SALTEK®

Overvoltage controlled. ANYWHERE.

SOLUTION

Ethernet and general structured cabling

Surge protection of ICT technologies

Why to Protect?

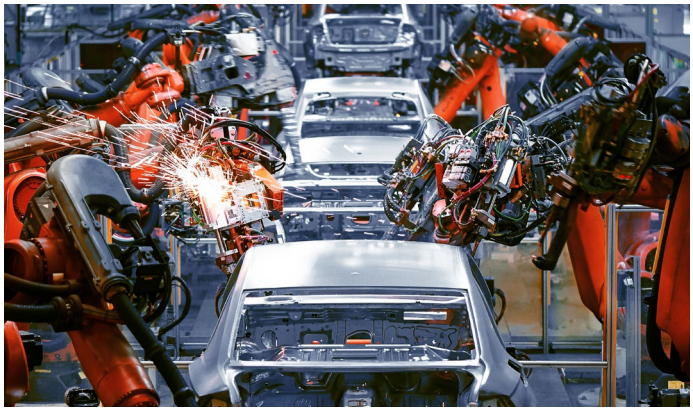
Information exchange is an essential part of our lives in today's "digital age". It is part of industrial processes, communication technologies and networks, research, transport, crisis infrastructure, etc. We can hardly find an activity without information transfer anymore. In some situations, even our health or life may depend on reliable communication. It is therefore clear that it is essential to maintain the highest possible reliability and availability of data transmissions and take proper care of them. Part of this care is to protect data networks against overvoltage, the effects of which can be fatal.

Ethernet and other data transmission networks operate at very low signal levels (millivolts or a few volts, at maximum) and the peripherals of the technology elements connected to the network are therefore very sensitive. Surge pulses of higher magnitude, whether of atmospheric (lightning) or transient (switching) origin, can easily damage them. Statistics from insurance companies show that about 1/3 of all claims settlements are caused by surges. This is the largest group of claims, significantly larger than damage caused by fires, theft, floods, etc.

Due to the need for high data transfer capacity, the IP protocol uses very short time intervals for the transmission of individual data blocks (symbols) in the order of nanoseconds. Thus, unwanted surge pulses several orders of magnitude longer can destroy a large part of the data stream, which, even in the absence of physical damage to the technological equipment, can cause disruption or loss of data transmission.

Damage to an unprotected data network by overvoltage is usually associated with its failure and the need for repair, resulting in either unavailability of data and interrupted communication, or, in extreme cases, associated with loss of life (unavailability of rescue system) or production failures, etc.

It can be calculated that an hour's outage of the data network associated with the disruption of production can have significant economic consequences. For example, in the paper industry or a brewery it may amount to about 10,000 Euros, in the automotive industry up to 250,000 Euros, and the loss of availability of a data centre with cloud services can cost the operator up to 500,000 Euros for one hour of downtime!

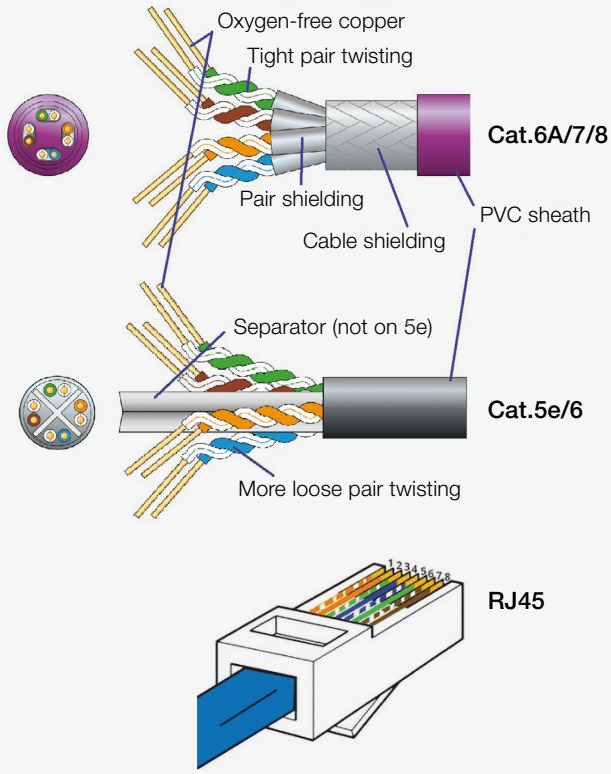


What to Protect?

