Minia

Application manual
Overvoltage protections

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THEORETICAL PART

Introduction

Due to the development in the overvoltage protection range and change of legislation, we have updated the 2010 Overvoltage protections application manual. The updated manual deals with the protection against overvoltage caused by lightning surges.

By means of this manual, we offer you simplified solutions for the designing of protection against pulse overvoltage in LV supply networks 230/400 V. Applications are divided in four groups according to the cause of damage at lightning stroke according to standard EN 62305 „Protection against lightning". This division shows the maximal level of lightning current for each group. The actual connection, back-up protection, conductor cross-section etc. for particular application groups are being solved as well.

1. PRINCIPLE OF PROTECTION AGAINST LIGHTNING AND OVERVOLTAGE

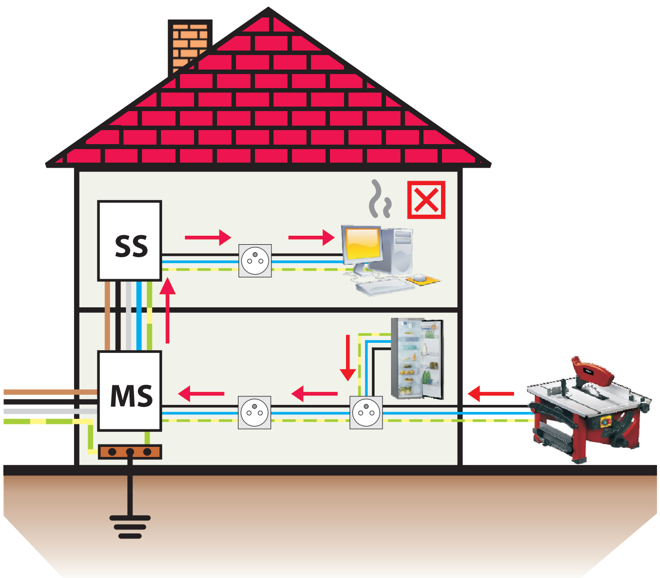
What is overvoltage? What is its origin? What are its effects? What is the protection against its effects? The answers are not as simple as it could seem. The overvoltage cannot be cancelled or predicted. However, we do not have to let it damage our electro installations and devices. We can reduce it to such extent that it is no longer dangerous to our property.

Overvoltage is generally defined as voltage exceeding the highest level of operating voltage in given electrical circuit. There are several types of overvoltage. We will deal with the protection against transition overvoltage (sometimes the terms transient or impulse are used). This overvoltage lasts in nanoseconds up to milliseconds and it is caused by:

a) switching processes in the network (switching overvoltage)
b) lightning strokes (atmospheric surge)

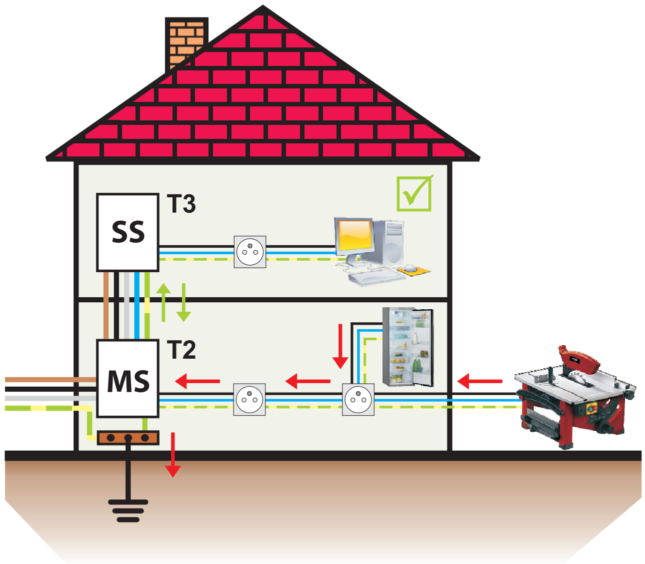
1.1. Switching overvoltage

This type of overvoltage is the more common one. There can be many devices connected to the electrical network that, while being switched on, can „send" electrical pulses to the circuit. Mostly they are common appliances. These overvoltage pulses can damage sensitive electronic devices as computers, LCD televisions, etc.



Electro installations without protection against overvoltage

We can eliminate overvoltage by arresting it by means of appropriate protection. If the potential (voltage) differential rises above the defined limit, the overvoltage protection connects line conductors to PEN (PE) conductors and equalizes the potential. After the elimination of overvoltage, the connection is disconnected and normal operation continues.



Electro installation with overvoltage protection

The energy of overvoltage wave caused by pulse overvoltage is significantly lower than the energy of overvoltage wave caused by lightning effect. Due to this fact the installation of overvoltage protection against lightning effects provides at the same time protection against switching overvoltage. Further in the text we will deal with the atmospheric surge.

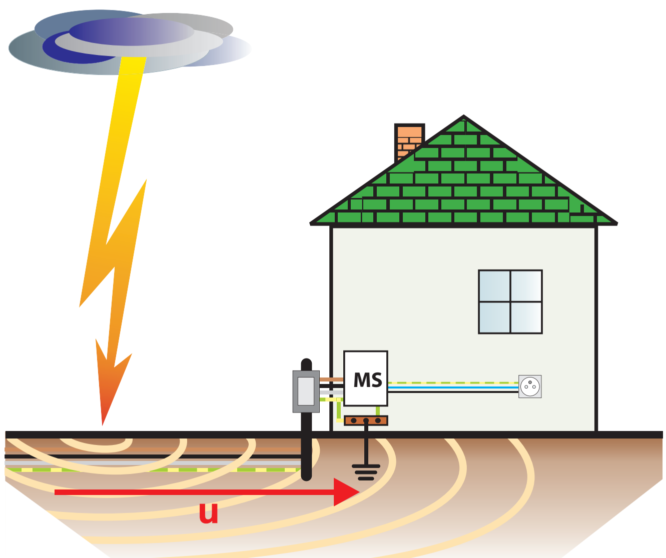
1.2. Atmospheric surge

Overvoltage caused by lightning effects is much more dangerous and usually cause bigger damage than switching overvoltage. The decisive criterion is the place where the lightning strikes. EN 62305 differentiates between four types of damage causes:

S1) stroke to the building
S2) stroke close to the building
S3) stroke to the engineering networks connected to the building
S4) stroke close to the engineering networks connected to the building

Definition of installation threat caused by lightning according to the cause of possible damage

Electromagnetic field that induces on all metal parts around the voltage originates when **the lightning strikes close to the engineering networks connected to the building (S4)** or when **it strikes close to the building (S2)**.



Stroke close to the engineering network connected to the building
Low installation threat

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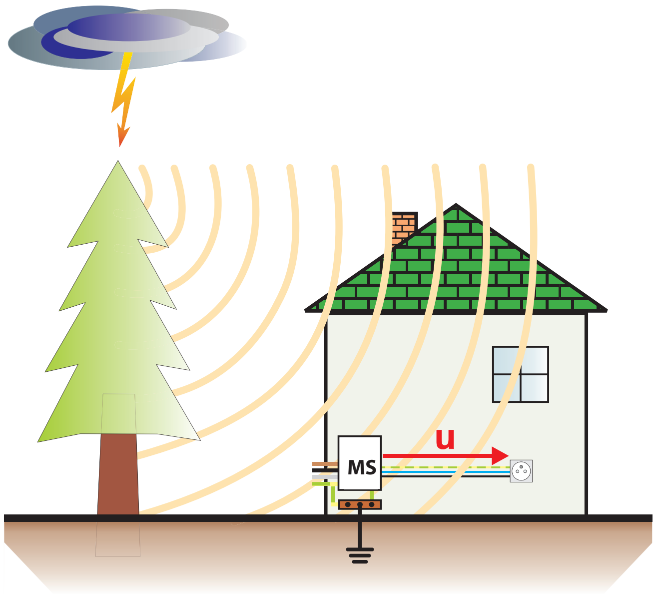
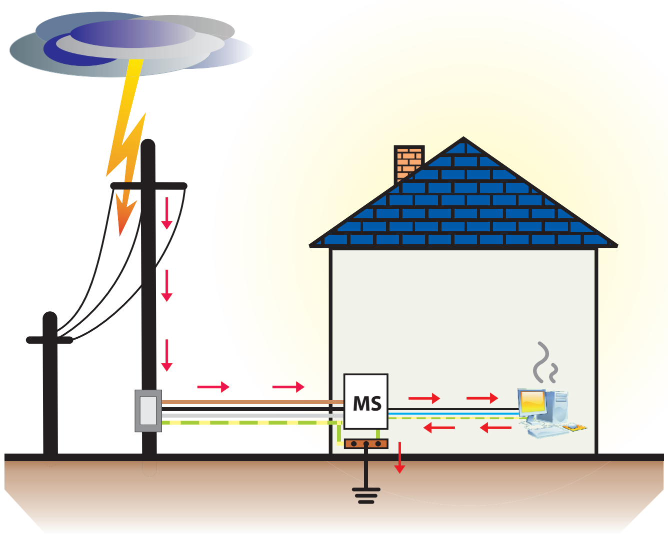
This voltage usually does not reach high values and the consequent figures of overvoltage pulse wave can be up to 5 kA in energy wave 8/20 µs. However, even this energy can damage sensitive electronic devices when there is not the adequate protection applied. Considering the overvoltage we will place such cases to the first application group – **Low installation threat.**



Stroke close to the building
Low installation threat

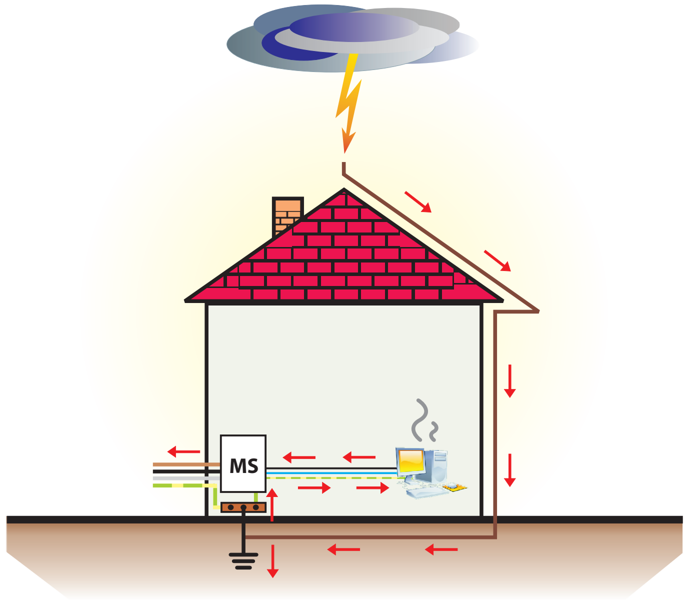
Higher stage of threat is **stroke to the engineering network connected to the building (S3)** – in our case LV supply lead.



Stroke to the engineering network connected to the building
Medium installation threat

In case of stroke to the network the overvoltage pulse wave can reach values up to 10 kA in energy wave 10/350 µs. We will place such cases to the second application group – **Medium installation threat.**

The biggest property damage, however, is caused by the overvoltage induced **at the direct stroke to the building (S1)** or to close buildings, that are galvanically connected to the building (etc. by means of cable**).** The lightning current can in some applications reach values up to 25 kA in energy wave 10/350 µs for one conductor of supply line.



Stroke to the building
Big installation threat

In this case the overvoltage is induced on the conductors thanks to their impedance and passing lightning current. Why does the lightning current reach such high values particularly in this case? The answer is galvanic connection of arresting equipment and the electro installation. Part of the lightning current is driven through the unprotected part of electro installation and may cause huge damage. These cases are placed to the application group – **Big installation threat.**

The last application group is **industrial and special applications.** In industrial applications there are also other requirements for overvoltage protection besides arresting of lightning current. For example it can be the level of short-circuit current up to 50 kA and its consequent quenching. In special applications we are speaking mostly about two-conductor connection of the building where there are higher requirements for individual poles of surge voltage arresters due to the division of lightning current into smaller number of conductors.

These four application groups are described in detail in chapter 2.

1.3. Overvoltage protection

How can we protect against overvoltage? The basic protection lies in the equalization of potentials (connection of all conductive parts in the building). The connection prevents the rise of potential differential, which causes dangerous voltage between conductive parts. However, it is not possible to galvanically connect each and every conductor in cables of fixed installation, for example by clamps. Such installation could not operate. In order to connect the individual conductors , we have to use the overvoltage protection. In case overvoltage exceeds the defined limit the overvoltage protection increases its impedance significantly to enable the equalization of potentials. The overvoltage then drops to an acceptable level. What is the defined permitted limit of overvoltage in particular parts of electro installation? These values are defined by standard EN 60664-1 by means of **pulse withstand voltage U_{imp}**.

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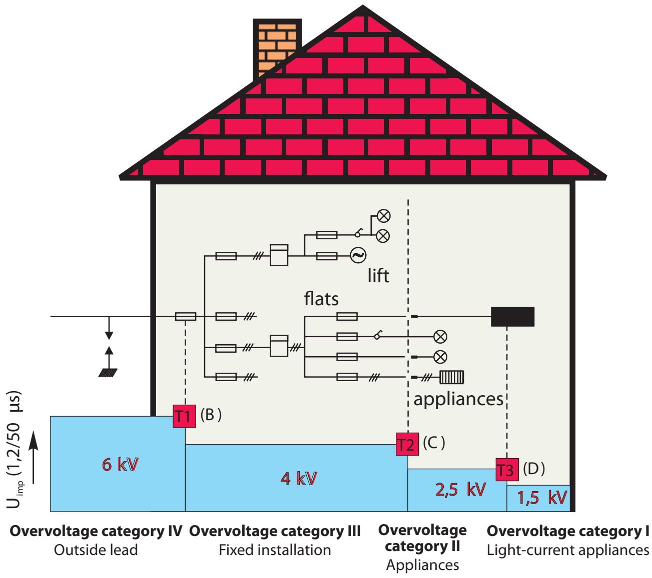


Pulse withstand voltage U_{imp} for LV network 230/400 V according to EN 60664-1

In principle the picture shows general multi-level overvoltage protection. There are given limit values of voltage for individual rated voltage of the networks. In our case the values are valid for LV network 230/400 V.

It is necessary to ensure that no more than 6 kV overvoltage can be present on the input side of the building. This is usually done by protective components installed in the power line. This level of overvoltage, however, can damage both the cables and the installed modular devices. In order to decrease the overvoltage the first protection stage „T1" (in other terminology – class B) is used on the input side as close to the edge of the building as possible. T1 then decreases the overvoltage level to 4 kV or lower – such overvoltage can be withstood by any fixed electro installation without any problem.

By means of another protection stage „T2"(C) the overvoltage level is reduced to 2.5 kV or lower. The majority of appliances are designed to withstand this value of overvoltage and therefore they are not endangered.

Third level of protection „T3" (D) protects very sensitive appliances. This fine protection guarantees that the overvoltage level will not exceed 1.5 kV. At the same time its reaction to overvoltage is the fastest of all three stages.

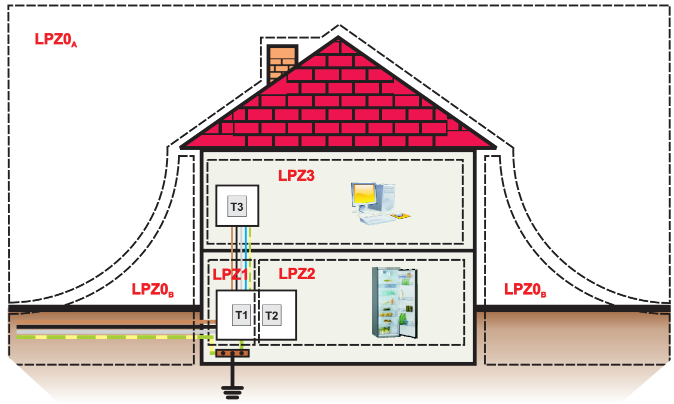
The following table shows the values of pulse withstanding voltage U_{imp}, which is defined by standard, and values of voltage protection levels U_p of OEZ overvoltage protections. For the sake of comprehensiveness we provide the overvoltage protection classification according to EN 61643-11 (T1, T2 and T3) and formerly used classification according to VDE 0675-6 (B, C and D).

