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Unrivalled Power Quality Solutions.

TITAN

Surge arresters

Introduction

In order to protect any type of electric or electronic equipment such as PLC's, computers, or even entire electrical installations against destructive overvoltage surges, the installer will nowadays use Surge Arresters or Surge Protection Devices (SPD 's).

Besides the trivial benefit of protecting the installation and the equipment against destructive overvoltage surges, the benefits indicated below are less obvious but most certainly more important:

- Avoid downtime; this secondary effect on a business may be much greater than just the cost of fee PCB which was destroyed by the surge;
- Avoid equipment lifetime reduction by avoiding degradation of internal components due to long term exposure to low level transients;
- Avoid disruption or malfunction; although no physical damage is apparent, surges often upset the logic of microprocessor-based systems causing unexplained data loss, data and software corruption, system crashes and lock-ups.

When comparing the cost of installing SPD's with the downtime cost and the cost of repairing an electrical installation and to replace all hooked-up equipment after a serious surge has "visited", there is no further justification needed and the need to install SPD's, even in the smallest installation, becomes obvious.

Background

Disturbances
Table 1 summarises the different disturbances causing different problems while propagating in an electrical Energy-distribution system.
Besides devices used to suppress overvoltage transients, typically characterised by a very big magnitude (1OOO's of volts) and very short duration (microsecond) devices for noise filtration (low voltage, low energy, random) are also offered.

Origin of Surges

The most commonly known "field"-surge generators are listed below:

- Motors and transformers. At startup, they are a real short-circuit, generating a very high inrush-current.
- Welding machines.
- Lightning strikes, both direct or indirect inductively coupled)
- Power-grid-switching by the energy-supplier

Voltage-generation mechanism

All surge originators are currents, the mechanism that translates this current into a voltage is **U = - L x (di/dt)** in which:

- U = generated voltage,
- L = inductance of the conductor in which the current is flowing,
- di = the change in current,
- dt = the time in which the current-change *di* took place.

As the change in current is very high, while the duration is very short, even with a low conductor inductance, the result of L x (di/dt) can become astronomical.

Overvoltages and *di* to protection

All electrical and electronic devices on the market are normally designed according to the applicable standards. According to these standards (the normal operating voltage and the applicable creepage distances) the equipment and the installation must be able to withstand against a certain voltage, without being destroyed. In general, this voltage is called the breakdown voltage and is equal to several times the normal operating voltage.
If the device is hit with a voltage above this breakdown voltage, no guarantee is given for the normal operation of the device and no guarantee is given that afterwards the device will still work properly. In the majority of cases where a device or installation is hit with a so-called over-voltage, the device or installation is completely ruined and becomes extremely dangerous towards the environment.

To avoid these severe surges from travelling through the installation, and destroying all connected devices, Titan SPD's should be installed.

The voltage at which an SPD clamps to is known as the protection voltage Up (see below) and should always be lower than the breakdown voltage of the device or installation that is to be protected. According to the standard 60364-4-443 IEC:1995+A.1:1998 the required impulse withstand voltage for equipments is:

Required impulse withstand voltage of equipment			
U_p=6 kV	U_p=4 kV	U_p=2,5 kV	U_p=1,5 kV

Equipment at the origin of the installation (impulse withstand category IV)	Equipment of distribution and final circuits (impulse withstand category III)	Appliances (impulse withstand category II)	Specially protected equipment (impulse withstand category I)

Most of the equipment can not withstand this impulses, so is needed a surge protection device to accomplish this requirements.

Terminology

Before going into more detail in technology matters, this chapter clarifies most of the SPD-related terminology.

I_{MAX}

Is the maximum current the SPD can carry (deviate to ground). According to the standard, an SPD should be able to carry this current at least once.

Class

The Class of the SPD defines the amount of energy the device is able to deviate towards the protective ground. As surges are impulses, and since the amount of energy is proportional to the surface below the curve (see fig.1), the class can also be defined by giving the rise-time, the time to fall back to 50% and the magnitude (I_{max}) of the impulse (see also fig.1).

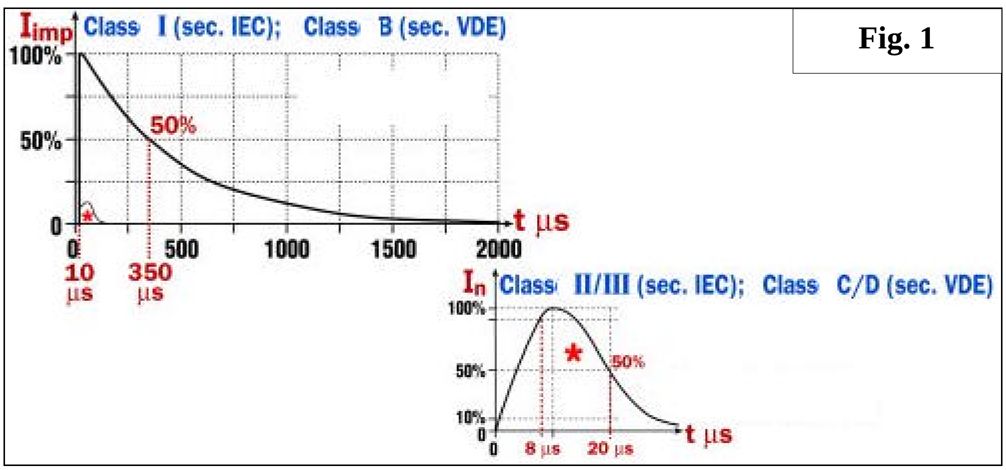


Fig. 1

In order to be able to compare different devices, 3 standardized impulse waveforms have been defined:

- 10/350 (Class 1) which has the highest energetic content,
- 8/20 (Class 2>, and
- 4/10 (Class 3) with the lowest energetic content.

Class 1 devices are normally used for front-end protection, i.e. for high-energy deviation coming from direct lightning strikes whereas class 2 and class 3 devices are used at a lower level in order to reduce the residual voltage (Up) as much as possible.

U_P

The protection voltage or residual voltage (Up) is the voltage to which the SPD clamps when it is hit with a standardised impulse waveform for its specific class, with a magnitude equal to I_{NOM}.

I_{NOM}

Is the current that the SPD can deviate (minimum 20 times). This current is of course much lower than I_{MAX}.