Perhaps the most widely used platform for data communication of today is the Ethernet. We have moved from the original Ethernet and Fast Ethernet networks of the 1980s and 1990s to the high-speed Gigabit Ethernet networks and beyond with the geometrically increasing volume of data transferred. Despite the fact that the development is moving in the direction of optical data transmission (especially on the backbone parts of the networks), there are still many existing and newly built networks using metallic cables. These parts of the network are vulnerable to surges of atmospheric and industrial origin and require a specific surge protective device (SPD).

Metallic Ethernet networks are physically based on twisted-pair cables (twisting the wires helps to maintain constant line impedance and higher resistance to interferences). Typically, four-pair cables come in many different designs from simple UTP (unshielded) to rugged STP/FTP (shielded) cables. The quality of the cable is a fundamental parameter in categorizing the transmission channel, which primarily determines the data throughput of the channel. There are many categories (see *Table 1*), but the dominant, i.e. most commonly used, are the categories 5e, 6 and 6A typically terminated with RJ45 connectors. For these categories SALTEK has developed a portfolio of compatible surge protective devices.

Fig. 1 Physical structure of cables



Tab.1 Categorization and recommended use of Ethernet cabling.

CAT	Data throughput	Protocol	Band width	Use
3/4/5	≤100 Mb/s	10BASE-T 100BASE-T	16 - 100 MHz	Old distribution lines (ISDN, Token Ring, phones ...). Not recommended for new networks.
5e	≤1 Gb/s	1000BASE-T	100 MHz	Currently the most widely used for IP networks. Not recommended for new networks and PoE++.
6	≤1 Gb/s (10 Gb/s max. 50 m)	1000BASE-T	250 MHz	New distribution lines for which a capacity increase in the future is not assumed, and with a lifetime of up to 5 years; **residential constructions**, networks with PoE++.
6A	≤10 Gb/s	10GBASE-T	500 MHz	New distribution lines for **ICT** (data, video, voice, security ...), standard for **datacentres, commercial construction, hospitals, university campuses ..., PoE++** with a lifetime of 10+ years
7	≤10 Gb/s	10GBASE-T	600 MHz	New distribution lines for ICT, especially **networks sensitive to interference and crosstalk** (double shielding), multiple services on one cable (voice, data, TV ...)
7A	≤10 Gb/s	10GBASE-T	1 000 MHz	New distribution lines for data and video, CATV at 862 MHz, **MULTIMEDIA**, for distribution lines with long-term future capacity development (over 15 years)
8	≤40 Gb/s (max. 30 m)	25GBASE-T 40GBASE-T	2 000 MHz	High-speed backbone connections up to 30 metres of length (e.g. patch panels etc.)

With the dynamic development of Ethernet networks, there is a growing group of peripheral devices (IP cameras, various sensors, PC terminals, monitors, WiFi terminals, etc.) that are integrated into the Ethernet networks. However, in addition to data communication, they also need a separate power supply to function. Separate power cables running in parallel with data cables proved to be impractical and expensive, and therefore data twisted pairs alone in the so-called **PoE (Power over Ethernet)** power system started to be used for powering the IP peripherals.

As the complexity of end devices grows, so does the need for higher power consumption, and several types of PoE have evolved over time - from the simple Type 1 with two-pair power supply to today's four-pair Type 4, which is capable of transmitting up to 100W of power. PoE power supplies and injectors are now commonly integrated into Ethernet servers, switches and similar technologies, so these parts of the system must as well be considered when designing surge protective devices. The principle of PoE injection from a 48V DC source (Power Sourcing Equipment - PSE) into the data twisted pairs as well as power extraction by the peripheral devices (PD) is shown in *Fig. 2*.

