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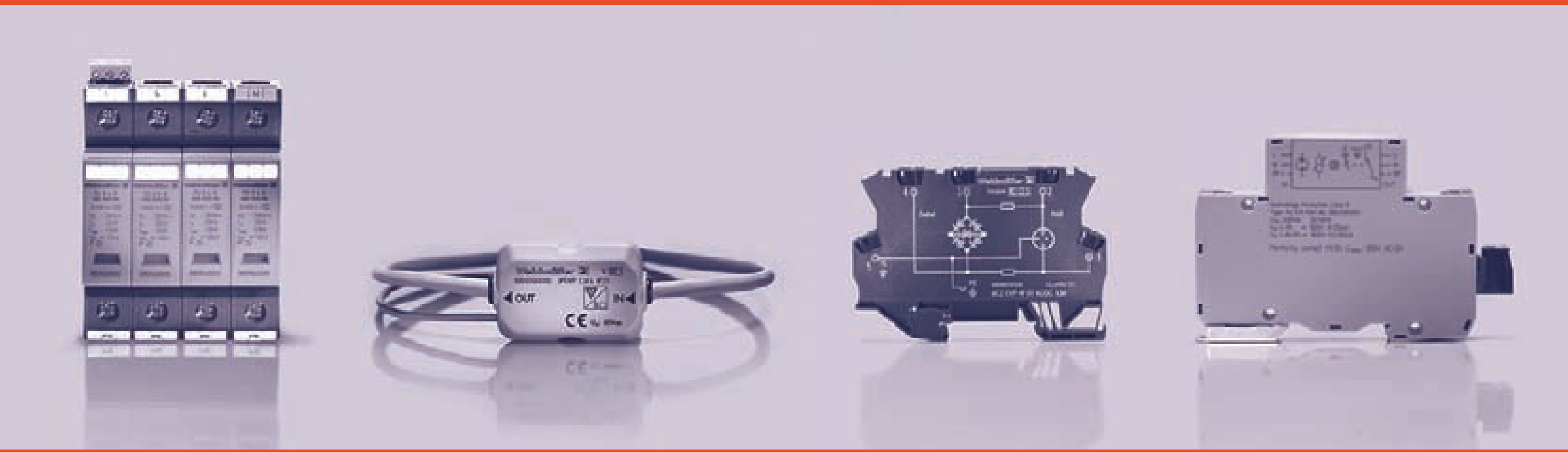
CATALOGUE 4.4

2011



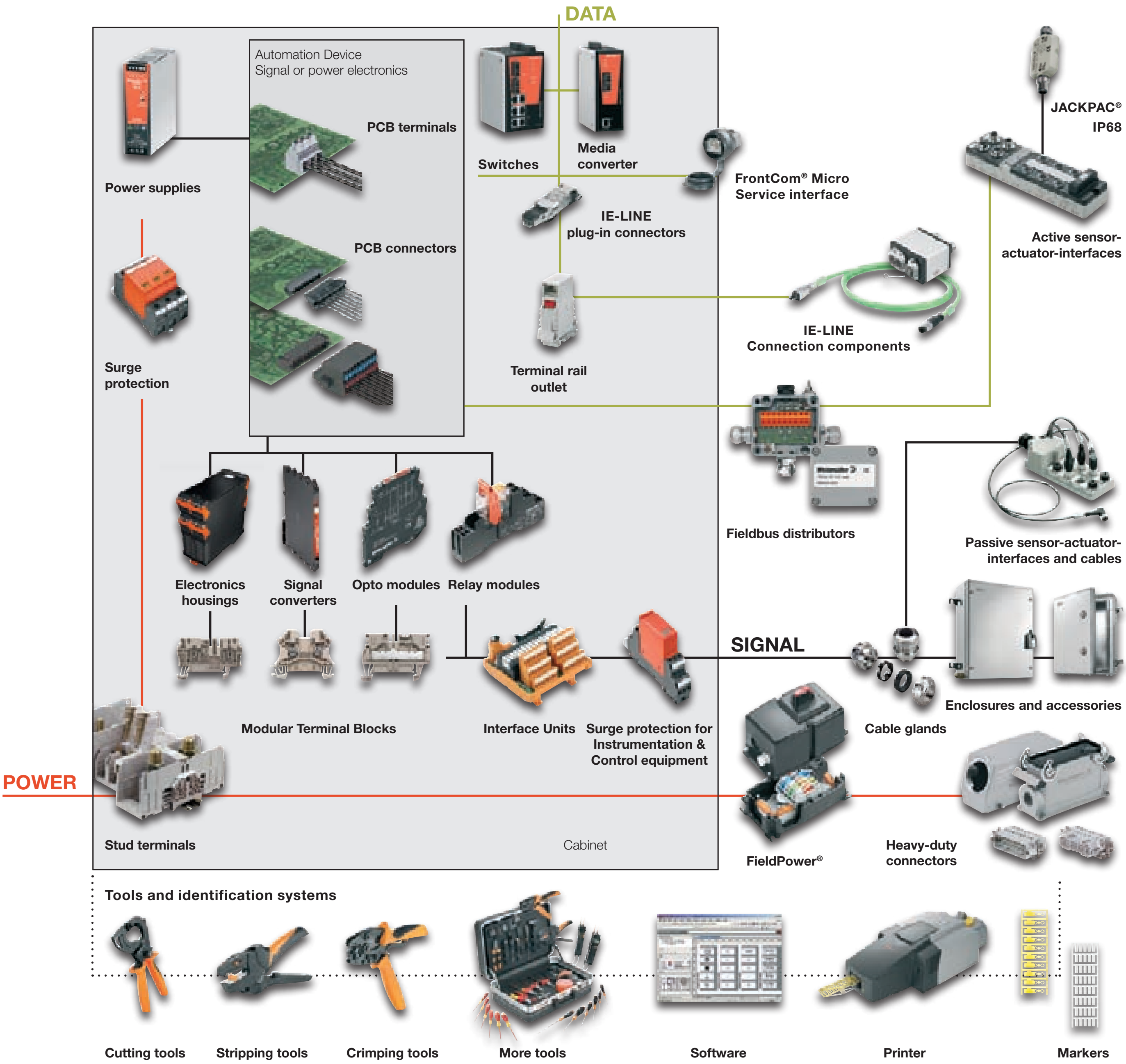
Electronics
Surge protection

Catalogue

Weidmüller

Product Portfolio

Weidmüller is a leading international provider of solutions for electrical connectivity, transmission and conditioning of power, signal and data in industrial environments. The company with headquarters in Detmold/Germany develops, produces and sells products in the field of electrical connectivity and electronics all over the world.
www.power-signal-data.com