SPD-technology

Table 2 shows the various technologies that can be applied to protect an installation or equipment against overvoltages. Their respective main characteristics are also shown. To protect a mainspower distribution system from overvoltage surges, only Zinc-Oxide-Var¡stor (or more in general the Metal-Oxide-Varistor; in short the MOV), Gas-Tube and Spark Gap technologies are used.

Titan SPD's

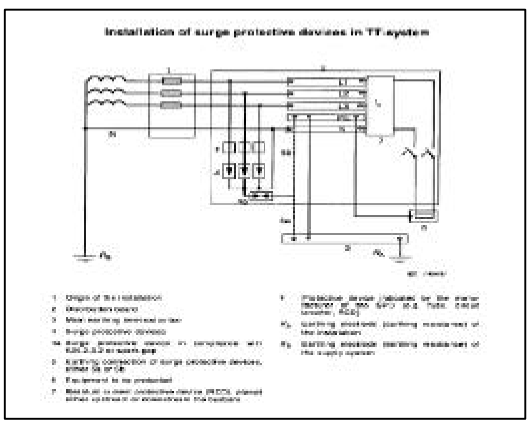
Class 2 Titan devices all have MOV-technology inside. Besides the MOV's, each phase is also equipped with a thermal fuse in order to take the device of-line in case the MOV breaks down and becomes a short-circuit (i.e. after thermal runaway). In addition, all devices have an optical faultindicator and some have a voltage-free contact for distant reporting. This contact reflects the status of the thermal fuse, and thus indirectly also the status of the MOV. Once the indicator turns red or the contact has switched over, the Titan should be replaced as soon as possible.

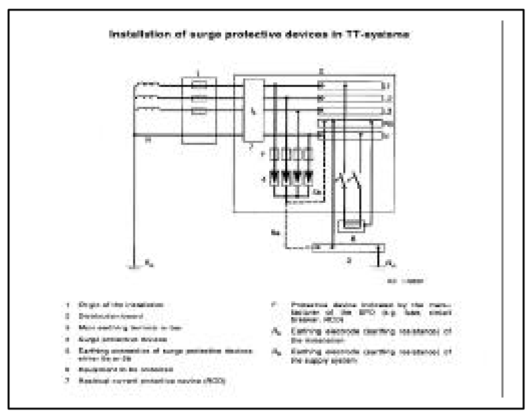
The class 1 Titan devices are based on spark-gap technology. As a spark gap can never turn into a short-circuit, the class 1 devices don't have a thermal fuse and as a consequence neither an auxiliary contact nor an optical status indicator.

Different methods of installation the SPD’s depending on the earth¡ng system

Depending on how the earthing of the power distribution system is implemented, single pole or multipole SPD's are required in order to fully protect the installation and the hooked-up equipment against destructive overvoltages.

TT - systems before and after RCB





Before RCB:

A Spark Gap between N - G should be installed in order to guarantee a total protection (surge protection device in compliance with 534.2.3.2 or Spark Gap).

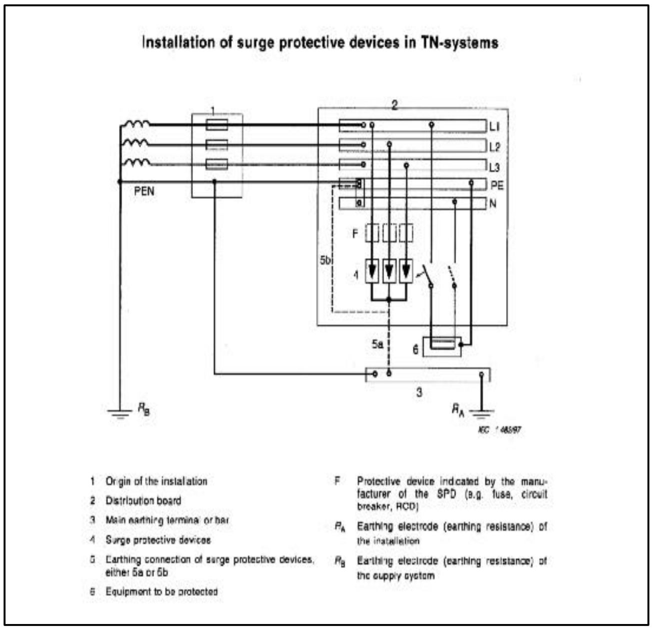
Please see the table 4.

After RCB:

No additional device should be installed between L – G and/or N – G, to guarantee a total protection

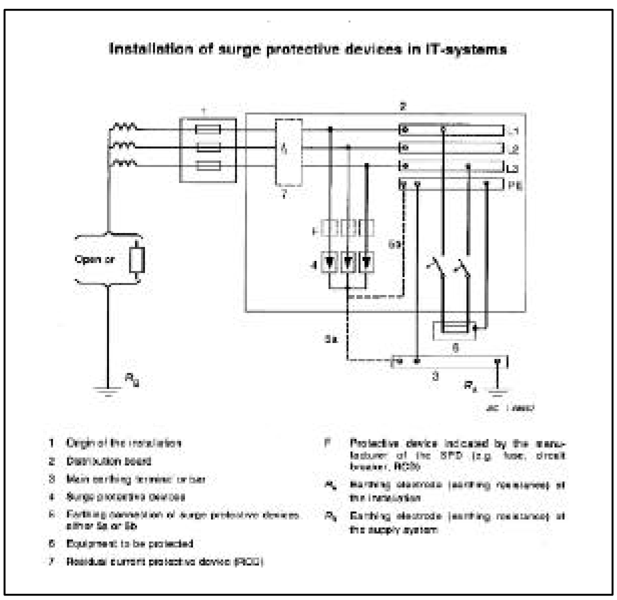
Please see the table 4.

TN - systems



Because of the fuses (failure to ground = short circuit in TNC-systems), the SPD´s can be installed directly between L - G.

IT - systems

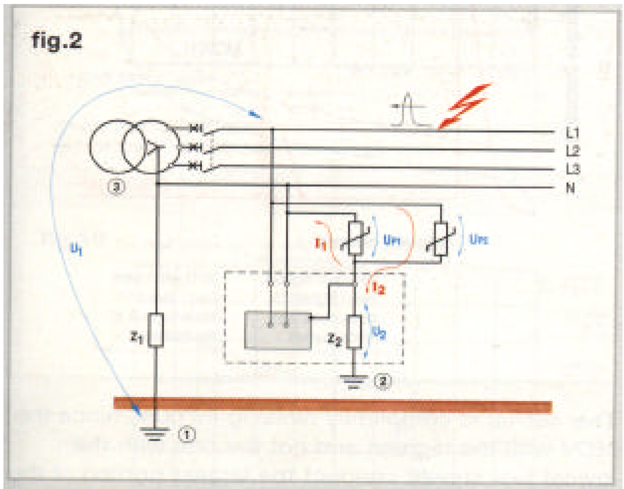


This systems assures that the V_c of the SPD's is, at least, the Voltage L – L.