IEEE Standard	Type	Transmitted power	Configuration; max. current
IEEE 802.3af	Type 1	15.4 W	2 pairs; I_L = 320 mA
IEEE 802.3at / PoE+	Type 2	30.8 W	2 pairs; I_L = 640 mA
IEEE 802.3bt / UPoE	Type 3	60 W	4 pairs; I_L = 2 × 640 mA
IEEE 802.3bt / PoE++	Type 4	90–95 W	4 pairs; I_L = 2 × 1 000 mA

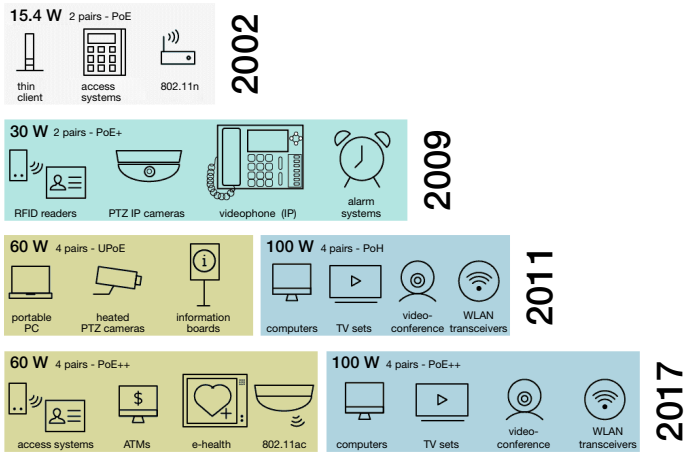
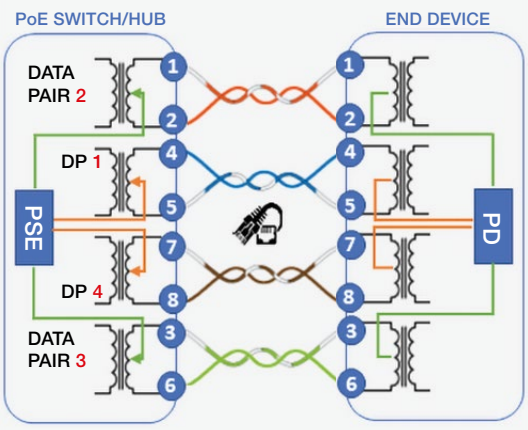


Fig. 2 Principle of DC power injection and extraction within PoE (here you can see a four-pair version, i.e the Type 4 acc. to IEEE 802.3bt)



A separate, rapidly developing and promoting infrastructure of information networks is the so-called general structured cabling. These networks differ from classical Ethernet networks in that they are able to transmit not only Ethernet data and PoE, but also signals from different data and information systems, the transmission of which also suits the physical structure of twisted-pair cables. Twisted pair cabling is thus elevated to the level of a general-purpose metallic network capable of transmitting both "classic" Ethernet data (signal amplitude swing of max. ± 1V) and other signals, e.g. KNX, DMX, RS-485, signals from instrumentation & control (I&C) systems, etc. Such signals often operate with significantly higher signal amplitudes compared to Ethernet. This is the main parameter to consider when selecting an SPD for structured cabling. The use of SPDs designed only for Ethernet networks (with low voltage response of the protection elements) would cause undesirable SPD response and failure even in normal operation.

In searching for the answer to the question "What to protect?" there are several parameters to consider:

1. **Operational reliability of the technology at risk** – a very compelling reason for the implementation of surge protective devices will be e.g. critical infrastructure networks for which high service/data availability is required (e.g. emergency and security services, online industrial process control, data centres and cloud services connectivity, security systems of important objects such as prisons, power plants, military facilities, ... and others).

2. **Acquisition costs of the equipment at risk** (or cost of repair) – ICT network elements are becoming more complex, expensive and vulnerable, not only the central ones, but increasingly also the peripheral ones (e.g. industrial robots and automata, IR PTZ cameras, etc.). The prices of SPDs to protect them from damage or destruction are usually only a small fraction of the purchase price of the technology. Often the expected time (and cost) of repairing damaged equipment is also an important parameter, as, especially in the context of the reliability (ad 1), it can play a critical role in assessing the return on investment of protective elements.

