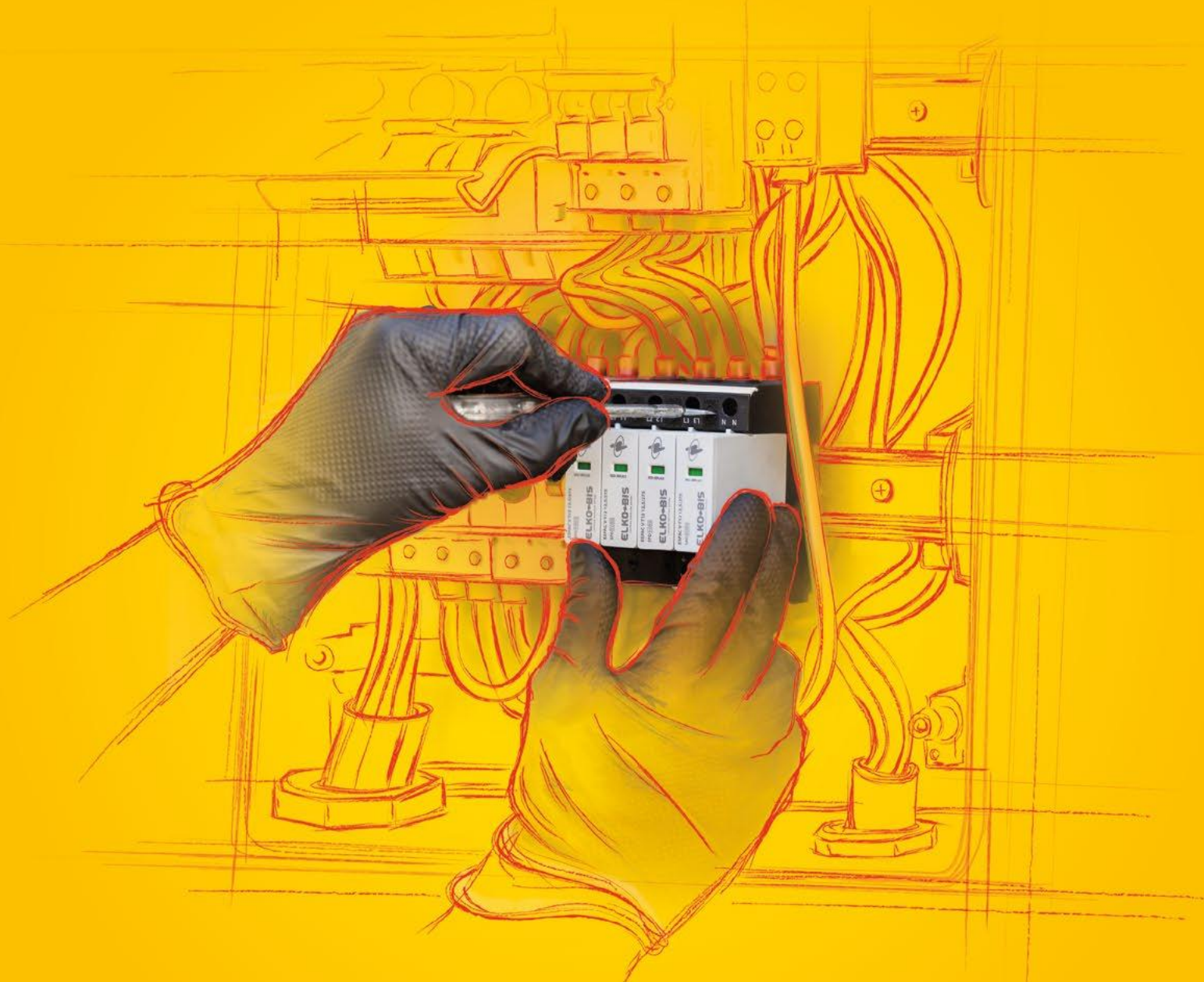


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ELKO-BIS

LIGHTNING PROTECTION SYSTEMS

INTERNAL AND EXTERNAL
LIGHTNING PROTECTION

INSTALLER'S GUIDE

SURGE PROTECTIVE DEVICES

www.elkobis.com

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1. Introduction

Over the past decades, there has been a significant increase in demand for electricity, accompanied by a systematic increase in the number of electrical and electronic devices.

Modern equipment is becoming increasingly complex, and its operation relies on expensive and extremely sensitive components.

Such systems are strongly affected by lightning discharges, which are a direct source of overvoltages that often lead to damage to cables and sensitive integrated circuits.

The internal circuits of modern devices draw small amounts of power, making them particularly susceptible to electromagnetic interference, including lightning electromagnetic pulses (LEMP). LEMP is caused by the flow of lightning current during a lightning discharge and can disrupt and damage electrical, electronic, telecommunications, and computer networks even at considerable distances from the point of impact.

Additional threats include potential differences of several thousand volts, surge currents of varying parameters, and follow currents. To limit the effects of surges in residential, industrial, commercial, office, public, and other building installations, modular surge protective devices are used.

SPDs protect the installation against transient overvoltages caused by lightning strikes and by switching operations, known as switching overvoltages.

Surge protective devices can operate in both AC and DC systems. According to current standards and regulations, those are a mandatory element of protection in buildings electrical installations.

This guide covers a comprehensive overview of the construction, selection, and use of ELKO-BIS surge protective devices and will be regularly updated as this product group expands.



2. Overvoltages

2.1 Types of overvoltages

The basic classification of surges is based on their duration:

A. Transient overvoltages – short-term voltage changes: short-duration overvoltages, not exceeding a few thousandths of a second (microseconds), oscillating or non-oscillating, usually strongly damped – such overvoltages can be effectively eliminated by using surge arresters.

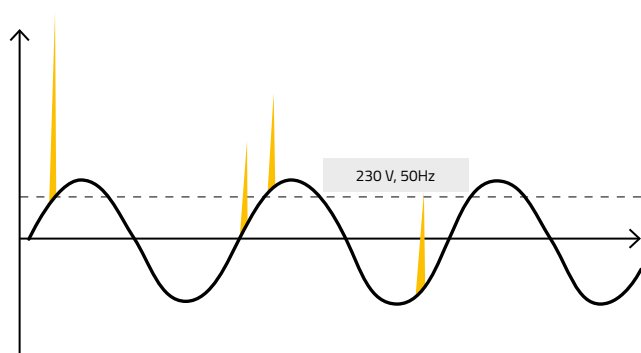


Fig. 2.1 - A.
Transient overvoltages

B. Temporary Overvoltages – Long-term voltage changes: Overvoltages with a relatively long duration (in milliseconds). Such overvoltages cannot be eliminated using modular surge protective device.