Other examples

TT and TN-S earthing systems require multipole SPD's

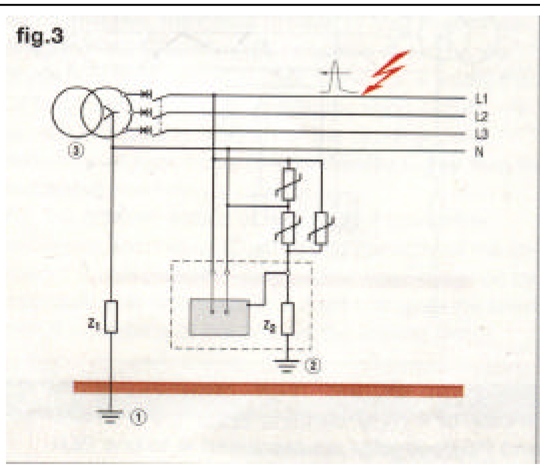
The figure below shows a TT-earthing system, with varistors installed only between each live conductor and protective earth (PE), and also between the neutral and the PE.



Right after the direct lightning strike hit, the tremendous amount of free charges injected in to the conductor, generates a very strong electrical field, pushing these free charges as far apart as possible. As a result, an impulse-wave-shaped current travels away from the point of impact, in both directions along the conductor towards the PE generating a voltage-drop across the conductor given by the law U = -Lx (di/dt). Typically, a 10kA 8/20 current-impulse generates a voltage of 1250V across a wire with a length of 1m.

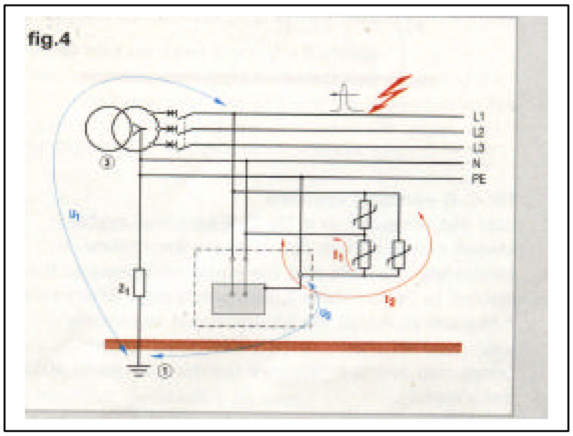
The varistor installed on the hit-by wire will clamp this generated voltage to a value corresponding to the instantaneous value of the current, given by the U-I-plot of the varistor (see table 2), and will deviate the current (I_2) towards the local PE.

Because of the relative high local PE-impedance (typically Z_2 = 10...30 ohm), the voltage-drop U_2 generated by I_2 could easily reach the level at which the varistor between local PE and Neutral starts to clamp, and therefore also starts to conduct current towards the PE of the energy supplier (I_1). Once this happens, the bulk of the current will flow through this parallel path, since on the side of the energy supplier, the earthing as well as the generator itself (or secondary of an intermediate step-down transformer) has a very low impedance (typically Z1 = 0,3 ... 1 ohm).



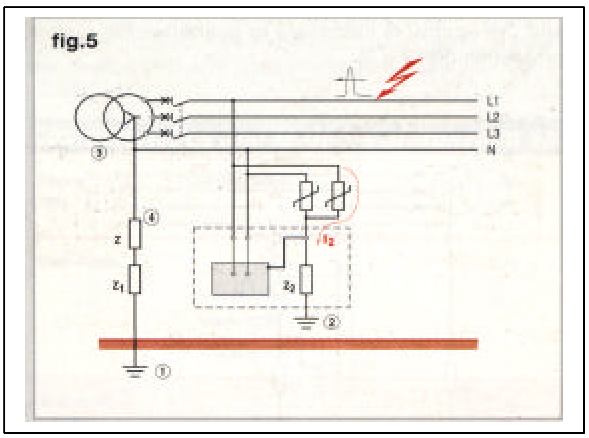
As you can easily see, the clamping voltage between live and neutral is U_{P1} + U_{P2}, which is roughly twice the clamping voltage of a varistor and not once as may be expected. This results in a very poor degree of protection. Therefore, in this case an additional varistor between each live conductor and the neutral is necessary to guarantee full protection (see the figure).

Based on the above explanation, you can easily see that in the case of a TN-S earthing system, multipole SPD's are required in order to fully protect the installation and hooked-up equipment against over-voltage-surges (see the figure below).



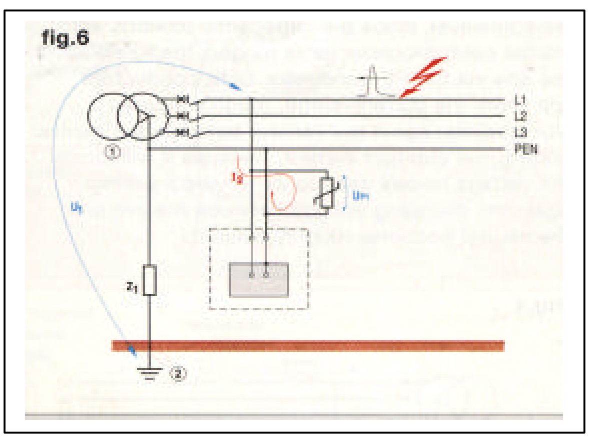
Here however, since the impedance towards earth via the neutral-conductor is roughly the same as the one via the PE-conductor, both conductors will share the current-surge, roughly equally. Nonetheless, again the varistor between the neutral and PE will conduct current, because it will clamp the voltage across itself to its U and therefore again the clamping voltage between the live and the neutral becomes roughly twice U_P.

IT and TN-C earthing systems require single-pole SPD's



As can be seen in figure, the main difference between an IT and an IT-earthing system is the high impedance Z through which the generator or the secondary of the step-down-transformer is grounded in an IT-system.

Therefore, the low-impedant current-path towards the PE of the energy-supplier, which exits in a TY-system, no longer exists in an IT-system, and for this reason will never conduct current. So no additional varistors between the live conductors and the neutral are required to guarantee full protection.