3. **Degree of exposure of the technological equipment to overvoltage** – probably the most vulnerable are devices connected to cables that pass through the outdoor environment, i.e. LPZ 0 zone. This is where the risk of direct or indirect lightning strike and the intensity of the unwanted energy pulse is greatest. We always recommend to protect this type of devices. The protection of technologies connected by cables located in LPZ1 and higher zones (i.e. inside the buildings) and the protection type depends on the evaluation of parameters ad 1 and 2 and other circumstances. These may include, for example, the passage of cables through areas with sources of electromagnetic interference (e.g. automatic welding machines, switched power supply units or other loads with thyristor or other electrical/electronic switching elements, electric motors,...), parallel run of data cables with power cables, etc. In similar cases, the need for multi-stage surge protective devices or at least "soft" protections for key technological elements of the system should be evaluated.

4. **Degree of threat to other infrastructure** – while the previous points concerned only the threat to the actual technological infrastructure of data networks, it is often necessary to assess the possible impact of the propagation of surge pulses over an unprotected data network and the transmission of surge pulses into other objects directly or indirectly connected to such a network. It may happen that even if we evaluate the surge protection for our own data network as unnecessary, the propagation of energy pulses over unprotected Ethernet infrastructure may cause damage to the building (fire), other technological systems installed nearby, etc.

The assessment and selection of surge protective devices requires at least a basic understanding of the physical configuration of the network and its protected components and is not complicated as such. In complicated cases, SALTEK technical support can be contacted.

How to Protect?

Choosing the SPD

1. Individual lines and simple Ethernet networks (with or without PoE)

The basic and also universal protection element of Ethernet networks are SPDs type **DL-1G-RJ45-PoE-AB** (or **DL-10G-RJ45-Po-E-AB** for high-speed networks of up to 10Gbps). They are designed as a two-stage protection especially for the protection of outdoor Ethernet lines with PoE (SPD type ST1+2+3), but can also be used for other applications within the Ethernet networks. This type of SPD is equipped with efficient protection not only of the data ports, but contains also special protection elements for PoE power sources and powered devices (inter-pair protection elements) – see *Fig. 3*. The SPD is designed in a way to handle and protect all types of PoE used today (two-pair and four-pair) according to IEEE802.3 af/at/bt standards up to 100W wattage. This means that there is no need to consider or examine the type of PoE used when applying this SPD.

Fig. 4 Ethernet line protection scheme with PoE using DL-xG-RJ45-PoE-AB

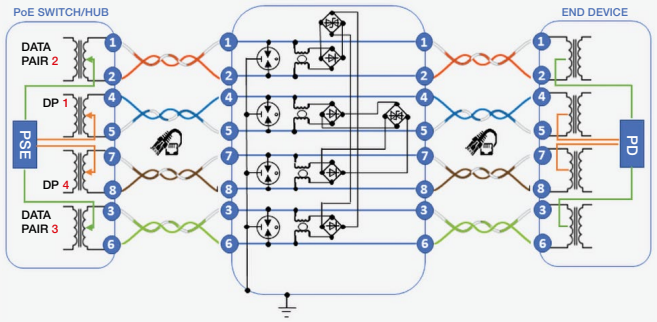


Fig. 3 Universal protection of a single Ethernet line with PoE – DL-xG-RJ45-PoE-AB (protective elements of PoE are highlighted)

