Network terminal 1	Allows exchange of information between the operator's network and the user's system	Basic	U	OVR TC 200 FR P	T0	OVR TC 48 V P
LT*	Line terminal		Primary	U	OVR TC 200 FR P	T2	OVR TC 6 V P
NT2 (PABX)	Network terminal 2 (Private Automatic Branch exchange)	Private switching exchange: allows internal devices to be connected to the external network	Basic	T0	OVR TC 48 V P	S0	OVR TC 48 V P
			Primary	T2	OVR TC 6 V P	S2	OVR TC 6 V P
TE1 digital	ISDN Terminal	Digital telephone or PC card	Basic	S0	OVR TC 48 V P	Voice or data	/
			Primary	S2	OVR TC 6 V P	Voice or data	/
TA	Terminal adapter	ISDN adaptor for analog terminal	Basic	S0	OVR TC 48 V P	R	OVR TC 200 FR P
			Primary	S2	OVR TC 6 V P	R	OVR TC 200 FR P
TE2 analog	Analog terminal	Analog terminal or modem		R	OVR TC 200 FR P	Voice or data	/

GNT**	Generalized network terminal	Allows communication between the operator's network and the user's system	Basic	U	OVR TC 200 FR P	S0	OVR TC 48 V P
						Z1 or Z2	OVR TC 48 V P
TE2 digital	Specific telephone terminal	Digital terminal adaptable to GNT	Basic	S0 x 5	5 x OVR TC 48 V P	Voice or data	/
TE2 analog	Analog terminal	Analog terminal or modem		Z1 or Z2	OVR TC 48 V P	Voice or data	/

* Connected to NT
** Without NT2

Note: For power supply of NT1 (required for large distances between operator and user) it is recommended the power supply switchboard be protected with OVR T2 1N 40 275s P.

Field BUS, company networks, management and control systems

<table>
<tr><th>Network type</th><th colspan="2">Application</th><th>Type of signal</th><th>Max signal voltage</th><th>Rated current</th><th>Max. transmission speed</th><th>Standard connection</th><th>Physical medium</th><th>Type</th></tr>
<tr><td>Line
4 - 20 mA</td><td rowspan="2" colspan="2">Long-distance transmission of analog signals</td><td>Analog</td><td rowspan="2">24 V</td><td rowspan="2">20 mA</td><td rowspan="2">20 kbps</td><td rowspan="2">clamps</td><td rowspan="2">1 pair (simplex) or 2 pairs (full duplex)</td><td>OVR TC 24 V P</td></tr>
<tr><td>Line
4 - 20 mA HART</td><td>Analog + digital</td><td>OVR TC 24 V P</td></tr>
<tr><td rowspan="2">RS 232 (24 V)</td><td rowspan="4" colspan="2">Serial communication between devices</td><td rowspan="4">Digital</td><td>± 15 V</td><td rowspan="4">~ 100 mA</td><td rowspan="2">20 kbps</td><td rowspan="4">clamps or SUB-D9 or SUB-D25 or RJ45</td><td rowspan="2">4, 8, (RJ45), 9 (SUB-D9) or 25 (SUB-D25) wires</td><td>(N wires /2) x OVR TC 24 V P</td></tr>
<tr><td>± 12 V</td><td>(N wires /2) x OVR TC 12 V P</td></tr>
<tr><td rowspan="2">RS 485</td><td>-7 … + 12 V</td><td rowspan="2">35 Mbps</td><td rowspan="2">1 pair</td><td>OVR TC 12 V P</td></tr>
<tr><td>± 6 V</td><td>OVR TC 6 V P</td></tr>
<tr><td>10 Base T</td><td rowspan="3" colspan="2">Company Ethernet network</td><td rowspan="3">Digital</td><td rowspan="3">5 V</td><td rowspan="3">~ 100 mA</td><td>10 Mbps</td><td rowspan="3">RJ45</td><td rowspan="3">2 pairs</td><td>2 x OVR TC 6 V P</td></tr>
<tr><td>100 Base T</td><td>100 Mbps</td><td>2 x OVR TC 200 V P</td></tr>
<tr><td>Token ring</td><td>4, 16, 100 Mbps</td><td>2 x OVR TC 6 V P or OVR TC 200 V P depending on the speed</td></tr>
<tr><td>Foundation FieldBUS (H1, H2)</td><td rowspan="3">Communications between PCs, actuators, sensors and field equipment</td><td></td><td rowspan="3">Digital</td><td>32 V</td><td>10-30 mA</td><td>32 kbps - 2.5 Mbps</td><td rowspan="3">clamps or SUB-D9 or SUB-D25</td><td rowspan="3">1 pair</td><td>OVR TC 48 V P</td></tr>
<tr><td>Field BUS Profibus DP</td><td>PROFIBUS Field BUS</td><td>± 6 V</td><td>~ 100 mA</td><td>35 Mbps</td><td>OVR TC 6 V P</td></tr>
<tr><td>Field BUS Modbus</td><td>MODICON Field BUS</td><td>-7 … + 12 V</td><td>~ 100 mA</td><td></td><td>OVR TC 12 V P</td></tr>
<tr><td>EIB / KNX (ABB i bus)</td><td colspan="2">Office automation and control systems</td><td>Digital</td><td>24-34 V</td><td>~ 10 mA</td><td>9.4 kbit/s</td><td>clamps</td><td>1 pair</td><td>OVR TC 48 V P</td></tr>
</table>

Solutions for all uses
Protecting domestic installations

OVR PLUS is an auto-protected SPD for the TT/TNS single-phase systems and 3 phase + Neutral. Designed for the home and small offices, thanks to its extremely reduced level of protection it is ideal to protect the most delicate equipment from overvoltages of atmospheric origin or maneuvers: LCD, LED and plasma televisions, computers, household appliances.

Benefits of OVR PLUS SPDs

Universal
Thanks to the nominal current of 5 kA or 20 kA, the device is perfect for protection against indirect lightning strikes in all domestic installations, but also commercial and industrial applications, even in areas with high lightning-strike frequency. Ensures surge protection for many years.

Auto-protected
The integrated back-up miniature circuit breaker ensures automatic disconnection of the device at the end of its life, without the need for additional protection upstream.

No residual current to earth
Thanks to the 1+1 or 3+1 schemes with an N-PE spark gap to earth, it can be installed upstream of the main RCD, protecting it from overvoltage surges and preventing unwanted tripping.

Reduced dimensions
1P+N SPD with I_{Max} 20 or 40 kA and integrated back-up miniature circuit breaker in only two modules (35.6 mm).
3P+N SPD with I_{Max} 20 or 40 kA and integrated back-up miniature circuit breaker in only six modules (106.8 mm).

Mechanical status indicator
The state of the protection is immediately visible on the front of the product. The indication is easy to understand and allows the user to monitor just the status without calling in an electrician as for a standard MCB.

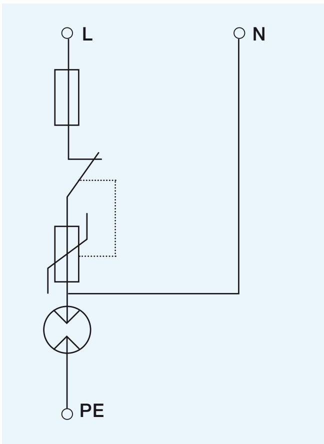
Ease of wiring
Installing OVR PLUS requires just three wires to be connected. No back-up protection needs to be added (it is already integrated) and no remote monitoring contacts need connecting (visual indicator on the front).

Optimum protection level
Thanks to the use of a varistor, the protection level is extremely low (Up=1.3 kV for OVR Plus N1 20) and the device is very fast acting. Safe and fast, the key to safety in domestic installations.

Protection from surges, prevention of unwanted tripping and operational continuity – OVR PLUS brings safety and peace of mind.

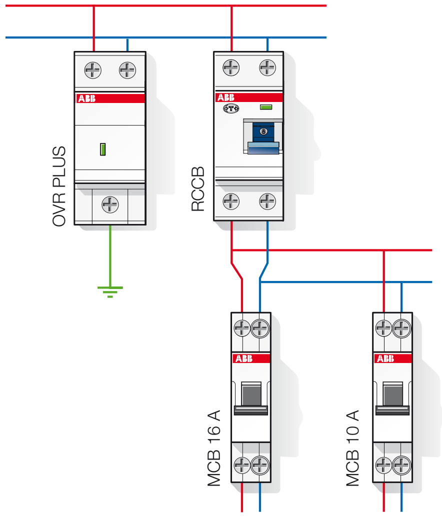
Reserve indicators
2 led: OK
1 led: reserve
2 off: to be replaced

OVR PLUS combines a 1P+N "1+1" SPD, thermal disconnector and MCB back-up protection in a single device.

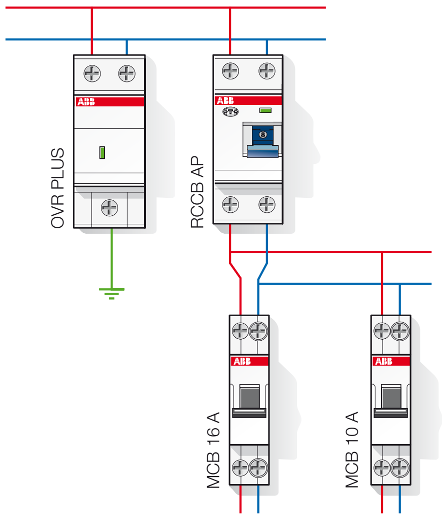


Practical examples of consumer units with OVR PLUS

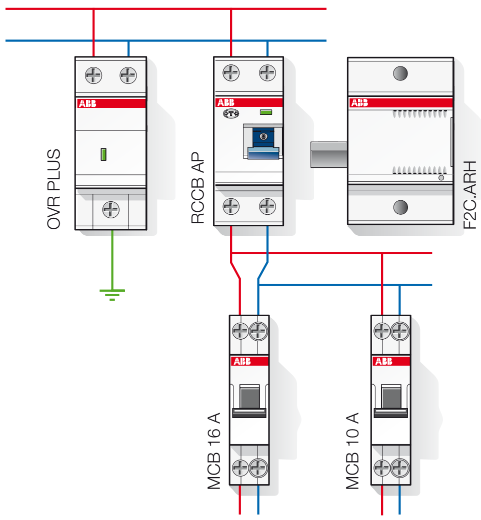
Surge protection and prevention of unwanted tripping



Surge protection and high-performance prevention of unwanted tripping

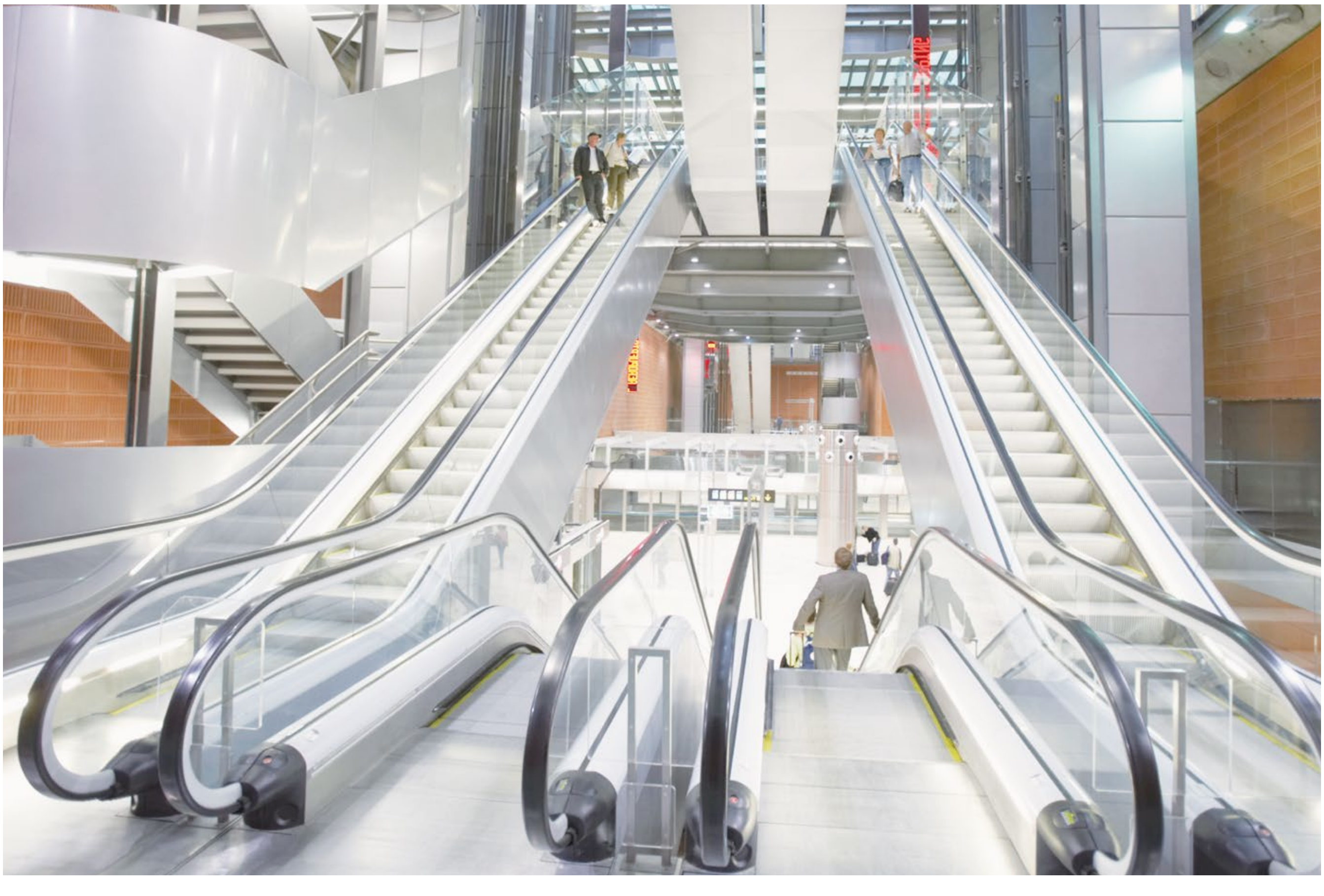


Surge protection, high-performance prevention of unwanted tripping and absolute continuity of service



E 90 Series
Designed by ABB for the most demanding customers

Disconnection and switching suitability, efficient dissipation of heat and certification by several international Standards are essential requirements to satisfy the expectations of the most demanding clients. ABB has dedicated the passion, competence and creativity of its designers to the development of the new range of E 90 fuse switch disconnectors.
The result is the first fuse switch disconnector AC-22B IMQ and cURus approved up to 32 A and 690 V.



Rules for installation of SPDs
General criteria, tips and tricks

The SPD at the origin of the plant must be installed immediately downstream of the master circuit breaker.