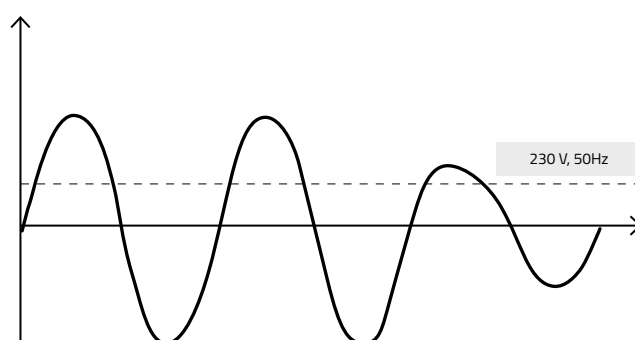
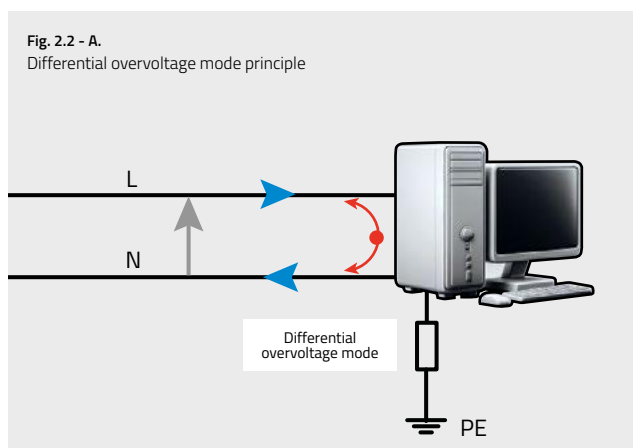


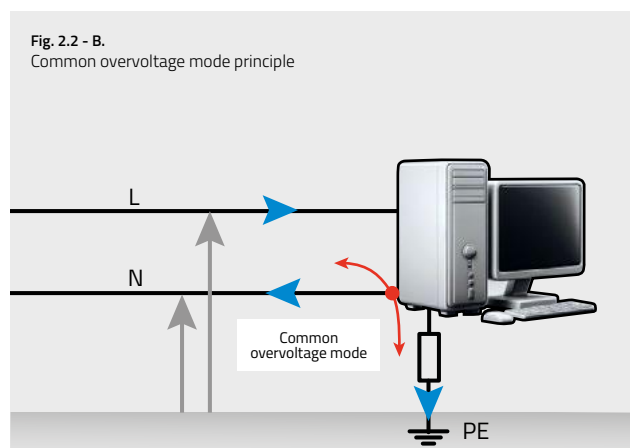
Fig. 2.1 - B.
Temporary Overvoltages

Short-term voltage changes - transient overvoltages - can be divided into two groups based on their origin:

A. Differential overvoltage mode: overvoltage between live conductors (phase conductors L1-L2, phase conductor and neutral conductor L-N). Such overvoltage occurs as a result of technological events – for example, switching non-linear loads (motors, refrigerators). They are particularly dangerous for electronic devices, sensitive control systems, and computers.



B. Common overvoltage mode: overvoltage between the phase conductor and the protective conductor or the neutral conductor and the grounding conductor (L-PE, N-PE), which is caused by atmospheric phenomena such as lightning strikes. Such overvoltages are particularly dangerous for technological devices where housing is grounded (insulation breakdown).



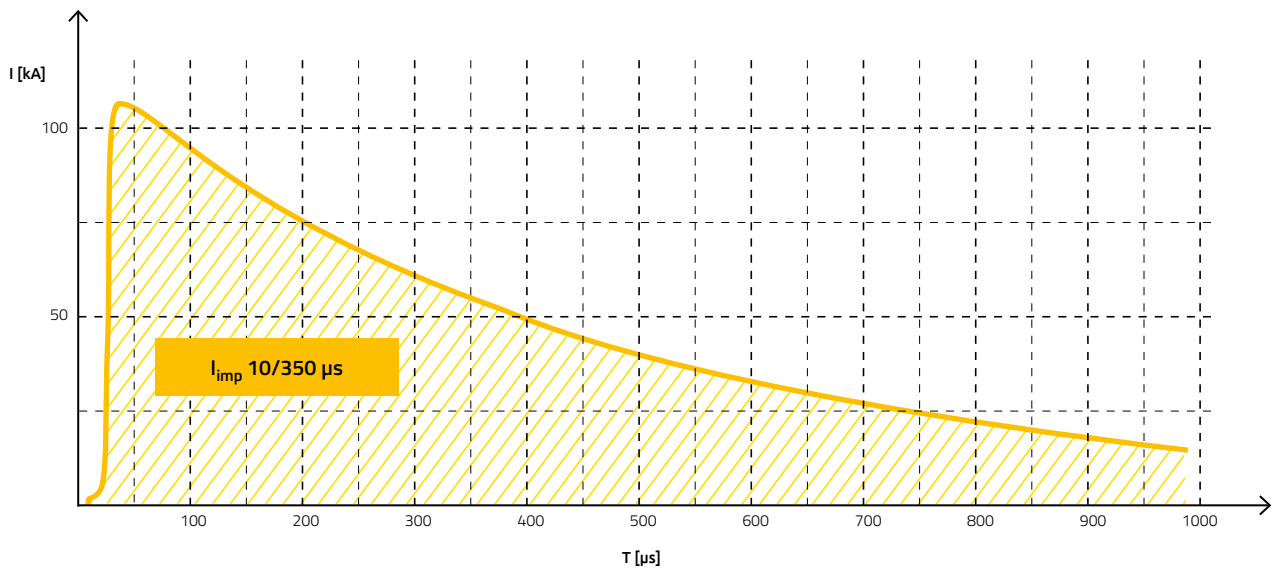


Fig. 2.3

The 10/350 μs test impulse simulates a lightning strike and Type 1 and Type 1 + Type 2 combined surge arresters are tested according to it.

Protection of electrical and electronic devices against overvoltages

The operating principle of surge protection devices is based on potential equalization. This is possible thanks to a properly installed grounding system throughout the entire building.

If the building is equipped with external lightning protection (LPS), both the downconductor and the protective conductor of the mains supply should be connected to the grounding conductor.

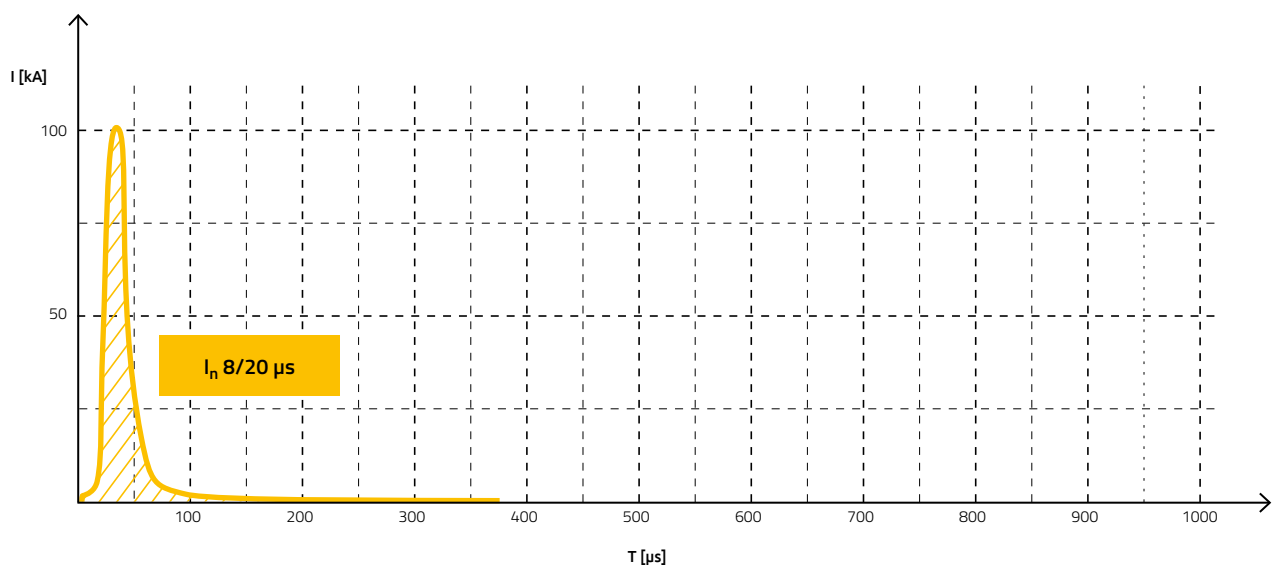


Fig. 2.4

Test impulse with an 8/20 μs waveform simulates a switching overvoltage or inductive coupling. This impulse is used to classify surge arresters as a Class II test (Type 2 SPD).