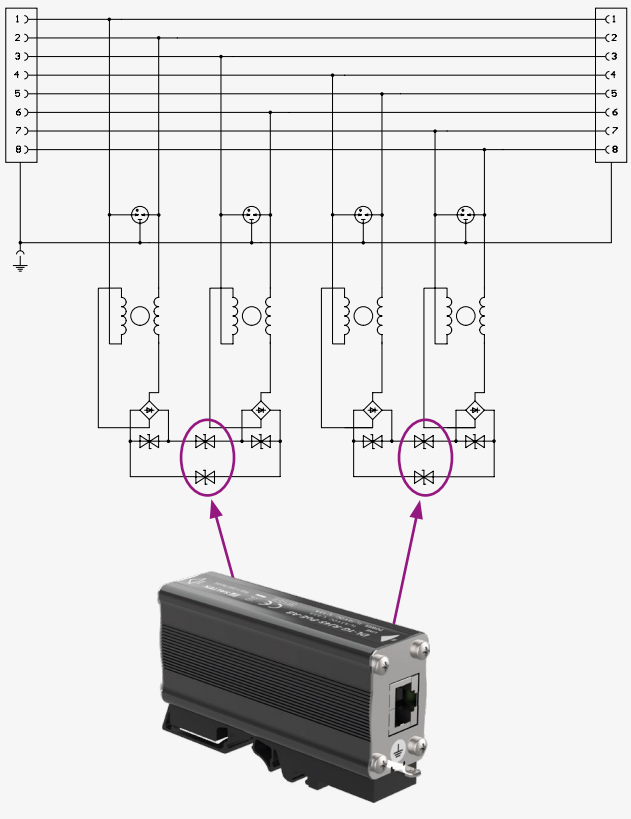
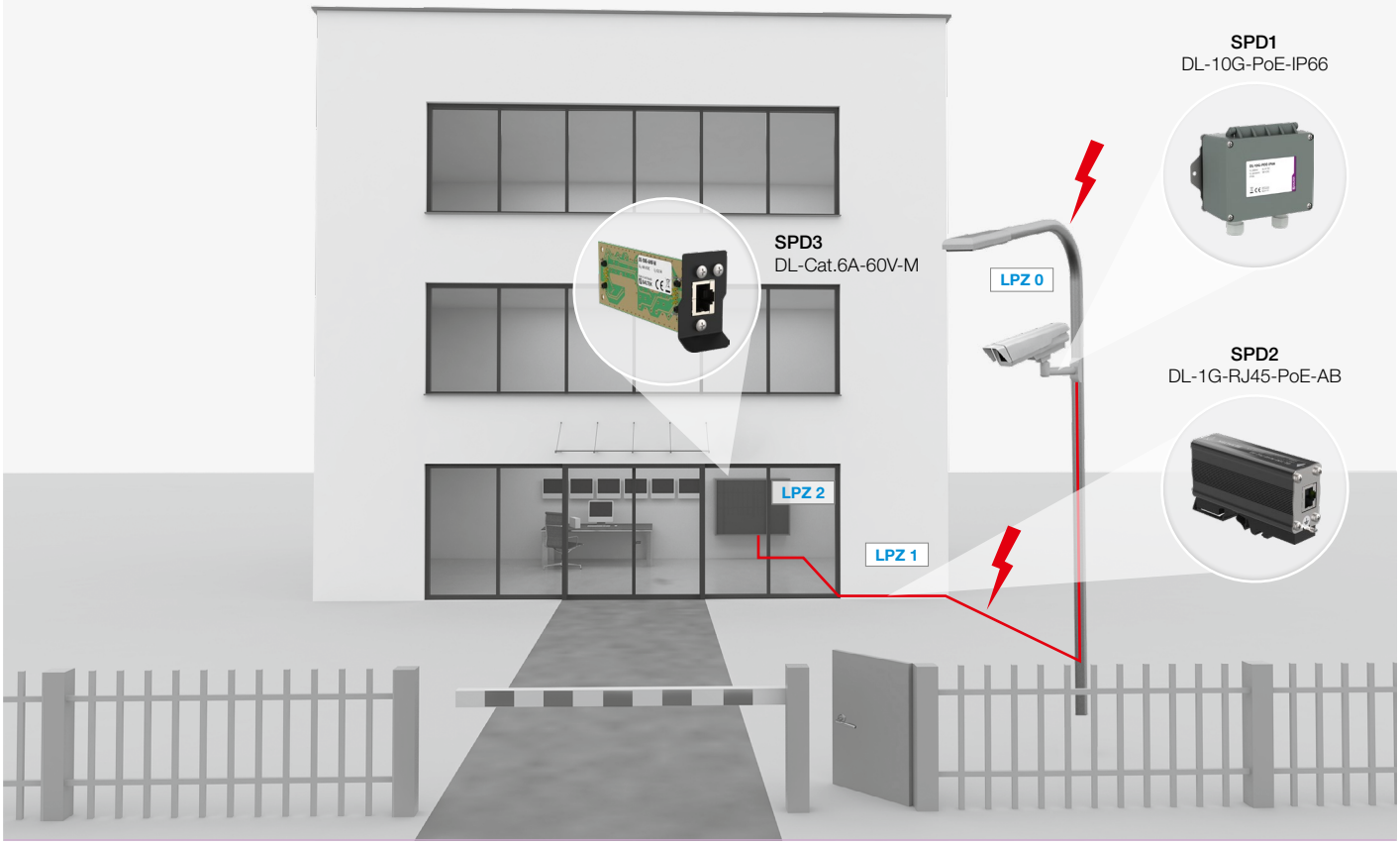