In case of a TN-C-earthing system, the Neutral and PE-conductor are combined in to one PEN conductor (see the figure). Therefore there is no alternative parallel current path as it exists in a TN-S-system and thus the highest possible voltage between the neutral and a live conductor is equal to the clamping voltage of only one varistor.

TN-C-S earthing Systems

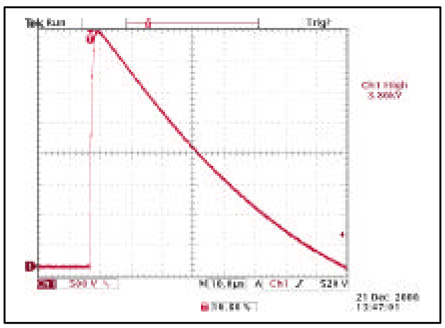
Last but not least, in a TN-C-S-earthing-system, always use multipole SPD's where the neutral is separately available and the equipment requires the Neutral to be connected. Use single pole SPD's only it you are sure that the neutral is not separately available or it the neutral doesn't need to be connected to the equipment (i.e. for a 3-phase 400V delta motor).

Cascading of SPD's

In areas where the exposure to lightning is very high, SPD's with a high I_{MAX}, must be installed (see below). In general, the U_P of those devices is too high to protect sensitive equipment like i.e. VCR-, and computer-equipment.

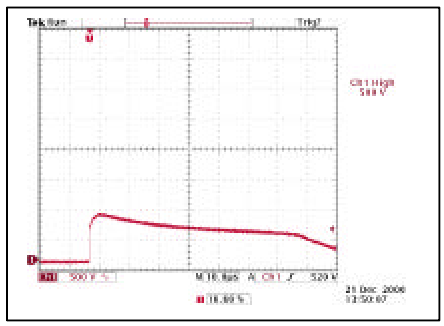
Therefore, besides these high I_{MAX} / high U_P front-end SPD's, devices with a lower U_P are to be installed in cascade (parallel) in order lo bring the protection voltage down to a reasonable level. Special care must be taken when two SPD's, both based on MOV-technology, are connected in parallel, especially when their electrical characteristics differ a lot from one another. As can be seen in the graphs below, there are the two different suppression technologies, according the table 2.

COMPARISON: MOV vs SPARK GAP



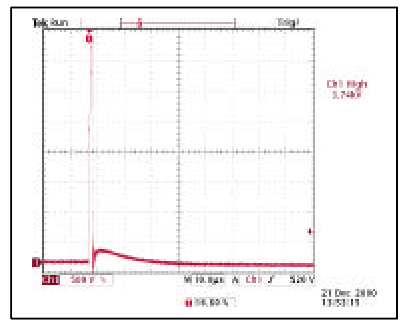
Initial Transient:

V high= 3,86 KV



MOV Technology:

The residual voltage is decreased to a very low value.



SPARK GAP Technology:

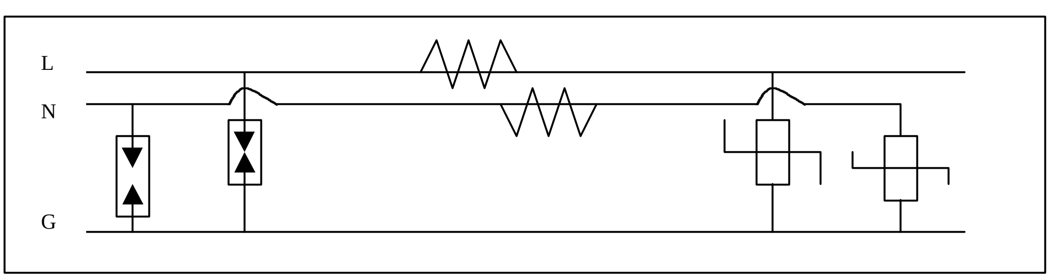
The ignition peak needed to trigger the device is very high.

V high= 3,74 KV

	MOV	**SPARK GAP**
Clamping voltage	Moderate	Low Clamp
Ignition peak	Low	Very High
Response	Very Fast	Very Low
Energy capability	Moderate	High

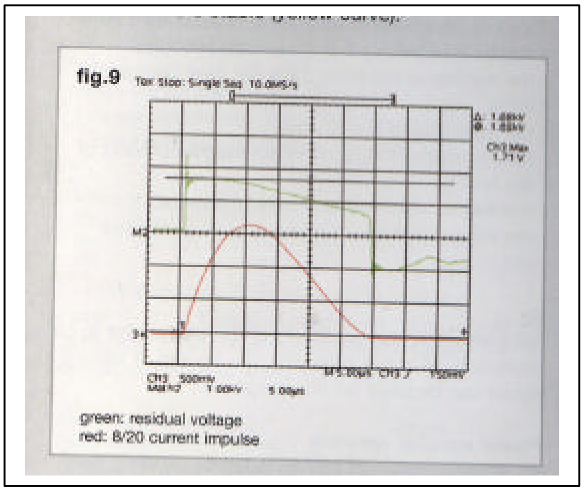
This set-up is completely missing its goal since the MOV with the highest and not the one with the lowest I_{MAX} should conduct the largest portion of the current.

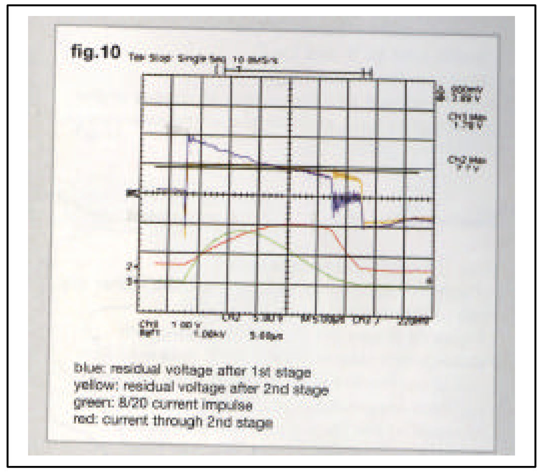
In order for this set-up to be effective, the interconnecting wire between both SPD's should have at least a length of 1 m (the longer, the better) introducing a series inductor. If this is practically impossible, a real inductor should be installed between both SPD's (see the figure below).



The Titan DR1P40Acoil has a l5 H coil, capable of conducting 40A, included in the range for this purpose. Figures 2 and 3 are illustrating the effect of cascaded MOV's.