Stage	Type	Class	U_{imp}	U_p	Type OEZ
1	T1	B	≤4 kV	≤1.5 kV	SJB-25E-...
2	T2	C	≤2.5 kV	≤1.4 kV	SVC-350-...
3	T3	D	≤1.5 kV	≤1.2 kV	SVD-253-...

Pulse withstanding voltage U_{imp} according to EN 60664-1 and voltage protection levels U_p

Voltage protection levels of the individual OEZ overvoltage protections are significantly lower than the values required by the standard.

In order to set up adequate protection it is necessary to divide all the devices and appliances in the building into categories according to pulse withstand voltage that is safe to them. Then we have to define specific zones in the building according to the position of the devices. This process can be called as **the definition of Lightning Protection Zones (LPZ).**



Lightning protection zones

Appropriate overvoltage protection devices in accordance with overvoltage categories of the individual zones have to be used in the dividing lines of the individual LPZs.

The most important is the selection of overvoltage protection of the outdoor and indoor zone dividing line. The type of protection used depends on the estimated magnitude of lightning current. We have to determine the so called Lightning Protection Level (LPL).

LPL	I	II	III	IV
I_{imp} (10/350 µs)	200 kA	150 kA	100 kA	100 kA

Relationship between Lightning Protection Levels (LPL) and the magnitude of lightning current I_{imp} according to EN 62305.

In order to determine LPL a lot of information is needed e.g. object purpose or exact features of electro installation. The correct values can be determined using the EN 62305-2 standard, which covers the analysis and management of risks associated with overvoltage caused by lightning. The calculations are quite difficult. Therefore, OEZ has developed the Prozik software application, which can save you a lot of time by helping you to calculate and find the best solution for your application. For more information on Prozik, see chapter 3.

2. APPLICATION GROUPS – SELECTION OF OVERVOLTAGE PROTECTION ACCORDING TO THE TYPE OF APPLICATION

Our aim is to offer simple, practical solutions for the most common used networks TN-C, TN-S and TN-C-S. We will deal with protection stages T1 and T2 in detail. Protection stage T3 has the same logic of usage for all applications. Whether to use T3 or not depends most of all on particular electro installation and on the type of connected devices. Rules for installation of protection stage T3 can be found in chapter 3.

When simplifying this process we can divide applications into four basic groups according to the value of pulse/lightning that can threaten the installation at lightning stroke. This value is determined by standard EN 62305-1, where maximum values of current for individual causes of damage can be found.

a) Low installation threat **(causes of damage S2 and S4)**
no threat of direct lightning current effects to the installation
no threat of stroke to the engineering network connected to the building

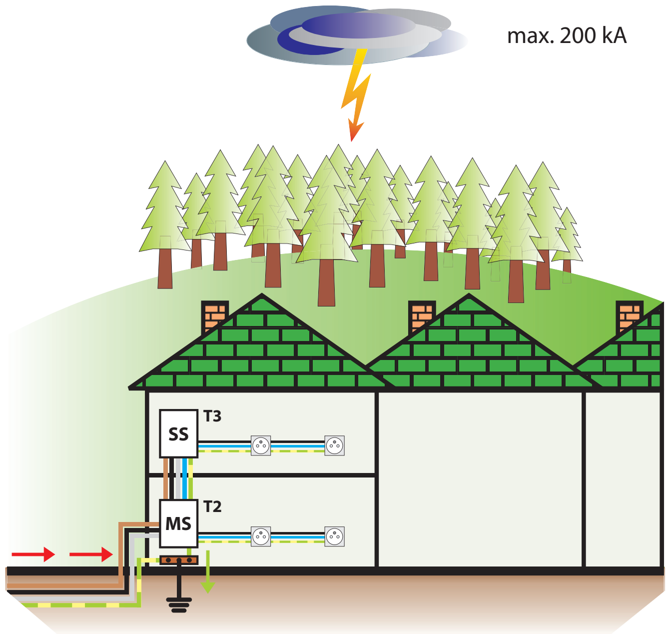
b) Medium installation threat **(cause of damage S1 and S3)**
threat of direct lightning current effects to the installation
peak value of lightning current does not exceed 100 kA (LPL III, LPL IV), threat of stroke to the engineering network connected to the building

c) Big installation threat **(cause of damage S1)**
threat of direct lightning current effects to the installation
peak value of lightning current (stroke to the building) does not exceed 200kA (LPL I, LPL II)

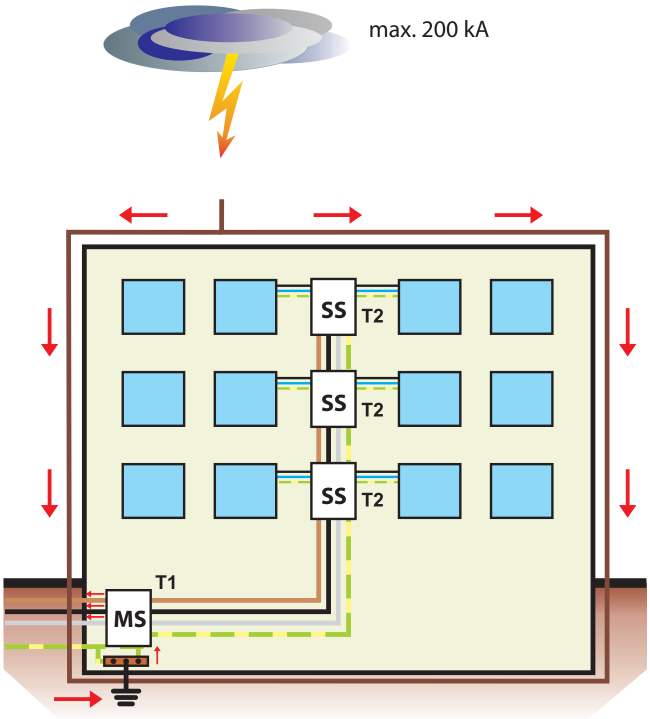
d) Industrial and special applications
higher requirements for overvoltage protection parameters

THEORETICAL PART

2.1. Low installation threat



- family houses without lightning conductor, with buried cable power lead, situated in high density development surrounded by higher buildings



- individual housing units in block of flats, on condition that the first stage of protection T1 is installed in the main switchboard

In case there is no threat of direct lightning stroke, neither to the building nor to the close buildings that are galvanically connected to it, then the installation is threatened only by overvoltage in the power lead. According to standard EN 62305-1 in case this power lead was buried we speak about pulse waves related to the engineering networks connected to the building **(cause of damage S4)**. In this case the expected value of overcurrent pulse wave for protection level against lightning I-II is 5 kA with wave form 8/20 µs. In case like this the first stage of protection can be left out from the design and only the second stage is used.

Switchboards in the flats can be placed to this application group as well, on condition that there is the adequate first stage of protection installed in the main switchboard.

We recommend installing replaceable models:

networks TN-C and TN-C-S ...... 1 pc **SVC-350-3-MZ(S)**
networks TN-S and TT ...... 1 pc **SVC-350-3N-MZ(S)**
networks TN-S ...... 1 pc **SVC-350-4-MZ(S)**

or economical design for:

networks TN-C and TN-C-S ...... 3 pcs **SVC-275-1(-S)**
networks TN-S and TT ...... 3 pcs **SVC-275-1(-S)** + 1 pc **SVC-255-N-S**
networks TN-S ...... 4 pcs **SVC-275-1(-S)**

Actual connection can be found in the attached application tables.

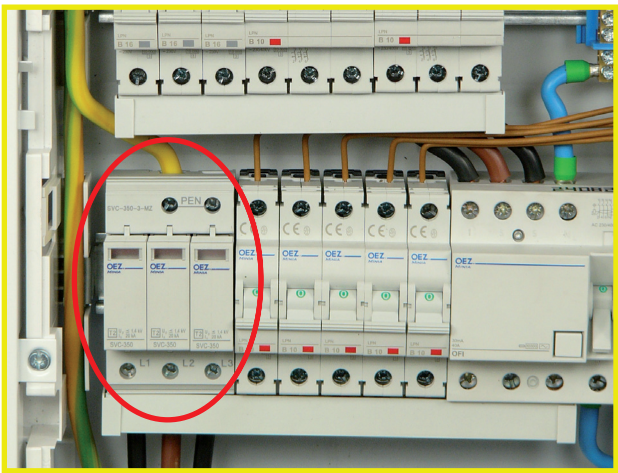


Photo of switchboard with second stage SVC-350-3-MZ
Compact design with replaceable modules

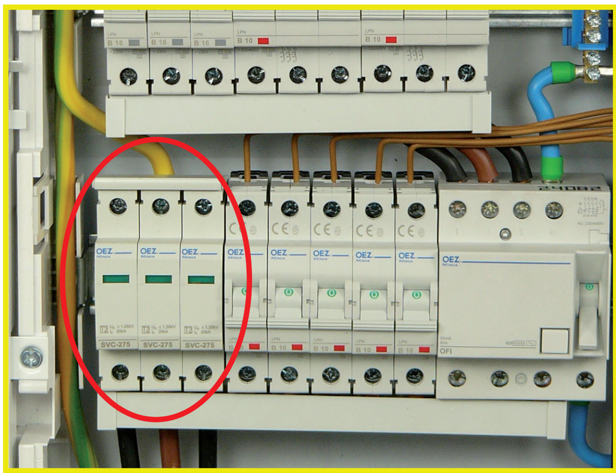


Photo of switchboard with second stage SVC-275-1 (3 pcs)
Fixed design, connection by means of interconnecting busbar G1L... on the top

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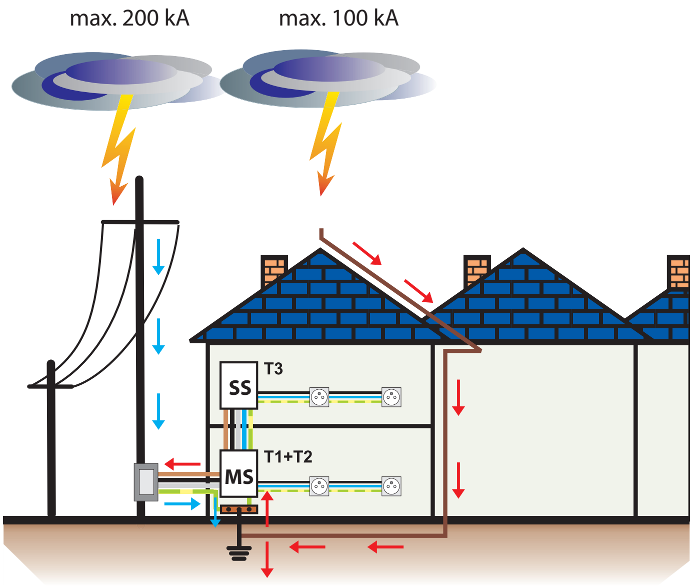
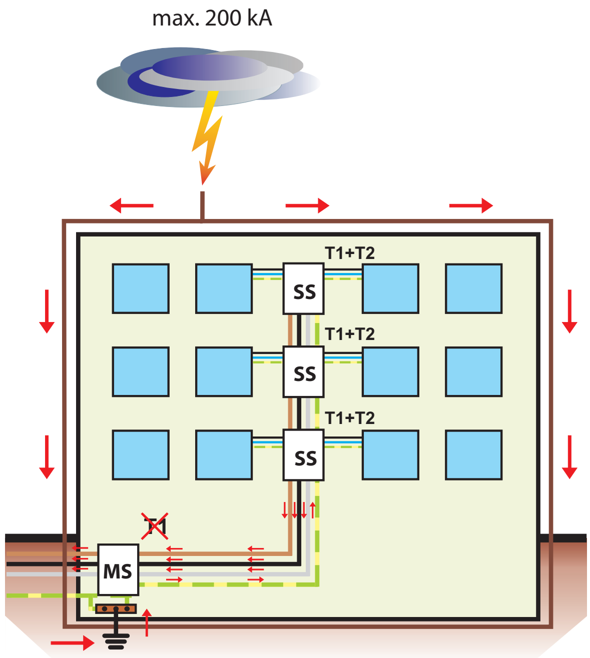
2.2. Medium installation threat



- buildings with external lightning protection (lightning onductor), with grounded roof superstructure (aerial) etc. - placed in protection level against lightning LPL III or LPL IV
- family houses with outside power lead above the ground



- individual housing units in block of flats, when the first stage of protection T1 is not installed in the main switchboard

When the arresting equipment installed in the building is struck directly **(damage cause S1)** the unprotected insulation might get broken and as a result the installation is exposed to direct lightning effects. This can be prevented by adequate protection. The given peak current of the first short discharge for protection level against lightning LPL III is 100 kA. Standard EN 62305-1 deals with the calculation of lightning current and its separation into individual lines and conductors. The procedure is as follows:

It is estimated that roughly 50 % of the lightning current is arrested to the earth and 50 % passes through the installation and flows away by means of connected engineering networks. The separation is done on the basis of ratio of their impedances. Here we consider only the LV power lead. The value of lightning current fl owing through the power lead is 50 kA with wave form 10/350 µs.

Supposing the power lead consists of four conductors, the lightning current in network TN-C is 12.5 kA with wave form 10/350 µs per one conductor.

Another possibility is the stroke to the engineering network (cause of damage S3). The expected value of overcurrent pulse wave for protection level against lightning I and II is 10 kA with wave form 10/350 µs.

This group includes also individual housing unit in bigger buildings with lightning conductor, where the lightning current is divided into sufficient number of branches in a way that its value does not exceed 12.5 kA with wave form 10/350 µs per one conductor. The division of lightning current means both the division of the current into a higher number of conductors and the division between electrical installations of individual flats.

We recommend installing the following models:

networks TN-C and TN-C-S ...... SVBC-12,5-3-MZ(S)
networks TN-S and TT ...... SVBC-12,5-3N-MZ(S)
networks TN-S ...... SVBC-12,5-4-MZ(S)

Actual connection can be found in the attached application tables.