Fig. 5 Typical Ethernet line protected with ST1+2+3 (connection of outdoor IP camera to the server via a long cable) and ST2+3 SPDs (internal line)



For less demanding applications, i.e. for lines that are not at risk of atmospheric overvoltage (e.g. protection of a long Ethernet line in an indoor area exposed to a risk of induced industrial switching overvoltage), a simple SPD type ST2+3 of the DL-Cat.6A-xx. series can be used. These are inexpensive, simple protections for different transmission infrastructure categories, which can be easily identified by the SPD name: **DL-Cat.6A** (for high speed Ethernet without PoE), or **DL-Cat.6A-60V** (for Ethernet with PoE or structured cabling networks). Most often, this series of SPDs is used as secondary (soft) protection just upstream of the protected devices (switches, servers, etc.) to limit induced pulses on long lines.

Figure 5 shows a situation with a typical deployment of individual protections in an outdoor installation of Ethernet components (here on the example of an IP camera on a lighting pole). Lighting poles (especially metal ones) and similar supporting structures are objects that act as natural lightning rods and the (not only) data network elements connected to them are extremely vulnerable to surges, similarly to outdoor Ethernet cables that transmit high-energy surge pulses to the connected equipment in case of lightning strikes. Such a case can be addressed by appropriately selected and installed surge protective devices (SPDs). SPD1 protects the IP camera on the pole. Following the principles of "What to protect?" listed above, this protection will not be necessary if it regards an unimportant and inexpensive surveillance street camera, but may be absolutely necessary to ensure a reliable operation of a camera monitoring the perimeter of a prison or nuclear power plant. Protection of outdoor installations being at risk of lightning strikes should by ensured by SPD1 of class ST1+2+3, in this particular case by new **DL-10G-PoE-IP66** type designed especially for exterior installation at the protected device (weather protection IP66) on a pole, TELCO mast, etc.

The SPD2 protects the building and connected technology against the ingress of a surge pulse over the Ethernet cable from the outside environment and is critical to the protection system. For the same reasons as for the SPD1, we choose the **DL-1G-RJ45-PoE-AB** (we assume that the PoE injector/power source is integrated in the server inside the building). The important thing in this case is the location of the SPD2 at the cable entry to the building (i.e. at the boundary of LPZ 0 and LPZ 1 zones).
If this is not possible for some reason, the input cable should be routed through the building in a grounded metallic shield up to the SPD2 installation point - this prevents electromagnetic pulses from the unprotected cable from exiting into inner areas of the building (in LPZ1). Alternatively, a grounded shield of the STP/FTP cable itself can be used.