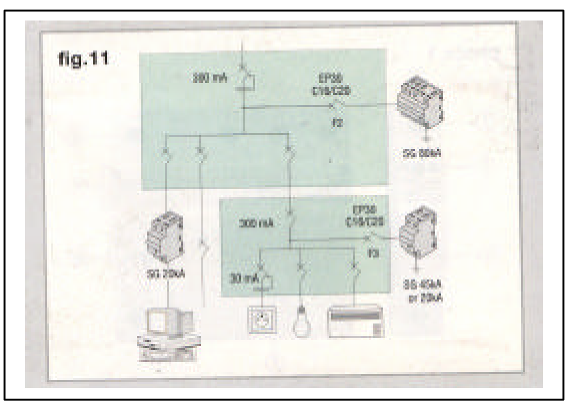
Figure 2 shows the clamping of a 2OkA-270V MOV alone. When the device is hit with a standard 20I<A-8/20 impulse wave (red curve), the voltage at which the MOV clamps is 1.68kV (green curve). Figure 3 shows the clamping of the same 2OkA 270V MOV in parallel with an 80kA-320V MOV upfront. The interconnection between the two MOV's has a length of 1 m and a cross-section of $32mm^2$. Applying the same standard 2OkA-8/20 impulse wave (green curve) to this cascade, the voltage at which the 20kA-270V MOV clamps is much lower (900V) and much more stable (yellow curve).





Selection of up-stream circuit breaker

Eventhough all MOV-based Titan SPD's incorporate internal protection (thermal fuse), as a general rule, a circuit breaker or fused disconnect should be installed up-stream of the SPD. In all cases, even in the case where a general circuit breaker 5 already installed, it's advisable to add a circuit breaker (F2) just up-stream of the SPD, in a selective way (Fig 4).



This provides a means of disconnecting the SPD and not the entire installation should the surge arrester fail. It also allows the disconnection of the SPD for service or maintenance. To be effective, the circuit breaker or fuse directly up-stream of the SPD should be capable of cutting the theoretical short-circuit current at the place where the SPD is installed. In other words, the short-circuit current interrupting capacity of the circuit breaker should be at least equal to or preferably higher than the calculated short-circuit current.

For the different values of I_{MAX}, table 3 shows the necessary short-circuit interrupting capacity of the upstream circuit breaker. These values were obtained by calculating the short-circuit current with only the short circuit resistance of the SPD as the limiting factor.

Table 3		
SPD$_{Imax}$	**MCB**	**Fuse**
80 kA	C 60 (C) (63 A)	63 A gL/gG
45 kA	C 60 (C) (32 A)	35 A gL/gG
20 kA	C 60 (C) (32 A)	35 A gL/gG
60 kA “10/350” (spark gap)	NG 125 (C) (100 A) or C 60 (C) (32 A)	100 A gL/gG

An important consideration here, is that these are worst case values, because in a real installation several other resistances add up to the short-circuit resistance of the SPD, and therefore decrease the short-circuit current even further. The size of the circuit breaker will not affect the performance of the SPD. The circuit breaker size should be co-ordinated with the connecting wire and should be sized accordingly to the applicable National Electrical Code.

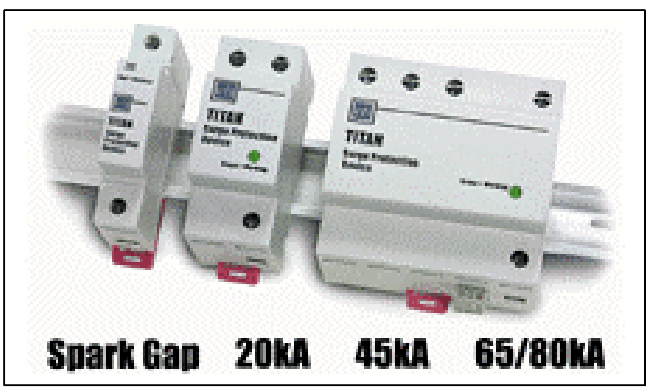
Features and benefits

What can be seen from the outside

The photo (see below) shows a single and multipole Titan SPD. As always for the Elfa+ range of products, the main characteristics are printed in the side part of the device.

These are:
- I_{MAX}
- Class
- U_n (L- N / PE)
- U_n (L- L)
- UP at I_{NOM}
- I_N
- V_n (L- N / PE)
- V_n (L- L)
- Wiring Diagram
- Single or multipole configuration

The I_{MAX} of the Titan SPD's goes from 20kA over 45 to 65kA for the plug-in class 2 devices, up to 80kA for the monobloc class 2 devices and up to 100kA for the class 1 devices.



All types are equipped with 50mm^2 terminals with captive Pozidriv screws. The terminal-position is aligned with the terminal-position of the Elfa+ MCB's offering the benefit of interconnecting both devices with a pin- or fork-type busbar. Easy DIN-rail extraction as is implemented on the MCB's and RCD's is also being used here due to the same DIN-rail clip used.

All single-pole SPD's are keyed plug-in-devices (4) and have a mechanical fault indicator, while all multipole devices are mono-block (not plug-in) and have an LED fault indicator.

The whole range of class 2 Titan SPD's is available with or without a voltage-free auxiliary contact for remote indication.

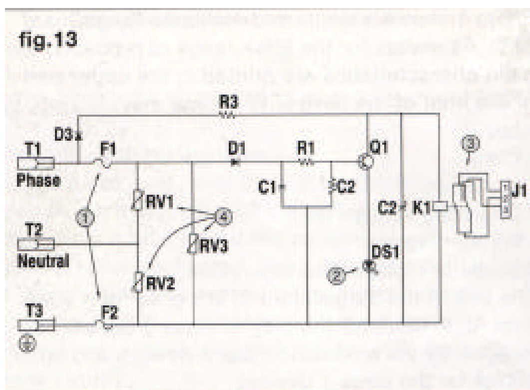
Both the auxiliary contact as well as the fault indicator reflect the status of the thermal fuse, and thus indirectly also the status of the MOV (see explanation below and fig.13).
Once the fault indicator turns red and the auxiliary contact has switched over; the Titan should be replaced as soon as possible since from that moment on there is no overvoltage protection.

What's inside

Class 2 Titan devices all have MOV-technology inside. The wiring diagram of a single-phase multipole Titan is drawn in the figure below.