The SPD must be:
- Sized according to the impulse withstand voltage of the equipment to be protected
- Installed near the equipment to be protected
- Co-ordinated with other surge protection devices

Appropriate steps for limiting voltage surges

Some useful tips for limiting overvoltage surges:
- Avoid connections which enclose a very large area, ensuring that the power and low-voltage cables follow the same path while respecting spacing rules for the two networks;
- Identify the equipment (lifts, lightning rods) which generate surges. Ensure that there is sufficient distance between them and sensitive equipment or that suitable overvoltage protection has been installed;
- Favour the use of shielding for equipment and cables as well as creating an equipotential connection between all the metal parts which access, come out of or are found inside the building, using braiding which is as short as possible;
- Identify the type of earthing system in order to choose the most suitable overvoltage protection; where possible, avoid the use of the TN-C system when there is sensitive equipment inside the plant;
- Select the back-up breakers correctly;
- Favour type-S selective RCDs (DDA 200 A S or F 200 A S) to provide protection against indirect contact in order to avoid unwanted opening of the circuit in the case that the RCD is located upstream of the SPD.

Back-up protection: a question of safety

The back-up protection has the function of opening the circuit in the case of the fault or a short circuit following through from the discharge which the SPD is not able to open. At the same time it must withstand the passage of the discharge to preserve the protection continuity.

Class 1 SPDs

During the electrical discharge, an arc forms between the electrodes of the spark gap. When the discharge has passed, the SPD must extinguish the arc and restore its isolating properties. This operation is performed with the arc extinguishing chamber. If this does not occur, as the value of the current is too high ($I_f > I_{fi}$), the electric arc will be maintained for an indefinite period of time, putting the electrical installation at risk and leading to a serious fire risk. At this point the back-up protection cuts in, opening the circuit and eliminating the short-circuit. The back-up protection ensures safety even in the case of SPD malfunction.

Class 2 SPDs

Class 2 SPDs contain varistors. A varistor slowly deteriorates throughout its working life, its isolation characteristics diminishing little by little. The end-of-life of the SPD is the moment when the current flowing (with mains voltage) is high enough to cause overheating sufficient to cause damage. At this point, the SPD must be disconnected from the network to prevent the risk of fire. This operation is performed with the thermal disconnector integrated into each varistor which disconnects it in the case of excessive overheating. In some cases the varistor can reach the end of its life in an instant (for example after a series of strong discharges), generating a short circuit in the varistor. The thermal disconnector may not be able to open the short-circuit, and the operation is therefore performed by the back-up fuse which safely disconnects the SPD.

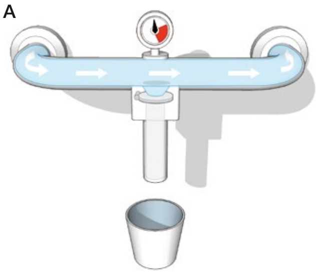
To make a plumbing analogy, the Class 2 SPDs can be considered similar to safety valves:
- When the pressure in the pipe (the system voltage) is normal, the valve is closed
- When the pressure increases (overvoltage surge) which could lead to the pipes (the electrical wires) or the equipment connected to them bursting or being damaged, the safety valve opens the bleed outlet, letting a little liquid (discharge current) flow out;
- When the pressure returns to a normal value, the valve closes by itself (isolation between phase and earth conductors restored);

After numerous sudden peaks in pressure, the safety valve becomes worn and starts to leak (the varistor is no longer able to isolate the network).
– According to Joule's law:
Loss in Watts = Resistance x Current ^{2}
therefore...

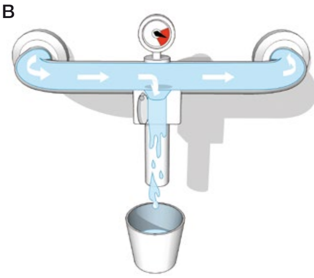
$$\mathbf{R}\text{ (large)} \times \mathbf{I}^2\text{ (small)} \times \mathbf{T}\text{ (minutes)} = \textbf{heat!}$$

The passage of this current through the varistor is problematic, provoking dangerous overheating!

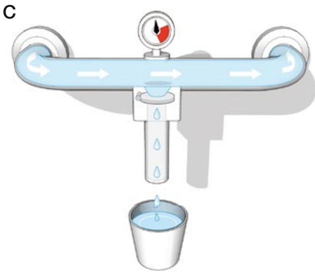
A



B



C

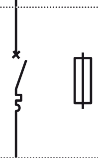
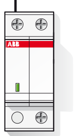


A - Normal water pressure
B - Sudden increase in pressure
C - Worn, the valve begins to leak

Rules for installation of SPDs
Back-up protection: a question of safety

To prevent the varistor overheating at the end of its life, the SPD must be suitably protected both with a thermal disconnector (integrated) and with a back-up protection. The back-up protection must be quick enough to disconnect the varistor at the end of its life in the case that the thermal disconnector is not able to isolate the network before the heat generated leads to tragic consequences.

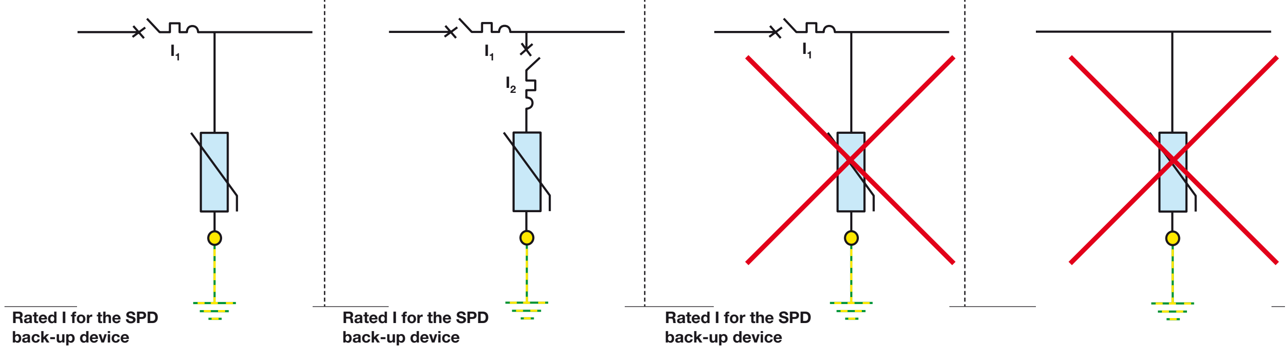
SPDs must be combined with suitable upstream back-up protection and with differential protection, depending on the distribution system.

Diagram	Function	Application
	Protection against indirect contact	The RCD is - mandatory for TT systems - Recommended for TN-S, IT and TN-C-S systems - Forbidden for TN-C systems RCDs installed upstream of the SPDs should preferably be type S. To avoid unwanted tripping, where possible the "3+1" scheme (or "1+1 for single-phase networks) is preferable in any case, in which the RCD may be installed downstream of the SPD.
	Back-up protection against faults or end-of-life	The back-up disconnector device can be: - An MCB - A fuse For Class 2 SPDs, the choice depends, apart from on the type of SPD, on the short-circuit current of the system at the installation point.
	Thermal protection	All ABB OVR SPDs are fitted with integrated thermal protection.

All Type 1 and Type 2 OVR 1P+N and 3P+N SPDs can be installed upstream of the RCD. This rule is recommended by standards to avoid the current from lightning strikes passing through the RCD. It allows the RCD to be protected on one hand, and maintains operational continuity on the other hand.
This rule is not possible in many country because of the Power Network operator.

The SPD can be protected with the line protection, or it may have a dedicated back-up device. The currents I1, I2 and I in the different diagrams are the rated protection currents (fuse or MCB).

Permitted		Not permitted	
Priority to protection I_1 < I of the SPD	Priority to operational continuity I_1 > I of the SPD and I_2 = I of the SPD	I_1 > I of the SPD	No protection



Note:
- I_1 and I_2: rated services of the MCB(s) or fuse(s).
- Back-up I of the SPD: rated current of the recommended back-up protection device (see table on next page).

Priority to protection: at the end of the SPD's life, the system downstream goes out of service and the line protection opens. To restore the power supply it is necessary to replace the used SPD (or cartridge).
Priority to operational continuity: at the end of the SPD's life it is isolated from the downstream system (in the same way if the back-up protection or MCB open). The network remains in service without the immediate need to replace the SPD. The downstream system is no longer protected from surges, however, until the SPD is replaced. It is therefore necessary to replace the SPD as quickly as possible.

In general it is recommended to prioritize operational continuity by installing back-up protection dedicated to the SPD. A SPD with a safety reserve increases the operational continuity.

Rules for installation of SPDs
Back-up protection: a question of safety

Note:
The cut-out device is also commonly called back-up protection.

Maximum rated current of breaker or fuse in function of I_{max} and I_{imp} of the SPD.

Type 1 and Type +2 SPDs

		
	Fuse (gG)	**Breaker (Curve C)**
25 kA per pole (10/350 µs)	125 A	125 A

Type 2 SPDs

		Fuse (gG)	**Breaker (Curve C)**
70 kA (8/20 µs)	I_{sc} da 300 A a 1 kA	20 A	30 A (1)
	I_{sc} from 1 kA to 7 kA	40 A	from 32 A to 40 A (2)
	I_{sc} greater than 7 kA	63 A	from 32 A to 63 A (3)
40 kA (8/20 µs)	I_{sc} da 300 A a 1 kA	16 A	25 A (1)
	I_{sc} from 1 kA to 7 kA	25 A	25 A (2)
	I_{sc} greater than 7 kA	50 A	from 25 A a 50 A (3)
15 kA (8/20 µs)	I_{sc} da 300 A a 1 kA	16 A	from 10 A a 25 A (1)
	I_{sc} from 1 kA to 7 kA	16 A	from 10 A a 32 A (2)
	I_{sc} greater than 7 kA	from 25 A to 40 A	from 10 A a 40 A (3)

1) Series S 200 L
2) Series S 200 L, S 200
3) Series S 200 M, S 290

ABB has always promoted the use of back-up protection for Class 2 SPDs with relatively low rated currents. What are the benefits of this choice?

The back-up protection solutions have been selected and tested in the lab to supply the maximum operational continuity and maximum safety.
- Operational continuity is obtained with a back-up protection which does not trip out during discharges, which can reach 5 kA for indirect lightning strikes.
- Maximum safety is obtained by disconnecting the SPD as soon as possible when it has reached the end of its life and the thermal disconnector is not able to open the circuit.

The solutions indicated in the table above are therefore the minimum ratings which allow the discharge current to flow and open the circuit rapidly in the presence of a short-circuit current. If there is a short-circuit inside the panel, it is better not to wait to disconnect it!

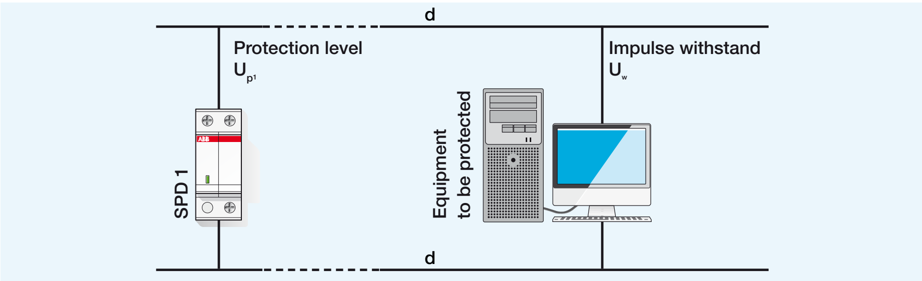
Protection distance

The length of the line between the installation point of the SPD and the equipment to be protected assumes great importance in terms of the effectiveness of surge protection.

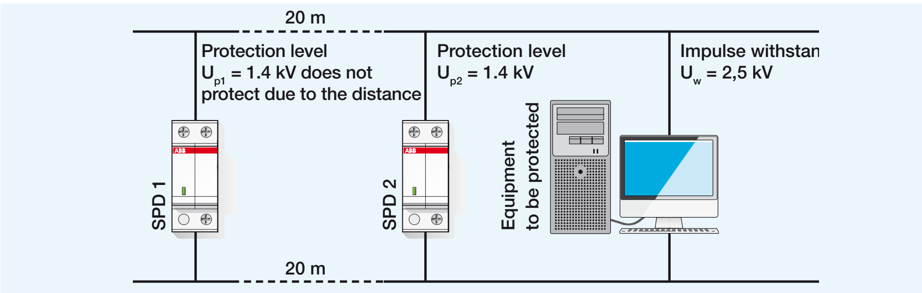
Indeed, if this distance is excessive, the effectiveness of the SPD decreases, as the cable loop behaves like an antenna and is therefore subject both to oscillatory reflection phenomena which can give rise to an increase of the surge voltage (up to 2 times U_p), and to electromagnetic induction phenomena, which increase with the size of the relevant loop.
The protected distance, in other words the maximum length of the conductors between the SPD and the equipment, essentially depends on the protection level U_p, U_{prot} with the voltage drops on the SPD connections and on the impulse withstand voltage U_w of the equipment to be protected. This distance can be calculated, but in any case must be contained, in light of experience in the area, within a maximum radius of 10 m. The installation of a SPD at the origin of the plant may not, therefore, be enough to protect it in its entirety; it is thus necessary to install further SPDs downstream with lower protection levels, co-ordinated with the one upstream, in order to make the whole system safe.

Recommendations for creating effective protection

- If the length of the line between the SPD and the equipment to be protected is less than 10 m, the protection is considered 100% effective (this according to the IEC 61643-12, please verify your National standard for further information)
- If the length exceeds 10 meters, the effectiveness of the protection decreases
- According to IEC 61643-12, the upstream protection must be repeated downstream if: U_{p1} x 2 > 0.8 x U_w



For example, a SPD with U_{p1} = 1.4 kV, installed in the main distribution switchboard, protects the terminal equipment over 10 m away only if the equipment has an impulse withstand voltage U_w of at least 3.5 kV. If the equipment to be protected has a lower withstand, it will be necessary to install a second SPD at less than 10 m distance or, if possible, move the first one closer.



Rules for installation of SPDs
Co-ordination principle

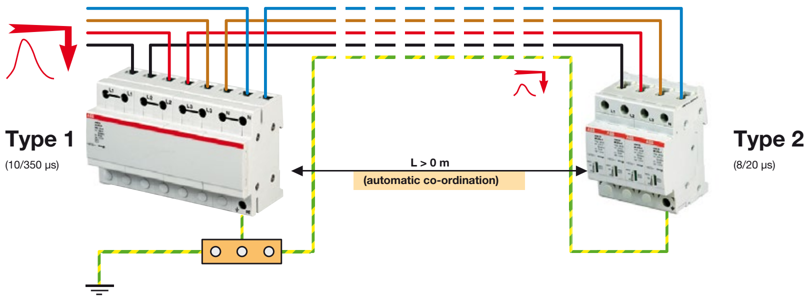
Note:
Co-ordination of the Type 2 SPDs is performed by considering the respective maximum discharge currents I_{max} (8/20 µs), starting at the main switchboard at the origin of the system, and working towards the equipment to be protected, keeping track of the progressive reduction of I_{max}.
For example, 70 kA followed by 40 kA.
All Type 2 ABB SPDs are automatically co-ordinated with one another, respecting a minimum distance of 1 m.

After defining the characteristics of the SPD at the origin of the electrical system, it may be necessary to complete the protection with one or more additional SPDs.