SPD3 is a fine surge protection placed at the LPZ1 and LPZ2 boundary or directly at the protected server port. It is useful in situations where the cable between the SPD2 and the server is long (>10m) or passes through an environment with high levels of industrial interference. The correct type of SPD3 protection depends on several circumstances.
The most important is the use of PoE power on the protected link. In this case (and this is also the case in *Fig. 5*), simple surge protective device (DL-Cat.6A) cannot be used and the **DL-Cat.6A-60V** (or the **DL-Cat.6A-60V-M** module) is needed at this position. If it is necessary to protect only data line (without PoE), the DL-Cat.6A series simple surge protector can be chosen. When installing, do not forget the correct SPD input/output orientation! The SPD input must be connected to the line along which the unwanted surge pulse can propagate, and the SPD output must always be connected to the side of the device to be protected.

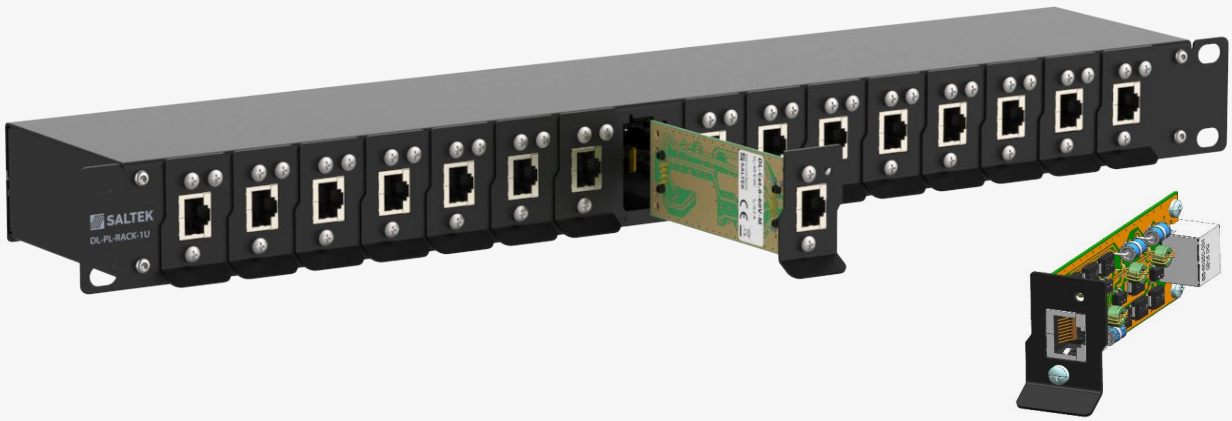
2. Multi-channel applications and central routers/switches

More and more often we encounter network applications where it is necessary to treat multiple cooperating devices in one place - so-called multichannel applications. Examples include wind farms, multi-camera security systems, parking lots with many electric vehicle charging stations, information technology systems at airports, railway stations, etc.

It is costly and impractical to implement protection with many individual SPDs including many grounding cables, terminals, boxes, etc. Therefore SALTEK offers flexible multi-channel box DL-PL-RACK-1U, in which up to 16 independent SPDs can be built-in for 16 independent Ethernet lines. The box can be installed either freestanding (or hanging) - most often at the LPZ0 and LPZ1 interfaces or integrated into a 19" rack and equipped with any combination of SPD modules adapted for this purpose. The modules are electrically identical with the individual SALTEK DL series SPDs, but mechanically adapted for simple Plug & Play mounting in the **DL-PL-RACK-1U** box. The smart design of the box and modules makes it possible to manipulate any channel/link without restricting the operation of other lines. By simply loosening a single screw, sliding out the old module and inserting the new one, and then fixing it with a screw, changing, replacing or adding a new module is a matter of seconds, and all this under unlimited operation running on the remaining parts of the network without the necessity of disconnecting many cables, adding PE cables, etc. In fact, the earthing of all SPDs is implemented through the construction of the box, which is earthed by a single common PE conductor to the equipotential terminal block.

The system of module installation is shown in *Fig. 6*. Table 2 lists the available SPD modules that can be installed in the **DL-PL-RACK-1U** box. The SPD modules are identified by the suffix "-M" or "-R-M" in their name. Modules with the "-M" designation have a protected output on the front panel of the box after the installation. In case a box with reverse orientation is required, i.e. with protected outputs on the rear panel of the box, the modules marked "-R-M" must be ordered.