All the catalogues at a glance

		Order No.
Catalog 1	Modular Terminal Blocks	5661400000
Catalog 2	PCB Terminals, PCB Connectors and Housings for Electronics	1000310000
Catalog 3	RockStar® – Heavy Duty Connectors	5664240000
Catalog 4.1	Electronics – Analogue Signal Conditioning	1203510000
Catalog 4.2	Electronics – Relays and Optos	1158120000
Catalog 4.3	Electronics – Power Supplies	1158070000
Catalog 4.4	Electronics – Surge protection	1271290000

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Catalog 4.5	Electronics – Interface units and PLC solutions	1102340000
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Catalog 6	Tools	1161520000
Catalog 7	Identification systems	1125590000
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Surge protection 2011

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Pluggable surge protection for C&I circuits (IEC 61643-21)

VARITECTOR SPC EX

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Pluggable surge protection for intrinsically safe current loops for gas and dust atmoshere up to zone 0

VARITECTOR SSC 6AN

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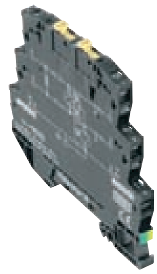

2-stage surge protection with 6 screw-connection for C&I circuits (IEC 61643-21)

VARITECTOR SSC 4AN

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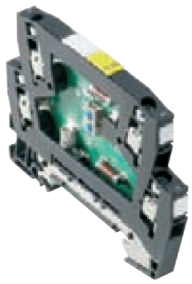

2-stage surge protection with 4 screw-connection for C&I circuits (IEC 61643-21)

PU II 750 V

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Pluggable overvoltage protection class II for 750 V application, e.g. wind power

PU I TSG+

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Enclosed lightning arrester class I up to 100 kA (10/350 µs) for installation in front of the meter. (ligtning protection Level 1)

Surge protection for low-voltage supplies

PU I series

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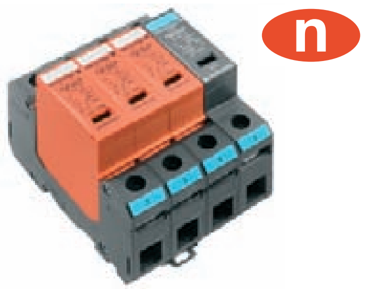

Class I + II plug-in arrester for lightning protection equipotential bonding. Suitable for lightning protection level III and IV

PU BC/PU BCR

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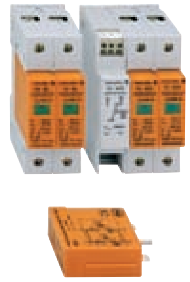

Class I + II plug-in arrester for lightning protection equipotential bonding. Suitable for lightning protection level II and III

PU 1 TSG

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Enclosed lightning arrester class I up to 35/50 kA (10/350 µs), 17.5 mm wide, for use in main distribution boards, 230 V

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Enclosed lightning arrester class I up to 100 kA (10/350 µs), 35 mm wide, for insertion between N and PE

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Lightning arrester class I up to 50 kA (10/350 µs) per unit with triggered sparkover gap for industrial main distribution boards, 330 V

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Combination arrester

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Combination arrester for 4-conductor and 5-conductor system

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Surge voltage protector class II, with varistors for main distribution or subdistribution boards (also with remote signalling contact)

PU III series

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Surge voltage protector class III, single-phase with gas discharge tube and varistor for equipment protection, slimline model with remote signalling contact

Surge protection for low-voltage supplies / instrumentation and control equipment

PO DS

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Surge voltage protector class III, single-phase with gas discharge tube and varistor for equipment protection, build-in module with visual indication

Wavefilter

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Mains filter, 3/6/10 A, with screw connection for 230 V devices or voltage supplies

MCZ HF

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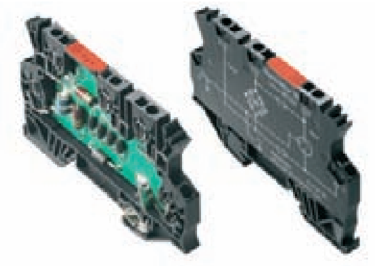

Measurement and control surge protection for binary and analogue signals. In a thin design (6 mm) with tension clamp connection and mounting rail contact

MCZ CL/SL

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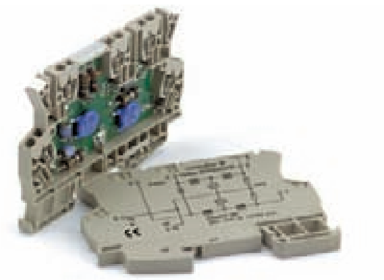

Instrumentation and control engineering surge protection for binary and analogue signals, slimline model (6 mm) with tension spring connection and mounting rail contact

MCZ Filter

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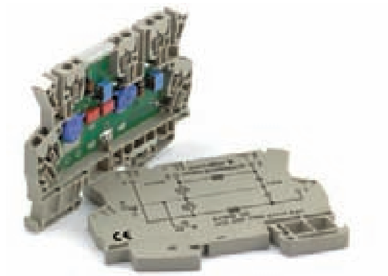

Instrumentation and control engineering filter for analogue signals, slimline model (6 mm) with tension spring connection and mounting rail contact

MCZ GDT, MOV, TAZ

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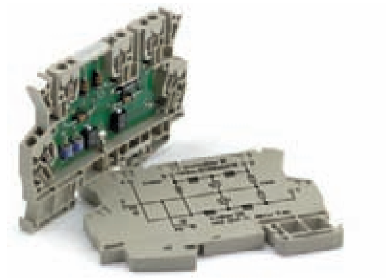

Instrumentation and control engineering surge protection with individual protective elements (GDT, MOV, TAZ), slimline model (6 mm) with tension spring connection and mounting rail contact

LPU

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Instrumentation and control engineering surge protection for binary and analogue signals, plug-in model with screw connection (connection variations and test option)

Surge protection for instrumentation and control equipment

DKU

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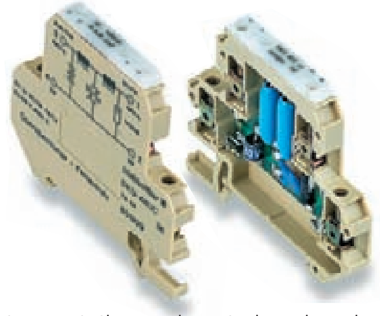

Instrumentation and control engineering surge protection for binary and analogue signals, slimline model (5 mm) with screw connection