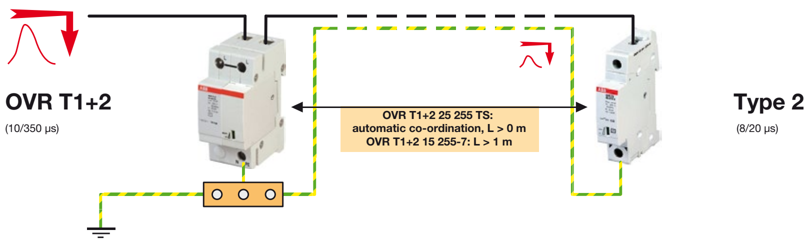
The main SPD at the origin may indeed not be sufficient to ensure effective protection for the entire plant. If the length of the cable downstream of the SPD is greater than 10 m, various electromagnetic phenomena can increase the residual voltage of the SPD installed upstream. It is therefore necessary to upgrade the protection with a SPD placed in proximity to the equipment to be protected (at less than 10 m). The SPDs must be co-ordinated on installation (see tables below).

Additional protection must be installed downstream of the SPD present in the main switchboard if:
- The initial SPD does not reach the required level of protection (U_P) on its own; for example if sensitive equipment is connected to a switchboard protected by a Class 1 SPD.
- The initial SPD is at more than 10 m from the equipment to be protected.

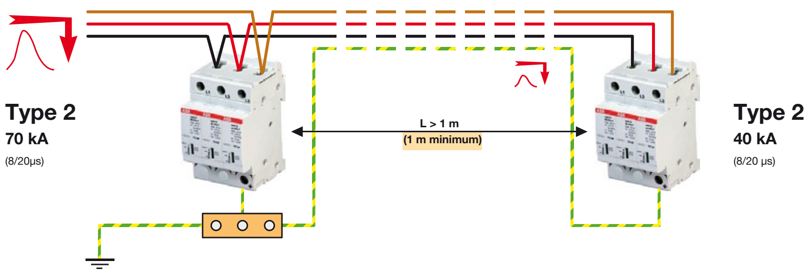
Co-ordination of OVR Type 1 and Type 2
Installation of a Class 2 SPD downstream of a Class 1 SPD in proximity to the terminal equipment ensures it is protected against overvoltage surges.



Co-ordination between OVR T1+2 and OVR T2



Co-ordination of OVR Type 2
Given that protection is 100% ensured up to 10 meters, co-ordination between two Class 2 SPDs is always obtained.



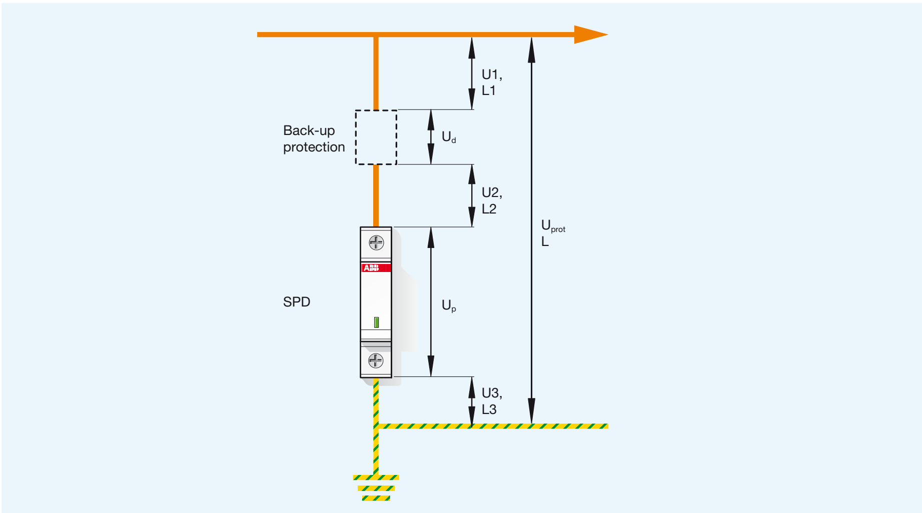
Rules for installation of SPDs
Installation and wiring of SPDs in an electrical switchboard

Connection distance
50 cm rule

A lightning current of 10 kA generates a voltage drop of approximately 1200 V in 1 m of cable due to the inductance of the conductor. Equipment protected by a SPD is therefore subject to a voltage of U_{prot} equal to the sum of:
- Protection level of the SPD U_p
- Voltage at the terminals of the back-up protection U_d
- Voltage in the connections U_1, U_2, U_3

$$U_{prot} = U_p + U_d + U_1 + U_2 + U_3$$

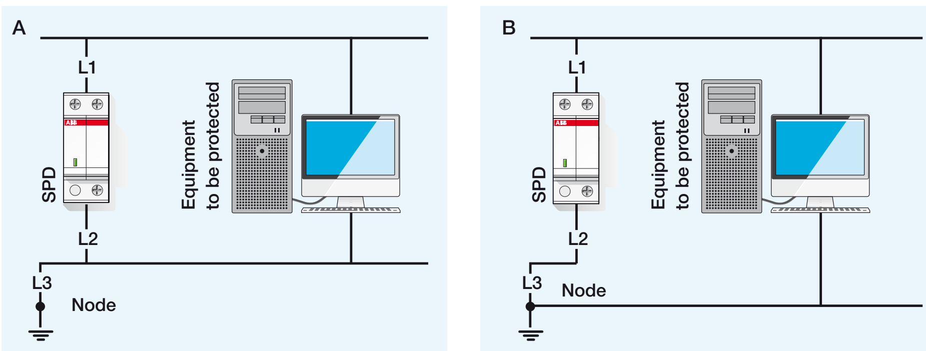
To maintain the level of protection below the impulse withstand voltage (U_w) of the devices to be protected, the total length (L = L1 + L2 + L3) of the connecting cables must be as short as possible (less than 0.50 m).



It is necessary to pay attention to the actual length of the connections, which must be measured from the SPD's terminals to the point at which the cable is taken off as a spur from the main conductor. Here is an example which demonstrates the importance of the lengths of connections (for simplicity the diagram omits the back-up protection).

A: in this case…
L = L1 + L2
The length L3 has no effect on the protection of equipment.

B: in this case…
L = L1 + L2 + L3
If the length of L3 is several meters, considering that every extra meter of wire increases the protection voltage by 1200 V, the protection loses a lot of effectiveness.

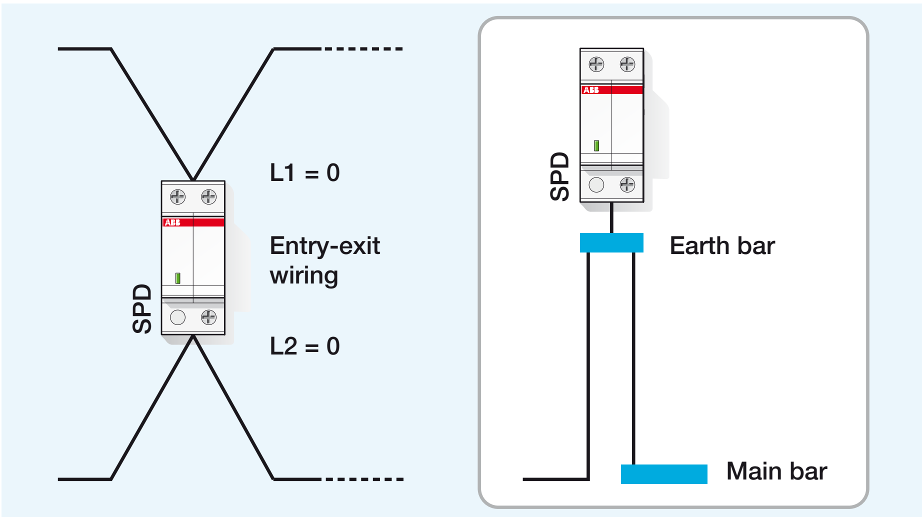


The equipment's earth connection must be distributed, starting from the connection of the SPD which protects it.

Installation and wiring of SPDs in an electrical switchboard

In the case where the length of the connection (L = L1 + L2 + L3) exceeds 0.50 m, it is recommended to adopt one of the following steps:

1) Reduce the total length L:
- By moving the installation point of the SPD in the switchboard;
- Using V, or "entry-exit" wiring, which allows the lengths of the connections to be reduced to zero (it must, however, be ensured that the rated line current is compatible with the maximum current tolerated by the SPD's terminals);
- In large switchboards, connect the PE coming in to an earth bar near the SPD (the length of the connection is only the spur off from this point, so a few cm); downstream of the connection point, the PE can be taken to the main earth bar.



2) Choose a SPD with a lower level of protection U_p

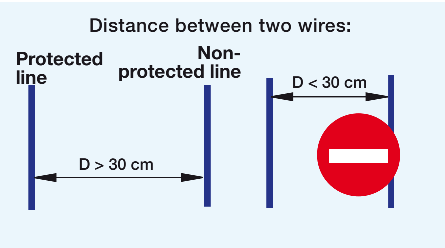
Install a second SPD co-ordinated with the first as close as possible to the device to be protected, so as to make the level of protection compatible with the impulse withstand voltage of the equipment.

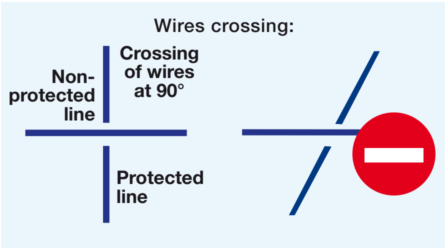
Electrical lines and connection area

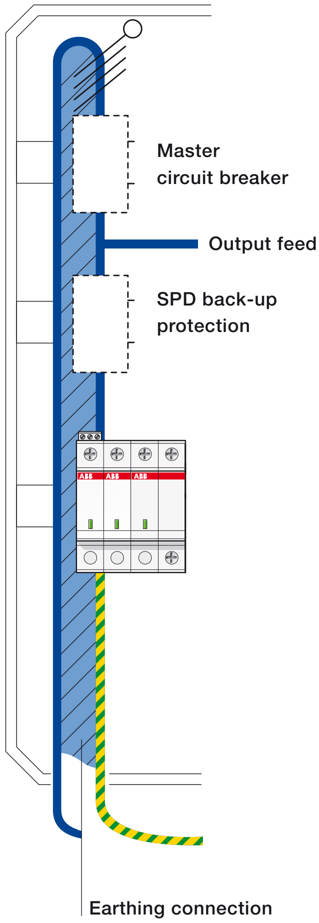
It is necessary to arrange the lines so that the conductors are as close as possible to each other (see figure) to avoid surges induced by inductive coupling of an indirect lightning strike with a large loop contained between the phases, the neutral and the PE conductor.

Cabling of protected and non-protected lines

During installation, run the protected and non-protected wiring according to the instructions in the diagrams below.
To avoid the risk of electromagnetic coupling between different types of wires, it is strongly recommended they be kept at a distance from one another (> 30 cm) and that when it is not possible to avoid them crossing, this needs to be performed at a right angle.







Equipotential earthing

It is fundamental to check the equipotentiality of the earths of all the equipment. The equipment's earth connection must also be distributed, starting from the connection of the SPD which protects it.
This allows the connection distances and therefore the voltage U_{prot} to be limited.

Section of the connections

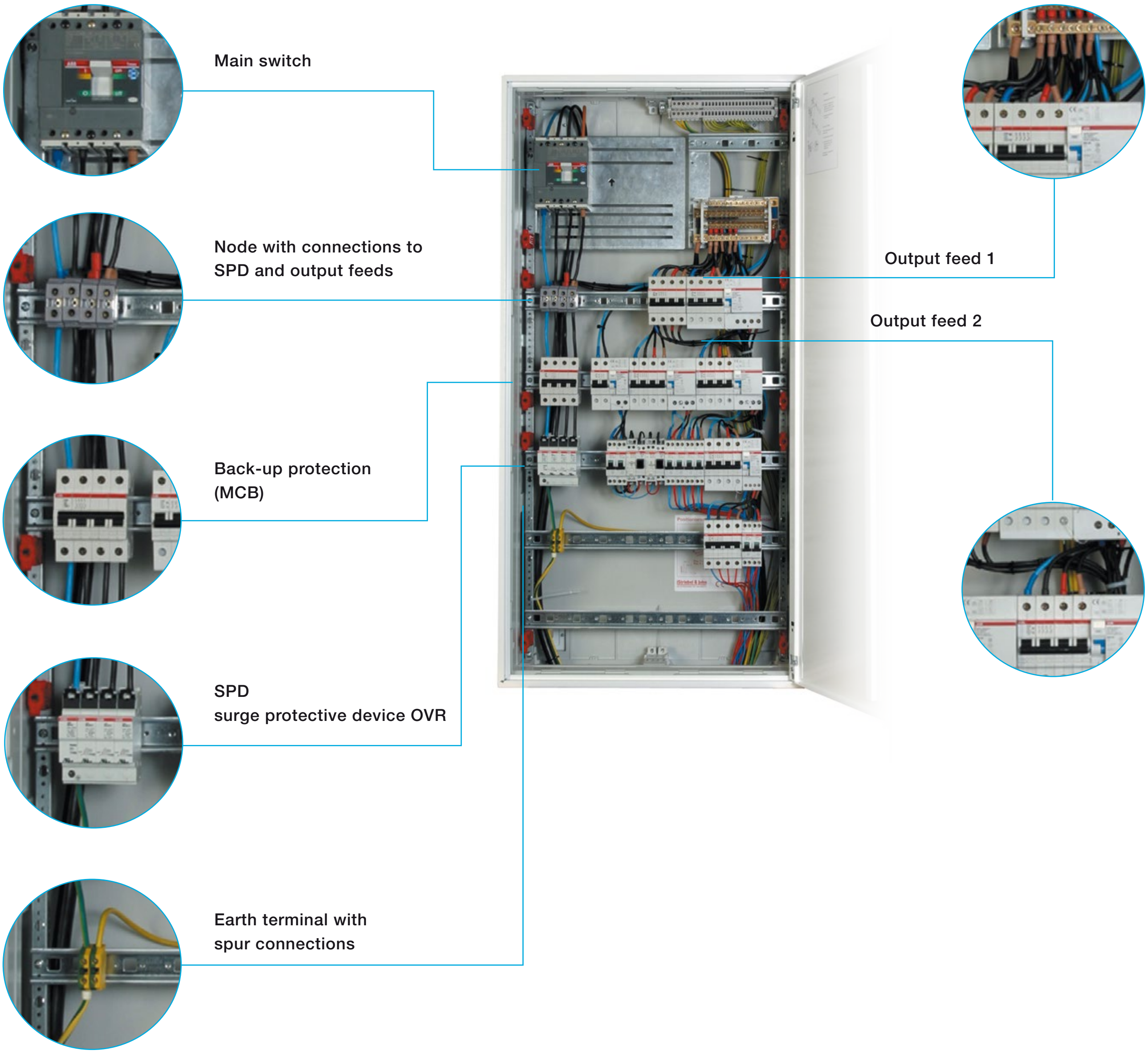
Wiring between active network conductors and the SPD

The cable section must be at least the same as the upstream wiring. The shape of wiring is more important than the section. The recommended section for Main Board is 10 mm² for phase and Neutral and 16 mm² for earth.

Wiring between the SPD and earth

The minimum section is 4 mm² in the case where there is no lightning conductor, and 10 mm² in the case one is installed. It is nevertheless recommended to use a cable with a greater section to leave a safety margin, e.g. 10-20 mm² section.