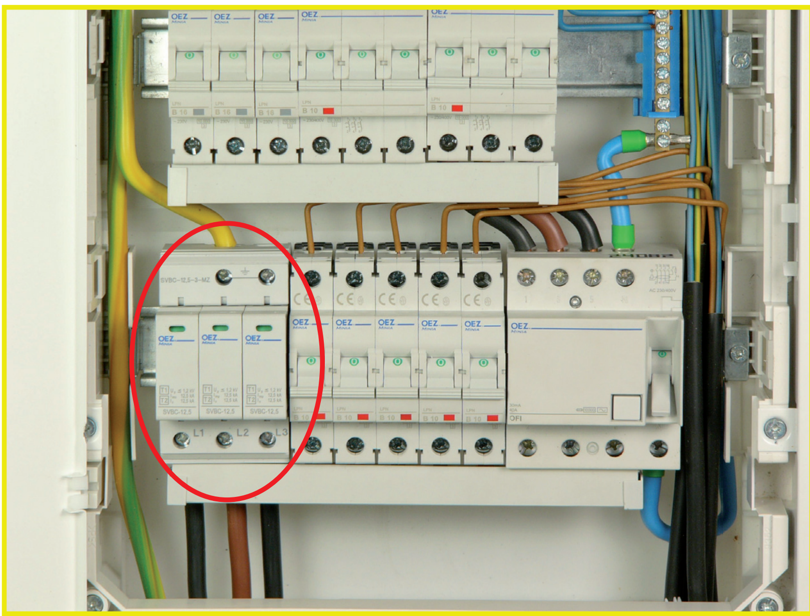
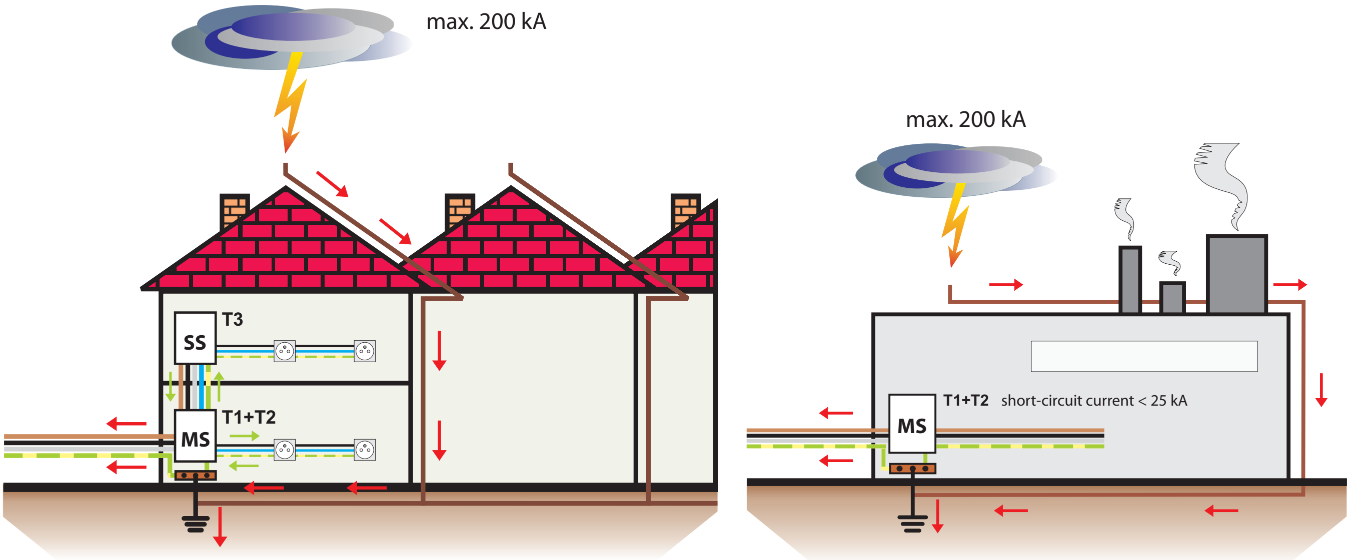


Photo of switchboard with SVBC-12,5-3-MZ
First and second stage of protection with removable modules

THEORETICAL PART

2.3. Big installation threat



- buildings with external lightning protection (lightning conductor), with grounded roof superstructure (aerial) etc. - placed in protection level against lightning LPLI or LPLII

Similarly to the previous group the lightning current might affect the electro installation in the building. The given peak current of the first short discharge for protection level against lightning LPL I is 200 kA. Standard EN 62305-1 deals with the calculation of lightning current and its separation into individual lines and conductors.

The procedure is as follows:

It is estimated that roughly 50 % of the lightning current is arrested to the earth and 50 % passes through the installation and flows away by means of connected engineering networks. The separation is done on the basis of ratio of their impedances. Here we consider only the LV power lead. The value of lightning current flowing through the power lead is 100 kA with wave form 10/350 µs.

Supposing the power lead consists of four conductors, the lightning current in network TN-C is 25 kA with wave form 10/350 µs per one conductor.

We recommend installing the following models:

networks TN-C and TN-C-S ...... 1 pc **SJBC-25E-3-MZS**
networks TN-S and TT ...... 1 pc **SJBC-25E-3N-MZS**

A combination of (T1) SJB-25E-... + (T2) SVC-350-... in other parts of installation can be used for the protection of large buildings – e.g. block of flats, where T1 in main switchboard and T2 in individual switchboards of flats can be used.

Actual connection can be found in attached application tables.

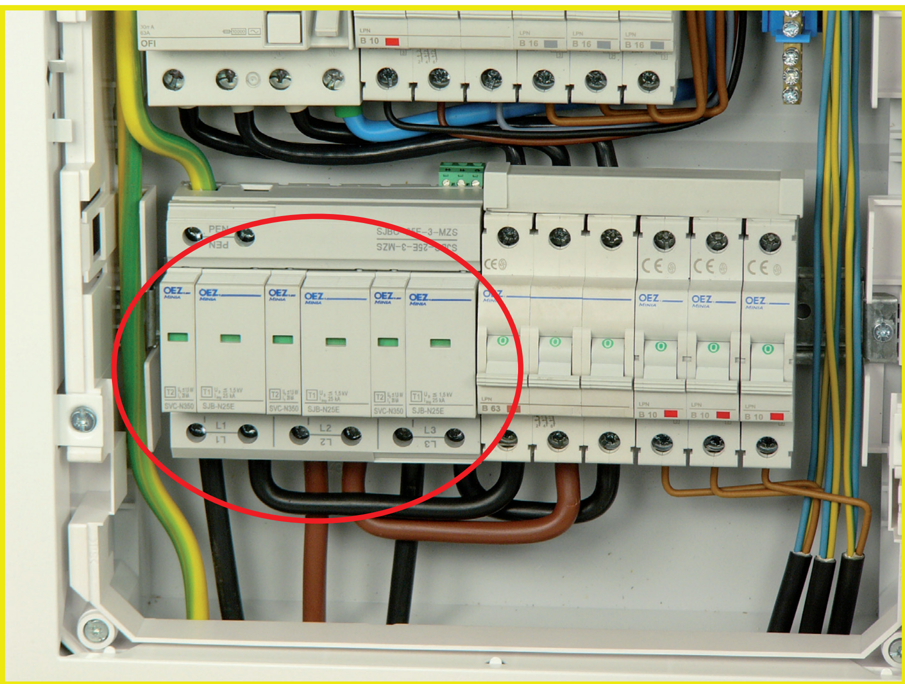


Photo of switchboard with SJBC-25E-3-MZS – 3-pole design
First and second stage of protection T1 (spark gap) + T2 (varistor)

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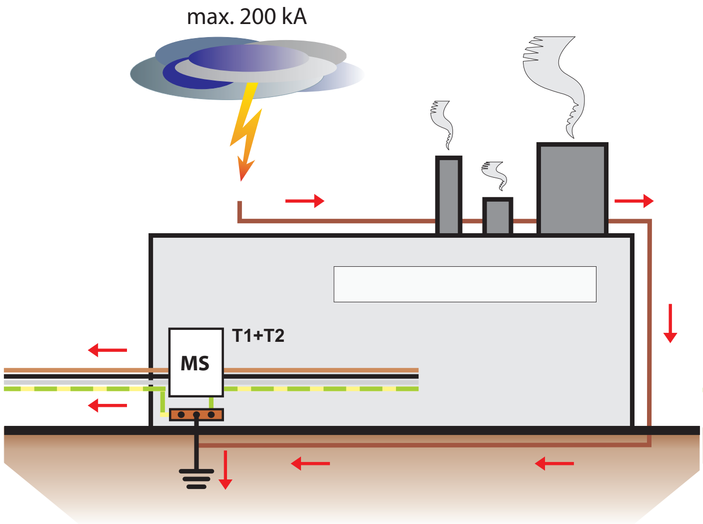
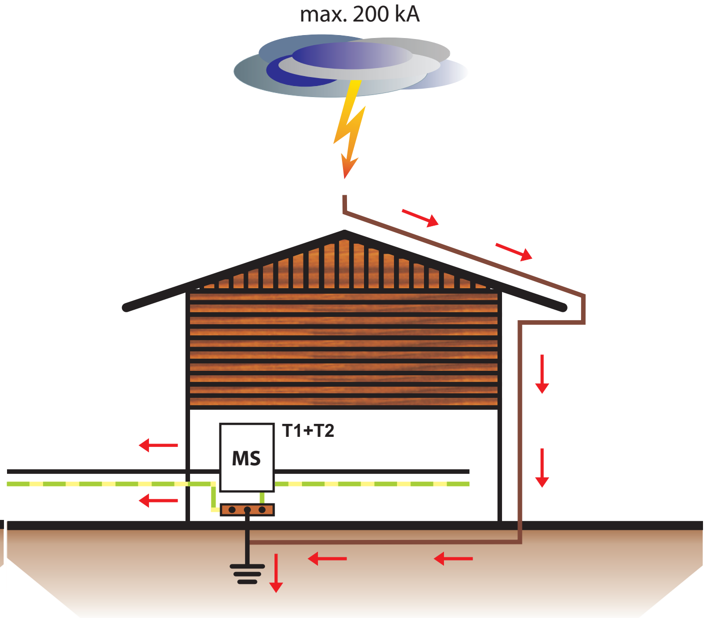
2.4. Industrial and special applications





- mostly industrial buildings, where the short-circuit current at the place of installation exceeds 25 kA

- building with two-conductor lead and at the same time with external lightning protection (lightning conductor) or with grounded roof superstructure (aerial) etc.

If there are high requirements for the overvoltage protection parameters, in particular the ability to quench high follow short--circuit currents, it is necessary to use following combinations:

We recommend installing the following models as the first stage of protection (T1):

network TN-C and TN-C-S ...... 3 pcs **SJBplus-50-2,5**
networks TN-S and TT ...... 3 pcs **SJBplus-50-2,5** + 1 pc **SJB-NPE-1,5**
networks TN-S ...... 4 pcs **SJBplus-50-2,5**

As the second stage we can choose 3 pcs (4 pcs) of **SVM-440-Z(S)** that can be placed directly next to the first stage of protection.

In case the overvoltage protections are installed by means of two-conductor cable (one phase) in buildings with external lightning protection, the total value of lightning current is similar to the previous case. The supply conductor, however, has only two conductors in this case. On condition that the lightning current is divided 50 % to the earth and 50 % to the installation the value of lightning current fl owing through the installation is 100 kA. This current is then divided into two conductors, that means 50 kA with wave from 10/350 µs per one conductor.

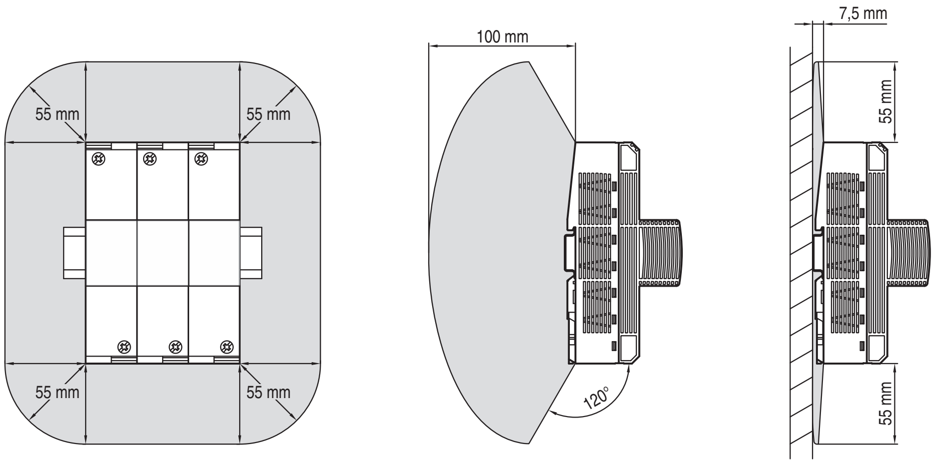
We recommend installing the following models as the first stage of protection (T1):

networks TN-C and TN-C-S ...... 1 pc **SJBplus-50-2,5**
networks TN-S and TT ...... 1 pc **SJBplus-50-2,5 + 1 pc SJB-NPE-1,5**
networks TN-S ...... 2 pcs **SJBplus-50-2,5**

1 pc (2 pcs) of **SVM-440-Z(S)** can be selected as the second stage of protection, which can be installed directly next to the first stage of protection.

Actual connection can be found in attached application tables.

SJBplus-50-2,5 is designed on the basis of open spark gap. During the installation it is necessary to follow the given rules with respect to the minimum distance from combustible materials and live bare conductive parts under voltage.



Deionization space of SJBplus-50-2,5

THEORETICAL PART

3. PROZIK CALCULATION SOFTWARE

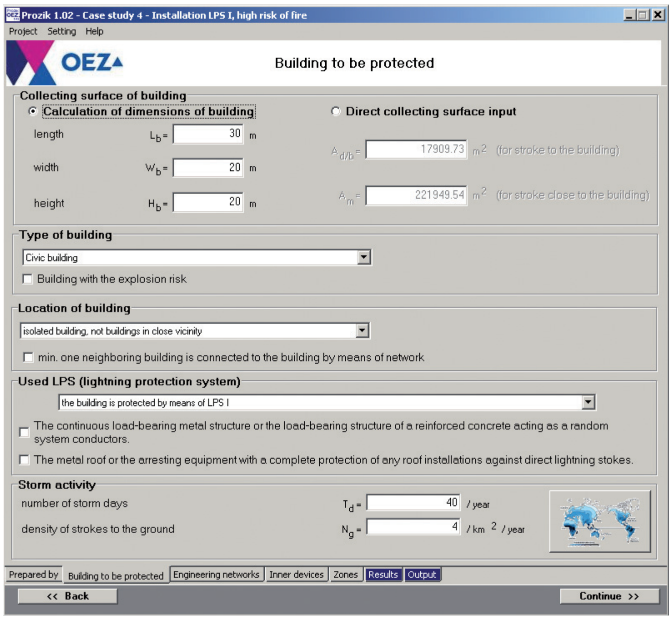
– selection of overvoltage protection in accordance with EN 62305-2 Protection against lightning – Part 2: Risk management

3.1. Calculation and management of risk of damages caused by lightning stroke

The risks of damages caused by lightning strikes are determined by a high number of parameters. Therefore, it is necessary to calculate and manage these risks for all buildings, where lightning strokes can endanger life or health, cause damages to public services or cultural heritage, cause fire, explosions, etc. The calculations have to be in accordance with relevant standards.

The calculations are relatively difficult. It is necessary to include many parameters of the protected building and connected network, determine protection measures installed to mitigate the risks, etc.

Software for the calculation and management of risks (Prozik) has been developed in accordance with EN 62305-2. National standards can be adopted with modifications. Some differences may be found between the individual national versions.



View of Prozik environment

What is the relationship between the calculation of risks and the selection of type of overvoltage protection? In chapter 2, LPL (lightning protection level) has been described as information, which is needed to determine the right application group for a building:

Low installation threat
- no threat of lightning current
- no protection against overvoltage caused by lightning surges is needed (LPL is not defined)
- first stage of overvoltage protection is not needed

Medium installation threat
- lightning current up to 12.5 kA / pole
- LPL III and LPL IV
- peak value of lightning current does not exceed 100 kA (10/350 µs)
- both first and second stages of protection have to be used (high-performance varistor)

Big installation threat
- lightning current up to 25 kA / pole
- LPL I and LPL II
- peak value of lightning current does not exceed 200 kA (10/350 µs)
- both first and second stages of protection have to be used (spark gap + varistor)

However, chapter 2 does not include a detailed LPL verification procedure. The procedure is as follows:

1) Calculate the risk by using LPL (corresponding to the installed overvoltage protections) as an input parameter.
2) Compare the results. If the resulting risk is lower than the risk defined by the standard, you can use the selected overvoltage protection.
3) If the risk is higher, risk mitigating protection measures have to be installed.
4) On of the possible actions is to install better overvoltage protections (e.g. by using LPL I instead of LPL IV).

However, the selection of LPL is not the only protection measure available. Other measures may include e.g. the class of lightning protection system (arresting equipment, conductors, earth conductors), shielding, fire detection and alarm system, etc.

3.2. Example of management of risk of damages caused by lightning strokes – Medium installation threat application group

The following example has been taken from EN 62305-2 (Case study H.1 – Country house).

Example:

Verify the protection measures taken to prevent damages caused by lightning strokes.