Besides the MOV's, each phase and the earth are also equipped with a thermal fuse (1) in order to take the device OFF-line in case the MOV breaks down and becomes a short-circuit (i.e. after thermal runaway).

In addition, al devices have an optical fault indicator (2) and some have a voltage-free contact for remote indication (3).



The class 1 Titan devices are based on spark-gap technology. As a spark gap can never turn into a short-circuit, the class 1 devices don't have a thermal fuse and as a consequence neither an auxiliary contact nor an optical status indicator.

Selecting the correct SPD

The correct selection of an SPD is based on 3 factors:

I_{MAX}

This key parameter is determined based on a risk analysis (see below) that takes into account:

- the number of lightning days per year (=keraunic level),
- the geometry of the facility,
- the environment directly in the neighbourhood of the facility,
- the way in which the power is distributed,
- the value (£) of the equipment to be protected
- etc.

U_P

Determined by the sensitivity of the equipment to be protected. As a rule of thumb, the figures of table 2 above can be used for this purpose.

Power supplier network

As already explained above, different earthingsystems require different SPD's:

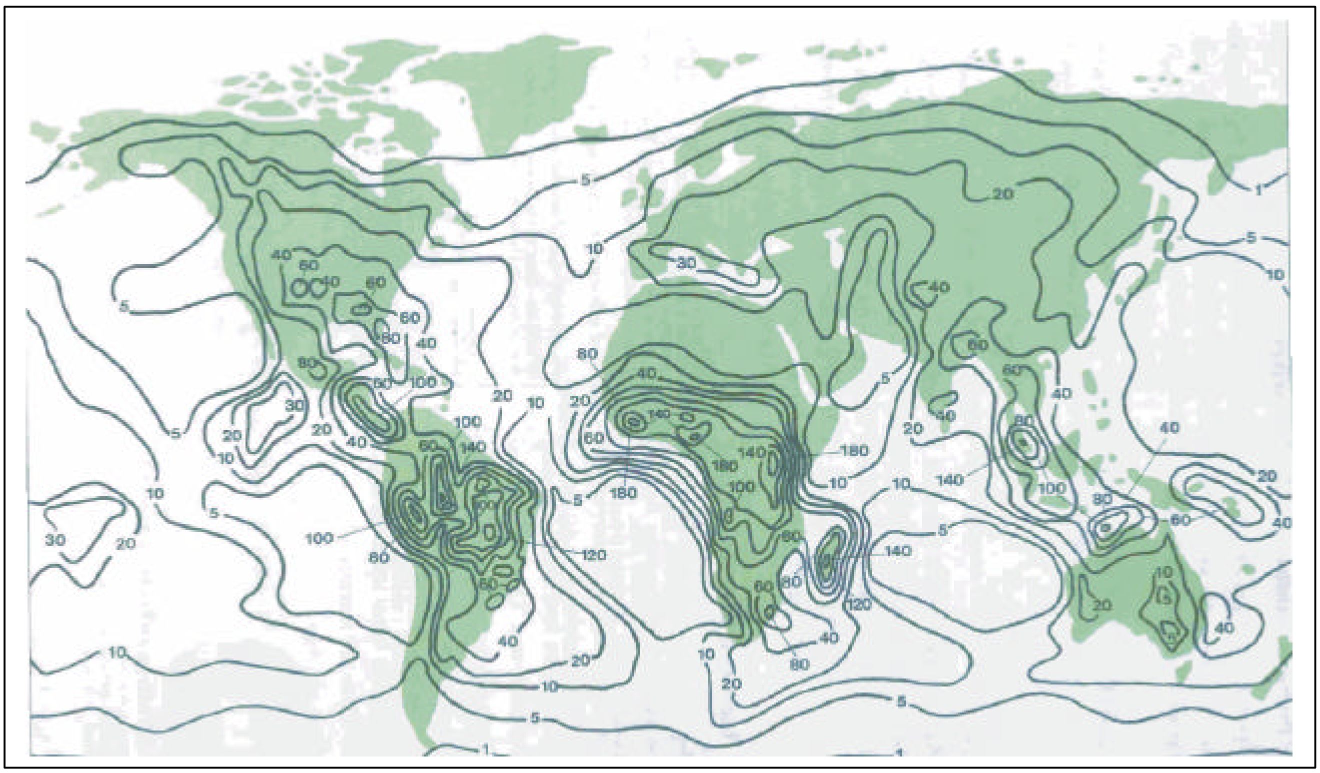
- Single-pole for IT and TN-C
- Multipole or singlepole for TT and TN-S.

Also the voltage and the number of phases of the power supply have an influence on the selection of the SPD.

Determination of I_{MAX}

<u>Step 1: Facility exposure analysis (FEA)</u>

The more lightning strikes per year, the higher the risk of the building being hit: the following figure shows the map of the world with isokeraunics superimposed on it. (Isokeraunic = line of same number of lightning days per year). For each area, a more accurate map should be available at the Metreologic Institute of the country.



LOCATION

Locate the area of the facility and read the keraunic level. The probability of damage is:

Keraunic level above 60	High
Keraunic level between 30 and 60	Medium
Keraunic level below 30	Low

STRUCTURAL

The structural exposure of your facility is:

Multi-story building	High
Single story with roof >10m	Medium
Single story building	Low

FACILITY SQUARE FOOTAGE

The physical exposure level of your facility is:

Ground surface more than 3500 m^2	High
Ground surface from 1000 to 3500 m^2	Medium
Ground surface leas than 1000 m^2	Low

UTILITY SERVICE AREA

The utility service area exposure level of your facility is:

Rural	High
Suburb	Medium
Downtown	Low

UTILITY FEED

The utility feed exposure level of your facility is:

Overhead direct service drop	High
Overhead to facility then underground	High
Underground service from utility substation	Medium
Metropolitan service grid	Low

NEAREST UTILITY SUBSTATION

The utility-grid location exposure level of your facility is:

600 m to 3km from facility	High
300 m to 600m from facility	Medium
Lass that 300 meters from facility	Low

Facility Exposure Risk Level (FER-level)

The number of "HIGH" exposure levels checked: _______ x 4 = _______
The number of "MEDIUM" exposure levels checked: _______ x 2 = _______
The number of "LOW" exposure levels checked: _______ x 1 = _______
Add the three lines together for the exposure total: TOTAL = ___________

Determine the facility exposure risk looking up the facility exposure risk level in the following table:

If the total is:	FER-level
Less or equal to 10	LOW
Between 11 and 17	MEDIUM
Above or equal to 18	HIGH

Step 2. Function and value analysis

Critical facilities like hospitals, air-traffic control centres, etc. cannot afford to be out of operation by losing expensive (sensitive) electronic equipment.