Rules for installation of SPDs
Example of an electrical switchboard protected by ABB surge protection solutions



Rules followed by the installer:
- Connection distances < 50 cm
- Earth terminal in proximity to SPD
- Back-up protection dedicated to the SPD
- Protection installed upstream of RCDs
- Reduction of the loop between the phases, neutral and PE

Further technical information for the curious

My neighbor has installed a lightning conductor, could it have an effect on my electrical system in the case of a storm?

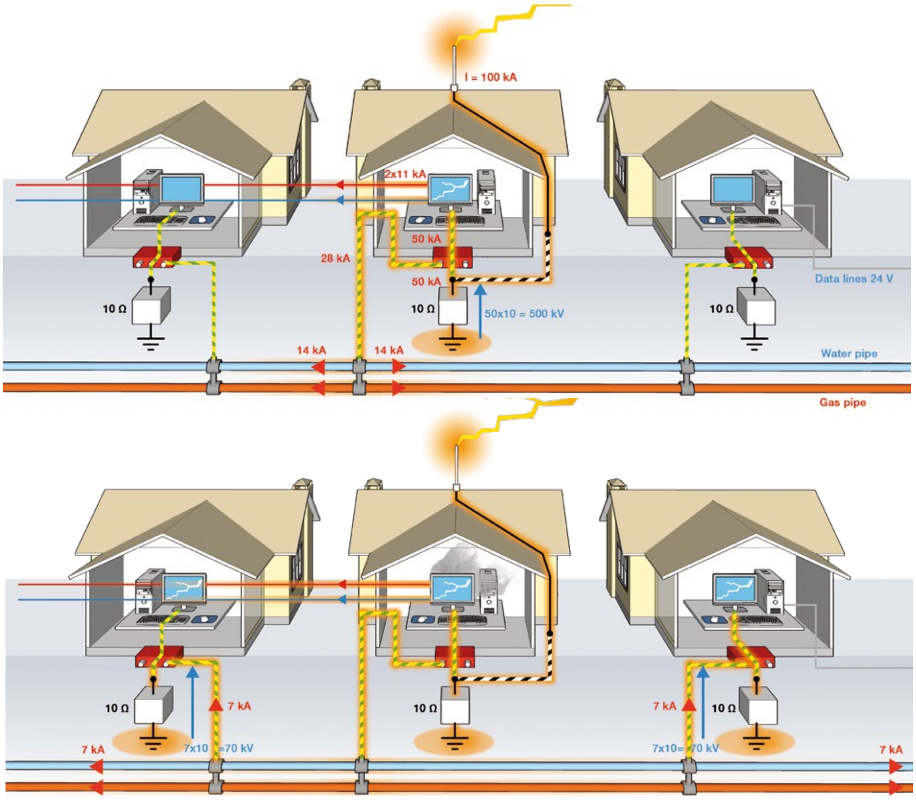
Two phenomena could occur in the case of a direct lightning strike on your neighbor's house:

- The first is the conduction of the lightning current to your system through the electrical network or other conductive elements, if they are interconnected.
- The second is the indirect effect resulting from the strong current of the lightning passing through your neighbor's lightning ground system.

If your neighbor has installed a lightning conductor, it is highly recommended to install a SPD on your own installation.

In densely populated areas the electrical connections and the water/gas mains can be common to different buildings. The metal pipes are earthed in different points.
In the case of a direct lightning strike on a lightning rod, about half of the current flows to earth, while the rest flows into the electrical network and the other services entering the building (electrical network, pipes...).
The equipment connected near the lightning rod can be hit by the voltage surge through the electricity network or other services. The presence of a lightning rod in the area therefore increases the risk of suffering from a lightning strike.

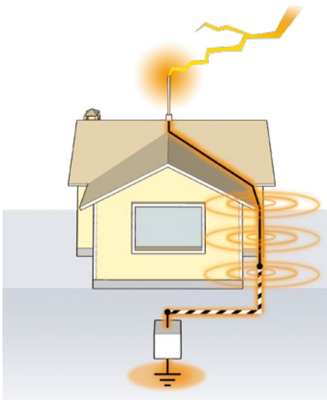
Conduction of the lightning current to your electrical system



The passage of the lightning current in the conduit generates a strong surge. A surge can damage the equipment connected to the nearby electrical installations: this is the phenomenon of an indirect lightning strike.

Multiple factors attenuate the effect of an indirect lightning strike: The distance between the two houses, the presence of metallic meshes (e.g. in concrete), shielding of wiring…
A detailed calculation of the effects of the passage of the lightning current inside the building is given on the next page.

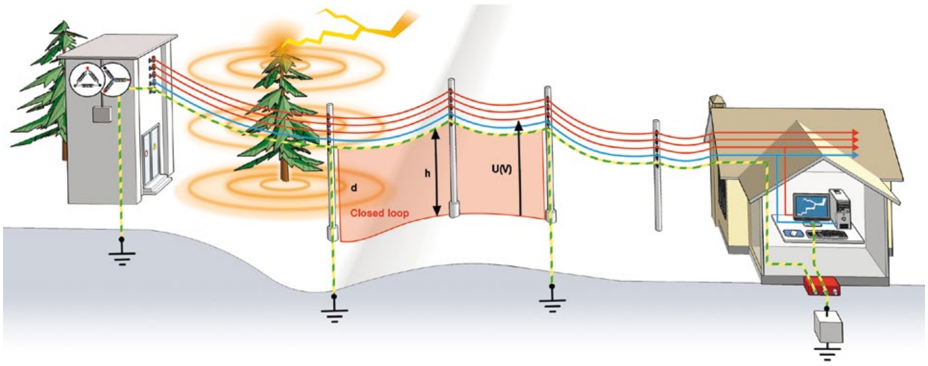
Indirect lightning strikes resulting from a direct strike in the surrounding area



If there is a lightning rod nearby it is always preferable to install surge protection.

Further technical information for the curious
Example calculations of the effects of indirect lightning strikes

Indirect lightning strike on the aerial electricity lines



Example: k = 1, i = 40 kA, d = 60 m, h = 6 m => U = 120 kV
The voltage surge runs through the aerial electricity lines to arrive on the connected equipment and damaging it.

The lightning provokes a sudden increase in the magnetic field (dB/dt), causing an overvoltage surge in the loops (transformer effect).

The aerial electricity supply lines behave like closed loops (due to the connection to earth of the PE in TNS systems and neutral to earth for TT). The loops generate an overvoltage U when they are struck by the magnetic wave. The formula is :

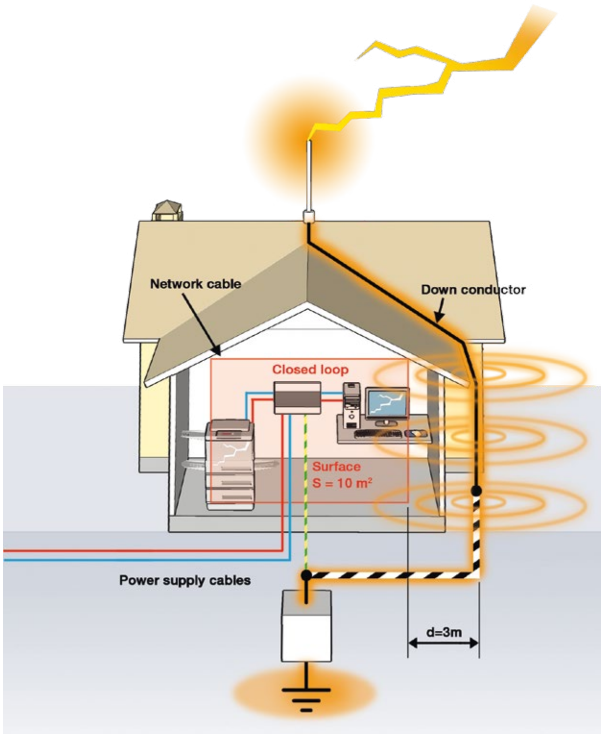
$$U = 30 \times k \times \frac{h}{d} \times I$$

(IEC 61 643-12 Annex C.1.3.)

I = Lightning current
h = Height of the conductor from the ground
k = A factor which depends on the return speed of the discharge in the lightning conduit (k = 1-1.3)
d = Distance from the lightning

Indirect lightning strike due to passage of current through the lightning conductor

The direct lightning strike on the building creates an indirect lightning strike in the surrounding area.
Calculation of overvoltage U with the effect of the indirect lightning strike inside the building:



$$U = \frac{\Delta\phi}{\Delta t} \quad \begin{cases} \phi = B \times S \\ B = f(i, d, \mu ...) \end{cases}$$

$$U = \frac{200 \times S \times \Delta i}{d \times \Delta t} \quad \begin{cases} \Delta I/\Delta t\text{: Speedness of the current wave} \\ d\text{= Distance between down conductor and closed loop} \\ S\text{= Surface of the closed loop} \end{cases}$$

Example	
	$\Delta I/\Delta t = 15kA/\mu s$
	d=3m
	S=10m ^{2}

$$U = \frac{200 \times 10 \times 15\ (kA)}{3 \times 1\ (\mu s)} = 10\ kV$$

Note: Annex B of IEC 61024-1-2 indicates the calculation for the overvoltage caused by lightning striking a structure.

The effect of the indirect lightning strike is large even in the area surrounding the lightning rod, for example in the neighboring houses.

Further technical information for the curious
Protection distance

As previously described in the guide, protection is 100% assured up to a distance of 10 m downstream of the SPD. Beyond that distance it is always recommended to repeat the devices in order to protect the equipment, since the residual voltage tends to increase and can become greater than the equipment's impulse withstand voltage. A surge exceeding the impulse withstand voltage value would damage the equipment.

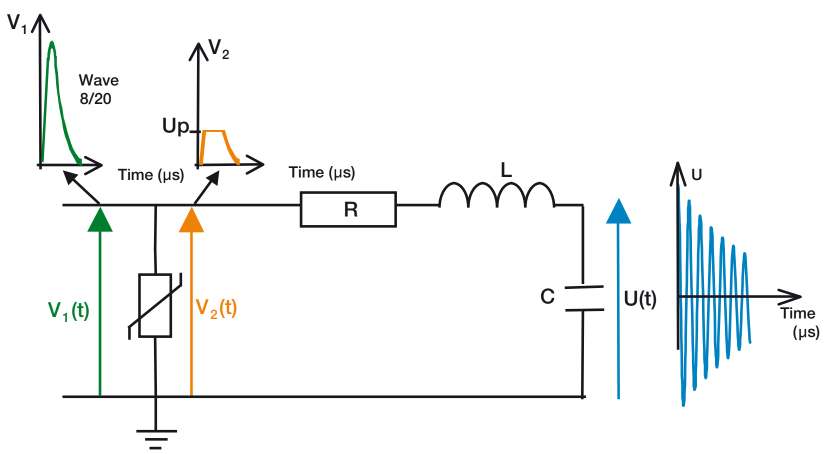
There are two factors which have the greatest influence on the voltage downstream of the SPD:
- The first is the propensity of the electrical network downstream of the SPD to collect the magnetic field variations. The cables downstream of a SPD can be subject to an indirect lightning strike causing surges to occur in the circuit, even if positioned downstream of a SPD!
- The second is linked to the phenomenon of oscillation: the voltage U_p that the SPD limits at its terminals is amplified downstream of the installation. The greater the distance between the SPD and the device requiring protection, the greater this amplification will be. The oscillations can create voltages in the equipment which can reach two times the U_p value. The amplification depends on the SPD itself, the electrical network, the length of the conductors, the discharge gradient (spectral composition of the discharge) and the equipment connected.

The worst case is encountered when the equipment has a high impedance or is internally disconnected from the network (a device turned off at a switch acts as a capacitor).

The phenomenon of oscillation needs only be considered if the distance between the SPD and the equipment is greater than 10 m (IEC 61 643-12 § 6.1.2 & annex K.1.2). Below this distance, protection is 100% guaranteed.

The electrical circuit can be modeled as an RLC circuit (Resistor – Inductor – Capacitor): a diagram of it is shown in the figure

Legend:
V_1: Supply voltages
V_2: Voltage at SPD terminals
U: Voltage at equipment terminals (disconnected from network)



Impulse voltage downstream of the SPD

The voltage at the terminals of the SPD during a discharge is characterized by the sum (Fourier series) of the sinusoids of approximately a half period and of frequency between 0 and 400 kHz. For frequencies greater than 400 kHz, the amplitude is low enough to be able to consider the effect of the oscillation to be negligible (for the 10/350 μs and 8/20 μs waves).

Behavior of an RLC circuit with a sinusoidal impulse

The voltage u(t) in the equipment in function of the voltage at the SPD terminals (v_2) is governed by the following formula:

$$\frac{d^2u}{dt^2} + \frac{R}{L}\frac{du}{dt} + {\omega_0}^2 u = {\omega_0}^2 v_2$$

With $v_2(t)$ sinusoidal voltage ($v_2(t)=V_2 \cos \omega t$), the voltage in the equipment is:

$$U = \frac{V}{\sqrt{(1-LC\omega^2)^2 + R^2C^2\omega^2}}$$

Resonance of the RLC circuit occurs at the angular frequency of:

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

And the resonance voltage is:

$$V_2 \frac{1}{R}\sqrt{\frac{L}{C}}$$

Influence of the distance between the SPD and the equipment to be protected in the RLC circuit

The phenomenon of resonance can become dangerous when the resonance frequency downstream of the SPD is less than 400 kHz (that is when the circuit is inclined to resonate with the waves which the SPD lets through during a discharge).
In these cases the circuit downstream of the SPD starts to resonate with the waves composing the residual voltage of the discharge. The resonance of the circuit creates surges which can be dangerous to the equipment connected to it.
Despite this, if no delicate equipment is connected downstream of the SPD or if the protection is repeated in proximity to it (at less than 10 meters), protection is ensured.

Distance between the SPD and the equipment to be protected	L (inductance of the downstream cables)	Resonance frequency of the downstream circuit (RLC with C=10nF)	Resonance frequency > 400 kHz = Negligible resonance
1 m	1 μH	1592 kHz	✓
10 m	10 μH	503 kHz	✓
30 m	30 μH	290 kHz	✗
50 m	50 μH	225 kHz	✗
100 m	100 μH	159 kHz	✗

The length of the wires between the SPD and the equipment to be protected must therefore be a maximum of 10 meters to guarantee 100% protection. Above this distance the protection is reduced by the combined effects of the indirect lightning strike (the circuit acts like an antenna) and the resonance of the residual voltage of the discharge.
For this reason the Class 2 SPDs must be installed as close as possible to the equipment to be protected or, if that is not possible, the protection must be repeated.

Further information
Exploding the myths and reconsidering convictions

Nowadays we use surge protective devices every day, but we still have doubts and curiosities fed by the many urban legends on the subject. Let's look at a few and try to better understand.

"The discharge kilo amperes of a SPD must be coordinated with the short-circuit current of the switchboard"

This belief is due to a misunderstanding. The short circuit current of a switchboard and the discharge current of a SPD are both measured in kilo amperes. However, a short-circuit current normally has a sine wave with a frequency of 50 Hz whilst the discharge current of a SPD has the form of a very brief impulse of just a few microseconds.