The building has the following parameters:
- Isolated building, not buildings in close vicinity
- dimensions: 15 x 20 x 6 m
- no lightning conductor installed

Two lines are connected to the building:

a) power line
- underground power line, length: 1000 m
- isolated, rural environment
- no shielding
- no internal wiring precaution
- no coordinated protection (overvoltage protection)
- withstand capacity of connected systems: 2.5 kV

b) overhead telecom line
- overhead telecom line, height: 6 m, length: 1000 m
- isolated, rural environment
- no shielding
- no internal wiring precaution
- no coordinated protection (overvoltage protection)
- withstand capacity of connected systems: 1.5 kV

Only one zone is inside the building:
- termination of power line and telecom line
- wooden floors
- low risk of fire, no fire protection
- no special hazards
- no spatial shielding

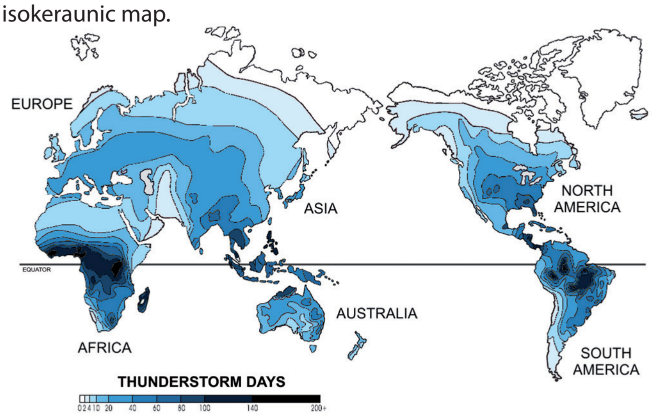
THEORETICAL PART

If we consider that no people are outside the building during a storm, outside zones can be disregarded.

Solution:
a) without overvoltage protection

Calculate the risk of loss of human life. Unlike the risk of damages to public services, cultural heritage and financial damages, this type of risk has to be always calculated.

Determine the annual number of storm days, eg. from an isokeraunic map.



World/Europe isokeraunic map
Annual number of storm days

Calculate the annual number of lightning strokes to the ground per km². For example, the number of thunder days is 20 ÷ 40 per year in Central Europe.

The resulting risk of loss of human life (as calculated by Prozik) is $\mathbf{2.4 \cdot 10^{-5}}$. The allowable risk defined by the standard is $\mathbf{1 \cdot 10^{-5}}$. Because the calculated risk of loss of human life is higher than the value required by the standard, protection measures have to be installed.

b) with overvoltage protection

To lower the risk, LPL IV overvoltage protections have to be installed at the entrance point of all lines connected to the building. According to Prozik, these measures lower the risk to $\mathbf{0.17 \cdot 10^{-5}}$. The installation of overvoltage protections for LPL IV lightning protection level is sufficient and the building is sufficiently protected.

3.3. Logical verification of calculation results

Let's evaluate the calculation results from the logical point of view. According to the calculation method determined by the standard, the total risk is lower than the allowed risk, even in the absence of lightning conductor (LPS). The lightning conductor is installed primarily to protect the building from direct lightning stroke and subsequent fires. According to the calculation, the lightning conductor is not needed. However is it worth to take the risk?

A similar problem can be encountered with the overvoltage protections. If the overhead telecom line is taken out from the case study (only the power line is left), the total risk without overvoltage protection installed (0.98 · 10-5) will be lower than the allowable limit. Therefore, according to the calculation, lightning protection will not be needed in this case. However you can be almost one hundred percent certain that a lightning stroke will cause damages or losses.

3.4. How to choose overvoltage protection?

A spark gap type overvoltage protection (25 kA) protects the installation against lightning current of peak values up to 200 kA (99 % of lightning strokes). In case of varistors (12.5 kA), the installation is protected against lightning strokes up to 100 kA (97 % of lightning strokes). The spark gap overvoltage protections have also the advantage that the active component – power spark gap – is able to repeatedly arrest high lightning currents without significant harm. If you use a varistor, each lightning stroke will cause irreversible damage to its semiconductor structure, and the varistor will need to be replaced more frequently. Therefore, in the long-term, varistors can be more expensive than spark gaps.

There are some applications, where no risk can be taken, because of the purpose of the application. These applications will be directly classified in LPL I or LPL II. The applications include e.g. hospitals, where internal system faults can lead to loss of life, or power plants, where internal system faults can lead to power outages or accidents.

3.5. Influence of quality of selected overvoltage protection on the risk of damages caused by lightning strokes

Application group **Medium installation threat** can include also an office building protected by overvoltage protections LPL IV (Case study H.2 – Office building) or block of flats (Case study H.4 – Block of flats). How is this possible?

The quality of protection depends on the selected lightning protection level (LPL), i.e. on the peak value of lightning current (see table on page 5). For LPL IV, the maximum peak value of lightning current is 100 kA. Only 3 % of lightning strokes exceed this value. Therefore, the probability that a lightning stroke will cause an internal system fault is 30 times lower than in an unprotected installation.

For LPL I the maximum peak value of lightning current is 200 kA. Only 1 % of lightning strokes exceed this value. Therefore, the probability that a lightning stroke will cause an internal system fault is 100 times lower than in an unprotected installation. In terms of application groups, this level is used for Big installation threat.

By selecting a higher rating protection, you can almost always minimize the risk of damages caused by lightning strokes.

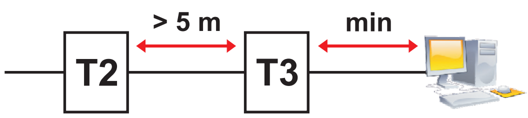
3.6. Influence of quality of selected overvoltage protection on the risk of damages caused by switching overvoltage

Calculations according to EN 62305-2 may confirm that it is not necessary to install protection against lightning strokes. Regardless of whether you decide to install the lightning stroke protection or not, protection against switching overvoltage has always to be installed. The energy of switching overvoltage is significantly lower than the energy of overvoltage caused by lightning stroke. However, switching overvoltages can be just as dangerous due to the frequent occurrence. Follow the rules for **Low installation threat** application group when selecting the appropriate protection devices.

4. OVERVOLTAGE PROTECTION: INSTALLATION PRINCIPLES

4.1. Installation of the third stage of protection

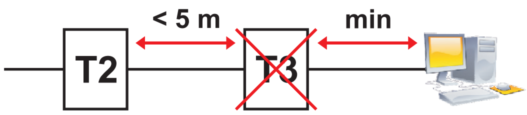
If the protected device is located more than 10 m (cable distance) from the previous stage of overvoltage protection, it is necessary to repeat the overvoltage protection. Overvoltage induced on too long cable cannot be eliminated by the second stage and the device can be endangered. The closer the T3 is to the protected device, the better protection is ensured.



Correct installation of T3

THEORETICAL PART

Installation in shorter distance (cable distance) than 5 m from the second stage is not permitted. Coordination of the individual stages would not be ensured and the third stage could be destroyed.

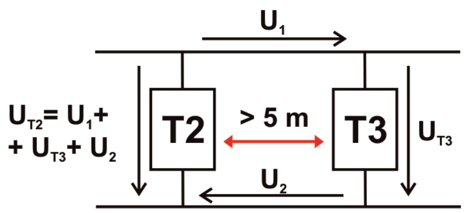


Incorrect installation of T3

4.2. Coordination of overvoltage protections

Coordination of overvoltage protections can be explained on the example of coordination of second (T2) and (T3) stage of protection.

a) Coordination of second and third stage



Coordination of T2 and T3

T3 is the first to respond to the rising voltage. T3 lowers its impedance and begins to arrest the lightning current. The current flowing through the stage causes a voltage drop at T3 (U_{T3}) and induces voltage in line conductors (U_1 and U_2) at the same time. The sum of overvoltage at terminals T2 is (U1 + U2 + UT3). The voltage at T2 is greater than the voltage at T3, the difference corresponds exactly to the line conductor loss, and thus the T2 opens sooner. If the T3 was installed closer to T2, the voltage difference at the different stages would not be sufficient for the timely opening of T2. The entire lightning current would be transmitted through T3, which is not designed for it. This principle is called the coordination of overvoltage protection.

As stated in section 4.1., the OEZ overvoltage protection T3 must be installed at least 5 m from T2. If the T2 is closer to the protected device, T3 is not needed. The upstream T2 can protect the connected equipment thanks to its voltage protection level (1.4 kV).

b) Coordination of first and second stage

If a compact solution T1 (spark gap) and T2 (varistor) is used, we do not have to deal with coordination. The solution uses an electronic ignition release technology, which enables to place both stages of protection in one base without a need of choking coils. These choking coils were formerly used to increase the impedance of line.

The choking coils are not needed even in case of combination of T1 (spark gap) and T2 (varistor) both 1-pole design. Similarly to the coordination of T2 and T3, in case of separated T1 and T2 the first one to react to the rising voltage is the faster one – that is the varistor. Hand in hand with the rising current rises voltage at the varistor and also at the inlet conductors. Simultaneously, voltage at the spark gap rises. When a certain limit is exceeded the spark gap is ignited and takes over major part of the current. Thanks to this, the varistor is safe from damage

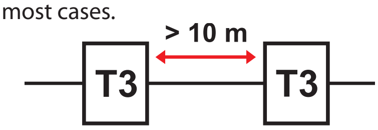
Certain distance between individual stages of protection has to be observed with respect to the type of used varistor in T2. It is similar when the combination T1+T2 and T2 is used. Minimum distances are stated in the following table.

Minimum distance for the guarantee of coordination of OEZ overvoltage protections

Coordination of OEZ overvoltage protections		T2		
		SVC-350-…	SVC-275-…	SVM-440-…
T1+T2	SVBC-12,5-…	10 m	10 m	10 m
	SJBC-25E-…	0 m	10 m	0 m
T1	SJB-25E-…	0 m	10 m	0 m
	SJBplus-50-2,5	5 m	10 m	0 m

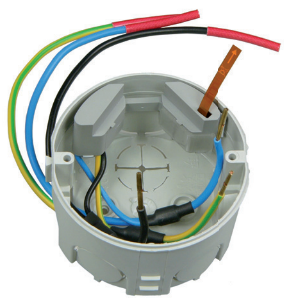
0 m, 5 m, 1 0m … minimum distance between the devices that has to be observed

If the protected device is installed more than 10 m from the last protection stage, an additional protection stage has to be installed – that is T3 in most cases.



Repetition of overvoltage protection

SVD-253-1N-MZS or SVD-335-3N-MZS are designed for the installation into switchboards, SVD-335-1N-AS are designed for the installation into mounting boxes with sockets.



SVD-335-1N-AS installed in a mounting box

The figure shows the location of the overvoltage protection level three SVD-335-1N-AS in a mounting box. Thanks to the design, socket and switch can be easily installed in the same box, without limiting the space for conductors behind the devices. The basic version of overvoltage protection includes conductors, which enable through-wiring to a next mounting box without the need for additional terminals. At the end of life, overvoltage protection begins to emit acoustic signal. In this case it is necessary to replace the protection. It is possible to interrupt the signalling system by pulling the disconnection strip out.

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4.3. Overvoltage protection connection methods according to the type of LV system

An appropriate overvoltage connection method exists for each of the following systems.

TN-C (3+0) system

T … Direct connection of a supply source with earth.
N … Exposed conductive parts are connected to the supply source by means of a protective conductor.
C … A combined PEN conductor fulfils the functions of both a PE and an N conductor.

TN-S (3+1, 4+0) system

T … Direct connection of a supply source with earth.
N … Exposed conductive parts are connected to the supply source by means of a protective conductor.
S … Protective PE and neutral N conductors are separated.

TN-C-S (3+0, 3+1, 4+0) system

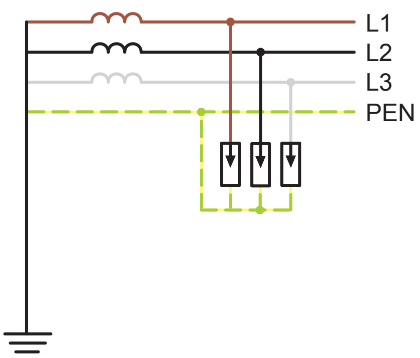
T … Direct connection of a supply source with earth.
N … Exposed conductive parts are connected to the supply source by means of a protective conductor.
C-S … Part of the system uses a combined PEN conductor, which is at some point split up into separate PE and N lines.

TT (3+1) system

T … Direct connection of a supply source with earth.
T … Exposed conductive parts are connected with earth by means of a protective conductor.

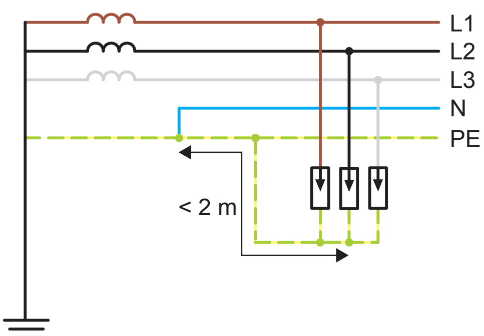
Connection 3+0

Connection 3+0 uses three overvoltage protections between the individual phase conductors and PEN conductor.



Connection 3+0 in TN-C system

The 3+0 connection is used for TN-C. However, it can be used also for TN-C-S, if the „cable" distance from the N and PE splitting point to the overvoltage protection terminal is less than 2 m. Voltage induced in conductor of such short length is not dangerous to the installation.



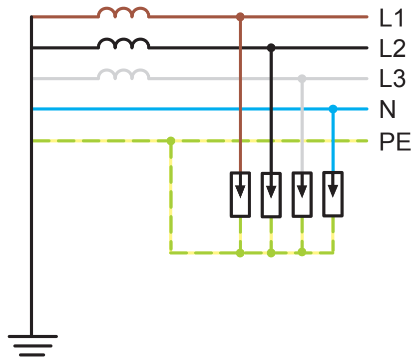
Connection 3+0 in TN-C-S system

If the distance from the N and PE splitting point to the overvoltage protection terminal is more than 2 m in a TN-C-S network, connection 3+1 or 4+0 has to be used.

Connection 4+0 and 3+1

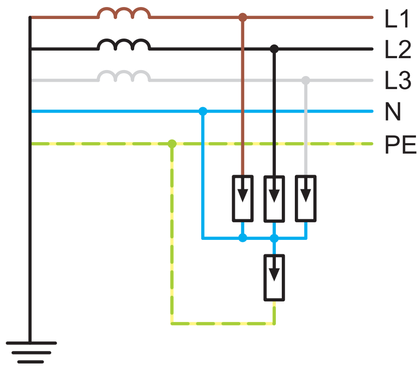
In a TN-S (TN-C-S) system, there are two overvoltage connection methods available – 4+0 or 3+1 connection.

The 4+0 connection uses four identical overvoltage protections between line conductors and protective conductors (L1-PE, L2-PE, L3-PE and N-PE).



Connection 4+0 in TN-S system

The 3+1 connection uses four overload protections – three connected between the individual phase conductors and neutral conductors and the fourth (summing spark gap) between N and PE conductors.



Connection 3+1 in TN-S system

Connection 4+0 does not use galvanic isolation of N and PE conductors. If the overvoltage protection is connected downstream from a residual current circuit breaker (RCCB), the probability of nuisance tripping of the RCCB rises. This problem can be solved by galvanic isolation of N and PE (3+1 connection), where the risk of nuisance tripping is eliminated.

The 4+0 connection is worse than the 3+1 connection also in terms of reaction to overvoltage. In case of lightning currents of lower peak values in 4+0 system, the main portion of the current flows through a varistor between L and PE – i.e. outside the RCCB circuit. When the peak value of the current exceeds certain limit, the residual current circuit breaker may evaluate the current as a fault current and perform nuisance tripping.

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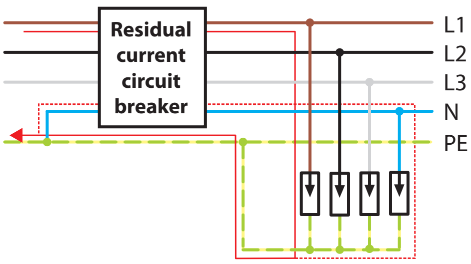
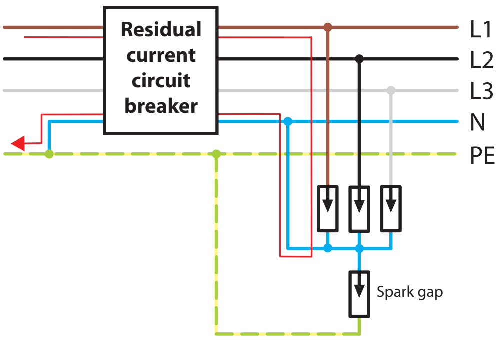


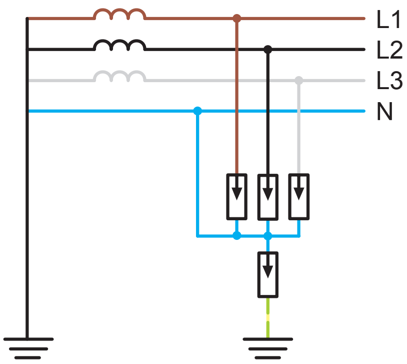
Connection 4+0 in a circuit with a residual current circuit breaker

In case of overvoltage in 3+1 connection, the main portion of the current flows through the varistor between L and N, and therefore back through the residual current circuit breaker. Therefore, the residual current circuit breaker does not react to the current and does not perform nuisance tripping.