2.2. Power supply networks – basic principles of connecting surge protective devices

Surge protective devices in power supply networks are found in two connection types – x+0 configuration (CT1 connection type) and x+1 configuration (CT2 connection type). The CT1 connection type is designated as 3+0 (TN-C) or 4+0 (TN-S) configuration for three-phase power supply and 1+0 (TN-C) or 2+0 (TN-S) configuration for single-phase power supply. This connection type is beneficial

in eliminating surges in common mode. The CT2 connection type is designated as a 3+1 configuration for three-phase power supply and a 1+1 configuration for single-phase power supply. Surge protective device with a 3+1 configuration cannot be used in an electrical installation with a TN-C network system. It is advantageous to use it to eliminate overvoltage in differential mode.

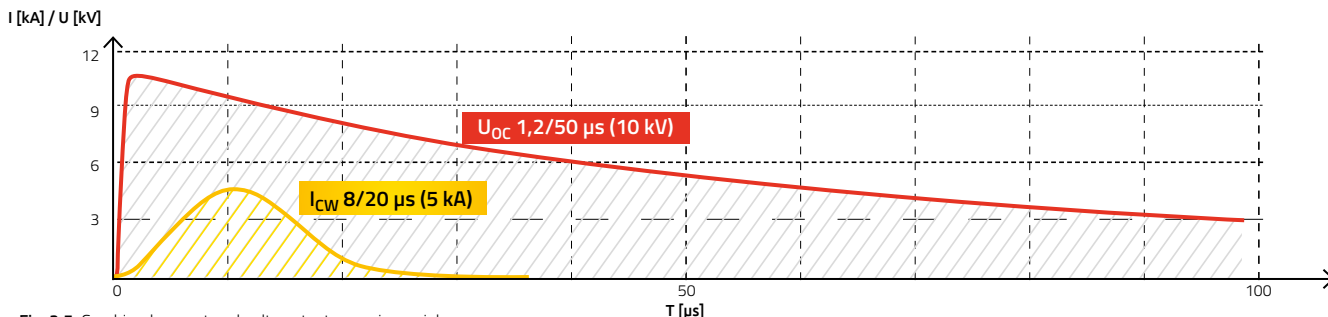


Fig. 2.5. Combined current and voltage test surge is crucial for testing Type 3 surge protective devices.

TN-S network system

A Type 1 surge protective device or a combined Type 1 and Type 2 surge protective device should be placed on the power supply side (usually in the main distribution board of the building). These surge arresters are primarily designed to limit currents and voltages induced by electromagnetic impulses from lightning (direct and indirect lightning strikes). Type 2 surge arresters should be placed in a sub-distribution board as part of a cascade protection system. It is possible for a Type 2 SPD to act as the main surge protection, but only if the power supply line is a cable line and the building is not equipped with a lightning protection device (without an LPS). In electrical installations, a Type 2 surge arrester can be connected as an x+0 configuration (to eliminate lightning impulses) or an x+1 configuration (to limit surges affecting electronic devices). The CT1 connection type is designated as a 3+0 (TN-C) or 4+0 (TN-S) configuration for three-phase power supplies

and a 1+0 (TN-C) or 2+0 (TN-S) configuration for single-phase power supplies. This connection type is beneficial in eliminating surges (e.g., lightning impulse energy comparison of 10/350 μ s (Type 1) and 8/20 μ s (Type 2)). In a TN-S network, the connection of a Type 2 SPD must be compatible with the type of overvoltages that will most frequently occur in the electrical installation under consideration. Therefore, in industrial plants, where a large number of switching overvoltages occur, it is more advantageous to install a Type 2 SPD with an x+1 (CT2) configuration, while in administrative and residential buildings, it is more advantageous to connect a Type 2 SPD with an x+0 (CT1) configuration.

A Type 3 surge protective device must always be installed near the sensitive electronic devices it is intended to protect (at a maximum distance of 10 m from the receiver).

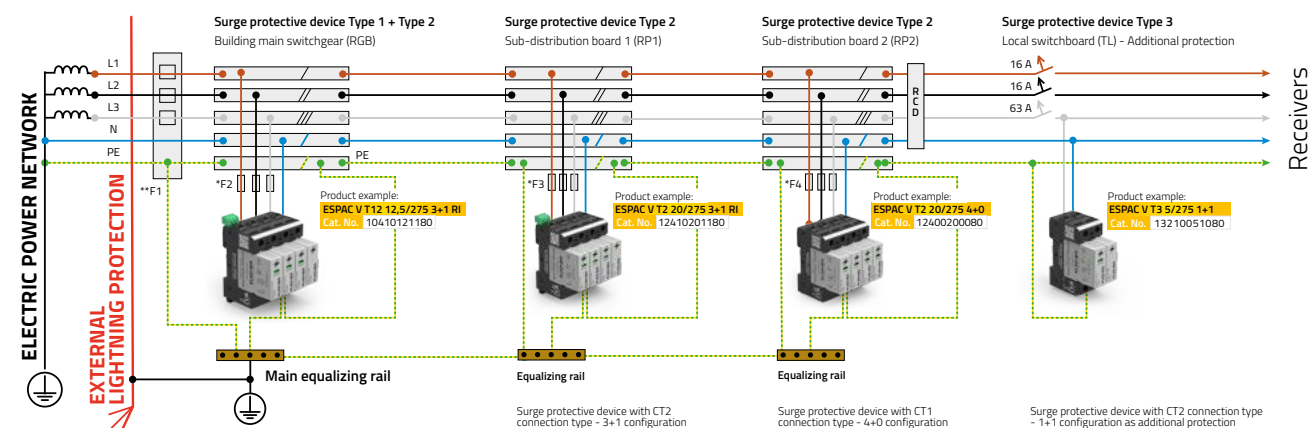
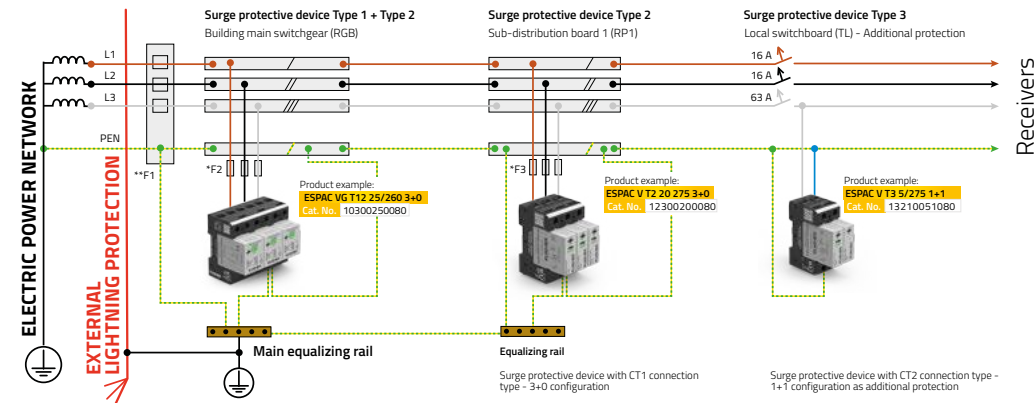


Fig. 2.5.1 Example selection of surge protective devices in a TN-S network system.