DK5U

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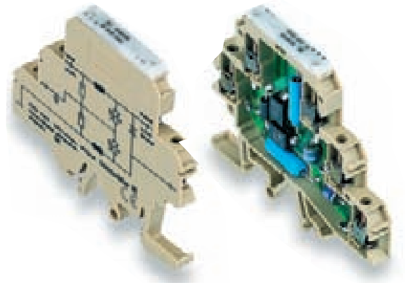

Instrumentation and control engineering surge protection for binary and analogue signals, slimline model (6 mm) with screw connection

DK6U

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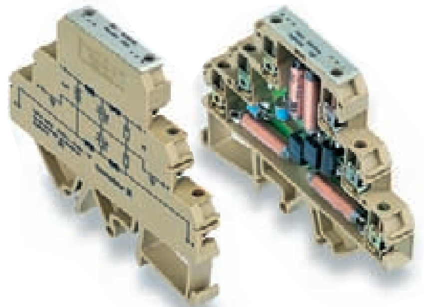

Instrumentation and control engineering surge protection for binary and analogue signals, slimline model (8 mm) with screw connection

DK4U

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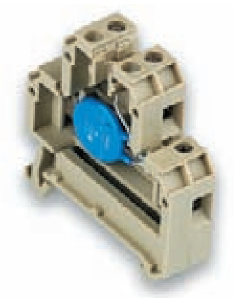

Instrumentation and control engineering surge protection with individual protective elements (GDT, MOV, TAZ), slimline model with screw connection

DK4RC

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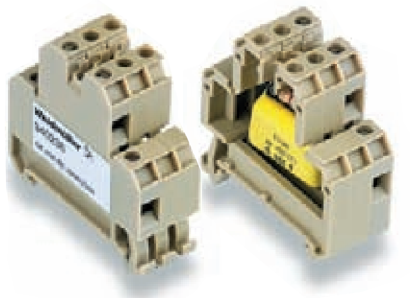

RC combination, suppressor circuit for contactors and solenoid valves, with screw connection

EGU 1/2

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Two-stage instrumentation and control engineering surge protection for binary signals, with integral fuse (5 x 20 mm) and screw connection

EGU 3 / EGU 4

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Two- and three-stage surge protection for binary and analogue signals up to 1.5 A, with rotating clip-in foot.

JACKPAC®

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Single- and three-stage surge protection in IP67 quality: for protecting binary switching signals up to 24 V, or for analogue measuring circuits with 0…20 mA or 0…10 V.

RSU 6/10 A

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Three-stage surge protection for analogue signals with high current requirement, or for power supplies in instrumentation and control systems

Surge protection for data interfaces

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Surge protection for RS 232 data interface in EG4 housing, with screw connection

ZS RS232
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Surge protection for RS 232 data interface in flat connector housing, available as plug or socket connector

LPU RS485 / RS422
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Surge protection for RS 485 and RS 422 data interface, plug-in model with screw connection

RS485
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Surge protection for RS 485 data interface, in protected housing with T-junction option and optional earth connection via gas discharge tube

LON™ Termination
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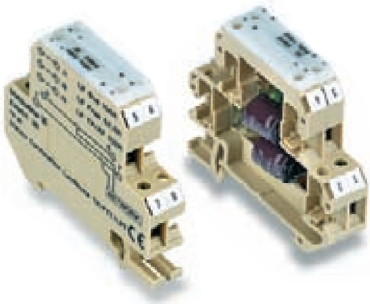

Bus termination terminal for LON Termination LPT/FTT/TP 78, with screw connection

MCZ OVP LON™
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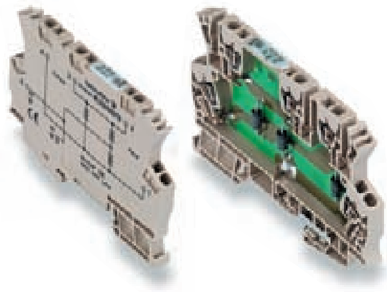

Surge protection for LON bus in MCZ housing, with tension spring connection and mounting rail contact

DME Ethernet Cat.5
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DME Ethernet cat.5 surge protection

COAX
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Surge protection for COAX interfaces, as BNC, N, F, and UHF adapter plug

Telecommunications interfaces
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TAE-NFN for analogue and ISDN lines

Surge protection for photovoltaic systems

PV box

Page F.10

PU II surge arrester, especially for photovoltaic systems

The basics of Surge protection

The basics of Surge protection

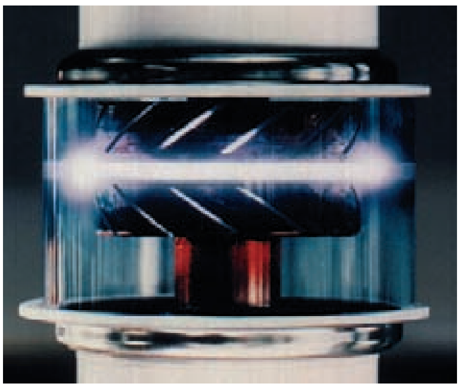
Is surge protection worthwhile?

You can rely on luck or take precautions.

The priority you give to surge protection depends on your willingness to take risks! Perhaps you think ”it'll never happen to me”. Then you won't have lost anything, but will have gained only very little. However, the subject of overvoltage is then a daily worry for you.
But if you wish to be on the safe side, you should include surge protection in your corporate strategy. Such an investment brings you operational reliability and can prove invaluable when disaster strikes.

Disaster comes from the sky

The violent forces of nature in the form of a thunderstorm are a spectacular show. Potentially, this is a dangerous event for human beings and no less dangerous for industrial and commercial premises and equipment.
While a person is mainly exposed to the risk of a lightning strike in his or her immediate vicinity, this is not the case for electrical equipment. Lightning strikes up to 2 km away can damage electrical components.
Apart from this, electrical systems are considerably more sensitive to the indirect effects of the energy of a bolt of lightning. Lightning strikes generate secondary voltages in anything that conducts and therefore endanger the insulation of electrical equipment.
The number of lightning strikes per annum in europe alone are considerable. Lightning strikes are registered worldwide. You can get the latest figures by visiting the Internet address www.wetteronline.de/eurobli.htm.



Electric arc in a 10 kV switch while being switched off

But disaster also comes from inside

And to a much greater extent than from the sky. Wherever electricity is used, it must also be switched on and off. And the physical processes of a switching operation can also cause overvoltages.
These overvoltages are nowhere near as high as those of lightning. But as they are generated directly in the lines, they are also directly in the system and place a stress on the insulation. Although switching operations are not as spectacular as lightning strikes, they do take place more frequently. Added to this are overvoltages caused by electrostatic discharges or faulty switching operations.