FACILITY FUNCTION

Mission critical / 24 hours critical	4
Critical / 8 hours critical	2
Non - critical / 8 hours commercial	1

LOAD PROFILE

Large concentration of sensitive equipment	4
Sensitive equipment only in certain areas	2
Very limited presence of sensitive equipment	1

LOAD VALUE

Above $100k	4
$100k to $30k	3
$30k to $19k	2
Less than $10k	1

HISTORICAL DATA

Past history of power problem with damage	4
Past history of power problem without damage	2
No past history of power problems	1

Facility Function and Value Factor (FF&V-factor)

Determine your facility function and value factor by adding the above scores and looking up the facility function and value level in the following table:

If the total (sum of above) is	FF&V-factor
Less or equal to 6	3
Between 7 and 11	2
Above or equal to 12	1

Step 3: Lookup I_{MAX}

Based on the Facility Exposure Risk level (FER) and the Facility Funct¡on and Value factor (FF&V), use the chart below to know the Current Suppression (I_{max}) needed to protect your facility.

RECOMMENDED SPECIFICATIONS							
By Facility Exposure and Function Level							
FACILITY LEVELS		INSTALLATION POINT					
EXPOSURE RISK	FUNTION AND VALUE LEVEL	DOMESTIC		INDUSTRIAL		TERCIARY	
		MAIN PANEL	SUB PANEL	MAIN PANEL	SUB PANEL	MAIN PANEL	SUB PANEL
HIGH	LEVEL 1	45KA		80KA	20KA	45KA	20KA
	LEVEL 2	80KA		SGAP/80KA	45KA/20KA	80KA	20KA
	LEVEL 3	SGAP	20KA	SGAP	80KA	SGAP	45KA
MEDIUM	LEVEL 1	45KA		45KA	20KA	45KA	20KA
	LEVEL 2	45KA		80KA	20KA	80KA	20KA
	LEVEL 3	45KA	20KA	SGAP/80KA	45KA	80KA	45KA
LOW	LEVEL 1	20KA		45KA	20KA	20KA	
	LEVEL 2	20KA		45KA	20KA	20KA	20KA
	LEVEL 3	20KA		45KA	20KA	45KA	20KA

Determination of the Titan type

The I_{MAX}-value found above, together with the operating voltage, the protection voltage and the kind of earthing system, determines the correct Titan type. Please see the following table.

TABLE 4

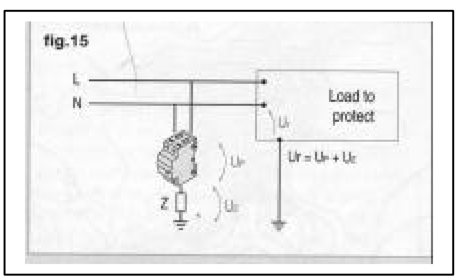
TITAN	TT	TN-C	TN-S	IT
3 phase	1 x DR4P80K400AC 1 x DR4P80K400S 1 x DR4P45K400AC 1 x DR4P45K400S 1 x DR4P20K400S 3 x DR1P65K230DC + 1 x DR1PSGAP 4 x DR1P65K230DC 4 x DR1P65K230S 4 x DR1P45K230DC 4 x DR1P45K230S 4 x DR1P20K230S	3 x DR1PSGAP 3 x DR1P65K230DC 3 x DR1P65K230S 3 x DR1P45K230DC 3 x DR1P45K230S 3 x DR1P20K230S	1 x DR4P80K400AC 1 x DR4P80K400S 1 x DR4P45K400AC 1 x DR4P45K400S 1 x DR4P20K400S 4 x DR1PSGAP 4 x DR1P65K230DC 4 x DR1P65K230S 4 x DR1P45K230DC 4 x DR1P45K230S 4 x DR1P20K230S	3 x DR1P65K400DC 3 x DR1P65K400S 3 x DR1P45K400DC 3 x DR1P45K400S 3 x DR1P20K400S
1 phase	1 x DR2P45K230S 1 x DR2P20K230S 1 x DR1P65K230DC + 1 x DRSGAP 2 x DR1P65K230DC 2 x DR1P65K230S 2 x DR1P45K230DC 2 x DR1P45K230S 2 x DR1P20K230S	1 x DR1PSGAP 1 x DR1P65K230DC 1 x DR1P65K230S 1 x DR1P45K230DC 1 x DR1P45K230S 1 x DR1P20K230S	1 x DR2P45K230S 1 x DR2P20K230S 2 x DR1PSGAP 2 x DR1P65K230DC 2 x DR1P65K230S 2 x DR1P45K230DC 2 x DR1P45K230S 2 x DR1P20K230S	1 x DR1P65K400DC 1 x DR1P65K400S 1 x DR1P45K400DC 1 x DR1P45K400S 1 x DR1P20K400S

Installation guidelines

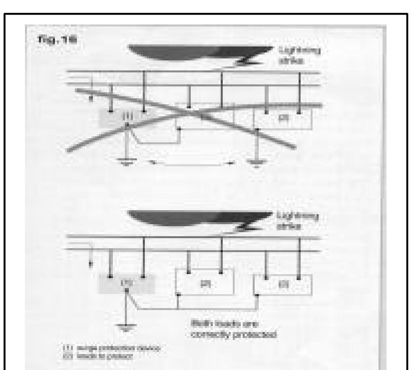
Although the installation of an SPD is relatively easy and can be done very fast, correct installation is vital. Not just for the obvious reasons of electrical safety but also because a poor installation technique can significantly reduce the effectiveness of the SPD. Below some installation guidelines are summarised in order to assure the best possible protection against over-voltage surges you can achieve by applying Titan SPD's.

Install a high quality ground (PE) and avoid ground loops

Proper grounding and bonding is important to achieve a source of equal potential ensuring that electronic equipment is not exposed to differing ground potentials that would introduce ground loop currents.