TN-C network system

In a TN-C power supply network, surge protective devices that can be connected are those with an x+0 configuration (CT1). In the case of Type 3 SPDs with a 1+1 config-

uration (CT2), the N (neutral) terminal and the PE (protective) terminal should always be connected to the PEN conductor.



2.5.2 Example selection of surge protective devices in a TN-C network system.

TN-C-S network system

In a TN-C-S power supply network, surge protective devices located upstream of the distribution point where the PEN conductor splits into N and PE conductors should always be connected as x+0. Downstream of the distri-

bution point, a Type 2 surge arrester can be connected as either x+1 or x+0, following the same principle as in a TN-S network.

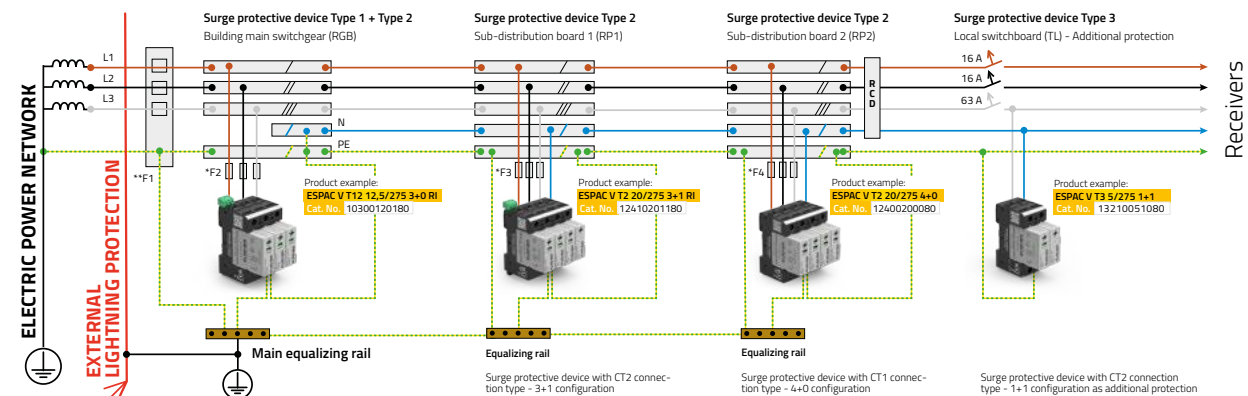
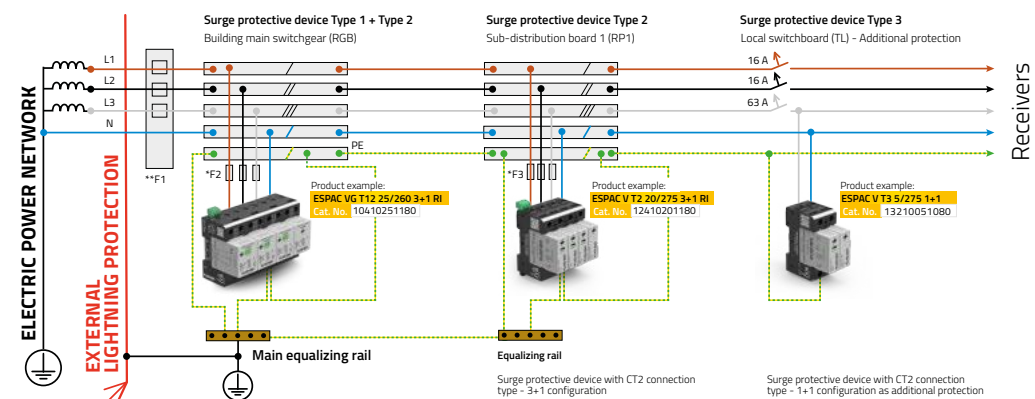


Fig. 2.5.3 Example selection of surge protective devices in a TN-C-S network system.

TT network system

In the case of a TT network configuration, where only the L1, L2, L3, and N conductors are connected from the

power source, all surge protective devices should always be connected as x+1 (CT2) configurations.



2.5.4 Example selection of surge protective devices in a TT network system.

2.3 Principles of applying short-circuit protection (back-up protection) for surge protective devices.

The surge protective device should be backed up using the main short-circuit protection of the electrical installation (if possible). Another option is to use dedicated short-circuit protection for the SPD. Dedicated short-circuit protection for the SPD will not disconnect the entire electrical installation, but only the surge arrester circuit.

The short-circuit protection values for each surge protective device are specified by the manufacturer and are available in the technical documentation for each device. Short-circuit protection for the surge arresters should be selected as shown in Fig. 2.6 below.