Consequently, even the energy content (I_2t) of a short circuit and of a discharge are very different. Once the misunderstanding has been cleared up it is evident that there is no relationship between the I_{sc} of a switchboard and the discharge current of a SPD.

So, how do you choose the discharge current or impulse of a SPD?

It is easier than it seems:

- For a Type 1 SPD there is nothing to choose as the value is imposed by IEC 62 305-1: almost all SPDs have a value of 25 kA per pole and are therefore sized for the worst case provided for by current regulations
- If the risk calculation following the IEC 62305-2 was done a precise current for SPD can be calculated
- For Type 2, the maximum discharge current value foreseen by the standard IEC 62 305-1 is 5 kA, therefore a Type 2 SPD must have at least 5 kA of I_n.

For practical reasons it is nearly always advisable to choose a SPD with at least 20 kA of I_n to ensure an adequate length of working life.

"In a three-phase system with 400 V AC voltage a SPD with a rated voltage of 400 V AC must be installed"

Other misunderstandings. Type 1 and Type 2 surge protective devices are designed to be installed between network and ground, not in series. The "rated voltage" of a SPD is, therefore, that measured between the active conductors (phase and neutral) and the earth conductor.

In a 400 V three-phase network, with or without neutral, this voltage will always be equal to 230 V! The only rare case in which 400 V SPDs are required in a 400 V three-phase network is that of IT systems: in these, indeed, automatic breakage of the power does not happen with a first earth fault. A SPD with 230 V voltage would be subjected to a phase/earth voltage much higher than the nominal voltage and consequently there would be the risk of a failure or fire.

"In a main distribution board it is always best to use a Type 1 SPD"

It depends! In a very large public building or an industrial unit, the risk analysis pursuant to IEC 62 305-2 will probably provide for the installation of an LPS, acronym for "Lightning Protection System", in other words a lightning rod or Faraday cage. In this case the Type 1 SPD will be necessary to protect against damage due to lightning striking the building.

If no LPS is provided for, however, the installation of a Type 1 SPD in the MDB will cause a notable increase in costs without any benefits – it will simply never have to operate!

"To protect a SPD it is necessary to use fuses, breakers are not suitable"

This is also an "Urban legend". Some say that the inductance in series to a circuit breaker reduces the efficiency of the SPD with the discharge current flowing through it. In truth, the SPD product Standard, IEC EN 61643, requires that the manufacturer provide suitable and co-ordinated back-up protection to install upstream from the SPD.

The sizing is carried out in the laboratory trying numerous, different, combinations of SPD and protective devices. With most of its products ABB offers the possibility of using either fuses or MCBs.
So what about inductance? As we all know, the inductance of a coil depends on the frequency; a few tests in the laboratory are sufficient to show that the inductance of an MCB at the typical frequencies of atmospheric phenomena (many kHz) becomes negligible.

OVR T2 3N 40 275s P SPDs

"When lightning strikes and the SPD trips, the SPD must always be replaced"

No, SPDs are not "disposable"! Also because, if this was the case, since there can be numerous atmospheric discharges during a thunderstorm, the SPD would be totally ineffective. In reality, SPDs are designed and tested in order to intervene and to go back to being as good as new at least 20 times, if subjected to their rated discharge current.
Given that statistically speaking the discharge current induced by the atmospheric phenomenon is inferior to the rated current, the SPD can trip even hundreds of times before reaching the so-called "end of life". This is the reason why SPDs are installed every day, but changing a cartridge at the end of its life is a rare occurrence.

"A Type 2 SPD is nothing more than a varistor..."

The varistor is a fundamental component of all Type 2 SPDs, but we must not forget that varistors have two characteristics which a SPD must provide a solution to: they end their operative life in short circuit and they conduct a small permanent current.
In order to prevent the short circuit effects at the end of the varistor's life, a small, essential element is provided inside a SPD: a thermal disconnector which isolates the varistor from the network in case of overheating, ensuring a safe end of life for the SPD.
In order to prevent the permanent current to earth, on the other hand, which could involve the risk of indirect contact, in some Type 2 SPDs the N-PE module which is designed to lead the discharge current towards the earth conductor is not realized with a varistor, but with a voltage switching type element (for example, a spark gap), able to permanently prevent the current flow towards the PE.
All ABB OVR T2 1N and 3N SPDs are realized with this technology.

"The remote signaling contact tells me the SPD has intervened"

No, the signaling contact switches only when the SPD has reached the end of its operative life. Very useful in the event of unmonitored distribution switchboards, the information can be used, for example, in order to quickly replace the cartridge at the end of its life and to restore the protection against overvoltage surges.

"A SPD for alternating current can also be used in direct current; it is just a matter of multiplying its rated voltage by the square root of two"

This is the principle for which many SPD for alternating current at 400 V have without warning become SPDs for photovoltaic at 600 VDC
ABB's position on this is very clear: sooner or later the varistors go into short circuit, and interrupting a short circuit in direct current is much more difficult than in alternating current. It cannot, therefore, be absolutely ensured that the thermal disconnector integrated in a SPD designed for alternating current is able to ensure disconnection when the same SPD is installed in a photovoltaic plant: the manufacturer must test it in a laboratory and, in general, must provide for new back up protection, sized for DC applications.

Further information
SPDs and MCBs, two complementary protection devices

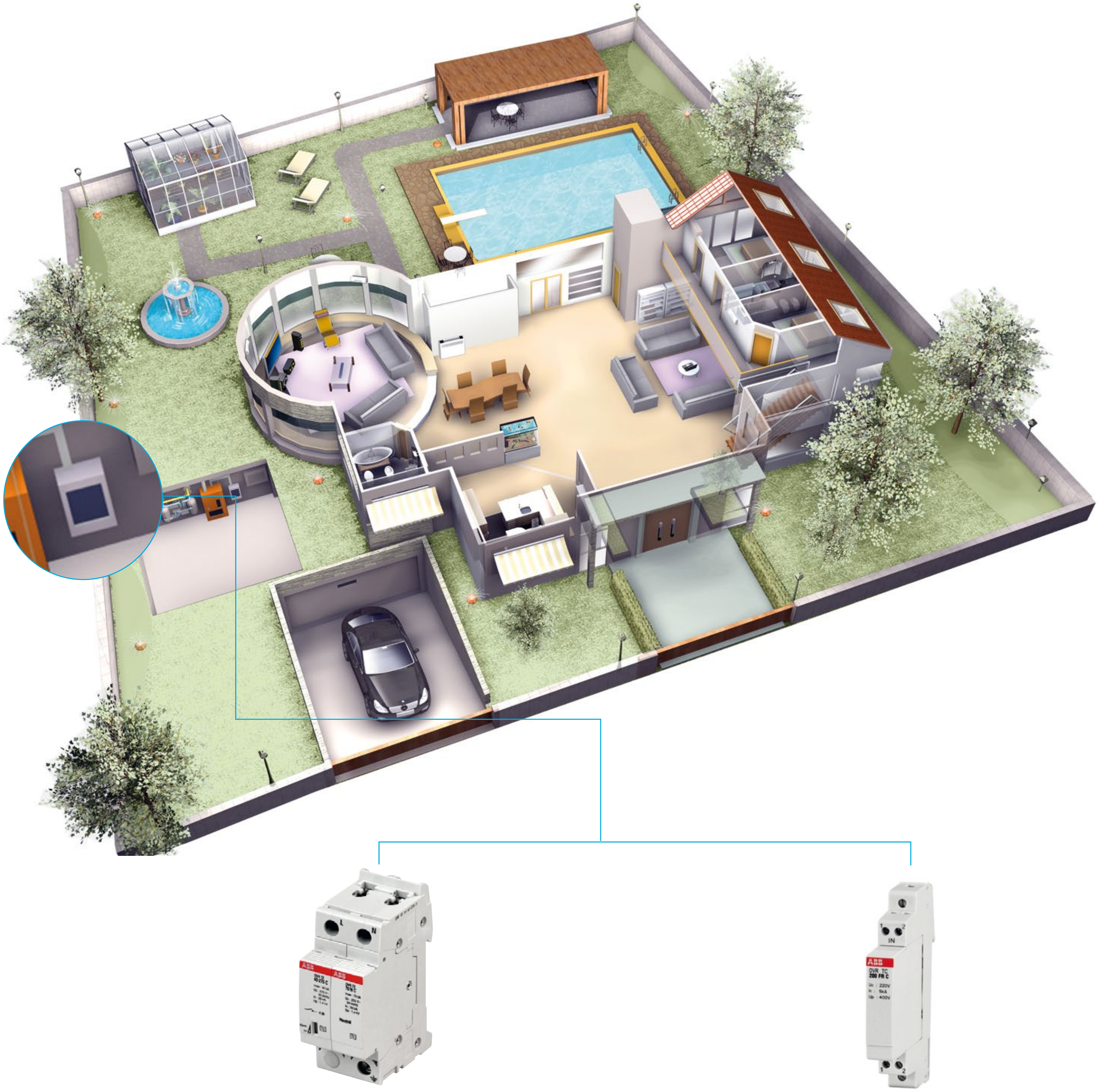
**SPDs and MCBs are two protection elements for electrical systems. They are both installed on DIN rails and have similar dimensions…
But how valid is the comparison?**

From some points of view they are very different. Let's see why:

	OVR T2 SPD	S200 MCB
Are 4-phase or 3-phase plus neutral versions preferable for three-phase networks?	The 3N versions (three-phase + neutral) have superior performance: they can be installed upstream of the RCD to protect it and avoid unwanted tripping. Furthermore, no current flows to earth at rated voltage throughout the life of the SPD.	The 4-phase versions are more complete, as they also protect neutral.
Product wiring	It is wired in parallel	It is installed in series, in different points of the installation.
Nominal voltage	This is the voltage between phase and earth, because SPDs are connected between phase and earth.	This is the voltage between phases, or between phase and neutral.
A current in kA?	This is the SPD's rated or maximum discharge current (I_n or I_{max}).	This is the breaking power of the breaker at 50 Hz.
Operation	It cuts in and continues to work. It is tested to function 20 times at its rated discharge current.	When it trips out it must be re-armed, after checking the system.
Co-ordination	The upstream SPD operates first, then those downstream in a cascade. All SPDs work one after the other to reduce the effect of the discharge.	Only the breaker immediately upstream of the fault trips out.
Short circuits are its…	Working tool – the SPD short-circuits phase and earth for an instant. After the discharge it restores its isolation.	Enemy, as soon as a short circuit occurs it opens the faulty circuit.

SPDs and MCBs are two complementary products for protecting electrical switchboards; each product operates very differently, but their aim is the same: safety.

Practical examples
Example for protecting household equipment



OVR T2 1N 40 275s P
Protection of the electrical system

OVR TC 200 FR P
Protection of telephone systems

Protecting household equipment

Type	Order code	Maximum discharge current I_{max} (8/20)	Rated discharge current I_n	Rated voltage U_n	Protection level U_p
OVR T2 1N 40 275s P	2CTB803952R0800	40 kA	20 kA	230 V	1.4 kV
OVR TC 200 FR P	2CTB804820R0500	10 kA	5 kA	200 V	400 V

Practical examples
Example for protecting equipment in the office

OVR TC 48 V P - ISDN
Protection of telephone lines

OVR TC 24 V P
Protection of entry-phone systems

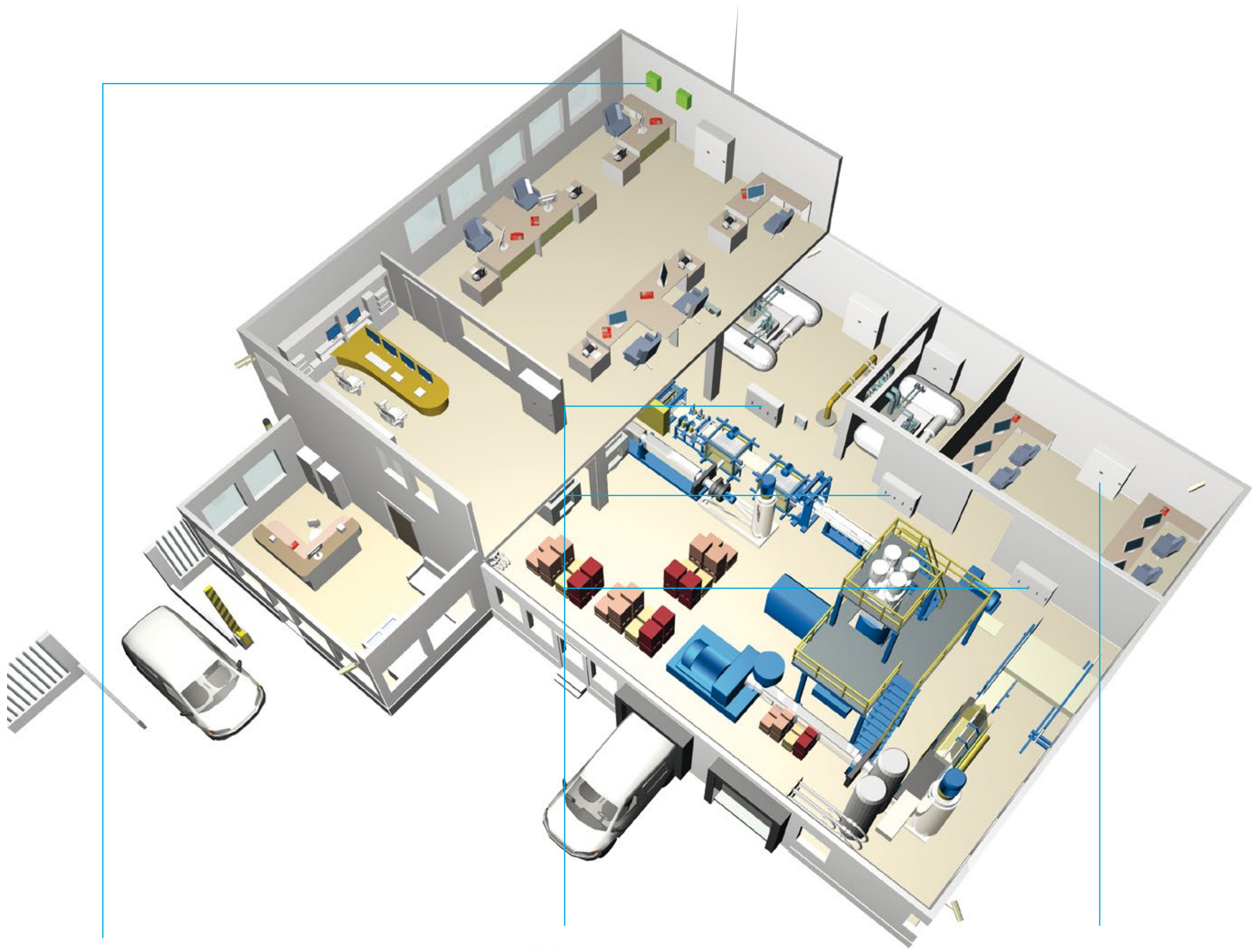
OVR T1 3N 25 255 TS
Protection against direct lightning strikes