Protection would seem to be a matter of common-sense

Our modern working lives would be inconceivable without power supply systems, instrumentation and control equipment, IT networks and much more besides. They have become matter-of-fact and we realise their significance only when they break down. The potential scenarios range from a brief interruption in the work to bankruptcy. Good protection can prevent that.

Surge protection is a topic for today

Surge protection is an important aspect of electromagnetic compatibility and is required by law. There have been many technical improvements in the field of surge protection over the years. The quality and quantity of surge protection systems have increased. This is also revealed by the statistics of the umbrella organisation for the German insurance industry: the annual total damages for the insurance of electronic equipment has fallen slightly despite the fact that more electronic equipment is almost certainly being used and electrical and electronic systems are becoming increasingly complex with the degree of integration ever higher.
Nevertheless, each year in Germany about 450,000 claims are registered across the whole electronic spectrum.
The total loss in Germany for 2005 amounted to 230 mio. €. It is estimated that about one-third of these are due to overvoltages.

Voltages that exceed the limits

Surges are voltages that exceed the normal values. These normal values determine the insulation, which is designed and tested according to the appropriate regulations. The degree of insulation varies depending on the type of electrical equipment. We therefore speak of "insulation coordination".

An item for use with 230 V, e.g. an electric motor, is fitted with insulation tested with a few kilovolts. It is obvious that a chip on a PCB operating with 5 V cannot have the same dielectric strength. For this chip 10 V could mean disaster.

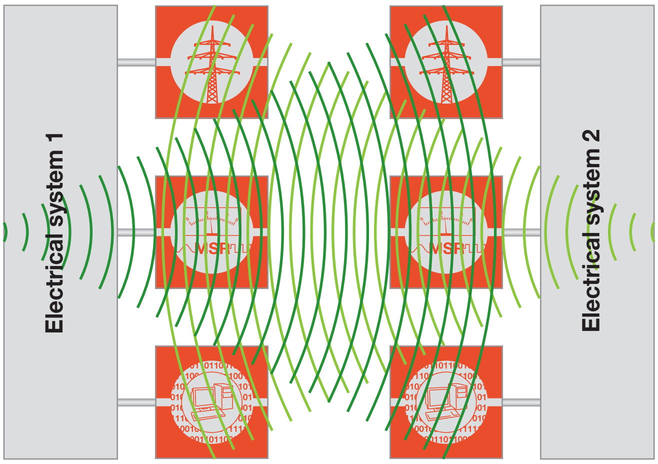
Component destroyed

Surge protection calls for special knowledge

Surge protection must differentiate in order to take into account insulation coordination. It must be able to deal with high voltages at high currents just as safely as low voltages at low currents. These could be completely normal in other parts of the system.
Therefore, surge protection is a complex subject.
It comprises of not just one electrical component but rather several functional elements combined in one circuit. This calls for special engineering expertise – not just for the provision of functional surge protection modules, but also for their utilisation, planning and installation.
Therefore, this catalogue does not just present our products but instead provides comprehensive information to help you understand the subject of surge protection.

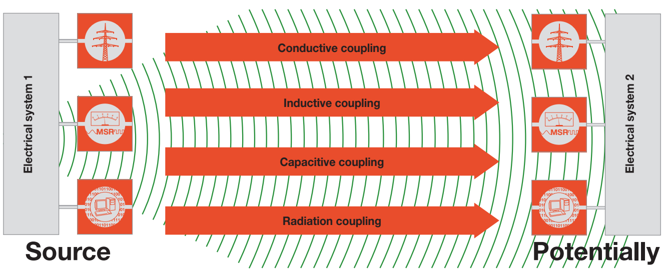
Electromagnetic compatibility

EMC – electromagnetic compatibility – means the trouble-free interaction between electrical and electronic systems and devices without mutual interference. In this respect, any electrical item can act both as transmitter (source of interference) and receiver (potentially susceptible device) simultaneously.



EMC laws and directives

There are a multitude of standards and statutory requirements aimed at controlling mutual interference-free operation. As the Single European Market was set up in 1989, an EEC directive covering electromagnetic compatibility was passed and subsequently ratified by the governments of the member states. In Germany this is covered by the Electromagnetic Compatibility Act, passed on 9 November 1992. There was a period of transition in which the 1992 Act, the Radio Interference Act of 1979 and the High-Frequency Equipment Act of 1949 were all valid. However, since 1 January 1996 only the 1992 Act has been valid. The second amendment to the Act has been in force since 25 September 1998. Electromagnetic influences can be caused by natural processes, e.g. a lightning strike, and also technical processes, e.g. high-speed changes in the status of currents and voltages.



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

- reduced functionality
- malfunctions
- failure of functions
- damage

These last two functional interferences result in stoppages for entire production facilities and cause high breakdown costs. The following points must be taken into account in order to achieve a system or plant that operates according to EMC guidelines:

- lightning protection
- earthing
- routing of cables
- cable shielding
- panel construction
- sensors and actuators
- transmitters and receivers
- frequency converters
- bus and field devices
- ESD

What are overvoltages?

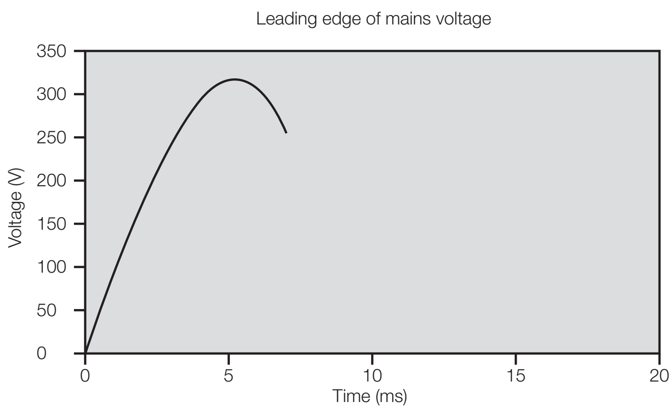
Surge protection (OVP) installations

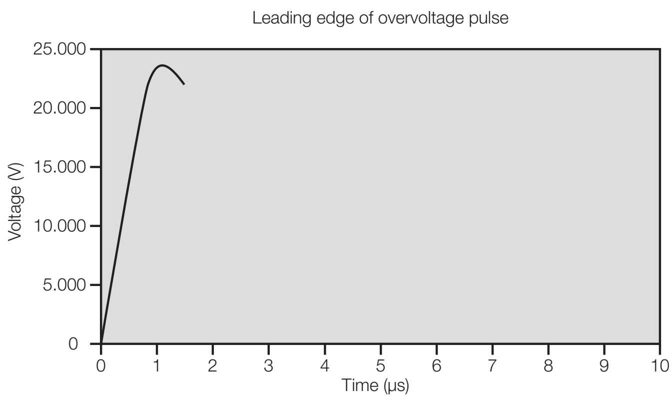
Constructing an electrical or electronic system in accordance with EMC guidelines using suitable components is generally not sufficient to guarantee operation free from interference. Only by employing **surge protection systems** at the appropriate points in a plant is it possible to achieve operation without breakdowns caused by coupled surges. The procedure for the use of surge protection systems is also linked to the model of influences between interference source and potentially susceptible device and be integrated in a comprehensive protective system in conjunction with a lightning protection zoning concept and insulation coordination.