Connection 3+1 in a circuit with a residual current circuit breaker

Connection 3+1 can be used in TT systems, where a residual current circuit breaker (used in most cases) ensures safe disconnection of circuits from the power supply.

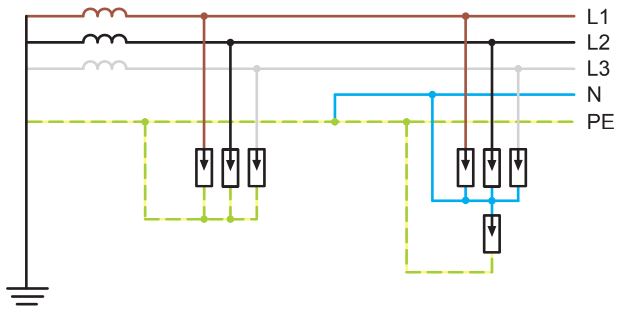


Connection 3+1 in TT system

Generally, the potential differential between the N conductor and earth is higher in TT systems than in TN systems. The current flowing through varistor between N and PE (in 4+0 connection) is therefore significantly higher and nuisance tripping occurs more frequently in 4+0 connection.

Combined connection 3+0 and 3+1 (4+0)

Frequently in TN-C-S systems, the first stage of overvoltage protection is installed upstream of the point, where PEN is split into separate N and PE conductors and the second stage is installed downstream from this point.



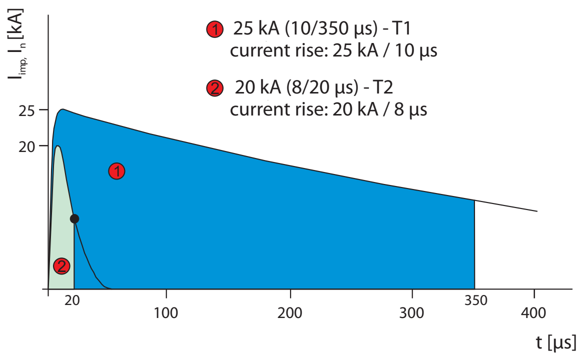
Combined connection 3+0 and 3+1 in TN-C-S network

Installation of overvoltage protection in the TN-C part is carried out according to the rules for TN-C systems; TN-S part according to the rules for TN-S systems.

4.4. Rules for the actual installation / connection

Due to the high values of lightning currents (up to tens of kiloamperes), high voltage is induced in the inlet conductors. This voltage can reach such values that can damage the downstream installation.

This principle applies also to the passage of lightning current through the overvoltage protection of first, second and other stages. The induced voltage depends primarily on the peak current value, rate of current change and the length of inlet conductors. The following figure shows examples of current wave forms loading the overvoltage protection.



Current wave forms 8/20 µs and 10/350 µs

Common first stage has to be able to arrest 25 kA (10/350 µs)[1] current pulse and second stage has to be able to arrest 20 kA (8/20 µs) current pulse. Due to the similar rate of change of current in both cases, the voltage induced in the inlet conductors is almost the same for both pulses.

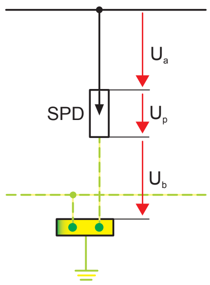
Reduction of long inlet conductors

The length of inlet conductors has been determined in ČSN 33 2000-5-534[2], which recommends that the total length of inlet conductors should not exceed 0.5 m, and requires that the total length must not exceed 1 m. The standard defines inlet conductors as conductors leading from line conductors to overvoltage protection and from overvoltage protection to main earth terminal or protective conductor. It is because that during the passage of lightning current, there is a decrease of voltage not only on the overvoltage protection, but also in the inlet conductors.

1 *The parameters of lightning current are defined in EN 62305-1*

2 *Valid legislation of the Czech Republic. Because of possible differences between the individual national standards, different requirements for cross-section or length of inlet cables may be found in the text.*

THEORETICAL PART



Voltage induced in inlet conductors
(T-connection)

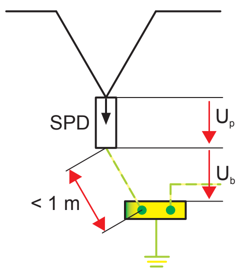
Sum of voltage in inlet conductors (U_a, U_b) and voltage on overvoltage protection (U_p) must be lower than the value of impulse withstand voltage (U_{imp}) for the given category according to EN 60664-1.

Specific values of Uimp for LV networks 230/400 V according to EN 60664-1 are shown in figure “Impulse withstand voltage” on page 5.

Voltage protection level Up of the overvoltage protection is specified by the manufacturer. Therefore, the shorter the inlet conductors are, the more efficient the protection of the electro installation is. In ideal case – zero length of inlet conductors – the installation would be affected only by the voltage protection level Up of the overvoltage protection.

1) V-connection

The closest to the above mentioned ideal case is the so called V-connection, where the line conductors are connected directly to the terminals of the device.



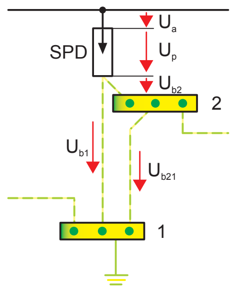
Voltage induced in inlet conductors
(V-connection)

The length of conductors between line conductors and the overvoltage protection terminals is almost zero. The value of induced voltage depends only on the PEN conductor parameters. The PEN conductor must not be longer than 1 m. The shorter the PEN conductor is, the more efficient the protection is.

2) Local grounding busbar

In many cases the above described overvoltage protection connection cannot be implemented. This applies mainly to switchboard cabinets that have phase busbars in the upper part and PEN busbar in lower part. This problem can be solved by the creation of local grounding busbar.

Place the overvoltage protection as close as possible to the phase busbars (to minimize the length of inlet conductors) and connect the PEN conductor according to the figure.

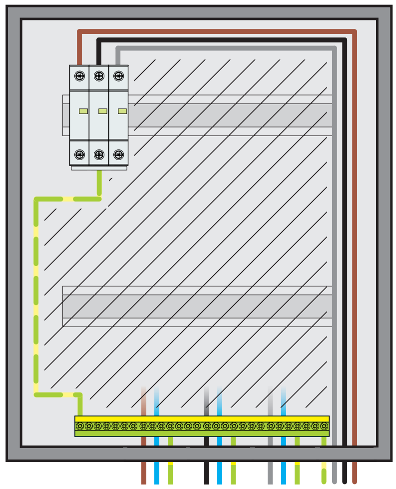


Voltage induced in inlet conductors
Local grounding busbar

In this way, the length of connecting wires, which affects the voltage in downstream electro installation can be minimized. The resulting overvoltage consists only of U_{b2} voltage between the device terminals and the local busbar (2). Voltage U_{b21} is also induced on the conductor between the device terminal and the main grounding busbar (1). However, this voltage does not endanger the electro installation. Downstream electro installation has to be connected to busbar 2.

Minimization of the current loop

During the switchboard cabinet design, it is also is also necessary to pay attention to the routing of conductors, which will be exposed to lightning current. Each current loop induces a magnetic field proportional to its area. This field in turn induces a voltage in all the wires in vicinity and endangers other equipment. The worst possible scenario is shown in the following figure.

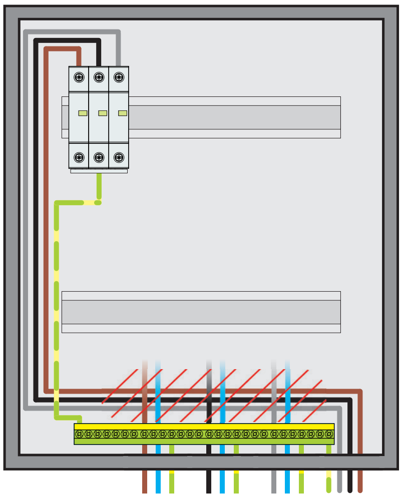


Current loop circling around the whole switchboard cabinet

The current loop goes around the whole switchboard cabinet. All equipment and conductors are exposed to the electromagnetic field.

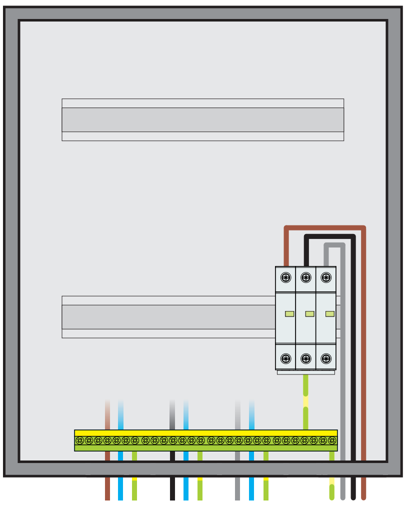
It seems that it is sufficient to lead the inlet and PEN conductors together up to the overvoltage protection to solve this problem.

THEORETICAL PART



Undesirable intersection of inlet and outlet conductors

You would minimize the area of current loop in this way, however you would most probably cause the interference between upstream and downstream conductors. Bond between these conductors could transfer the voltage from inlet conductors to outlet conductors (unprotected part of the installation) and endanger the connected equipment. Another mistake is intersection or common routing upstream or downstream the overvoltage protection, which occurs quite frequently in actual installations. The solution is to physically move the overvoltage protection as close to the inlet as possible.



Optimal solution

The solution minimizes both the area of current loop and length of inlet conductors, and separates the protected and unprotected part of the electro installation at the same time.

4.5. Protection of overvoltage protections

It is necessary to protect the overvoltage protections against destruction. All overvoltage protections have built-in protective cut-off device that disconnect them from the circuit in case the given safety values of electric power are exceeded. When this thermal protection takes effect the overvoltage protection stops working and the circuit is not protected anymore. In case of replaceable design it is sufficient to replace the module, in case of fixed design the whole device is replaced.

In some situations, the cut-off device is not able to open the circuit safely. Because of this, maximum rating of upstream fuses, which can safely disconnect the connected circuit, has been specified. The maximum fuse rating can be found in the catalogue part of this manual.

Fuses are required for upstream protection of the first and second stage. Fuses are able to arrest the current (energy) more efficiently than circuit breakers of the same rating. If you want to achieve the same parameters with a breaker, you need a breaker with lower rating. Such breaker would trip more often. After tripping, also the overvoltage protection would go out and the circuit would not be protected against overvoltage. However for T3, it is possible to use breakers.

It is not necessary to use upstream fuses with maximum rating. Any fuse with lower rating can be used. There is a relationship between the fuse rating and the energy that can go through the fuse. The lower the rating of the fuse installed, the higher the probability of melting.

Cross-section of inlet conductors

The required cross-sections of inlet conductors are specified in ČSN 33 2000-5-534.

For type 1 overload protection (B or B+C) at least 16 mm cross--section is required.

For type 2 or 3 overload protection (C or D), the minimum cross--section is defined as follows:

If the cross-section of line conductors is higher or equal to 4 mm², the cross-section of earth conductors has to be at least 4 mm².

If the cross-section of line conductors is lower than 4 mm², the cross-section of earth conductors must not be lower than the cross section of line conductors.

The values apply to copper conductors. If different materials are used, the conductor cross-sections have to be dimensioned accordingly.

The cross-sections have to be designed according to the parameters of upstream protection. The table below shows examples of minimum cross-sections for the first (B) and first and second (B+C) spark gap type overvoltage protection stage.

Fuse gG/gL	S_L	S_{PEN}
≤80 A	10 mm²	16 mm²
100 A	16 mm²	16 mm²
125 A	16 mm²	16 mm²
160 A	25 mm²	25 mm²
200 A	35 mm²	35 mm²
250 A	35 mm²	35 mm²
315 A	50 mm²	50 mm²

Relationship between cross section of connecting conductors and upstream fuse rating for SJBC-25E-… a SJB-25E-…

Tables for upstream protection and cross-section of inlet wires for all types of OEZ overvoltage protections can be found in the attached application sheets.

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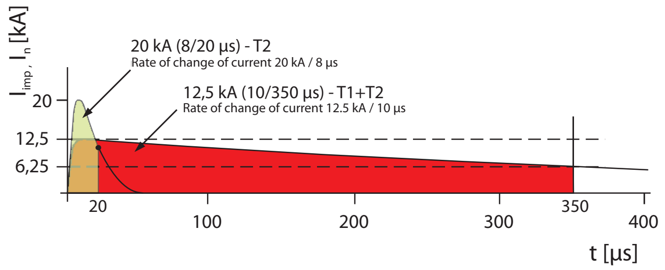
5. TERMS, DEFINITIONS

i - lightning current
Current that flows at the spot of stroke.

I_{imp} – impulse current
Used for the classification of class I overvoltage protection tests.
Wave form 10/350 µs.

I_{max} – maximum discharge current
Peak value of current flowing through an overvoltage protection during a class II operational load test.
Wave form 8/20 µs.

I_n – rated discharge current
Used for the classification of class II overvoltage protection tests and for preparation for class I and II tests.
Wave form 8/20 µs.



Surge current

8/20 µs … 8 µs increase of current (wave front), 20 µs decrease of current to half the peak value
10/350 µs … 10 µs increase of current (wave front), 350 µs decrease of current to half the peak value

T1, T2, T3 – overvoltage protection type
Type 1 – Test class I – Tested: I_{imp} and I_n
Type 2 – Test class II – Tested: I_{max} and I_n
Type 3 – Test class III – Tested: U_{oc}

B, C, D – overvoltage protection class
Old classification according to VDE 0675-6
B … T1
C … T2
D … T3

U_p – voltage protection level
Parameter, which characterizes the effect of overvoltage protection in voltage limitation.
Its value is determined in such way, so that all voltage values measured during tests are lower.

U_{imp} – pulse withstand voltage
Peak value of voltage pulse of a prescribed shape and polarity which the device is able to withstand without failure under specified conditions.

U_a – loss of voltage on inlet conductor L between line conductors and overvoltage protection terminal

U_b – loss of voltage on inlet conductor PEN (PE)
U_b, U_{b1} – between the overvoltage protection terminal and main earth terminal (or protective conductor)
U_{b2} – between overvoltage protection terminal and local grounding busbar
U_{b21} – between local grounding busbar and main earth terminal (or protective conductor)

MS (SS) – main (secondary) switchboard

LPZ – lightning protection zone
ZLPZ 0A – Threat caused by direct lightning stroke and full electromagnetic field (outside of the building, threat of direct lightning stroke)

LPZ 0B – Threat caused by full electromagnetic field, no threat of direct lightning stroke (outside of the building, no threat of direct lightning stroke)

LPZ 1 – The threat is reduced by the division of lightning current by overvoltage protections at building interfaces. Spatial shielding can reduce weaken the electromagnetic field of the lightning stroke (inside the building).

LPZ 2…n – The threat is reduced by the of lightning current by overvoltage protections at building interfaces. Sufficient spatial shielding can weaken the electromagnetic field of the lightning stroke (inside the building) even more.

LPS … lightning protection system
Complex system used to reduce material damages caused by lightning strokes to buildings.