OVR T2 1N 40 275s P
Protection of system

Protecting equipment in the office

Type	Order code	Impulse current I_{imp} (10/350) per pole	Follow-through current interruption I_{fi}	Maximum discharge current I_{max} (8/20)	Rated discharge current I_n	Rated voltage U_n	Protection level U_p
OVR TC 24 V P	2CTB804820R0200	/	/	10 kA	5 kA	24 V	35 V
OVR TC 48 V P	2CTB804820R0300	/	/	10 kA	5 kA	48 V	70 V
OVR T1 3N 25 255 TS	2CTB815101R0700	25 kA	50 kA	/	25 kA	230 V	2.5 kV
OVR T2 1N 40 275s P	2CTB803952R0800	/	/	40 kA	20 kA	230 V	1.4 kV

Practical examples
Example for protecting equipment in an industrial scenario



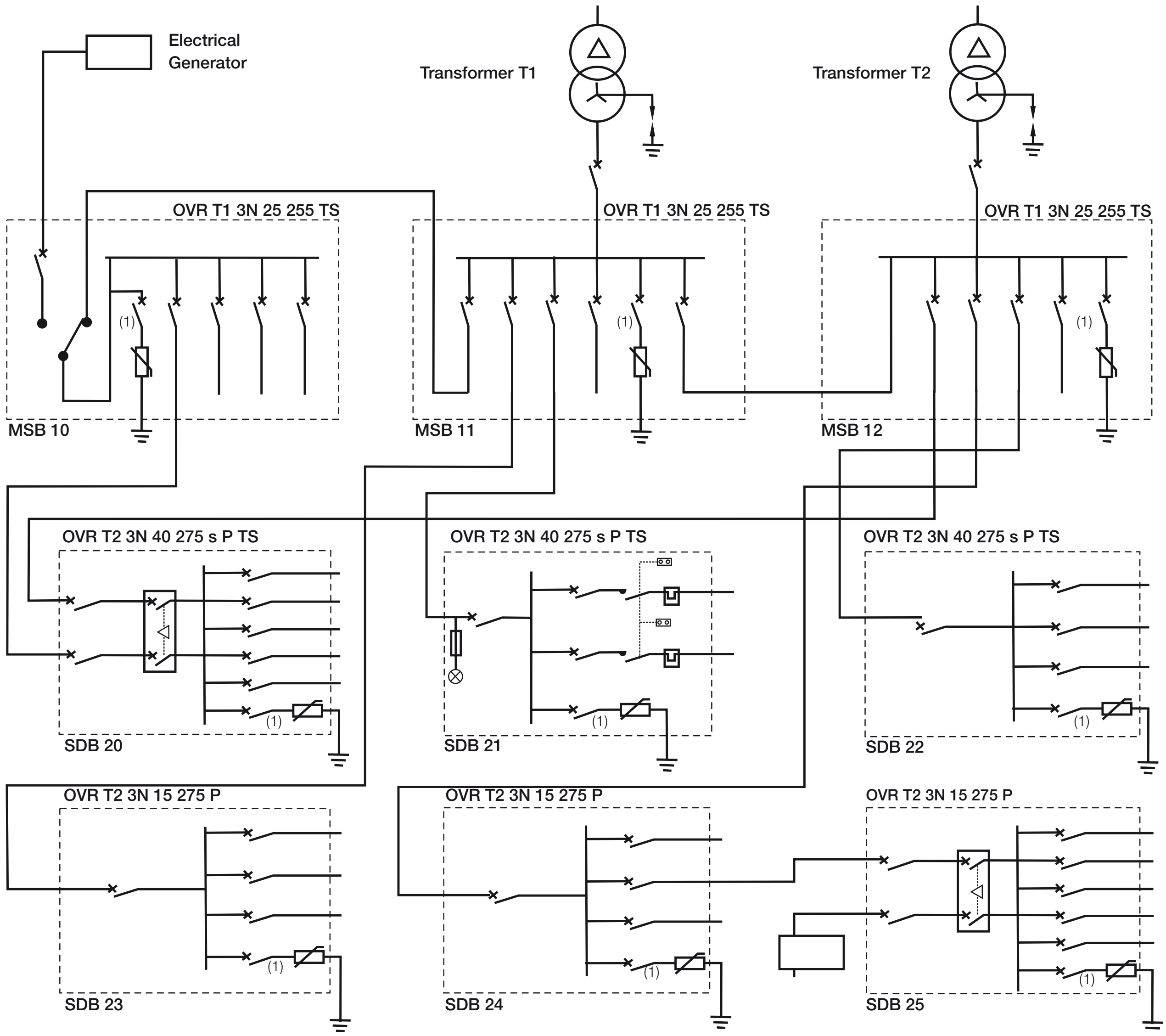
OVR TC 48 V P - ISDN
Protection for telecommunications and data lines

OVR T2 3N 40 275 s P TS
Protection against indirect lightning strikes

OVR T1 3N 25 255 TS
Protection against direct lightning strikes

Protecting equipment in an industrial scenario

Type	Order code	Impulse current I_{imp} (10/350) per pole	Follow-through current interruption I_{fi}	Maximum discharge current I_{max} (8/20)	Rated discharge current I_n	Rated voltage U_n	Protection level U_p
OVR TC 200 FR P	2CTB804820R0500	/	/	10 kA	5 kA	200 V	400 V
OVR TC 48 V P	2CTB804820R0300	/	/	10 kA	5 kA	48 V	70 V
OVR TC 24 V P	2CTB804820R0200	/	/	10 kA	5 kA	24 V	35 V
OVR TC 06 V P	2CTB804820R0000	/	/	10 kA	5 kA	6 V	15 V
OVR T1 3N 25 255 TS	2CTB815101R0700	25 kA	50 kA	/	25 kA	230 V	2.5 kV
OVR T2 3N 40 275 s P TS	2CTB803953R0200	/	/	40 kA	20 kA	230 V	1.4 kV



The diagram given above represents an example of an industrial application located in an area in which the lightning density (Ng) is 1.2 lightning strikes/km^2/year:

– The building is protected by an external lightning protection;
– The lightning conductor's earth bar is connected to the installation's earthing system;
– The earthing system is IT (with distributed neutral) and therefore TN-S for the secondary distribution switchboards;
– MSBs (Main Switch Boards) 10, 11 and 12 are fitted with OVR T1 3N 25 255 TS Type 1 SPDs;
– SDBs (Secondary Distribution Boards) 20, 21 and 22 are fitted with OVR 3N 40 275 s P TS Type 2 SPDs;
– SDBs 23, 24 and 25 are fitted with OVR T2 3N 15 275 s P TS Type 2 SPDs.

[1] The protection device upstream of each SPD may be chosen from the ABB series S 2 MCBs or from the E 9F fuses and E 90 fuse holders.

Product range
OVR T1

Type 1 SPDs provide input protection for installations in areas with high levels of lightning strikes, and are typically installed in main distribution switchboards. Among their main features:

- High performance, with 2.5 kV protection level and 25 kA per pole lightning current
- High operational continuity and low maintenance costs thanks to extinguishment of follow-through currents up to 50 kA
- Suitable for installation upstream of the RCD ("3 + 1" and "1 + 1" schemes)
- Reduction of the effective protection level U_{prot} thanks to the double terminals allowing "V" cabling up to a rated current of 125 A
- Flexible wiring, with cables and bars
- Flexible application, suitable for everything from service industries to heavy industry.

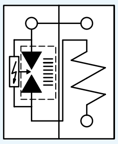
The single-pole module allows common-mode configurations to be freely installed; combined with the neutral modules, common and differential mode configurations can be obtained. The multi-pole modules integrate the different configurations in a single device.
Type 1 SPDs from the OVR range are automatically co-ordinated with OVR Type 2 SPDs.

Standards: IEC 61643-1/IEC EN 61643-11
Test parameters:
Lightning current with 10/350 µs waveform

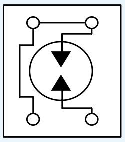


Current current per pole (10/350 µs wave) I_{imp} kA	Follow-through current extinguishment If @ Uc kA	Level of protection U_p kV	Protection fuse gG A	Distribution system
Without remote contact, Uc = 255 V AC, Un = 230/400 V AC				
25	50	2.5	125	-
25	50	2.5	125	TT, TN-S
25	50	2.5	125	TN-S
25	50	2.5	125	TN-C
25	50	2.5	125	TN-S
25	50	2.5	125	TT, TN-S
With remote contact, Uc = 255 V AC, Un = 230/400 V AC				
25	50	2.5	125	TT, TN-S
25	50	2.5	125	TN-S
25	50	2.5	125	TN-C
25	50	2.5	125	TN-S
25	50	2.5	125	TT, TN-S
Neutral modules N-PE				
50	0.1	2.5	-	-
100	0.1	4.0	-	-

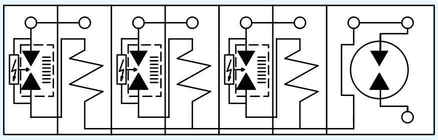
* only for the single-pole module U_n = 230 V AC



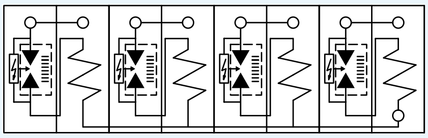
OVR T1 25 255



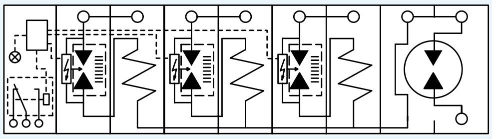
OVR T1 50 N
OVR T1 100 N



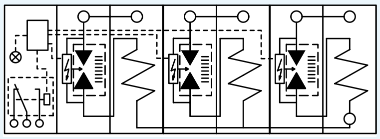
OVR T1 3N 25 255



OVR T1 4L 25 255



OVR T1 3N 25 255 TS



OVR T1 3L 25 255 TS

Poles	Type	Order code	Unit weight kg	Packaging
1*	OVR T1 25 255	2CTB815101R0100	0.25	1
1+N	OVR T1 1N 25 255	2CTB815101R1500	0.50	1
2	OVR T1 2L 25 255	2CTB815101R1200	0.50	1
3	OVR T1 3L 25 255	2CTB815101R1300	0.75	1
4	OVR T1 4L 25 255	2CTB815101R1400	1.00	1
3+N	OVR T1 3N 25 255	2CTB815101R1600	1.00	1
1+N	OVR T1 1N 25 255 TS	2CTB815101R1000	0.50	1
2	OVR T1 2L 25 255 TS	2CTB815101R1100	0.50	1
3	OVR T1 3L 25 255 TS	2CTB815101R0600	0.85	1
4	OVR T1 4L 25 255 TS	2CTB815101R0800	1.10	1
3+N	OVR T1 3N 25 255 TS	2CTB815101R0700	1.10	1
N	OVR T1 50 N	2CTB815101R0400	0.25	1
N	OVR T1 100 N	2CTB815101R0500	0.25	1

Product range
OVR T1+2

T1+2 type SPDs combine high discharge performance for lightning impulse currents with an extremely reduced level of protection, making them ideal in all small plants: it is possible to obtain both protection against lightning currents and protection of terminal equipment with a single product. Among their main features:

- An integrated solution equivalent to an automatically co-ordinated Type 1 and Type 2 SPD, inside the same distribution switchboard
- High performance, with 1.5 kV protection level and up to 25 kA per pole lightning current
- High operational continuity and low maintenance costs thanks to extinguishment of follow-through currents up to 7-15 kA depending on the version
- Suitable for installation upstream of the RCD ("3 + 1" and "1 + 1" schemes)
- Reduction of the effective protection level U_{prot} thanks to the double terminals allowing "V" cabling up to a rated current of 125 A (25 kA version)
- Quick and easy maintenance thanks to the pluggable cartridge format (25 kA version).

Combined with the OVR T1 50 N and OVR T1 100 N neutral modules, it is possible to create configurations for single-phase and three-phase TT, TN-C and TN-S distribution systems. T1+2 SPDs from the OVR range are automatically co-ordinated with OVR Type 2 SPDs.

Standards: IEC 61643-1/IEC EN 61643-11
Test parameters:
- Lightning current with 10/350 µs waveform
- Discharge current with 8/20 µs waveform

Current from lightning per pole (10/350 µs wave) I_{imp} kA	Rated discharge current per pole (8/20 µs wave) I_n kA	Maximum discharge current per pole (8/20 µs wave) I_{max} kA	Level of protection U_p kV	Follow-through current extinguishment I_f @ U_c kA	
Single-pole, Uc = 255 V AC, Un = 230 V AC					
25	25	40	1.5	15	
15	15	60	1.5	7	
Neutral modules, N-PE					
50	-	-	2.5	0.1	
100	-	-	4.0	0.1	

Accessories

	Type	Order code	Unit weight kg	Packaging
Spare cartridge for OVR T1+2 25 255 TS	OVR T1+2 25 255 C	2CTB815101R3700	0.05	1

Multi-pole configuration with OVR T1+2

System	Poles	Configurations
TT, TN-S	3+N	3 x OVR T1+2 + 1 x OVR T1 100 N
TT, TN-S	1+N	1 x OVR T1+2 + 1 x OVR T1 50 N
TN-C	3	3 x OVR T1+2
TN-C	3	OVR T1+2 3L

Type	Order code	Unit weight kg	Packaging
OVR T1+2 25 255 TS	2CTB815101R0300	0.3	1
OVR T1+2 15 255-7	2CTB815101R8900	0.12	1
OVR T1 50 N	2CTB815101R0400	0.25	1
OVR T1 100 N	2CTB815101R0500	0.25	1

Product range
OVR T1, OVR T1+2

		OVR T1...			
		25 255	1N 25 255	2L 25 255	3L 25 255
Technical features					
System		TT - TNS - TNC	TT, TN-S	TN-S	TNC
Number of poles		1	2	2	3
Type		1	1	1	1
Operation		Spark	Spark	Spark	Spark
Current type		AC	AC	AC	AC
Un Rated voltage	V	230	230	230	230
Maximum continuous voltage U_c	V	255	255	255	255
Impulse current I_{imp} (10/350)	kA	25	25	25	25
Rated discharge current I_n (8/20)	kA	25	25	25	25
Protection level Up at In (L-N/N-PE)	kV	2.5	2.5/1.5	2.5	2.5
Interruption of follow-through current I_f	kA	50	50	50	50
Behavior in case of temporary overvoltage (TOV) Ut (L-N: 5 s / N-PE: 200 ms)	V	400	400/1200	400	400
Residual current IPE	mA	< 0.001	< 0.001	< 0.001	< 0.001
Maximum short-circuit current Isc	kA	50	50	50	50
Response time	ns	100	100	100	100
Maximum load current	A	125	125	125	125
Back-up protection: gG/gL fuse	A	125	125	125	125
Mechanical features					
Modules (TS version)		2	4 (5)	4 (5)	6 (7)
L/N/PE terminals rigid	mm²	2.5 … 50			
flexible	mm²	2.5 … 35			
L/N tightening torque	Nm	3.5			
Status indicator		TS version			
Safety reserve indicator		no			
Remote signaling contact		no	TS version		
Other features					
IP rating		IP20			
Operating temperature	°C	-40 … +80			
Maximum altitude	m	2000			
Case material		RAL 7035 grey PC			
UL 94 fire resistance		V0			
End-of-life		open circuit			
Standards		IEC 61643-1/IEC 61643-11			

OVR T1…				OVR T1+2…		
4L 25 255	3N 25 255	50 N	100 N	25 255 TS	15 255-7	3L 15 255-7
TNS	TT - TN-S	TT, TN-S	TT, TN-S	TT - TNS - TNC		TNC
4	4	1	1	1		3
1	1	1	1	1/2		
Spark	Spark	Spark	Spark	Combined	Spark	
AC	AC	AC	AC	AC		
230	230	-	-	230		
255	255	255	255	255		
25	25	50	100	25	15	
25	25	50	100	25	25	
2.5	2.5/1.5	-/1.5	-/1.5	1.5		
50	50	0.1	0.1	15	7	
400	400/1200	-/1200	-/1200	334	650	
< 0.001	< 0.001	< 0.001	< 0.001	< 1	< 2	
50	50			50		
100	100	100	100	25		
125	125	125	125	125	-	
125	125	-	-	125		
8 (9)	8 (9)	8 (9)	8 (9)	2	1	
2.5 … 50				2.5 … 50		
2.5 … 35				2.5 … 35		
3.5				3.5		
TS version				Yes		
no				no		
TS version				Yes	no	
IP20						
-40 … +80						
2000						
RAL 7035 grey PC						
V0						
open circuit						
IEC 61643-1/IEC 61643-11						

Product range
OVR T2

Type 2 SPDs with pluggable cartridges are suitable for installation at the origin of the network, in intermediate switchboards and near the terminal equipment. The whole range has end-of-life indicators. The "s" versions also have an operational safety reserve: when a cartridge reaches its reserve, it is still able to operate, but with reduced performance. Among their main features:

- Installation upstream of RCDs ("3+1" and "1+1" versions)
- Simplified maintenance thanks to the possibility to change the cartridge instead of the whole product and the safety reserve on all "s" versions
- Constant monitoring of the product's status thanks to the integrated signalling contact (TS versions)
- Flexibility in application, from residential to industrial.