What are surges?

Surges are extremely high voltages that damage or even completely destroy insulation and hence impair or completely disrupt the function of electrical and electronic components of all kinds. Every electrical component is provided with insulation to isolate the electrical voltage from earth or other voltage-carrying parts. The insulation strength is dependent on the rated voltage and the type of electrical component, as stipulated by the IEC/VDE regulations. It is tested by applying the prescribed voltages for a defined period of time.
If the test voltage is exceeded in operation, the safety effect of the insulation is no longer guaranteed. The component can be damaged or completely ruined. Surges are the voltage pulses that are higher than the test voltage and therefore could have a detrimental effect on the respective electrical component or system. This means that components with a high rated voltage may be capable of withstanding a surge voltage. But components with a lower rated voltage would be very much at risk from the same surge. An overvoltage allowable in an electric motor can spell disaster for an electronic circuit!
Permanently higher voltages also occur with the 50/60 Hz mains frequency. These voltages can be coupled or may occur as a result of faulty switching operations. The resulting continuous interference voltages are then another case for overvoltage protection.
Individual surge pulses, which have a high frequency because of their physical formation, have a current rise that is about ten thousand times steeper compared with 50 Hz voltage. If the current rise time in the 50/60 Hz range is 5 ms, then for an overvoltage it is around 1 µs.
These surges are designated as “transient” voltages.

This means that they are short-lived, temporary oscillations. Their shape and frequency depends on the impedance of the circuit.





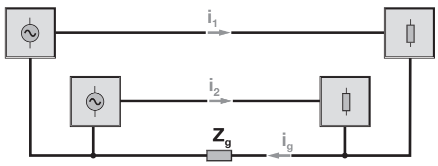
How do overvoltages occur?

Surges are primarily caused by:
- transient switching operations
- lightning due to atmospheric discharges
- electrostatic discharges
- faulty switching operations

Lightning

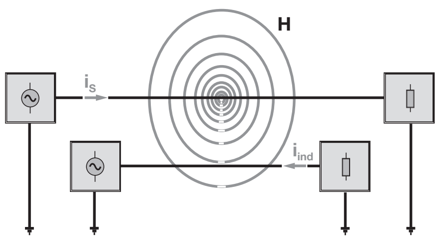
Bolts of lightning exhibit extremely high currents. Therefore, they cause a large voltage drop and, accordingly, a large rise in potential even in well-earthed buildings or systems despite low earthing resistances.
This will then cause a galvanic, inductive or capacitive coupling of surge voltages within the circuits of electrical or electronic facilities. It will also penetrate through the insulation.

Conductive coupling



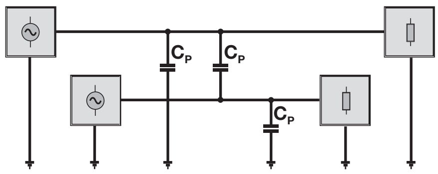
Surges are transferred directly into circuits via common earthing impedances. The magnitude of the overvoltage depends on the amperage of the lightning and the earthing conditions. The frequency and the wave behaviour are mainly determined by the inductance and the speed of the current rise. Even distant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

Inductive coupling



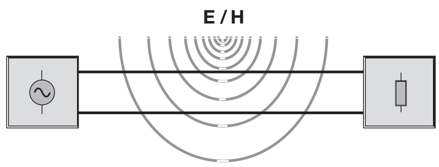
A high-amperage lightning strike generates a strong magnetic field. Starting from here, overvoltages reach nearby circuits by means of an induction effect (e.g. directly earthed conductor, power supply lines, data lines, etc.). According to the transformer principle, the coupling of induced voltages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

Capacitive coupling



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

Radiation coupling



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

Switching operations – transients

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

Electrostatic discharges – ESD

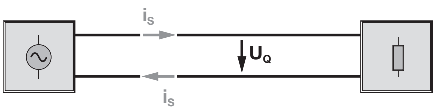
Electrostatic discharges (ESD) caused by frictional charges are well known. You can experience them when getting out of a car or walking across a carpet. These discharges can be over 10,000 volts in strength. We speak of ESD when these discharge to a lower potential. If such a charge strikes, for example,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

Faulty switching operations

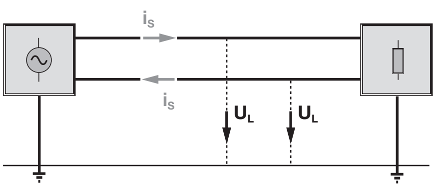
Again and again, we experience faulty switching operations in the 50/60 Hz mains. This can be caused by a failed power supply unit controller or incorrect wiring in a panel. The relatively high voltages that can occur as a result also represent dangerous overvoltages. Protection against these is vital.

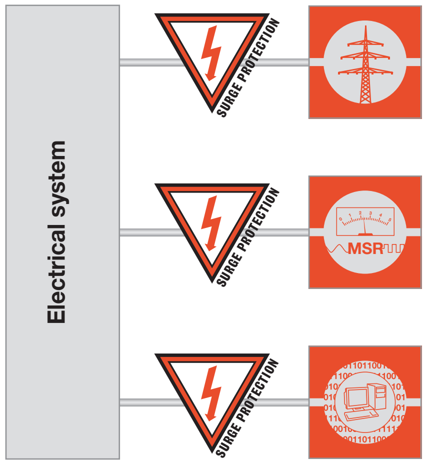
Description of interference voltages

Surges that occur between current-carrying conductors or between a current-carrying conductor and the neutral conductor are designated as transverse voltages or symmetrical interference.



Surges that occur between a current-carrying conductor and the protective earth conductor are designated as longitudinal voltages or asymmetrical interference.





The forms of interference voltage

Basically, coupled transient overvoltages are either normal-mode or common-mode interference measured as a longitudinal or transverse voltage. The interference voltages occur as symmetrical, unsymmetrical or asymmetrical voltages depending on the particular systems involved.

Normal-mode interference (symmetrical interference)

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

How do overvoltages occur?