Parallel connection

Series connection „V“

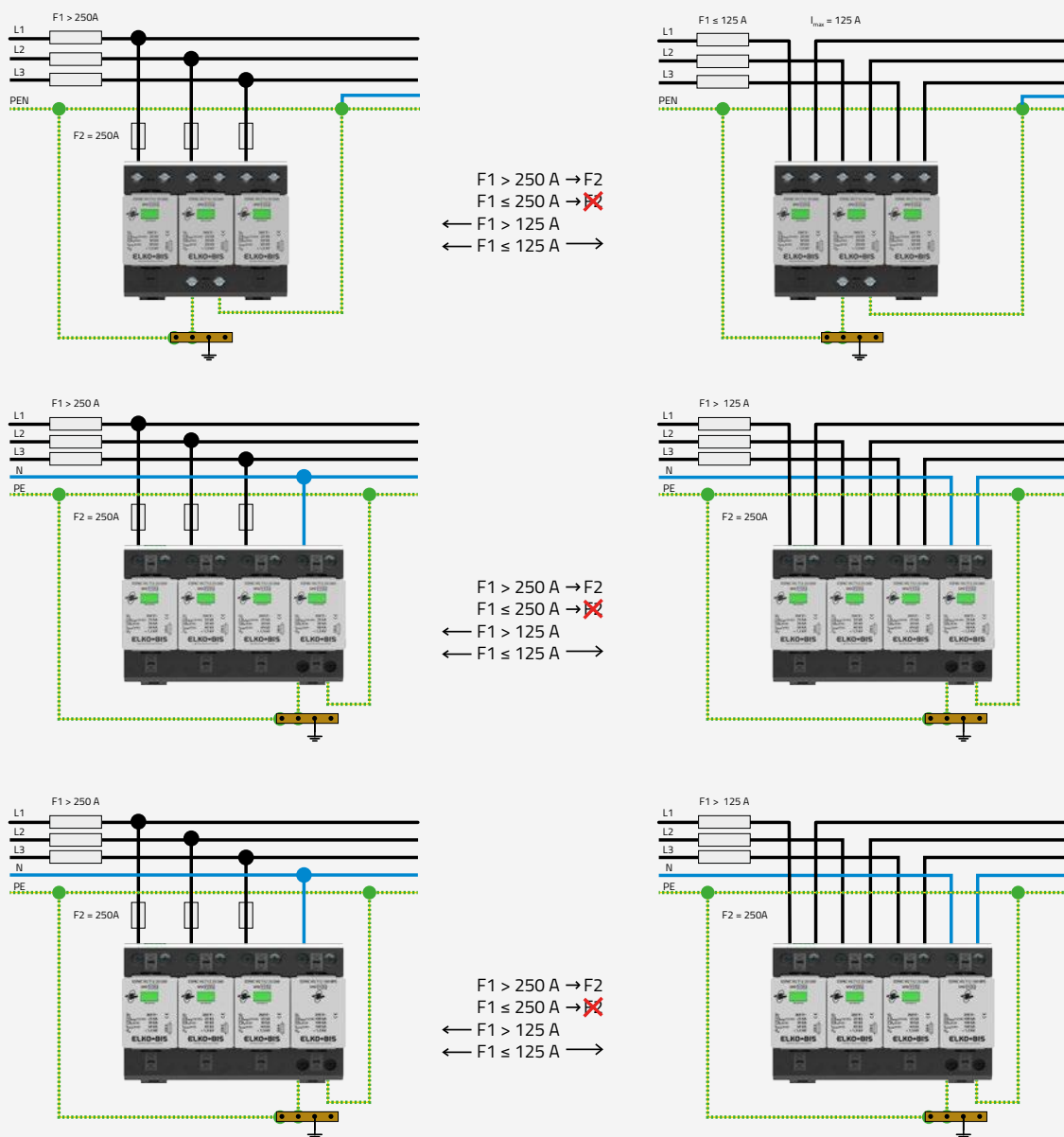
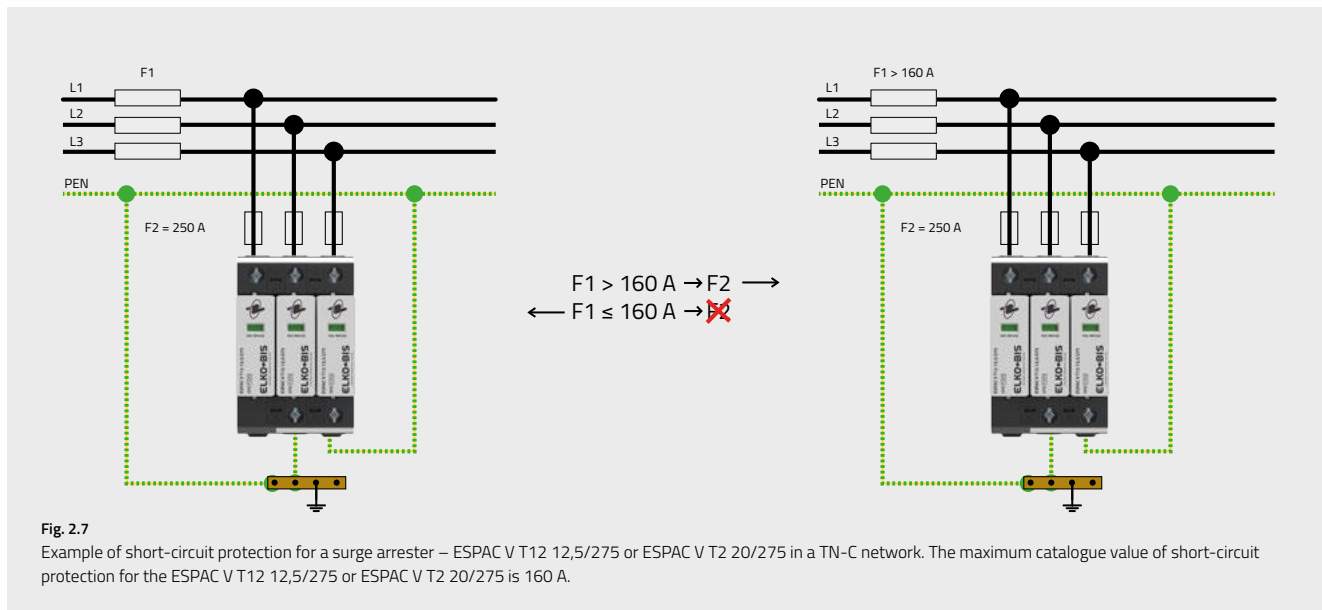


Fig. 2.6

Example of short-circuit protection for an SPD – ESPAC VG T12 25/260 – in various power supply networks. The maximum catalogue value of short-circuit protection for the ESPAC VG T12 25/260 is 250 A, and for the „V“ connection, 125 A.



3. Technical parameters dimensioning of surge protective devices

Only Type 1 surge protective devices should be dimensioned. Dimensioning of Type 1 surge protective devices should be based on the calculation of the lightning protection level (LPL) for the lightning protection system (LPS).

The table below shows the minimum lightning current values, taking into account the building's lightning protection class (LPL), for Type 1 SPDs.

Table 3.1 Minimum lightning current values, taking into account the building's lightning protection class (LPL) for SPD Type 1.

If the LPL class is unknown, assume a worst-case scenario.			Low voltage network										
LPL	Maximum lightning current corresponding to the LPL class	Number of conductors (n)	TT			TN-C	TN-S			IT without N		IT with N	
			Connection type				Connection type			Connection type			
			CT1	CT2			CT1	CT2		CT1		CT2	
			L-PE N-PE	L-N	N-PE	L-PEN	L-PE N-PE	L-N	N-PE	L-PE		L-N	N-PE
I or unknown	200 kA		I _{imp} (kA)										
		5	N/A	N/A	N/A	N/A	20,0	20,0	80,0	N/A		N/A	N/A
		4	25,0	25,0	100,0	25,0	N/A	N/A	N/A	N/A		25,0	100,0
		3	N/A	N/A	N/A	N/A	33,3	33,3	66,7	33,3		N/A	N/A
		2	50,0	50,0	100,0	50,0	N/A	N/A	N/A	N/A		50,0	100,0
II	150 kA		I _{imp} (kA)										
		5	N/A	N/A	N/A	N/A	15,0	15,0	60,0	N/A		N/A	N/A
		4	18,8	18,8	75,0	18,8	N/A	N/A	N/A	N/A		18,8	75,0
		3	N/A	N/A	N/A	N/A	25,0	25,0	50,0	25,0		N/A	N/A
		2	37,5	37,5	75,0	37,5	N/A	N/A	N/A	N/A		37,5	75,0
III or IV	100 kA		I _{imp} (kA)										
		5	N/A	N/A	N/A	N/A	10,0	10,0	40,0	N/A		N/A	N/A
		4	12,5	12,5	50,0	12,5	N/A	N/A	N/A	N/A		12,5	50,0
		3	N/A	N/A	N/A	N/A	16,7	16,7	33,3	16,7		N/A	N/A
		2	25,0	25,0	50,0	25,0	N/A	N/A	N/A	N/A		25,0	50,0