All Type 2 SPDs from the OVR range are automatically co-ordinated by respecting a minimum distance of 1 m between upstream and downstream devices.

Rated discharge current per pole (8/20 µs wave) I_n kA	Maximum discharge current per pole (8/20 µs wave) I_{max} kA	Protection level U_p (L-L/L-PE) kV	Protection fuse gG A	Distribution system
SPDs for TT, TN-S and TN-C systems without remote signaling contact, Uc = 275 V AC, Un = 230/400 V AC				
5	15	1.0	16	-
5	15	1.0/1.4	16	TT, TN-S
5	15	1.0/1.4	16	TT, TN-S
20	40	1.4	16	-
20	40	1.4/1.4	16	TT, TN-S
20	40	1.4	16	TN-C
20	40	1.4/1.4	16	TT, TN-S
20	40	1.4	16	TN-S
30	70	1.5	20	-
30	70	1.5	20	TN-C
30	70	1.5/1.4	20	TT, TN-S
SPDs for IT systems without remote signaling contact, Uc = 440 V AC, Un = 230/400 V AC				
5	15	1.5	16	IT
20	40	1.9	16	IT
30	70	2	20	IT
SPDs for IT systems without remote signaling contact, Uc = 760 V AC, Un = 400/690 V AC				
20	40	2.9	50	IT
SPDs for TT, TN-S and TN-C systems with remote signaling contact, Uc = 275 V AC, Un = 230/400 V AC				
20	40	1.4	16	-
20	40	1.4/1.4	16	TT, TN-S
20	40	1.4	16	TN-C
20	40	1.4/1.4	16	TT, TN-S
20	40	1.4	16	TN-S
30	70	1.5	20	-
30	70	1.5/1.4	20	TT, TN-S
30	70	1.5	20	TN-C
30	70	1.5/1.4	20	TT, TN-S
30	70	1.5	20	TN-S
SPDs for IT systems with remote signaling contact, Uc = 440 V AC, Un = 230/400 V AC				
20	40	1.9	16	IT
30	70	2.0	20	IT
SPDs for IT systems with remote signaling contact, Uc = 760 V AC, Un = 400/690 V AC				
20	40	2.9	50	IT

Standards: IEC 61643-1/IEC EN 61643-11
Test parameters:
Discharge current with 8/20 μs waveform

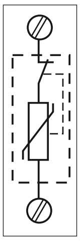
Poles	Type	Order code	Unit weight kg	Packaging
1*	OVR T2 15 275 P	2CTB803851R2400	0.12	1
1+N	OVR T2 1N 15 275 P	2CTB803952R1200	0.22	1
3+N	OVR T2 3N 15 275 P	2CTB803953R1200	0.45	1
1*	OVR T2 40 275s P	2CTB803851R2000	0.12	1
1+N	OVR T2 1N 40 275s P	2CTB803952R0800	0.22	1
3	OVR T2 3L 40 275s P	2CTB803853R2200	0.35	1
3+N	OVR T2 3N 40 275s P	2CTB803953R0800	0.45	1
4	OVR T2 4L 40 275s P	2CTB803853R5400	0.45	1
1*	OVR T2 70 275s P	2CTB803851R1900	0.12	1
3	OVR T2 3L 70 275s P	2CTB803853R4100	0.35	1
3+N	OVR T2 3N 70 275s P	2CTB803953R0700	0.45	1
1	OVR T2 15 440 P	2CTB803851R1100	0.12	1
1	OVR T2 40 440s P	2CTB803851R0800	0.12	1
1	OVR T2 70 440s P	2CTB803851R0700	0.12	1
3	OVR T2 3L 40 440/690 P	2CTB803853R4500	0.35	1
1*	OVR T2 40 275s P TS	2CTB803851R1400	0.15	1
1+N	OVR T2 1N 40 275s P TS	2CTB803952R0200	0.27	1
3	OVR T2 3L 40 275s P TS	2CTB803853R2300	0.40	1
3+N	OVR T2 3N 40 275s P TS	2CTB803953R0200	0.50	1
4	OVR T2 4L 40 275s P TS	2CTB803853R5000	0.50	1
1*	OVR T2 70 275s P TS	2CTB803851R1300	0.15	1
1+N	OVR T2 1N 70 275s P TS	2CTB803952R0100	0.27	1
3	OVR T2 3L 70 275s P TS	2CTB803853R4400	0.40	1
3+N	OVR T2 3N 70 275s P TS	2CTB803953R0100	0.50	1
4	OVR T2 4L 70 275s P TS	2CTB803919R0400	0.50	1
1	OVR T2 40 440s P TS	2CTB803851R0200	0.15	1
1	OVR T2 70 440s P TS	2CTB803851R0100	0.15	1
3	OVR T2 3L 40 440/690 P TS	2CTB803853R4600	0.35	1

* Only for the single-pole model Un = 230 V AC.

Product range
OVR T2

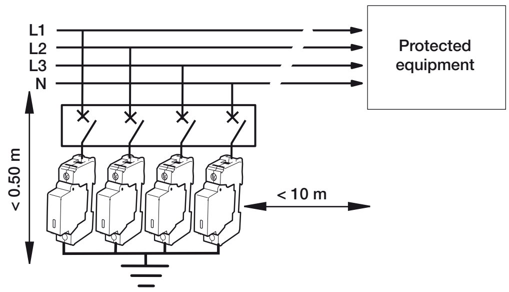
Single-pole Type 2 SPDs with pluggable cartridges

Diagrams



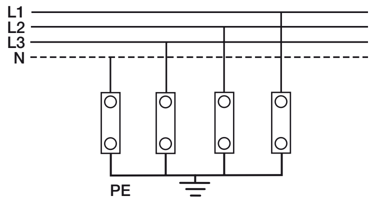
OVR T2 15 / 40 / 70 P

Connection

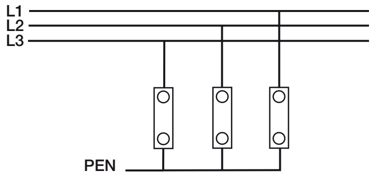


OVR T2 15 / 40 / 70 P

Network types



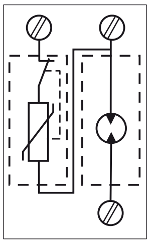
TT-TNS-IT networks



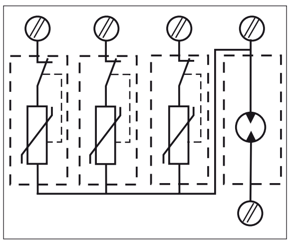
TNC networks

Multi-pole Type 2 1P+N, 3P+N SPDs with pluggable cartridges

Diagrams

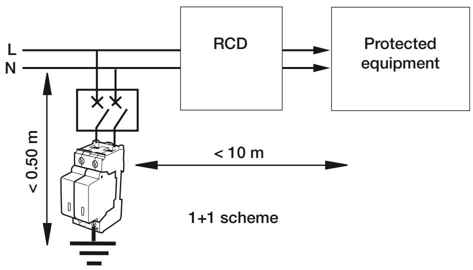


OVR T2 1N 15 / 40 / 70 P



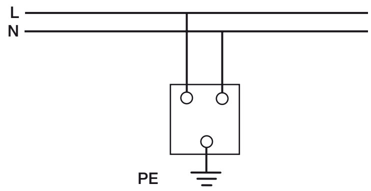
OVR T2 3N 15 / 40 / 70 P

Connection



OVR T2 1N P (all models)

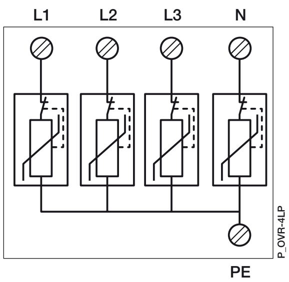
Network types



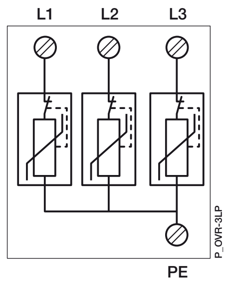
TT-TNS networks

Multi-pole Type 2 3P and 4P SPDs with pluggable cartridges

Diagrams

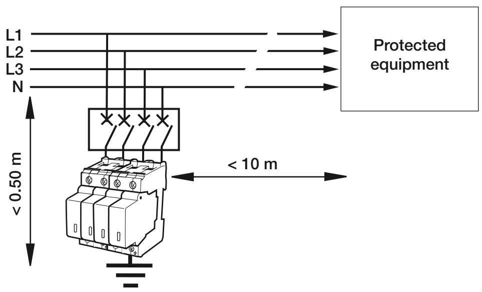


OVR T2 4L 40 / 70 P



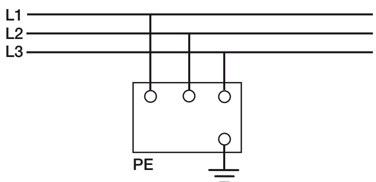
OVR T2 3L 40 / 70 P

Connection

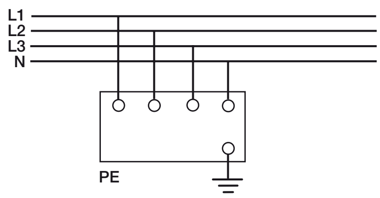


OVR T2 4L P (all models)

Network types



TNC network (3L)



TNS network (4L)

All OVR 1P+N and 3P+N SPDs can be installed upstream of the RCD. This rule is recommended by standards to avoid the current from lightning strikes passing through the RCD. It allows the RCD to be protected, on the one hand, and maintains operational continuity on the other.

Product range
OVR T2

Technical features		15 kA 8/20	40 kA 8/20	70 kA 8/20
Electrical features				
Type		2	2	2
Operation		Combined	Combined	Combined
Behavior in case of temporary overvoltage (TOV) Ut (L-N: 5 s)	**V**	340 (275 V), 440 (440 V)	340 (275 V), 440 (440 V)	340 (275 V), 440 (440 V)
Residual current IPE	**mA**	< 1	< 1	< 1
Maximum short-circuit current I_{sc}	**kA**	10	25	25
Response time	**ns**	< 25	< 25	< 25
Back-up protection				
gG / gL fuse	**A**	16	16	20
Breaker (Curve C)	**A**	10	25	32
Mechanical features				
L/N/PE terminals				
rigid	**mm²**	2.5...25	2.5...25	2.5...25
flexible	**mm²**	2.5...16	2.5...16	2.5...16
L/N tightening torque	**Nm**	2	2	2
Integrated thermal protection device		Yes	Yes	Yes
Status indicator		Yes	Yes	Yes
Safety reserve indicator		-	"s" versions	"s" versions
Remote signaling contact		"TS" versions	"TS" versions	"TS" versions
Other features				
IP rating		IP20	IP20	IP20
Operating temperature	**°C**	-40...+80	-40...+80	-40...+80
Maximum altitude	**m**	2000	2000	2000
Case material		RAL 7035 grey PC	RAL 7035 grey PC	RAL 7035 grey PC
UL 94 fire resistance		V0	V0	V0
Standards		IEC 61643-1/IEC 61643-11	IEC 61643-1/IEC 61643-11	IEC 61643-1/IEC 61643-11

Replacement cartridges for Type 2 SPDs

Rated discharge current I_n kA	Maximum discharge current I_{max} kA	Maximum continuous voltage U_c V	Type	Order code	Unit weight kg	Packaging
5	15	275	OVR T2 15 275 C	2CTB803854R1200	0.10	1
5	15	440	OVR T2 15 440 C	2CTB803854R0600	0.10	1
20	40	275	OVR T2 40 275s C	2CTB803854R0900	0.10	1
20	40	440	OVR T2 40 440s C	2CTB803854R0300	0.10	1
30	70	275	OVR T2 70 275s C	2CTB803854R0700	0.10	1
30	70	440	OVR T2 70 440s C	2CTB803854R0100	0.10	1
30	70	Neutral cartridge	OVR T2 70 N C	2CTB803854R0000	0.05	1

Product range
OVR PV

SPDs for photovoltaic installations with pluggable cartridges

The production of energy with solar panels is one of the most promising of the renewable energy sources.

For solar panels, often located in isolated areas and with a generally large surface area, lightning represents a major risk, to be evaluated both for the direct effects of lightning on the panel and for the voltage surges generated in the system.

The OVR PV range allows the DC side of each PV installation to be effectively protected.