Transverse voltage U_Q (normal-mode voltage)

Coupled transient interference voltage between two active conductors. In the case of unsymmetrical circuits with earth potential, the transverse voltage is equal to the longitudinal voltage. It is limited by twisting groups of associated wires together and providing one or more layers of shielding by way of cable sheathing. This reduces the induction of transverse voltages.

Common-mode interference (unsymmetrical interference)

Voltage between conductor and reference potential (earth), common-mode voltage/current. Mainly caused by a capacitive coupling (electrical field).
Therefore, significant common-mode interference currents only flow at higher interference frequencies. The interference voltage at the potentially susceptible device is caused by different voltage drops at the supply and return conductors (in each case between input terminal and reference earth). Source of interference between signal wire and reference conductor, e.g. due to a capacitive coupling or an increase in reference potential between separate earths.
In symmetrical circuits, common-mode interference occurs as asymmetrical voltages between the d.c. offset of the circuit and the reference earth. The forward and return conductors have the same interference voltages compared to the reference ground. In unsymmetrical circuits, common-mode interference occurs as unsymmetrical voltages between the individual conductors and the reference earth.

Longitudinal voltage U_L (common-mode voltage)

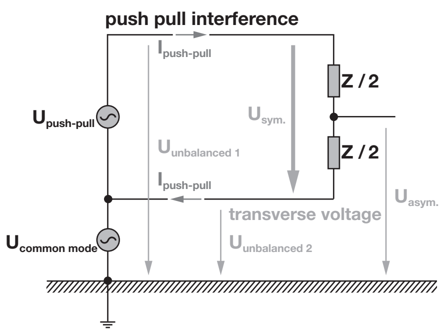
Coupled transient interference voltage between an active conductor and the earth potential. As a rule, the longitudinal voltage is higher than the transverse voltage (transverse voltage is lower owing to cable shielding and twisting).
Longitudinal voltages caused by lightning currents on cable shielding can assume quite high values, especially in the case of long lines entering a building from the outside.

Symmetrical, unsymmetrical and asymmetrical interference voltages

The symmetrical interference voltage is measured between the supply and return conductors of a circuit.
$U_{sym.} = U_{unsym.\,1} - U_{unsym.\,2}$
The unsymmetrical interference voltage is measured between one conductor and the reference potential (earth) of a circuit.
$U_{unsym.\,1} = U_{sym.} + U_{unsym.\,2}$
$U_{unsym.\,2} = U_{unsym.\,1} - U_{sym.}$
The asymmetrical interference voltage is measured between the d.c. offset and the reference potential (earth) of a circuit.
$U_{asym.} = (U_{unsym.\,1} + U_{unsym.\,2}) / 2$

Normal-mode interference in symmetrical circuit

1. Series connection between voltage source and consumer. Circuit designed without reference potential or virtual potential has connection to reference potential. Interference voltage is added to signal because signal currents are, as a rule, normal-mode currents.
2. Symmetrical signal transmissions, e.g. as with a microphone, use two wires with shielding. Virtual potential has connection to reference potential. Symmetrical interference voltage is added to signal and asymmetrical interference voltage occurs between virtual potential and reference potential.



Normal-mode interference in unsymmetrical circuit

Series connection between voltage source and consumer. Circuit designed with connection to reference potential, e.g. coaxial cable. Interference voltage occurs as unsymmetrical voltage between wire of one line and reference potential.

Common-mode interference in symmetrical circuit

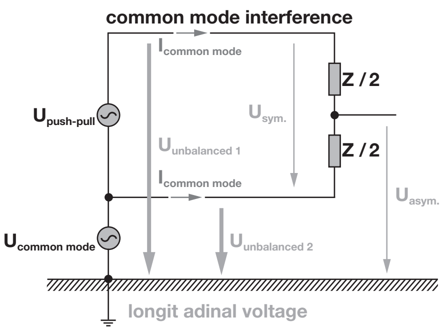
Does not cause any interference voltage in ideal (completely symmetrical) circuits. However components are put under a heavier load by additional current.

Common-mode interference in unsymmetrical circuit

Does not cause any interference voltage in ideal (completely symmetrical) circuits.

Common-mode interference at higher frequencies

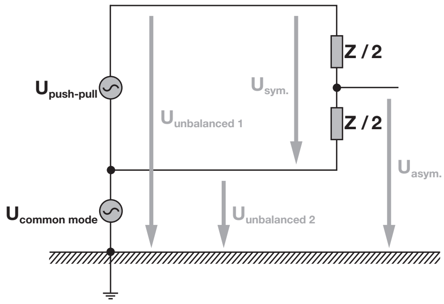
The parasitic impedances have a stronger influence as the frequencies increase. The common-mode voltage drives common-mode currents through the different impedances of the supply and return conductors and to earth via stray capacitances and back to the source of interference.



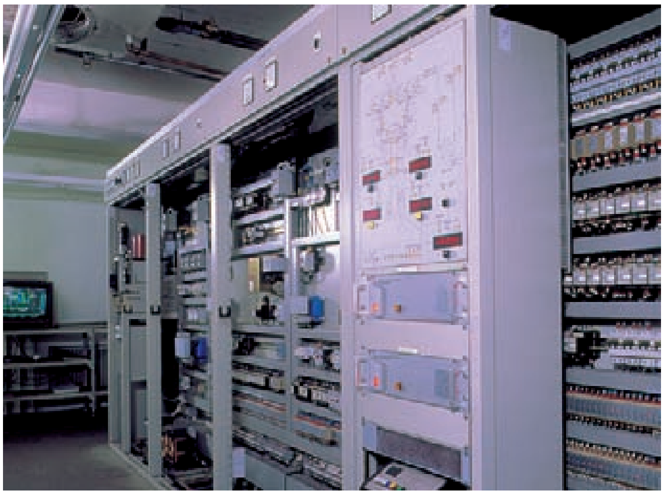
Consequences

The impedances and stray capacitances are equal in ideal circuits. This means that the currents in the supply and return conductors generated by coupled overvoltages are also equal and so do not generate any interference voltage.
However, in practice the impedances and stray capacitances in the supply and return conductors are different. This results in unequal currents which cause different voltages to earth in the supply and return conductors.

So the unequal impedances lead to the common-mode voltage becoming, for the most part, a normal-mode voltage because of the dissimilarity in the voltages to earth of the supply and return conductors.