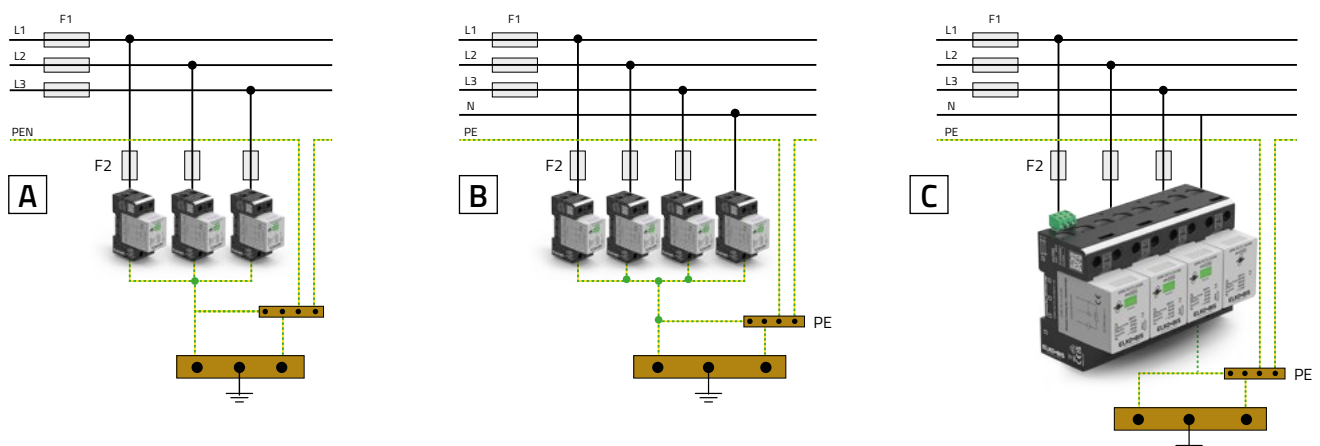


Fig. 3.1

Possible methods of connecting surge protective devices in various electrical installations: A. 3 x ESPAC VG T12 25/260 1+0 arrester (TN-C network system); B. 4 x ESPAC VG T12 25/260 1+0 arrester (TN-S network system); C. ESPAC VG T12 25/260 4+0 arrester (TN-S network system).

4. Selection of surge protective devices for various construction projects

Type 1 surge protective devices can be selected using the table in the previous section (see Table 4.1). It is also necessary to consider the specific situation, review the risk analysis performed, or verify the conditions for

a given building – the power line configuration, the presence of a lightning protection system on the building, and the intended use of the protected structure.

Table 4.1 below presents variants of surge protective devices applications in buildings:

CONDITIONS:	SPD USED	
A house with a lightning protection system (LPS), a grounded antenna, or a metal roof	SPD Type 1 ✓	SPD Type 2 ✗
House with overhead power line	SPD Type 1 ✓	SPD Type 2 ✗
A house with grounded metal parts or a lightning protection system (LPS) nearby	SPD Type 1 ✓	SPD Type 2 ✗

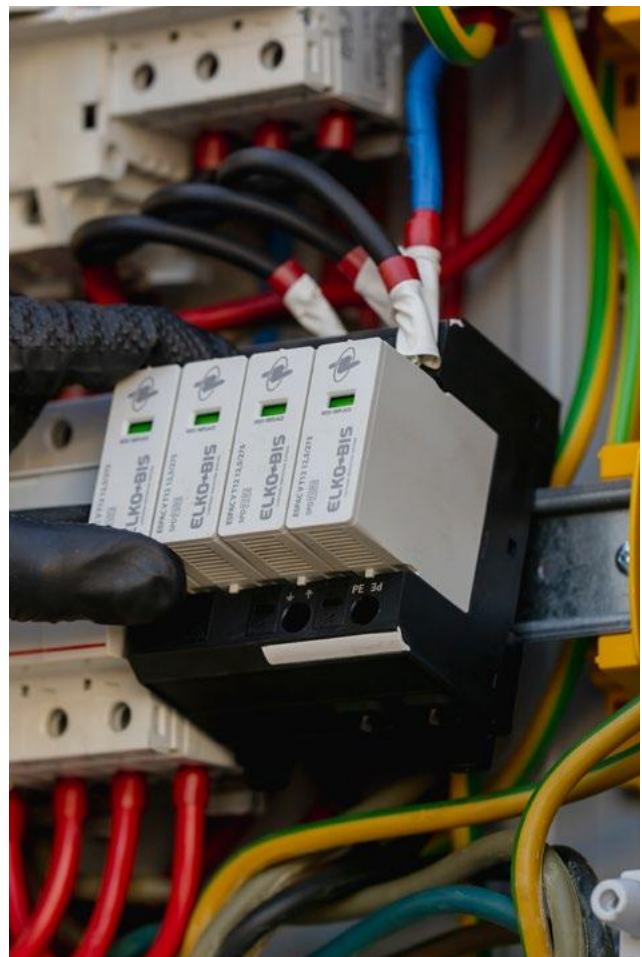
4.1 Selection of surge arresters in AC electrical installations

Surge protective devices should definitely be used when the building is equipped with a lightning protection system (LPS). In such cases, Type 1 or combined Type 1 + Type 2 surge arresters with a specific I_{imp} value according to the PKN-CLC/TS 61643-12:2007 standard should always be used. This is presented in detail in Table 4.2 below.

Table 4.2

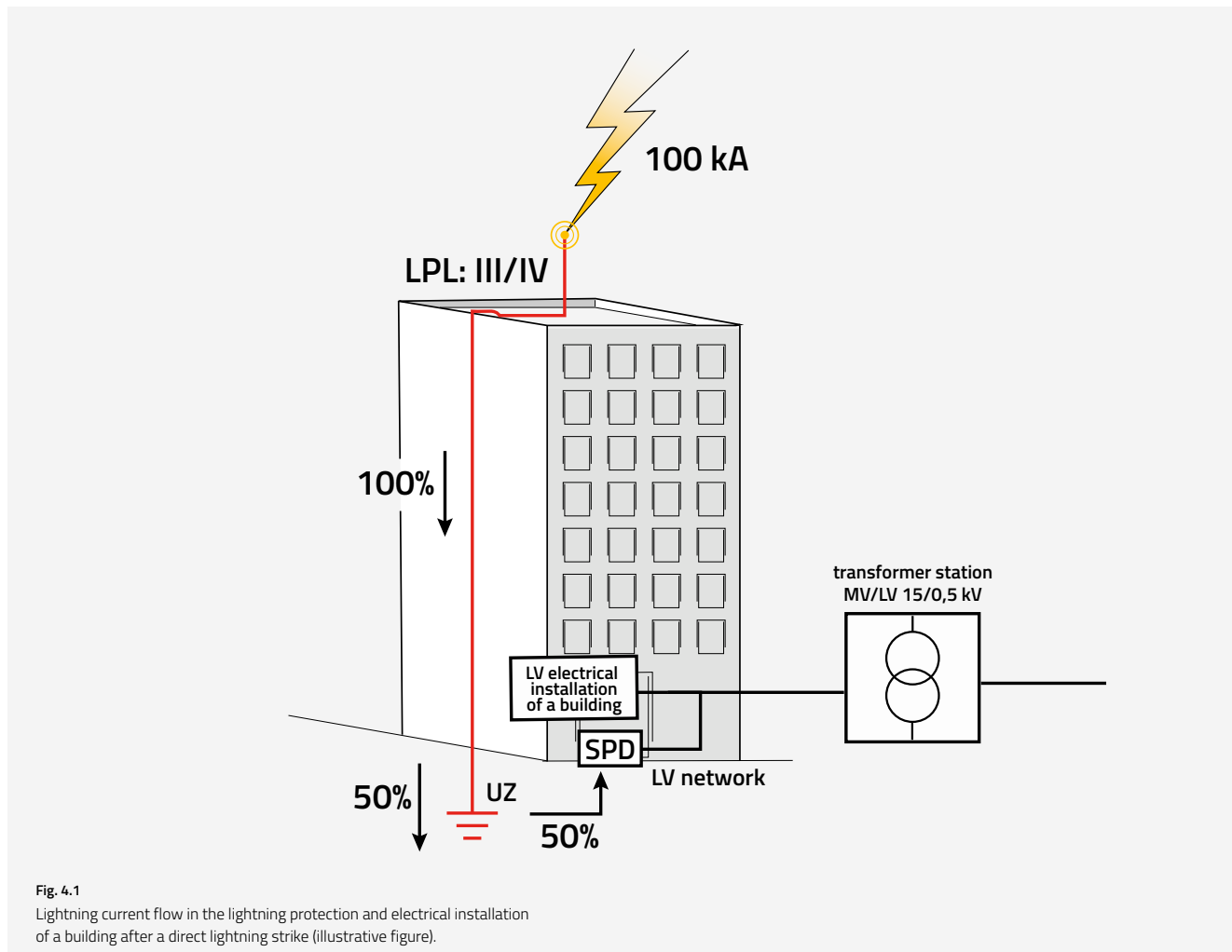
The need to use Type 1 surge arresters with different values of the lightning discharge current (surge current) I_{imp} , depending on the class of the lightning protection system the building is equipped with.