Among their main features:

- Self-protected from end of life short circuit: no back-up protection required up to 100 A DC thanks to the integrated thermal protection with direct current breaking capacity
- Pluggable cartridges, for easy maintenance without the need to disconnect the line
- Remote warning contacts for monitoring the operational status (TS versions)
- No follow-through short-circuit current
- No risk if polarity is reversed

Rated discharge current for pole I_n kA	Rated voltage U_n V DC	Maximum voltage of the plant U_{cpv} Voc DC	Level of protection (L-L/L-PE) kV	Remote signalling contact	Type	Order code	Unit Weight kg	Packaging
20	600	670	2.8/1.4	-	OVR PV 40 600 P	2CTB803953R5300	0.38	1
20	600	670	2.8/1.4	Integrated	OVR PV 40 600 P TS	2CTB803953R5400	0.38	1
20	1000	1000	3.8	-	OVR PV 40 1000 P	2CTB803953R6400	0.38	1
20	1000	1000	3.8	Integrated	OVR PV 40 1000 P TS	2CTB803953R6500	0.38	1
20	1000	1000	3.8	-	OVR PV 40 1000 P BW	2CTB804153R1900	0.38	30
20	1500	1500	4.5	-	OVR PV 40 1500 P BW NEW	2CTB804153R2200	0.38	1
20	1500	1500	4.5	Integrated	OVR PV 40 1500 P TS BW NEW	2CTB804153R2100	0.38	1

Spare cartridge

Rated discharge current per pole kA	Rated voltage Un V DC	Maximum voltage of the plant Ucpv Voc DC	Level of protection (L-L/L-PE) kV	Type	Order code	Unit weight kg	Packaging
20	600	670	2.8/1.4	OVR PV 40 600 C	2CTB803950R0000	0.1	1
20	1000	1000	3.8	OVR PV 40 1000 C	2CTB803950R0100	0.1	1
20	1500	1500	4.5	OVR PV 40 1500 C NEW	2CTB803950R2000	0.1	1

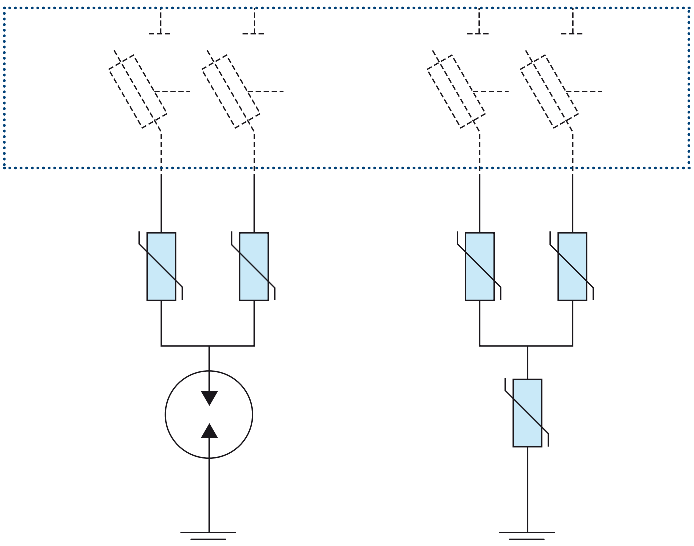
Spare cartridge

SPD type	Cartridge type
OVR PV 40 600 P	OVR PV 40 600 C
OVR PV 40 600 P TS	
OVR PV 40 1000 P	OVR PV 40 1000 C
OVR PV 40 1000 P TS	
OVR PV 40 1000 P TS BW	
NEW OVR PV 40 1500 P BW	OVR PV 40 1500 C NEW
NEW OVR PV 40 1500 P TS BW	

Technical features

Electrical features		
Network type		PV installations
Type		2
Response time	ns	25
Residual current	mA	< 1
IP rating		IP20
Integrated thermal protection		300 A DC (for 600 and 1000 V DC), 235 V DC (for 1500 V DC)
Back-up protection Isc < 100 A DC Isc > 100 A DC		 Not required 10 A gR fuse
Mechanical features		
L/PE terminals rigid flexible	 mm^2 mm^2	 2.5…25 2.5…16
Tightening torque	Nm	2.80
Status indicator		Yes
Remote signalling contact Type Minimum capacity Maximum capacity Cable section	 mm^2	for "TS" versions 1 NO/NC 12 V DC-10 mA 250 V AC-1 A 1.5
Other features		
Operating temperature	°C	- 40...+80
Storage temperature	°C	- 40...+80
Maximum altitude	m	2000
Case material		PC RAL 7035
UL94 fire resistance		V0
Reference standards		IEC 61643-1 IEC 61643-11 UTE C 61-740-51

Diagrams



OVR PV 600 P

OVR PV 1000 P

Back-up fuses, only required if I_{SC} > 300 (for 600 and 1000 V DC) and 235 A DC (for 1500 V DC)

Product range
OVR PLUS

OVR PLUS N3 20
OVR PLUS N3 40

Description

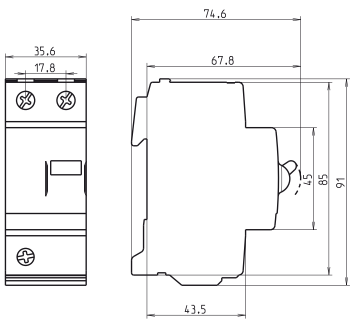
OVR PLUS N3 20 and OVR PLUS N3 40 for commercial and industrial applications:
- Auto-protected: Backup miniature circuit breaker integrated and fully coordinated with the surge protective device.
- Easy installation: Fully coordinated unit with easy wiring with the complete ABB pro M modular range.
- High discharge capacity: With Imax 20 and 40 kA the OVR Plus N3 insure the protection of your low voltage installations and electric equipment.
- High reliability: No welding inside the module and specific thermal disconnection with the "bilame" sensor.

OVR PLUS N1 40 for residential applications:
- Auto-protected: Backup miniature circuit breaker integrated and fully coordinated with the surge protective device.
- Compact: Only two modules (36 mm width), means more space and easy wiring with the complete ABB DIN rail range.
- High discharge capacity: With Imax 20 and 40 kA the OVR PLUS N1 can protect your electric equipment against high surges.
- High reliability: No welding inside the module and specific thermal disconnection.

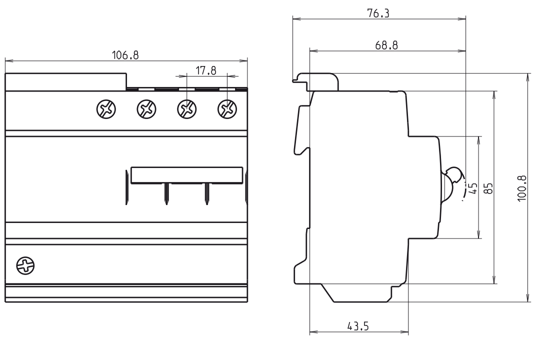
Ordering details

Protected lines	Max. discharge current Imax 8/20	Nominal current In	Voltage protection level Up	Nominal voltage Un	Max. cont. operating voltage Uc	Type	Order code	EAN code		Weight Pkg (1 pce)
	kA	kA	kV	V	V			3660308		kg
Type 2 autoprotected										
1+1	20	5	1.3	230/400	275	OVR PLUS N1 20	2CTB803701R0700	521286		0.28
1+1	40	20	1.8	230/400	320	OVR PLUS N1 40	2CTB803701R0100	517005		0.28
3+1	20	5	1.3	230/400	320	OVR PLUS N3 20	2CTB803701R0400	517081		0.84
3+1	40	20	2.0	230/400	320	OVR PLUS N3 40	2CTB803701R0300	517074		0.84

Main dimensions mm



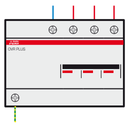
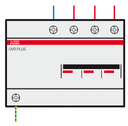
OVR Plus N1 20
OVR Plus N1 40



OVR Plus N3 20
OVR Plus N3 40

Type	Width	
	mm	*inches*
OVR PLUS N1 20	35.6	*1.40*
OVR PLUS N1 40	35.6	*1.40*
OVR PLUS N3 20	106.8	*4.20*
OVR PLUS N3 40	106.8	*4.20*

General technical data

Types		OVR Plus N1 20	OVR Plus N1 40	OVR Plus N3 20	OVR Plus N3 40
with auxiliary contact (TS)		S2C-H6R	S2C-H6R	S2C-H6R	S2C-H6R
Technology		Varistor	Varistor	Varistor	Varistor
Wiring diagram					
Electrical features					
Standard		IEC 61643-1 / EN 61643-11			
Type / test class		T2 / II	T2 / II	T2 / II	T2 / II
Protected lines		1+1	1+1	3+1	3+1
Types of networks		TNS / TT	TNS / TT	TNS / TT	TNS / TT
Type of current		AC	AC	AC	AC
Nominal voltage Un (L-N/L-L)	V	230 / 400	230 / 400	230 / 400	230 / 400
Max. cont. operating voltage Uc	V	275	320	320	320
Maximum discharge current Imax (8/20)	kA	20	40	20	40
Nominal discharge current In (8/20)	kA	5	20	5	20
Voltage protection level Up at In (L-N/N-PE/L-PE)	kV	1.3 / - / 1.3	1.6 / - / 1.8	1.3 / 1.3 / 1.3	2.0 / 1.5 / 2.0
Voltage protection level Up at 3 kA (L-N/N-PE/L-PE)	kV	1.1 / - / 1.1	1.1 / - / 1.1	1.1 / 1.1 / 1.1	1.1 / 1.1 / 1.1
TOV (Temporary overvoltage) withstand Ut (L-N: 5 s / N-PE: 200 ms)	V	334 / 1200	334 / 1200	334 / 1200	334 / 1200
Response time	ns	≤ 25	≤ 25	≤ 25	≤ 25
Residual current IPE	µA	10	10	10	10
Short-circuit withstand capability Isccr	kA	10	15	10	15
Backup protection					
Fuse (gG - gL)	A	integrated	integrated	integrated	integrated
Circuit breaker (B or C curve)	A	integrated	integrated	integrated	integrated
Pluggable cartridge		No	No	No	No
Integrated thermal disconnector		Yes	Yes	Yes	Yes
State indicator		Yes	Yes	Yes	Yes
Safety reserve		No	No	No	No
Auxiliary contact		Yes (S2C-H6R / 2CDS200912R0001)			
Installation					
Wire range (L, N, PE)					
Solid wire	mm²	2.5…25	2.5…25	2.5…25	2.5…25
Stranded wire	mm²	2.5…16	2.5…16	2.5…16	2.5…16
Stripping length (L, N, PE)	mm	11	11	11	11
Tightening torque (L, N, PE)	Nm	2.5	2.5	2.5	2.5
Auxiliary contact (TS)					
Contact complement		–	–	–	–
Minimum load		–	–	–	–
Maximum load		–	–	–	–
Connection cross-section	mm²	–	–	–	–
Miscellaneous characteristics					
Stocking and operating temperature	°C	-40 to +70 / -25 to +55	-40 to +70 / -25 to +55	-40 to +70 / -25 to +55	-40 to +70 / -25 to +55
Degree of protection		IP20	IP20	IP20	IP20
Fire resistance according to UL 94		V0	V0	V0	V0
Dimensions					
height x width x depth	mm	91 x 35.6 x 74.6	91 x 35.6 x 74.6	100.8 x 106.8 x 74.6	100.8 x 106.8 x 74.6
	inches	*3.58 x 1.40 x 2.94*	*3.58 x 1.40 x 2.94*	*3.97 x 4.20 x 2.94*	*3.97 x 4.20 x 2.94*

Product range
OVR TC

OVR TC SPDs are for fine protection of telephonic equipment, IT equipment and BUS systems connected to low-voltage signal lines.
Among their main features:
- Cartridges can be removed and replaced at the end of their lives, while the base remains reusable. The telecoms line remains active while they are being replaced, thanks to a bypass.
- Reduced dimensions: the modules with standard three-wire terminal blocks are all 12.5 mm wide.
- Bases with integrated RJ11 and RJ45 connectors: these ensure maximum speed of wiring up the telephone or data patch panel

It is also wise to provide for the installation a Type 1 or Type 2 SPDs on the power lines to provide effective protection of the telecoms and data equipment.

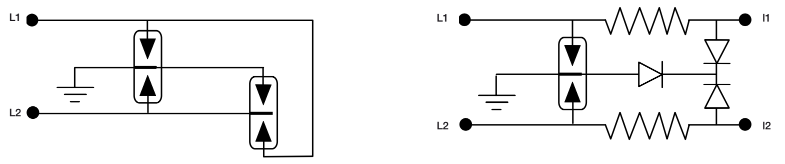
Rated discharge current I_n kA	Maximum continuous voltage U_C V	Level of protection kV	Type	Order code	Unit weight kg	Packaging
SPDs for telecommunications and data lines						
5	220	400	OVR TC 200 FR P	2CTB804820R0500	0.07	1
5	7	15	OVR TC 6 V P	2CTB804820R0000	0.07	1
5	14	20	OVR TC 12 V P	2CTB804820R0100	0.07	1
5	27	35	OVR TC 24 V P	2CTB804820R0200	0.07	1
5	53	70	OVR TC 48 V P	2CTB804820R0300	0.07	1
5	220	700	OVR TC 200 V P	2CTB804820R0400	0.07	1
Bases with incorporated RJ socket						
Base for cartridge with incorporated RJ11 socket			Base TC RJ 11	2CTB804840R1000	0.06	1
Base for 2 cartridges with incorporated RJ45 socket			Base TC RJ 45	2CTB804840R1100	0.11	1

SPD Type	Type	Order code	Unit weight kg	Packaging
Spare cartridge				
OVR TC 200 FR P	OVR TC 200 FR C	2CTB804821R0500	0.07	1
OVR TC 6 V P	OVR TC 6 V C	2CTB804821R0000	0.07	1
OVR TC 12 V P	OVR TC 12 V C	2CTB804821R0100	0.07	1
OVR TC 24 V P	OVR TC 24 V C	2CTB804821R0200	0.07	1
OVR TC 48 V P	OVR TC 48 V C	2CTB804821R0300	0.07	1
OVR TC 200 V P	OVR TC 200 V C	2CTB804821R0400	0.07	1

Technical features

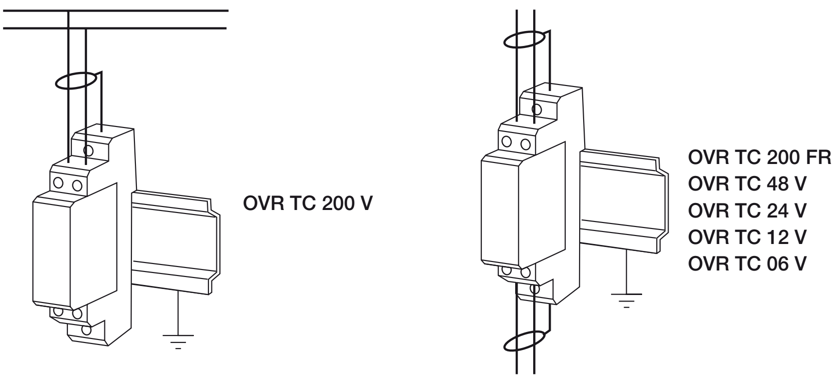
Electrical features		
Test class		2
Rated discharge current In (8/20)	kA	5
Maximum discharge current Imax (8/20)	kA	10
Short-circuit current (AC endurance test)	A	10
Rated current In	mA	140
Series resistance	Ω	10
Shielding - earth connection		Connected
Mechanical features		
Signal terminals	mm²	15
Signal conductors bare cable length	mm	6
Signal terminals tightening torque	Nm	0.2
Shielding terminals	mm²	2.5
Shielding conductors bare cable length	mm	7
Shielding terminals tightening torque	Nm	0.4
Status indicator		No
Other features		
IP rating		IP20
Storage temperature	°C	from -40 to +80
Operating temperature	°C	from -40 to +80
Maximum altitude	m	2000
Case material		RAL grey PC
UL 94 fire resistance		V0
Reference standard		IEC/EN 61643-21

Diagrams



OVR TC 200 V in parallel OVR TC / xx V / 200 FR in series

Connection



OVR TC 200 V in parallel OVR TC / xx V / 200 FR in series

Notes

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