Prevention is better than cure



Cause of overvoltage	Protective measures specified in:			Installation of protective devices specified in:
	ICE 62305-1	DIN VDE 0185-305-4	IEC 60364-4-443	IEC 60364-5-53
Direct lightning strike	X	X		X
Remote lightning strike	X	X	X	
Lightning fields		X		X
Switching operations			X	X

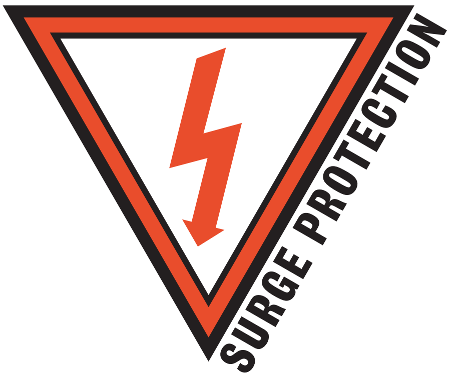
That is also true for the "health" of electrical and electronic components and systems.
Taking economic considerations into account also means investing in surge protection. This investment is only a fraction of the cost of the damage that can occur. Having to shut down a production plant because a control system has failed or the collapse of industrial data transmissions can be expensive experiences. It is not just the disruption or repairs that are expensive, the downtimes, too, have to be taken into account. The risks caused by surges are considerable. But the significant overhead in repairing the problem is not the only factor. You must also take into account the system down times. In addition, the mean time between failures is also reduced. Surge voltages present a significant danger. This is not only demonstrated by the damage statistics from property insurers. In general, all electrical equipment is threatened by surge voltages: this includes anything from free-standing high-voltage switching facilities to electronic micro-components.
For the low voltages, this risk is particularly present in the fields of power supply, measure and control technology, telecommunication, and data transmission. We offer the perfect form of surge protection for these
applications fields. Surge protection has become a theme of growing significance. On the one hand, electrical and electronic components continue to get smaller. On the other side, there are increasing levels of automation in the industrial and consumer electronics sectors.
The insulation safety margins are decreasing. This, in turn, lowers the levels of tolerance. Electronic circuits function at low voltage levels of only several hundred volts. Thus surge voltages can present a significant danger. Legislators have also recognized the importance of ensuring the proper surge voltage protection. The German "Law on electromagnetic compatibility in devices" establishes the proper EMC-compliant design and layout for electrical and electronic devices.
Surge protection is an element of these EMC measures. Measures for implementing this protection are described in a variety of IEC/VDE standards. Such measures can also help in obtaining the CE mark of approval.

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

How do we achieve surge protection?

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

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



Planning buildings and electrical installations

Much can be done to prevent damage due to overvoltages through the careful planning and construction of buildings and electrical/electronic systems. Although these measures provide only basic protection, they can amount to cost-savings in an effective, complete protection concept. It is vital to include an adequately dimensioned earthing system right from the very first construction phase. Only this guarantees full equipotential bonding in the event of interference.

When planning the electrical installation, care must be taken to ensure that electrical systems with dissimilar rated voltages are kept separate. Corresponding protection zones can then be set up and this leads to cost-savings for the surge protection.

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

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

Surge protection components

Surge voltages are kept away from at-risk electrical components by first reducing them to a harmless dimension before they reach the components.

To do this, we use surge arresters that react very quickly. They must respond during the high-frequency rising phase of the overvoltage, i.e. before a dangerous value has been reached, and quench the overvoltage. The response time lies in the nanoseconds range.

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

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

Good surge protection is characterised by:
- fast response behaviour
- high current-carrying capacity
- low residual voltage
- good reactivation time

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

The basics of Surge protection

A

Classification and protective zones

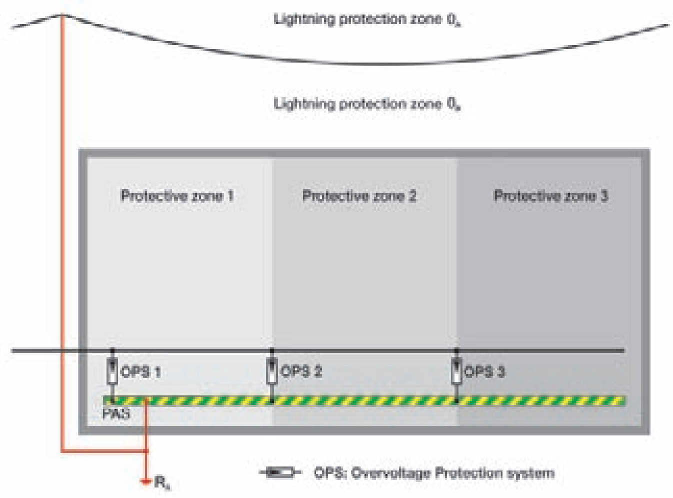
The requirements placed on surge protection and the necessary tests for surge protection components are stipulated by national and international standards.

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

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

Lightning protection zones

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



Classification

Originally, protective zones were classified according to coarse, medium and fine protection. These protective zones were designated classes B, C and D in IEC 60099 (VDE 0675-1). There was also a class A for external arresters (e.g. for low-voltage overhead lines); however, this class has now been abolished. The IEC 61643-1 (Feb 1998) classifies the protective zones as classes I, II and III.

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

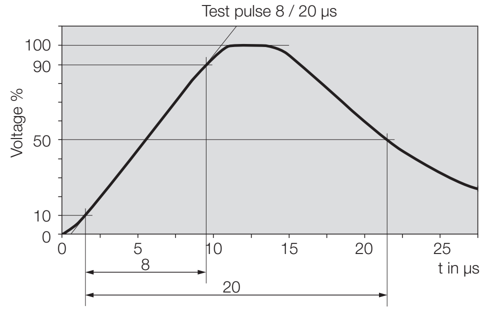
Formerly IEC 60099-1	**Now IEC 37A / 44 / CDV or IEC 61 643-1 (Feb 1998)**
Arresters of requirements class B, lightning protection equipotential bonding to DIN VDE 0185 part 1 ("B arresters")	**"Class I"** arresters
Arresters of requirements class C, surge protection in permanent installations, surge withstand voltage category (surge cat.) III ("C arresters")	**"Class II"** arresters
Arresters of requirements class D, surge protection in mobile/permanent installations, surge withstand voltage category (surge cat.) II ("D arresters")	**"Class III"** arresters