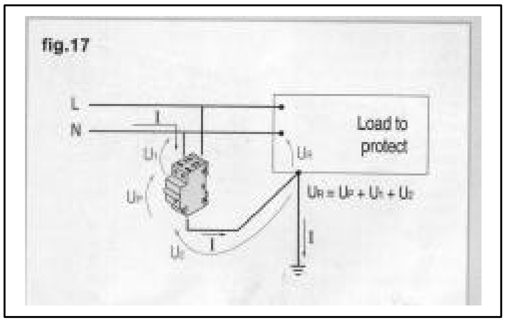
A high impedance towards ground introduces an additional voltage drop in series with the residual voltage of the SPD (fig. 5), so the lower this impedance towards ground the lower the total residual voltage across the load to be protected.



Bonding was not a concern in past years because computers, and all other devices, were predominantly stand-alone devices and the ground connection was simply a safety measure for that single device. However, in recent years we have begun interconnecting various devices via data and signal cables. Now, with each device having a separate ground connection, currents begin to flow between these various ground connections increasing the possibility of equipment damage. Figure 6 overleaf shows correct bonded ground interconnection between PE, SPD and the equipment to be protected.

Keep the lead length short

As the let-through or residual voltage of a SPD is the primary measurement of a protectors' effectiveness, special care needs to be taken when hooking up the device.



Indeed, the let-through voltage is directly affected by the impedance of the connecting leads, thus by their length and cross section (see fig. 7). Obviously, the performance of the entire circuit decreases as this impedance increases.

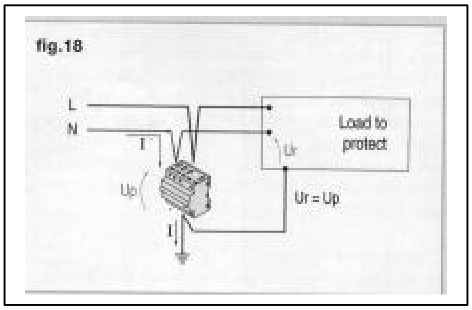
As an example, with two 50 cm connecting leads and diverting 3.000 amps:

4 mm^2 (cable size)	12,9 Volts (Resistive voltage drop)	
4 mm^2 (cable size)	376 Volts(Inductive voltage drop)	1,1 H (Inductance)

Increasing the conductor size will help to reduce the impedance. However, as at high frequencies the inductance is more important than the resistance reducing the wire length (thus reducing the inductance) will have a much bigger impact than increasing the cross section (= reducing the resistance).

Also, increasing the cross section implies increasing the installation cost, while reducing the length implies reducing the installation cost.

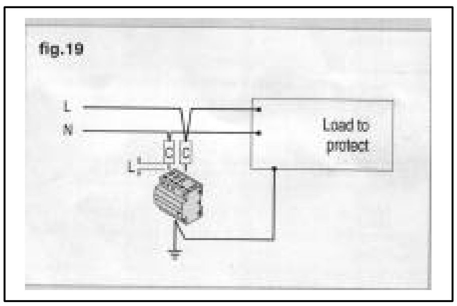
Use Kelvin connections



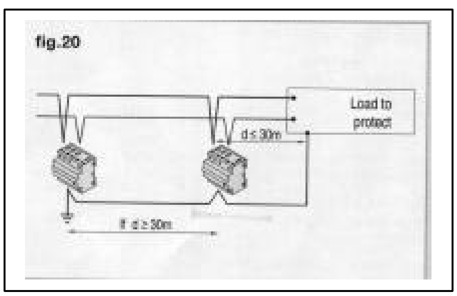
Wherever possible, ordinary parallel connections as shown in figure 8 should be avoided and Kelvin connections as shown in figure 18 should be applied. This way of connecting virtually reduces the additional voltage-drop in the connecting wires to zero obtaining the best U_P possible.

Theoretically, since the terminals of the Titan devices have a maximum capacity of lx5Omm^2 or 2x2Omm^2, Kelvin connection is possible up to 63A. However, due to the excessive heating of the terminal at higher currents, we advise not to use Kelvin connections above 50A.

Install the SPD as close as possible to the up-stream circuit breaker



Again in order to reduce the additional volt drop as much a possible in the interconnecting wiring, keep the length (L) of those wires as short as possible (fig. 9).



Install the SPD as close as possible to the equipment to be protected (fig. 10).

Avoid installing an SPD downstream of a sensitive RCD

A MOV-based SPD always has a leakage current towards earth. Normally, this leakage current is in the A-range and therefore negligible, but for a lot of SPD's on the market, (i.e. the multipole Titan devices), the optical indicator is a LED which also leaks current to ground. Unfortunately, the intensity of the multipole device is several mA's. As a result, installing an SPD downstream of a residual current device (RCD) could lead to nuisance tripping of the RCD. This doesn't influence the correct operation of the SPD, but indeed interrupts the service continuity.

We advise not to install a multipole Titan SPD downstream of an RCD with a sensitivity of less than 3OmA.

Bound wires together

In addition to keeping the lines short, where possible tightly bind the lives and neutral together over as much of their length as possible, using cable ties, adhesive tape, or spiral wrap. This is a very effective way to cancel out inductance.

Avoid sharp bending and winding-up of conductors

Besides keeping the interconnecting wires as short as possible, we also advise not to bend those interconnecting wires in a sharp way, but instead apply smooth bendings.
Never coil up interconnecting wires. Both coiling and sharp bending increase the inductance of the wire drastically.

Follow rigorously the product specific installation procedure

As each Titan device comes with a detailed instruction sheet, please read and follow these guidelines step by step during the installation of the SPD.

Regulations and standards

Titan SPD´s are all designed according to the following standards (latest version unless indicated otherwise):

- IEC 61643-1, IEC1643-1
- EN 61024-1, EN 61000-4-4, EN 61000-4-5
- UL 1449-2
- ANSI C62.41

Features and benefits

- In TT- and TN-S systems multipole or singlepole SPD´s are used while in IT- and TN-C systems only singlepole SPD´s are used.
- In IT- and TN-S- systems, one SPD is used between each live-conductor and PE.
- The single-pole SPD´s are all keyed plug-in devices (except the spark gap) while the multipole devices are all mono-block.
- All SPD´s have a terminal capacity of 1x50mm^2 or 2x20mm^2; the Pozidriv terminals are captive.
- The SPD´s can be interconnected with MCB´s by means of a pin- or fork-type busbar.
- All SPD´s have an optical fault indicator (except the spark gap).
- A complete range is available: Class 1, Class 2 and decoupling inductors.
- Devices with a built-in voltage-free auxiliary contact for remote indication are available.
- All MOV-based SPD´s have a built-in thermal fuse.
- The power-supply voltage is allowed to vary in the range of 110% Un… 85% Un without damaging the SPD.