CATALOGUE PART

6.1. Overvoltage protections type 1 (B)

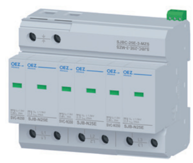
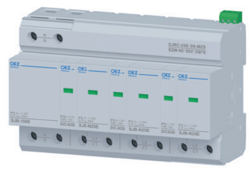
				Standard design		Special design	
T1 (B)							
Type				**SJB-25E-3-MZS**	**SJB-25E-3N-MZS**	**SJBplus-50-2,5**	**SJB-NPE-1,5**
Standards				EN 61643-11 IEC 61643-1 VDE 0675-6	EN 61643-11 IEC 61643-1 VDE 0675-6	EN 61643-11 IEC 61643-1 VDE 0675-6	EN 61643-11 IEC 61643-1 VDE 0675-6
Approval marks							
Rated voltage	U_N			230 V/400 V a.c.	230 V/400 V a.c.	400 V a.c.	230 V a.c.
Maximum constant operating voltage	U_c	L-N		-	350 V a.c.	440 V a.c.	-
		L-PEN		350 V a.c.	-	440 V a.c.	-
		N-PE		-	350 V a.c.	-	260 V a.c.
Impulse current ((10/350 μs)	I_{imp}	peak value I_{vrchol}	L-N	-	75 kA (25 kA / pole)	50 kA	-
			L-PEN	75 kA (25 kA / pole)	-	50kA	-
			N-PE	-	100 kA	-	100 kA
		charge Q		37.5 As	50 As	25 As	50 As
		specific energy W/R		1.4 MJ/Ω	2.50 MJ/Ω	0.625 MJ/Ω	2.5 MJ/Ω
Rated discharge current (8/20 μs)	I_n	L-N		-	25 kA / pole	50 kA	-
		L-PEN		25 kA / pole	-	50 kA	-
		N-PE		-	100 kA	-	100 kA
Rated frequency	f_n			50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz
Voltage protection level	U_p	L-N		-	≤ 1.5 kV	≤ 2.5 kV	-
		L-PEN		≤ 1.5 kV	-	≤ 2.5 kV	-
		N-PE		-	≤ 1.5 kV	-	≤ 1.5 kV
Arrester classification		according to EN 61643-11		type 1 T1	type 1 T1	type 1 T1	type 1 T1
		according to IEC 61643-1		class I	class I	class I	class I
		according to VDE 0675-6		class B	class B	class B	class B
Response time		L-N		-	≤ 100 ns	≤ 100 ns	-
		L-PEN		≤ 100 ns	-	≤ 100 ns	-
		N-PE		-	≤ 100 ns	-	≤ 100 ns
Quenching follow-current	I_{fi}	L-N		-	50 kA / 264 V a.c.	50 kA / 400 V a.c.	-
		L-PEN		50 kA / 264 V a.c.	-	50 kA / 400 V a.c.	-
		N-PE		-	0.1 kA	-	0.1 kA / 260 V a.c.
Max. backup fuse gG / gL		parallel connection (T)		315 A	315 A	500 A	-
		serial connection (V)		125 A	125 A	500 A	-
Degree of protection				IP20	IP20	IP20	IP20
Mounting on "U" rail according to EN 60715 – type				TH 35	TH 35	TH 35	TH 35
Connection							
Conductor - rigid (solid, stranded)				2.5 ÷ 35 mm²	2.5 ÷ 35 mm²	10 ÷ 50 mm²	10 ÷ 50 mm²
Conductor - flexible				2.5 ÷ 25 mm²	2.5 ÷ 25 mm²	16 ÷ 35 mm²	16 ÷ 35 mm²
Torque				4.5 Nm	4.5 Nm	8 Nm	8 Nm
Top or bottom connection				yes	yes	yes	yes
Optical signalling							
Functional state				green	green	-	-
Non-functional state				red	red	-	-
Remote signalling							
Arrangement of contacts [1]				001	001	-	-
Max. voltage / current	U_{max} / I_{max}			250 V a.c. / 1 A	250 V a.c. / 1 A	-	-
				125 V d.c. / 0.2 A	125 V d.c. / 0.2 A	-	-
Connection – Conductor (solid, flexible)				0.14 ÷ 1.5 mm²	0.14 ÷ 1.5 mm²	-	-
Torque				0.25 Nm	0.25 Nm	-	-
Operating conditions							
Ambient temperature				-40 ÷ 80 °C	-40 ÷ 80 °C	-40 ÷ 80 °C	-40 ÷ 80 °C
Working position				arbitrary	arbitrary	arbitrary	arbitrary

[1] Each digit indicates successively the number of make, break and break-make contacts

Product code	38357	38358	39227	34716
Weight	0.91 kg	1.31 kg	0.567 kg	0.32 kg
Package	1 pc	1 pc	1 pc	1 pc

CATALOGUE PART

6.2. Overvoltage protections type 1 + type 2 (B+C)

				Spark gap design TN-C	Spark gap design TN-S,TT
T1 + T2 (B+C)					
Type				SJBC-25E-3-MZS	SJBC-25E-3N-MZS
Standards				EN 61643-11 IEC 61643-1 VDE 0675-6	EN 61643-11 IEC 61643-1 VDE 0675-6
Approval marks				ESČ CE	ESČ CE
Rated voltage	U_N			230 V/400 V a.c.	230 V/400 V a.c.
Maximum constant operating voltage	U_C	L-N		-	350 V a.c.
		L-PEN		350 V a.c.	-
		N-PE		-	350 V a.c.
Impulse current (10/350 µs)	I_{imp}	peak value I_{vrchol}	L-N	-	75 kA (25 kA / pole)
			L-PEN	75 kA (25 kA / pole)	-
			N-PE	-	100 kA
		charge Q		37.5 As	50 As
		specific energy W/R		1.4 MJ/Ω	2.5 MJ/Ω
Rated discharge current (8/20 µs)	I_n	L-N		-	25 kA / pole
		L-PEN		25 kA / pole	-
		N-PE		-	100 kA
Max. discharge current (8/20 µs)	I_{max}	L-N		-	40 kA / pole
		L-PEN		40 kA / pole	-
		N-PE		-	-
Rated frequency	f_n			50/60 Hz	50/60 Hz
Voltage protection level	U_p	L-N		-	≤ 1.5 kV
		L-PEN		≤ 1.5 kV	-
		N-PE		-	≤ 1.5 kV
Arrester classification		according to EN 61643-11		type 1 a type 2 T1+T2	type 1 a type 2 T1+T2
		according to IEC 61643-1		class I and class II	class I and class II
		according to VDE 0675-6		class B and class C	class B and class C
Response time		L-N		-	≤ 25 ns
		L-PEN		≤ 25 ns	-
		N-PE		-	≤ 100 ns
Quenching follow-current	I_{fi}	L-N		-	25 kA / 264 Va.c.
		L-PEN		25 kA / 264 V a.c.	-
		N-PE		-	0.1 kA
Max. backup fuse gG / gL		parallel connection (T)		315 A	315 A
		serial connection (V)		125 A	125 A
Degree of protection				IP20	IP20
Mounting on "U" rail according to EN 60715 – type				TH 35	TH 35
Connection					
Conductor - rigid (solid, stranded)				2.5 ÷ 35 mm²	2.5 ÷ 35 mm²
Conductor - flexible				2.5 ÷ 25 mm²	2.5 ÷ 25 mm²
Torque				4.5 Nm	4.5 Nm
Top or bottom connection				yes	yes
Optical signalling					
Functional state				green	green
Non-functional state				red	red
Remote signalling					
Arrangement of contacts [1]				001	001
Max. voltage / current	U_{max} / I_{max}			250 V a.c. / 1 A	250 V a.c. / 1A
				125 V d.c. / 0.2 A	125 V d.c. / 0.2 A
Min. switched power				0.12 VA (12 V; 10 mA)	0.12 VA (12 V; 10 mA)
Connection – Conductor (solid, flexible)				0.14 ÷ 1.5 mm²	0.14 ÷ 1.5 mm²
Torque				0.25 Nm	0.25 Nm
Operating conditions					
Ambient temperature				-40 ÷ 80 °C	-40 ÷ 80 °C
Working position				arbitrary	arbitrary

[1] Each digit indicates successively the number of make, break and break-make contacts

Product code	38361	38362
Weight	1.04 kg	1.43 kg
Package	1 pc	1 pc

CATALOGUE PART

			Varistor design TN-C	Varistor design TN-S,TT
T1 + T2 (B+C)				
Type			**SVBC-12,5-3-MZ** **SVBC-12,5-3-MZS**	**SVBC-12,5-3N-MZ** **SVBC-12,5-3N-MZS**
Standards			EN 61643-11 IEC 61643-1 VDE 0675-6	EN 61643-11 IEC 61643-1 VDE 0675-6
Approval marks			CE	CE
Rated voltage	U_N		230 V/400 V a.c.	230 V/400 V a.c.
Maximum constant operating voltage	U_C	L-N	-	335 V a.c.
		L-PEN	335 V a.c.	-
		N-PE	-	264 V a.c.
Impulse current (10/350 µs)	I_{imp}	peak value I_{vrchol} L-N	-	37.5 kA (12.5 kA / pole)
		L-PEN	37.5 kA (12.5 kA / pole)	-
		N-PE	-	50 kA
		charge Q	18.75 As	25 As
		specific energy W/R	352 kJ/Ω	625 kJ/Ω
Rated discharge current (8/20 µs)	I_n	L-N	-	12.5 kA / pole
		L-PEN	12.5 kA / pole	-
		N-PE	-	50 kA
Max. discharge current (8/20 µs)	I_{max}	L-N	-	50 kA / pole
		L-PEN	50 kA / pole	-
		N-PE	-	50 kA
Rated frequency	f_n		50/60 Hz	50/60 Hz
Voltage protection level	U_p	L-N	-	≤ 1.2 kV
		L-PE / L-PEN	- / ≤ 1.2 kV	≤ 2 kV / -
		N-PE	-	≤ 1.7 kV
Arrester classification		according to EN 61643-11	type 1 and type 2 $\boxed{T1}$+$\boxed{T2}$	type 1 and type 2 $\boxed{T1}$+$\boxed{T2}$
		according to IEC 61643-1	class I and class II	class I and class II
		according to VDE 0675-6	class B and class C	class B and class C
Response time		L-N	-	≤ 25 ns
		L-PEN	≤ 25 ns	-
		N-PE	-	≤ 100 ns
Max. backup fuse gG / gL		parallel connection (T)	160 A	160 A
		serial connection (V)	80 A	80 A
Degree of protection			IP20	IP20
Mounting on "U" rail according to EN 60715 – type			TH 35	TH 35
Connection				
Conductor - rigid (solid, stranded)			1.5 ÷ 35 mm²	1.5 ÷ 35 mm²
Conductor - flexible			1.5 ÷ 25 mm²	1.5 ÷ 25 mm²
Torque			4.5 Nm	4.5 Nm
Top or bottom connection			only bottom	only bottom
Optical signalling				
Functional state			green	green
Non-functional state			red	red
Remote signalling				
Arrangement of contacts [1]			001	001
Max. voltage / current	U_{max} / I_{max}		250 V a.c. / 1.5 A	250 V a.c. / 1.5 A
			30 V d.c. / 1.5 A	30 V d.c. / 1.5 A
Connection – Conductor (solid, flexible)			0.14 ÷ 1.5 mm²	0.14 ÷ 1.5 mm²
Torque			0.25 Nm	0.25 Nm
Operating conditions				
Ambient temperature			-40 ÷ 80 °C	-40 ÷ 80 °C
Working position			arbitrary	arbitrary

[1] Each digit indicates successively the number of make, break and break-make contacts

Product code	**40619** **40620**	**40621** **40622**
Weight	0.553 kg 0.56 kg	0.672 kg 0.681 kg
Package	1 pc	1 pc

CATALOGUE PART

T1 + T2 (B+C)

			Varistor design TN-S	Varistor design TN-C	Varistor design TN-S,TT
					
Type			**SVBC-12,5-4-MZ** **SVBC-12,5-4-MZS**	**SVBC-12,5-1-MZ**	**SVBC-12,5-1N-MZS**
Standards			EN 61643-11 IEC 61643-1 VDE 0675-6	EN 61643-11 IEC 61643-1 VDE 0675-6	EN 61643-11 IEC 61643-1 VDE 0675-6
Approval marks			CE	CE	CE
Rated voltage	U_N		230 V/400 V a.c.	230 V a.c.	230 V a.c.
Maximum constant operating voltage	U_c	L-N	-	-	335 V a.c.
		L-PE / L-PEN	335 V a.c. / -	- / 335 V a.c.	- / -
		N-PE	335 V a.c.	-	264 V a.c.
Impulse current (10/350 µs)	I_{imp}	peak value I_{vrchol} L-N	-	-	12.5 kA
		L-PE / L-PEN	37.5 kA (12.5 kA / pole)	- / 12.5 kA	- / -
		N-PE	12.5 kA	-	50 kA
		charge Q	25 As	6.25 As	12.5 As
		specific energy W/R	625 kJ/Ω	39 kJ/Ω	160 kJ/Ω
Rated discharge current (8/20 µs)	I_n	L-N	-	-	12.5 kA
		L-PE / L-PEN	12.5 kA / pole / -	- /12.5 kA	- / -
		N-PE	12.5 kA	-	50 kA
Max. discharge current (8/20 µs)	I_{max}	L-N	-	-	50 kA
		L-PE / L-PEN	50 kA / pole / -	- / 50 kA	-
		N-PE	50 kA	-	50 kA
Rated frequency	f_n		50/60 Hz	50/60 Hz	50/60 Hz
Voltage protection level	U_p	L-N	-	-	≤ 1.2 kV
		L-PE / L-PEN	≤ 1.2 kV / -	- / ≤ 1.2 kV	≤ 2 kV / -
		N-PE	≤ 1.2 kV	-	≤ 1.7 kV
Arrester classification		according to EN 61643-11	type 1 and type 2 T1+T2	type 1 and type 2 T1+T2	type 1 and type 2 T1+T2
		according to IEC 61643-1	class I and class II	class I and class II	class I and class II
		according to VDE 0675-6	class B and class C	class B and class C	class B and class C
Response time		L-N	-	-	≤ 25 ns
		L-PE / L-PEN	≤ 25 ns / -	- / ≤ 25 ns	- / -
		N-PE	≤ 25 ns	-	≤ 100 ns
Max. backup fuse gG / gL		parallel connection (T)	160 A	160 A	160 A
		serial connection (V)	80 A	80 A	80 A
Degree of protection			IP20	IP20	IP20
Mounting on "U" rail according to EN 60715 – type			TH 35	TH 35	TH 35
Connection					
Conductor - rigid (solid, stranded)			1.5 ÷ 35 mm²	1.5 ÷ 35 mm²	1.5 ÷ 35 mm²
Conductor - flexible			1.5 ÷ 25 mm²	1.5 ÷ 25 mm²	1.5 ÷ 25 mm²
Torque			4.5 Nm	4.5 Nm	4.5 Nm
Top or bottom connection			only bottom	only bottom	only bottom
Optical signalling					
Functional state			green	green	green
Non-functional state			red	red	red
Remote signalling					
Arrangement of contacts [1)]			001	001	001
Max. voltage / current	U_{max} / I_{max}		250 V a.c. / 1.5 A 30 V d.c. / 1.5 A	250 V a.c. / 1.5 A 30 V d.c. / 1.5 A	250 V a.c. / 1.5 A 30 V d.c. / 1.5 A
Connection – Conductor (solid, flexible)			0.14 ÷ 1.5 mm²	0.14 ÷ 1.5 mm²	0.14 ÷ 1.5 mm²
Torque			0.25 Nm	0.25 Nm	0.25 Nm
Operating conditions					
Ambient temperature			-40 ÷ 80 °C	-40 ÷ 80 °C	-40 ÷ 80 °C
Working position			arbitrary	arbitrary	arbitrary

[1)] Each digit indicates successively the number of make, break and break-make contacts

Product code	**40623** **40624**	**40615**	**40618**
Weight	0.749 kg 0.753 kg	0.158 kg	0.360 kg
Package	1 pc	1 pc	1 pc