Test criteria

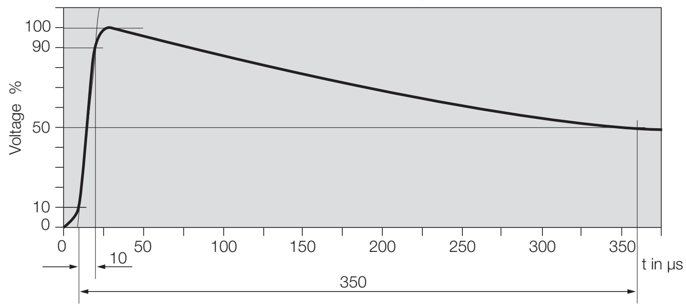
The new classification is based on the experience that "B arresters" can become overloaded in extreme situations, and also on more recent investigations into lightning discharges. This resulted in the new standardised 10/350 µs current curves for the testing of "class I" arresters. The test parameters lie between 12,5 and 25 kA Ipeak.
The term "10/350 µs" means that the surge current reaches 90% of its maximum value after 10 µs and then decays to half that value after 350 µs. The area beneath this curve corresponds to the current energy used in the test.
As in the past, "class II" arresters (formerly "C arresters") are tested with the 8/20 µs current curve. The rated discharge current for our arresters: for a 2-pole feed up to 75 kA; for a 4-pole feed up to 100 kA. "Class III" arresters (formerly "D arresters") are used for protecting equipment. These are tested with a 2 W hybrid surge current generator delivering a maximum charging voltage of 0.1 to max. 20 kV, which during a short-circuit supplies between 0.05 and 10 kA, 8/20 µs.

Classification formerly	VDE 0675	IEC 37A	**Test values**	**Application**
coarse protection	B-arrester	class I	I_{IMP} = 25 kA 10/350 µs curve	Protection against direct lightning strike (incoming (supply, main distribution board, etc.)
medium protection	C-arrester	class II	single pole I_N = 20 kA 8/20 µs curve 3 or 4-pole I_N = 100 kA 8/20 µs curve	Protection for permanent installations (electricity distribution etc.)
fine protection	D-arrester	class III	U_{OC} = 20 kV max. I_S = 10 kA max. hybrid generator	Protection for devices (sockets etc.)

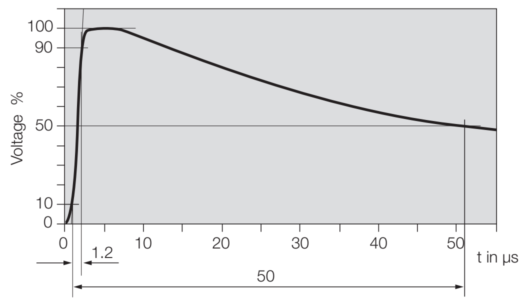
Test pulse 8 / 20 µs



Test pulse 10 / 350 µs



Test pulse 1.2 / 50 µs



Components for Surge protection

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

In practice we use three principal components:

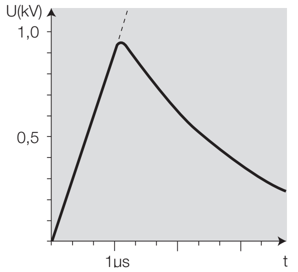
1. sparkover gaps
2. varistors
3. suppression diodes

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

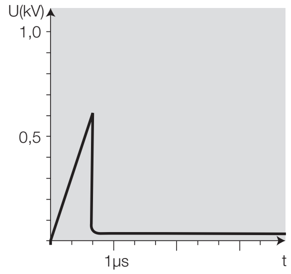
4. Combination circuits

1. Sparkover gaps

Pulse form shape without GDT

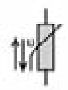


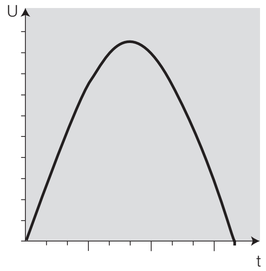
Pulse form shape with GDT

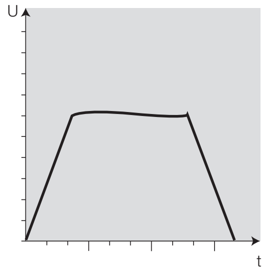


The name says it all. High voltages are discharged to earth via a spark gap (e.g. gas discharge tube) that has been fired. The discharge capacity of sparkover gaps is very high – up to 100 kA depending on type.
Gas sparkover gaps are incorporated in insulating glass or ceramic (aluminium oxide) housings. The electrodes of the sparkover gap are made from a special alloy and placed in housings which are vacuum seald and filled with a noble gas such as argon or neon. They are aligned with respect to shape and clearance distance, so that the applied voltage produces a distribution of field strengths. This results in a fairly precise voltage value for the complete ignition of the spark gap. The housings are vacuum-tight and filled with an inert gas such as argon or neon. The spark gap has a bipolar function. The ignition voltage value, however, is dependent on the steepness of the applied surge voltage.
The ignition characteristic curve for gas-filled spark gaps reveals that the ignition voltages increase for those surge voltages which climb more steeply. The consequence is that, for very steep surge voltages, the ignition voltage (that is, the protection level) is relatively high and can be well in excess of the rated voltage for the spark gap (approx. 600–800 V). The problematic quenching behaviour of the fired sparkover gap can be a disadvantage. The arc has a very low voltage and is only extinguished when the value drops below this. Therefore, when designing the geometry of a sparkover gap, care is taken to ensure that – through long distances and also through cooling – the voltage of the arc remains as high as possible and so
is quenched relatively quickly. Nevertheless, a longer follow current can ensue. This can draw its energy, in addition, from the incoming supply of the circuit to be protected. One effective solution is to wire a sparkover gap and a fast-acting fusible link in series.

2. Varistors

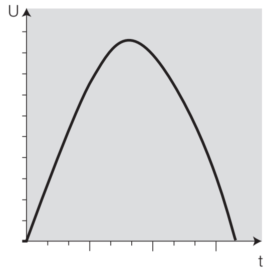


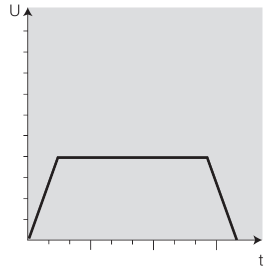




The varistors used with surge protection (MOV-Metal Oxide Varistors) have resistance which depends on the voltage. This is implemented with metal-oxide (zinc-oxide) discs. There is a low-ohm resistance in the range above the rated voltage. The surge voltage is limited since a current flows through the varistor.
The varistor works bi-directionally.
Depending on the type, varistors have either a middle or high discharging capacity. It is in the range from 40 kA to 80 kA.
The response time is less than 25 ns. However there are also disadvantages when using varistors. Two factors that must be taken into account are the relatively high capacitance and the aging characteristics.
Leakage currents occur over time, depending on the frequency of the triggering, because individual resistance elements break down. This can cause temperature rise or even destroy them completely.
The high capacitance of varistors causes problems in circuits with high frequencies. Attenuation of the signals must be reckoned with for frequencies above about 100 kHz. Therefore, varistors are not recommended for use in data transmission systems.

3. Suppression diodes





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