LPS I	
Maximum discharge current 200 kA	Requires a T1+T2 integrated or T1 SPD with a lightning discharge current rating of 200 kA and 25 kA/pole.
LPS II	
Maximum discharge current 150 kA	Requires a T1+T2 integrated or T1 SPD with a lightning discharge current rating of 150 kA and 18,5 kA/pole.
LPS III, IV	
Maximum discharge current 100 kA	Requires a T1+T2 integrated or T1 SPD with a lightning discharge current rating of 100 kA and 12,5 kA/pole.



Before presenting specific scenarios for selecting surge protective devices, it is worth analyzing the lightning current flow in the lightning protection and electrical installations of a building following a direct lightning

strike. To better understand this mechanism, it is illustrated in Figure 4.1 below.



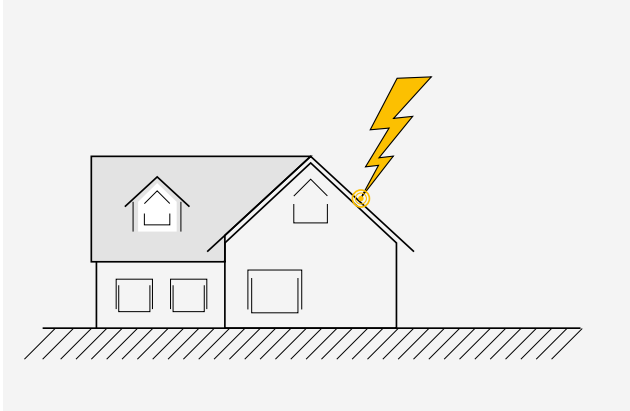
Looking at Figure 4.1 above, one can see a building equipped with a Class III or IV lightning protection system. The low-voltage electrical installation of this building is equipped with a surge protective device (SPD) and is powered by a 15/0.4 kV MV/LV transformer station. Assuming that lightning strikes directly at the lightning protection mast, causing a current of 100 kA, 100% of this current flows through the lightning conductors to the electrical installation and the UZ grounding electrode. Figure 4.1 graphically depicts only one air terminal; in reality, the building is equipped with at least two air terminals – the figure is illustrative. A hypothetical split of the lightning current occurs – it is assumed that 50% (50 kA) will flow to the UZ grounding electrode and 50% to the LV electrical installation. Current flowing to the earthing electrode is grounded, while current flowing into the LV electrical installation requires further discussion.

Assuming the building in question is equipped with an electrical installation with a TN-S network configuration. In this configuration, five conductors can be identified: L1, L2, L3, N, and PE. L1, L2, and L3 are the line (phase) conductors, N is the neutral conductor, and PE is the protective earth conductor. When a lightning current of 50 kA enters the electrical installation, it will hypothetically be divided into four active conductors (L1, L2, L3, and N; the PE conductor is not an active conductor). Each active conductor will have a hypothetical current of 12,5 kA. The conclusion is quite predictable – in this installation, a Type 1 or integrated Type 1 + Type 2 surge arrester with a discharge current I_{imp} of 12,5 kA/pole should be used to protect the electrical installation against the negative effects of a lightning strike. For lightning protection systems of other classes (I or II), the hypothetical mechanism for lightning current distribution is analogous.

There are several cases in which it is necessary to use an appropriate type of surge protective device with precisely defined technical parameters, depending on whether

the facility is equipped with an LPS lightning protection system. These situations are presented below, along with guidelines on which devices to use:

Risk of direct impact on building:



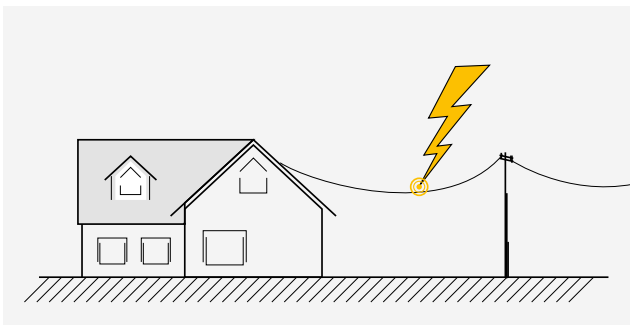
Buildings equipped with lightning protection class I or II.

Surge protective devices T1+T2 or T1 - $I_{imp} = 25 \text{ kA}$

Buildings equipped with lightning protection class III or IV.

Surge protective devices T1+T2 or T1 - $I_{imp} = 12,5 \text{ kA}$

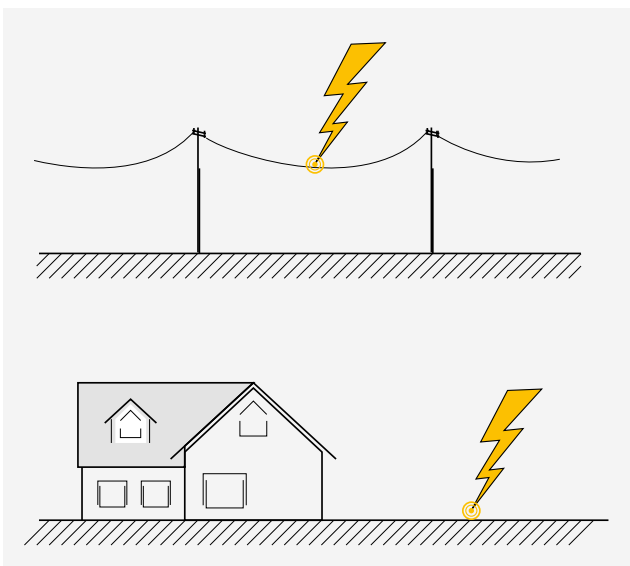
Risk of direct impact on the last section of the overhead line supplying the building with power (at a distance less than 50 m from the connection):



Buildings without LPS, powered by overhead lines

Surge protective devices T1 or T1+T2 - $I_{imp} \geq 5 \text{ kA}$
(recommended $I_{imp} = 12,5 \text{ kA}$)

Risk of direct strike to an overhead line located far from the protected building's connection point and risk of indirect effects of lightning discharges during a lightning strike in the vicinity of the building:



Buildings without LPS, powered by cable lines.

Surge protective devices T2 - $I_n = 5 \text{ kA}$
(recommended at least $I_n = 10 \text{ kA}$)

4.2 Selection of surge protective devices in DC electrical installations



Surge protective devices installed in photovoltaic systems are designed to protect DC electrical installations from the effects of lightning strikes. The following sections describe the situations in which they should be used and how:

- PV surge protective devices (for photovoltaics) are used when the building is equipped with an LPS or by conducting a risk assessment according to the PN-EN 62305-2 standard;
- The PV installation should be located in the LPZ 0B zone and separated from all parts of the lightning protection device in accordance with the PN-HD 60364-7-712 standard;
- The separation distance should be calculated according to section 6.3 of the PN-EN 62305-3 standard;
- The separation distance should be considered in the worst-case scenario, taking into account the parameters and coefficients specified in the standard;
- Constructing a PV installation in accordance with the above has a key impact on surge protection in a DC photovoltaic system.