CATALOGUE PART

6.3. Overvoltage protections type 2 (C)

			Standard design TN-C	Standard design TN-S, TT	Standard design TN-S
T2 (C)					
Type			**SVC-350-3-MZ** **SVC-350-3-MZS**	**SVC-350-3N-MZ** **SVC-350-3N-MZS**	**SVC-350-4-MZ** **SVC-350-4-MZS**
Standards			EN 61643-11 IEC 61643-1 VDE 0675-6	EN 61643-11 IEC 61643-1 VDE 0675-6	EN 61643-11 IEC 61643-1 VDE 0675-6
Approval marks					
Rated voltage	U_N		230 V/400 V a.c.	230 V/400 V a.c.	230 V/400 V a.c.
Maximum constant operating voltage	U_C	L-N	-	350 V a.c.	-
		L-PE / L-PEN	- / 350 V a.c.	- / -	350 V a.c. / -
		N-PE	-	264 V a.c.	350 V a.c.
Rated discharge current (8/20 µs)	I_n	L-N	-	20 kA / pole	-
		L-PE / L-PEN	- / 20 kA / pole	- / -	20 kA / pole/ -
		N-PE	-	20 kA	20 kA / pole
Max. discharge current (8/20 µs)	I_{max}	L-N	-	40 kA / pole	-
		L-PE / L-PEN	- / 40 kA / pole	- / -	40 kA / pole / -
		N-PE	-	40 kA	40 kA / pole
Rated frequency	f_n		50/60 Hz	50/60 Hz	50/60 Hz
Voltage protection level	U_p	L-N	-	≤ 1.4 kV	-
		L-PE / L-PEN	- / ≤ 1.4 kV	- / -	≤ 1.4 kV / -
		N-PE	-	≤ 1.5 kV	≤ 1.4 kV
Arrester classification		according to EN 61643-11	type 2 T2	type 2 T2	type 2 T2
		according to IEC 61643-1	class II	class II	class II
		according to VDE 0675-6	class C	class C	class C
Response time		L-N	-	≤ 25 ns	-
		L-PE / L-PEN	- / ≤ 25 ns	- / -	≤ 25 ns / -
		N-PE	-	≤ 100 ns	≤ 25 ns
Max. backup fuse gG / gL			125 A	125 A	125 A
Degree of protection			IP20	IP20	IP20
Mounting on "U" rail according to EN 60715 – type			TH 35	TH 35	TH 35
Connection					
Conductor - rigid (solid, stranded)			0.5 ÷ 35 mm²	0.5 ÷ 35 mm²	0.5 ÷ 35 mm²
Conductor - flexible			0.5 ÷ 25 mm²	0.5 ÷ 25 mm²	0.5 ÷ 25 mm²
Torque			4.5 Nm	4.5 Nm	4.5 Nm
Top or bottom connection			only bottom	only bottom	only bottom
Optical signalling					
Functional state			transparent	transparent	transparent
Non-functional state			red	red	red
Remote signalling					
Arrangement of contacts [1)]			001	001	001
Max. voltage / current	U_{max} / I_{max}		250 V a.c. / 1 A 125 V d.c. / 0.2 A	250 V a.c. / 1 A 125 V d.c. / 0.2 A	250 V a.c. / 1 A 125 V d.c. / 0.2 A
Min. switched power			0.12 VA (12 V. 10 mA)	0.12 VA (12 V. 10 mA)	0.12 VA (12 V. 10 mA)
Connection – Conductor (solid, flexible)			0.14 ÷ 1.5 mm²	0.14 ÷ 1.5 mm²	0.14 ÷ 1.5 mm²
Torque			0.25 Nm	0.25 Nm	0.25 Nm
Operating conditions					
Ambient temperature			-40 ÷ 80 °C	-40 ÷ 80 °C	-40 ÷ 80 °C
Working position			arbitrary	arbitrary	arbitrary

[1)] Each digit indicates successively the number of make, break and break-make contacts

Product code			38365 38366	38367 38368	40861 40862
Weight			0.393 kg 0.403 kg	0.433 kg 0.433 kg	0.433 kg 0.433 kg
Package			1 pc	1 pc	1 pc

CATALOGUE PART

T2 (C)

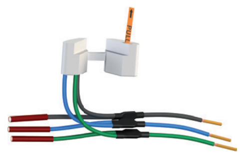
			Economical design		Special design	
						
Type			**SVC-275-1** **SVC-275-1-S**	**SVC-255-N-S**	**SVM-440-Z** **SVM-440-ZS**	**SVM-NPE-Z**
Approval marks			EN 61643-11	EN 61643-11	EN 61643-11	EN 61643-11
			IEC 61643-1	IEC 61643-1	IEC 61643-1	IEC 61643-1
			VDE 0675-6	VDE 0675-6	VDE 0675-6	VDE 0675-6
Approval marks			ESČ CE	ESČ CE	ESČ CE	ESČ CE
Rated voltage	U_N		230 V a.c.	230 V a.c.	400 V a.c.	230 V a.c.
Maximum constant operating voltage	U_C	L-N	275 V a.c.. 350 V d.c.	-	440 V a.c.. 585 V d.c	-
		L-PEN	275 V a.c.. 350 V d.c.	-	440 V a.c.. 585 V d.c	-
		N-PE	-	255 V a.c.	335 V a.c.	260 V a.c.
Rated discharge current (8/20 µs)	I_n	L-N	20 kA	-	20 kA	-
		L-PEN	20 kA	-	20 kA	-
		N-PE	-	30 kA	-	20 kA
Max. discharge current (8/20 µs)	I_{max}	L-N	40 kA	-	40 kA	-
		L-PEN	40 kA	-	40 kA	-
		N-PE	-	50 kA	-	40 kA
Rated frequency	f_n		50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz
Voltage protection level	U_p	L-N	≤ 1.35 kV	-	≤ 2.2 kV	-
		L-PEN	≤ 1.35 kV	-	≤ 2.2 kV	-
		N-PE	-	≤ 1.3 kV	-	≤ 1 kV
Arrester classification		according to EN 61643-11	type 2 T2	type 2 T2	type 2 T2	type 2 T2
		according to IEC 61643-1	class II	class II	class II	class II
		according to VDE 0675-6	class C	class C	class C	class C
Response time		L-N	≤ 25 ns	-	≤ 25 ns	-
		L-PEN	≤ 25 ns	-	≤ 25 ns	-
		N-PE	-	≤ 100 ns	-	≤ 100 ns
Max. backup fuse gG / gL			125 A	-	125 A	-
Degree of protection			IP20	IP20	IP20	IP20
Mounting on "U" rail according to EN 60715 – type			TH 35	TH 35	TH 35	TH 35
Connection						
Conductor rigid (solid, stranded)			0.5 ÷ 25 mm^2	0.5 ÷ 25 mm^2	0.5 ÷ 35 mm^2	0.5 ÷ 35 mm^2
Conductor flexible			0.5 ÷ 16 mm^2	0.5 ÷ 16 mm^2	0.5 ÷ 25 mm^2	0.5 ÷ 25 mm^2
Torque			2 Nm	2 Nm	4.5 Nm	4.5 Nm
Top or bottom connection			yes	yes	yes	yes
Optical signalling						
Functional state			green	green	transparent	transparent
Non-functional state			red	red	red	red
Remote signalling						
Arrangement of contacts [1]			001	001	001	-
Max. voltage / current	U_{max} / I_{max}		250 V a.c. / 1 A	250 V a.c. / 1 A	250 V a.c. / 1 A	-
			125 V d.c. / 0.2 A	125 V d.c. / 0.2 A	125 V d.c. / 0.2 A	-
Min. switched power			0.12 VA (12 V/ 10 mA)	0.12 VA (12 V/ 10 mA)	0.12 VA (12 V / 10 mA)	-
Connection – Conductor (solid, flexible)			0.14 ÷ 1.5 mm^2	0.14 ÷ 1.5 mm^2	0.14 ÷ 1.5 mm^2	-
Torque			0.25 Nm	0.25 Nm	0.25 Nm	-
Operating conditions						
Ambient temperature			-25 ÷ 45 °C	-25 ÷ 45 °C	-40 ÷ 85 °C	-40 ÷ 85 °C
Working position			arbitrary	arbitrary	arbitrary	arbitrary

[1] Each digit indicates successively the number of make, break and break-make contacts

Product code	**38842** **38843**	**38844**	**34720** **34721**	**34723**
Weight	0.095 kg 0.1 kg	0.1 kg	0.136 kg 0.143 kg	0.13 kg
Package	1 pc	1 pc	1 pc	1 pc

CATALOGUE PART

6.4. Overvoltage protections type 3 (D)

			Standard design 2-pole	Standard design 4-pole	Design for the installation with sockets in mounting boxes
T3 (D)					
Type			**SVD-253-1N-MZS**	**SVD-335-3N-MZS**	**SVD-335-1N-AS**
Standards			EN 61643-11 IEC 61643-1 VDE 0675-6	EN 61643-11 IEC 61643-1 VDE 0675-6	EN 61643-11 IEC 61643-1 VDE 0675-6
Approval marks			CE	CE	CE
Rated voltage	U_N		230 V a.c.	230 V/400 V a.c.	230 V a.c.
Maximum constant operating voltage	U_C	L-N	253 V a.c.	335 V a.c.	335 V a.c.
		N-PE	-	255 V a.c.	260 V a.c.
Rated discharge current (8/20 µs)	I_n	L-N	3 kA	1.5 kA / pól	1.5 kA
		L-PE	3 kA	1.5 kA	1.5 kA
		N-PE	-	1.5 kA	-
Max. discharge current (8/20 µs)	I_{max}	L-N	10 kA	4.5 kA	4.5 kA
		L-PE	10 kA	4.5 kA	4.5 KA
		N-PE	10 kA	10 kA	-
Rated loading current at 30 °C	I_L		26 A	26 A	16 A
Off -load voltage	U_{OC}		6 kV	4 kV	4 kV
Rated frequency	f_n		50/60 Hz	50/60 Hz	50/60 Hz
Voltage protection level	U_p	L-N	≤ 1.1 kV	≤ 1.2 kV	≤ 1.3 kV
		L-PE	≤ 1.5 kV	≤ 1.5 kV	≤ 1.5 kV
		N-PE	≤ 1.5 kV	≤ 1.5 kV	≤ 1.5 kV
Arrester classification		according to EN 61643-11	typ 3 T3	typ 3 T3	typ 3 T3
		according to IEC 61643-1	třída III	třída III	třída III
		according to VDE 0675-6	třída D	třída D	třída D
Response time		L-N	≤ 25 ns	≤ 25 ns	≤ 25 ns
		L-PE	≤ 100 ns	≤ 100 ns	≤ 100 ns
Max. backup circuit breaker (C) or fuse gG / gL			25 A	25 A	16 A
Degree of protection			IP20	IP20	IP40
Mounting on "U" rail according to EN 60715 – type			TH 35	TH 35	-
Other installation			-	-	into all types of mounting boxes
Connection					
Conductor - rigid (solid, stranded)			0.2 ÷ 4 mm²	0.2 ÷ 4 mm²	-
Conductor – flexible			0.2 ÷ 2.5 mm²	0.2 ÷ 2.5 mm²	part of the device including ferrules 1.5 mm²
Torque			0.8 Nm	0.8 Nm	-
Top or bottom connection			only bottom	only bottom	-
Visual / acoustic signalling					
Functional state			green green	green green	-
Non-functional state			red	red	acoustically
Remote signalling					
Arrangement of contacts [1]			01	01	-
Max. voltage / current	U_{max} / I_{max}		250 V a.c. / 3 A	250 V a.c. / 3 A	-
			50 V d.c. / 3 A	50 V d.c. / 3 A	-
Connection – Conductor (solid, flexible)			0.2 ÷ 4 mm²	0.2 ÷ 4 mm²	-
Torque			0.8 Nm	0.8 Nm	-
Operating conditions					
Ambient temperature			-40 ÷ 80 °C	-40 ÷ 80 °C	-25 ÷ 75 °C
Working position			arbitrary	arbitrary	arbitrary

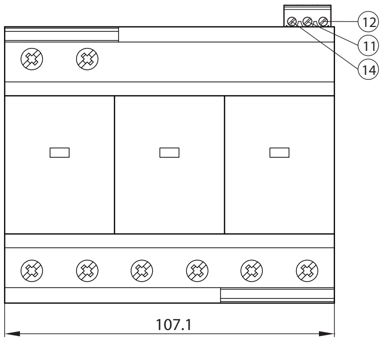
[1] Each digit indicates successively the number of make, break and break-make contacts

Product code	**38371**	**38372**	**39164**
Weight	0.081 kg	0.129 kg	0.0413 kg
Package	1 pc	1 pc	1 pc

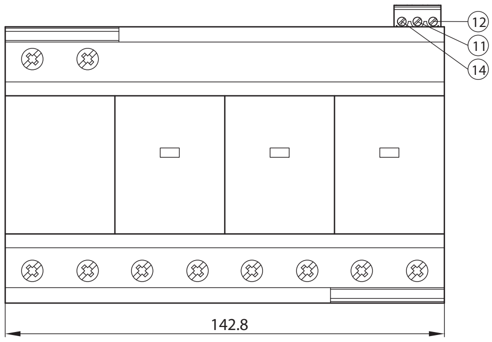
CATALOGUE PART

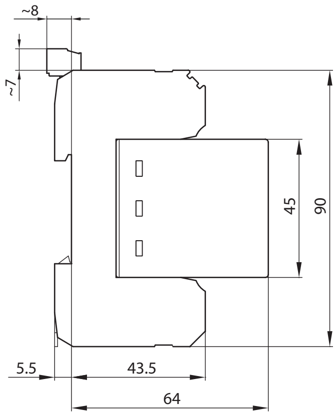
6.5. Dimensions

SJB-25E-3-MZS



SJB-25E-3N-MZS





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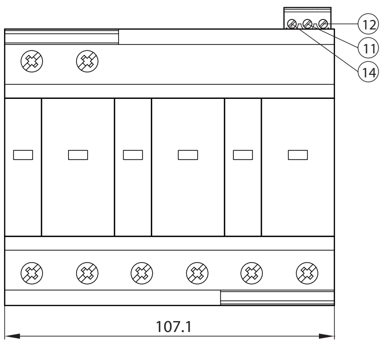

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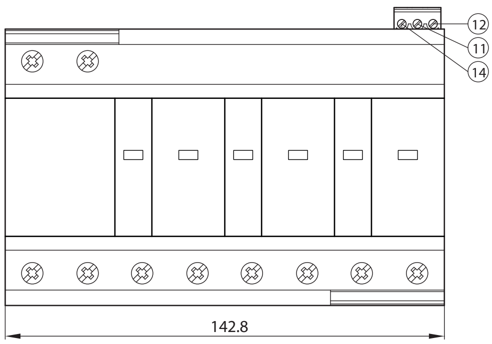
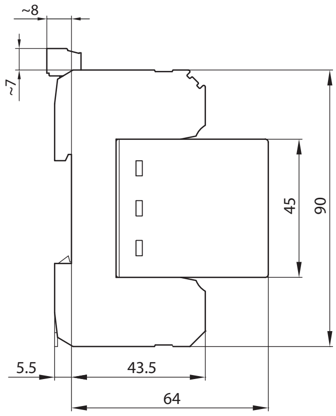
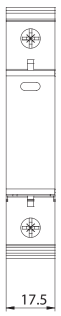




SVBC-12,5-1-MZ



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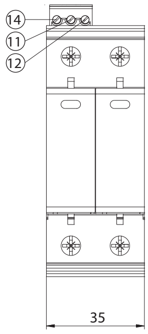