Fig. 6 Multi-channel surge protection using the plug-in Plug&Play modules in the DL-PL-RACK-1U box.



Tab. 2 Application table of SPD modules for use in DL-PL-RACK-1U.

Type of SPD module	Protection class	Suitable for PoE	Suitable for structured cabling	Max. dat transmission speed	Typical application
DL-1G-PoE-M	1+2+3	yes	no	1 Gbps	Outdoor cameras, WiFi antennas, sensors, cable entry points into a building object
DL-10G-PoE-M	1+2+3	yes	no	10 Gbps	Microwave connections, GSM repeaters, cable entry points into a building object
DL-1G-60V-PoE-M	1+2+3	yes	yes	1 Gbps	Outdoor connections to structured cabling systems, cable entry points into a building object, elements of the KNX, RS-485,… technology
DL-10G-60V-PoE-M	1+2+3	yes	yes	10 Gbps	Outdoor connections to structured cabling systems, cable entry points into a building object, elements of the KNX, RS-485,… technology
DL-Cat.6A-60V-M	2+3	yes	yes	10 Gbps	Fine protection of indoor technological equipment with PoE
DL-Cat.6A-M	2+3	no	no	10 Gbps	Fine protection of indoor technological equipment without PoE

3. Applications and networks running on general structured cabling

As mentioned above, the general structured cabling is an universal cabling not only for Ethernet but also for other signals with higher voltage levels (up to approx. 50V) for which twisted pair infrastructure is a suitable physical transmission layer. For these networks, two-stage overvoltage protection of class ST1+2+3 of similar design as for Ethernet are suitable, but with a higher permissible operating voltage $U_c \leq 60$ V DC. The type designation is **DL-1G-60V-PoE** and **DL-10G-60V-PoE**, differing only in the maximum transmission speed (or their modular versions **DL-..G-60V-PoE-M**). Within the ST2+3 class of fine surge protection there is the **DL-Cat.6A-60V** (or **DL-Cat.6A-60V-M** module) available (for mounting into the **DL-PL-RACK-1U** multichannel box).

Application-wise the surge protection in structured cabling networks is the same as in the previous paragraphs, i.e. the arrangement acc. to the diagram in *Fig. 5* can be used and the following products can be installed at the SPD positions:

SPD1 = DL-..G-60V-PoE
SPD2 = DL-..G-60V-PoE
SPD3 = DL-Cat.6A-60V (or DL-Cat.6A-60V-M)

All SPDs can be deployed in any type of PoE power transmission.

Basic rules for the implementation of surge protection in Ethernet networks

If we were to summarize the basic rules for protecting Ethernet networks or general structured cabling into a few basic points, at least the following principles should be observed:

- Placement of outdoor terminal devices (WiFi antennas, IP cameras,...) in the LPZ 0_B zone (or to create this zone).
- Proper equipotential bonding of technological devices and SPDs and connecting them to a common equipotential terminal block (shortest possible PE conductors, without unnecessary bends and loops to minimize the reactance of the interconnection network).
- The principle of complex protection = SPD mounted not only on data but also on other technological interfaces (power supply, signalling,...).
- Prevention of induction of surge pulses from LPS conductors (leads) means keeping a sufficient distance of signal cables from LPS (Lightning Protection System) terminals, or their shielding, avoidance of inductive (wire and cable) loops
- Avoiding parallel routing of data and power cables/surge-protected cables with unprotected cables
- Maintaining distance of signal cables from “power” cables (with high currents), switches, welding machines, elevator machine rooms,...
- Maintaining distance or shielding of ICT networks from sources of interference (elevators, transmitters, transformers and other sources of electromagnetic fields)
- Using closed metal cable trays/troughs for signal cable routing to shield interfering electromagnetic fields (industrial and atmospheric interferences)

Detailed technical information on suitable surge protective devices can be found in the online catalogue at **https://www.saltek.eu/en/vyrobky/ict**

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