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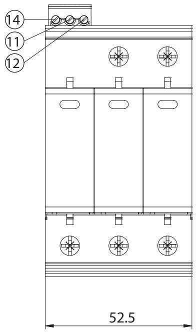
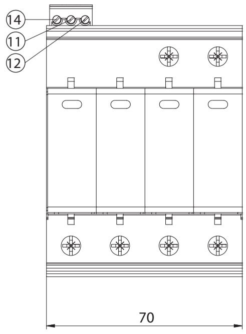
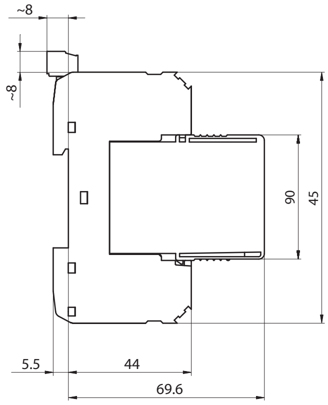
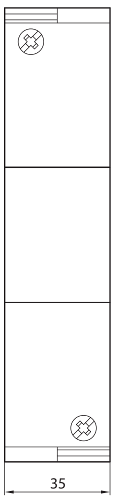


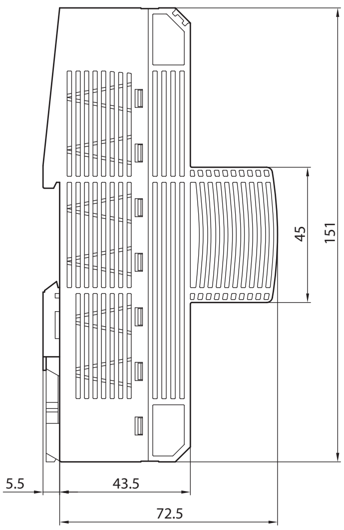
SVBC-12,5-3N-MZ(S)
SVBC-12,5-4-MZ(S)





SJBplus-50-2,5





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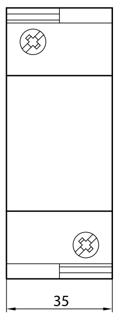
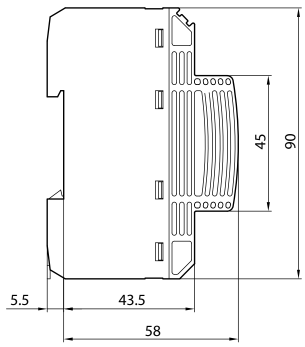
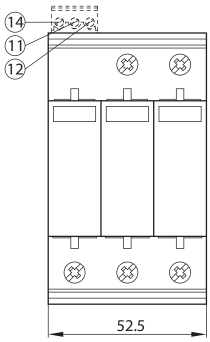




CATALOGUE PART

SVC-350-3-MZ(S)



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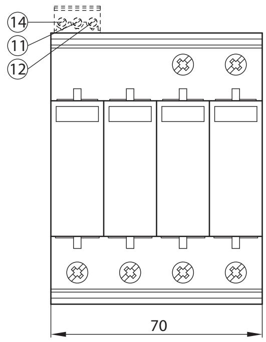
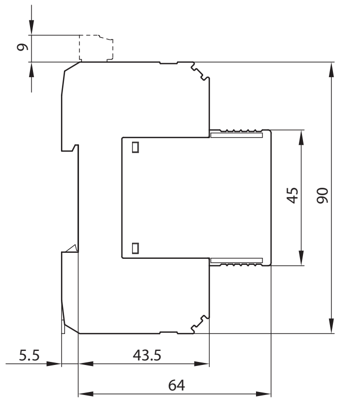
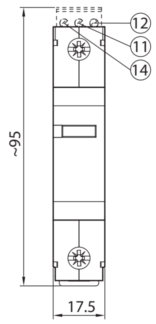
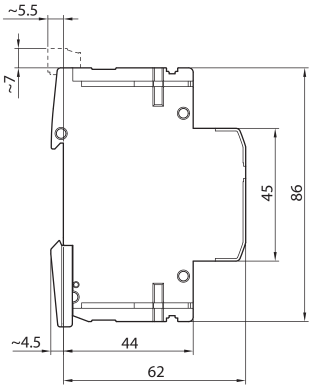
SVC-350-4-MZ(S)





SVC-275-...
SVC-255-...





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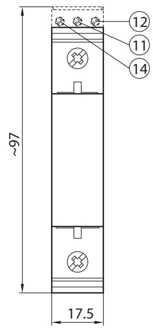

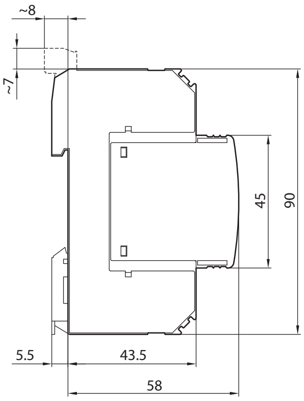

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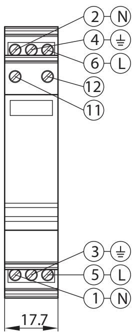

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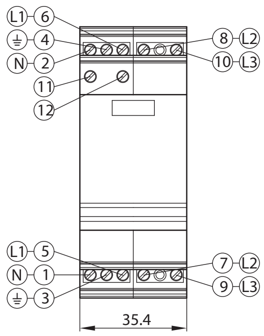
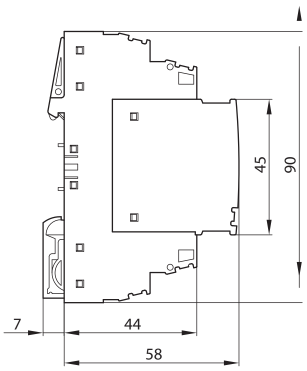
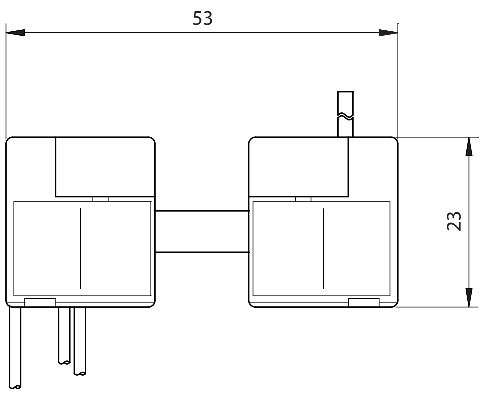




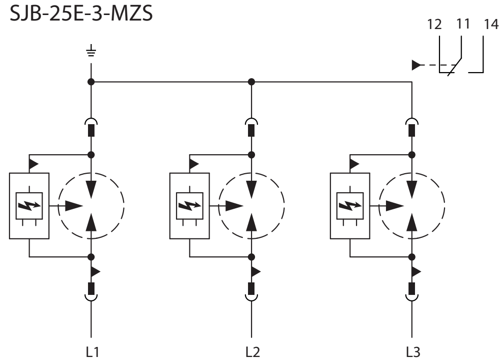
SVD-335-1N-AS



CATALOGUE PART

6.6. Internal connection

SJB-25E-3-MZS



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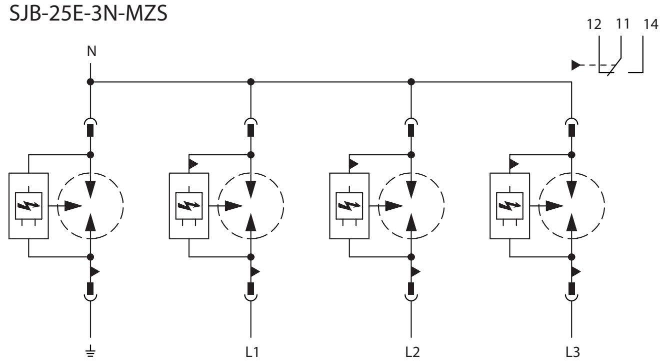

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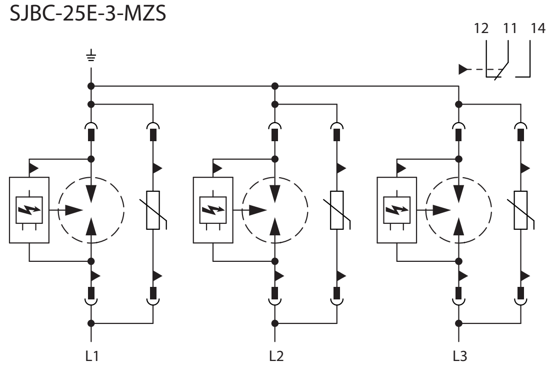

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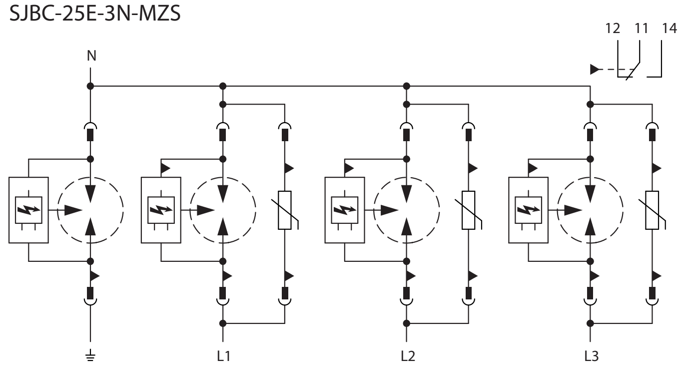
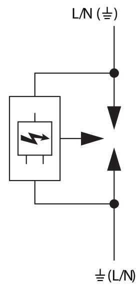
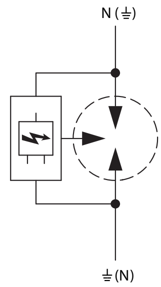


SJBplus-50-2,5



SJB-NPE-1,5



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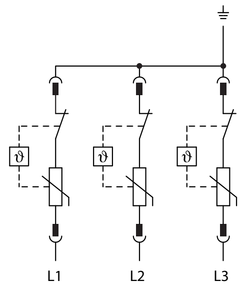

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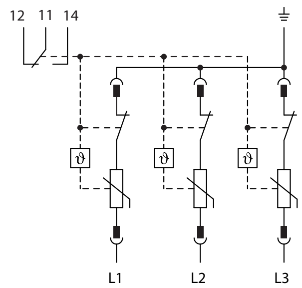

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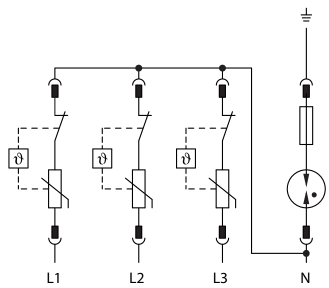

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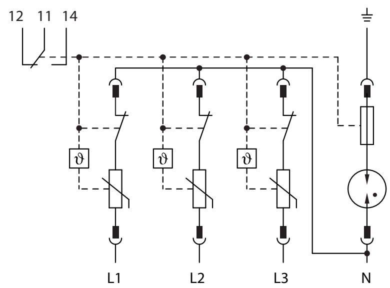
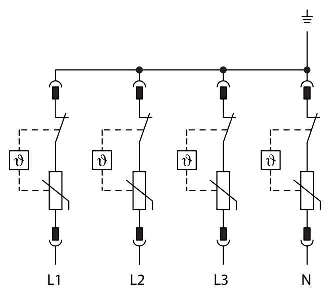


SVBC-12,5-4-MZ



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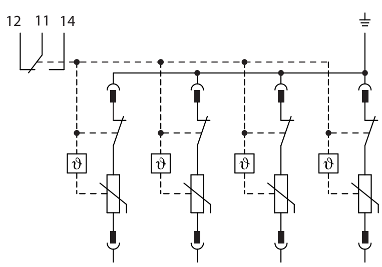
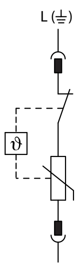
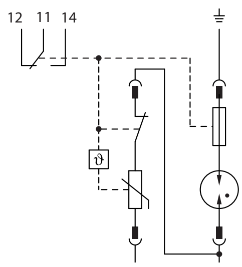


SVBC-12,5-1-MZ

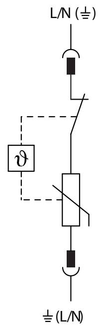


SVBC-12,5-1N-MZS

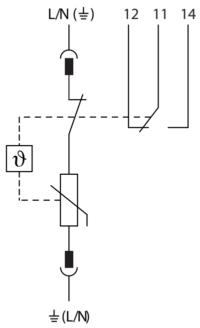


CATALOGUE PART

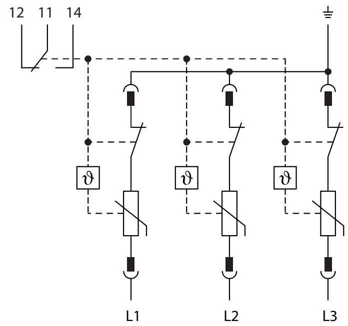
SVM-440-Z



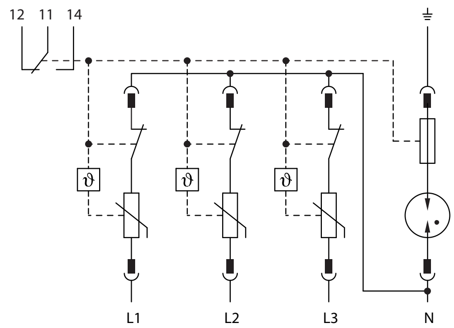
SVM-440-ZS



SVC-350-3-MZ(S)



SVC-350-3N-MZ(S)



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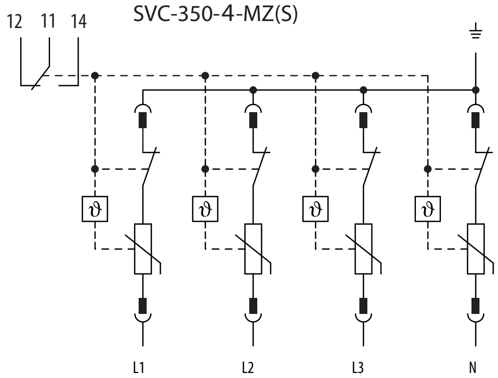
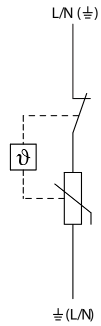


SVC-275-1



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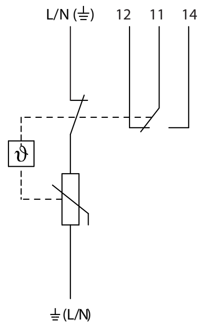

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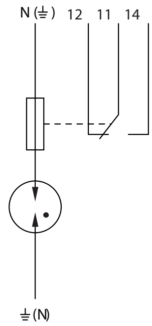

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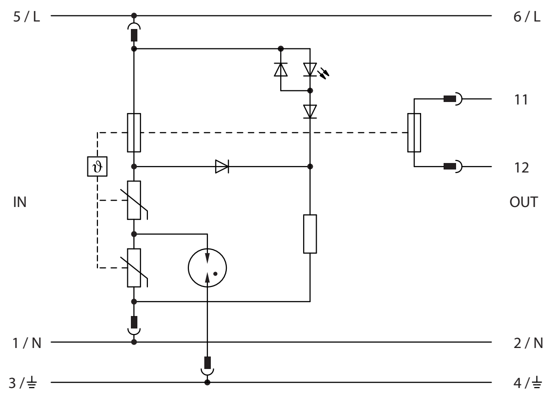

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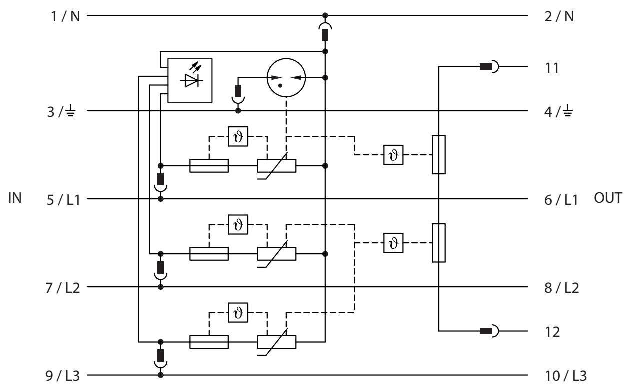
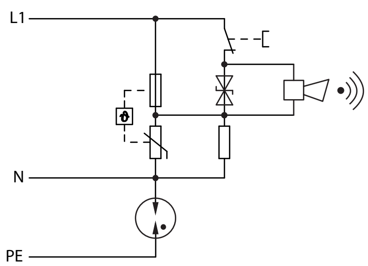


SVD-335-1N-AS



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