The risk assessment applies to facilities not equipped with an LPS. All other facilities must be equipped with surge protection. The need for surge protection on the DC side depends on the type of electrical installation in a given facility and its size. Protection is required when the length

L of the cable route between the inverter and the connection points of PV modules in different strings is greater than the L_{crit} parameter value. The data is presented in the table below.

Tab. 4.3 The need to use surge arresters with respect to the L_{crit} parameter.

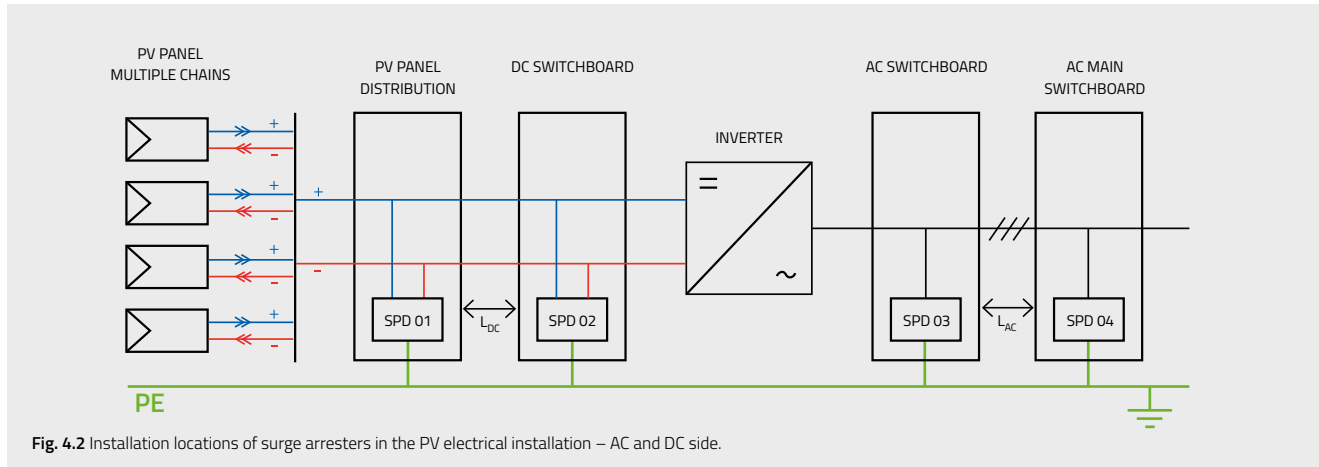
Installation type	Residential buildings	PV power plant in the open air	Non-residential buildings
L_{crit}	$115/N_g$	$200s/N_g$	$450/N_g$
L_{crit} for $N_g=2,5$ discharge/km ² /year	46 m	80	180
$L \geq L_{crit}$	DC side surge protection is required		
$L < L_{crit}$	No DC side surge protection required		

Explanation:

N_g – ground discharge density (discharge/km²/year) corresponding to the location of the power line and connected facilities.

Surge protective devices in PV systems should be installed in the following locations within the AC/DC electrical system: SPD 01 near the PV panels; SPD 02 in the

inverter's DC distribution board; SPD 03 in the inverter's AC distribution board; and SPD 04 in the facility's main AC distribution board. This is shown in Figure 4.2.



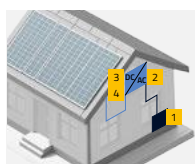
The rules for installing surge protective devices in a PV AC/DC installation are described in the following guidelines – according to the drawings, SPD 01 should be installed next to the panels when the L_{DC} distance is > 10 m. If the L_{DC} distance is < 10 m, this arrester can be omitted. SPD 02 should always be installed next to the inverter in every photovoltaic installation. SPD 03 should be installed on the AC side of the converter when the L_{AC} distance is > 10 m. If the L_{AC} distance is < 10 m, this arrester can be omitted. SPD 04 should be installed in the main distribution board of the facility on the AC side in every installation of this type. Additionally, when selecting the arrester type, the following guidelines should be followed:

- When the protected facility is powered by a cable line and does not have an LPS, then you can install: SPD 01 and SPD 02 – Type 2 DC surge arrester ($I_n = 20$ kA), e.g. 22121003080 ESPPV V T2 15/1000 Y; SPD 03 and SPD 04 – T2 AC surge arrester ($I_n = 20$ kA), e.g. 12400200080 ESPAC V T2 20/275 4+0;

- When the protected facility is powered by an overhead line or cable and additionally has an LPS, but the separation distances for the photovoltaic panels are maintained: SPD 01 and SPD 02 – T2 DC surge arrester ($I_n = 20$ kA), e.g., 22120703080 ESPPV V T2 20/700 Y; SPD 03 and SPD 04 – T12 AC surge arrester ($I_{imp} = 12,5$ kA), e.g., 10400120080 ESPAC V T12 12,5/275 4+0. The separation distance should be calculated according to section 6.3 of the PN-EN 62305-3 standard;

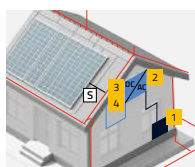
- When the protected facility is powered by an overhead line or cable and additionally has an LPS, but the separation distances for the photovoltaic panels are not maintained: SPD 01 and SPD 02 – T12 DC surge arrester ($I_{imp} = 12,5$ kA), e.g., 20121003080 ESPPV V T12 12,5/1000 Y; SPD 03 and SPD 04 – T12 AC surge arrester ($I_{imp} = 12,5$ kA), e.g., 10400250080 ESPAC VG T12 25/260 4+0.

EXAMPLE OF SELECTION SPDs FOR PHOTOVOLTAIC INSTALLATIONS



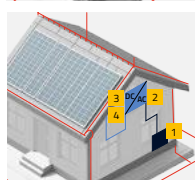
Exemplary conditions:

Building power supply via cable line, building without LPS.



Exemplary conditions:

Building supplied with power by cable or overhead lines, PV panel separation distances maintained, building equipped with LPS III or IV.



Exemplary conditions:

Building power supply via cable or overhead line, PV panel separation distances not maintained, building equipped with LPS I or II.

1 Main distribution board

ESPAC V T2 20/275 4+0
CAT. NO. 12400200080

T2 $I_n = 20$ kA



ESPAC V T12 12,5/275 4+0
CAT. NO. 10400120080

T1 $I_{imp} = 12,5$ kA

T2 $I_n = 30$ kA



ESPAC VG T12 25/260 4+0 RI
CAT. NO. 10400250180

T1 $I_{imp} = 25$ kA

T2 $I_n = 30$ kA



2 AC side

ESPAC V T2 20/275 4+0
CAT. NO. 12400200080

T2 $I_n = 20$ kA



ESPAC V T2 20/275 4+0
CAT. NO. 12400200080

T2 $I_n = 20$ kA



ESPAC V T12 12,5/275 4+0 RI
CAT. NO. 10400120180

T1 $I_{imp} = 12,5$ kA

T2 $I_n = 30$ kA



3 4 DC side

ESPPV T2 15/1000 Y
CAT. NO. 22121003080

T2 $I_n = 15$ kA



ESPPV T2 15/1000 Y
CAT. NO. 22121003080

T2 $I_n = 15$ kA



ESPPV V T12 12,5/1000 Y RI
CAT. NO. 20121003180

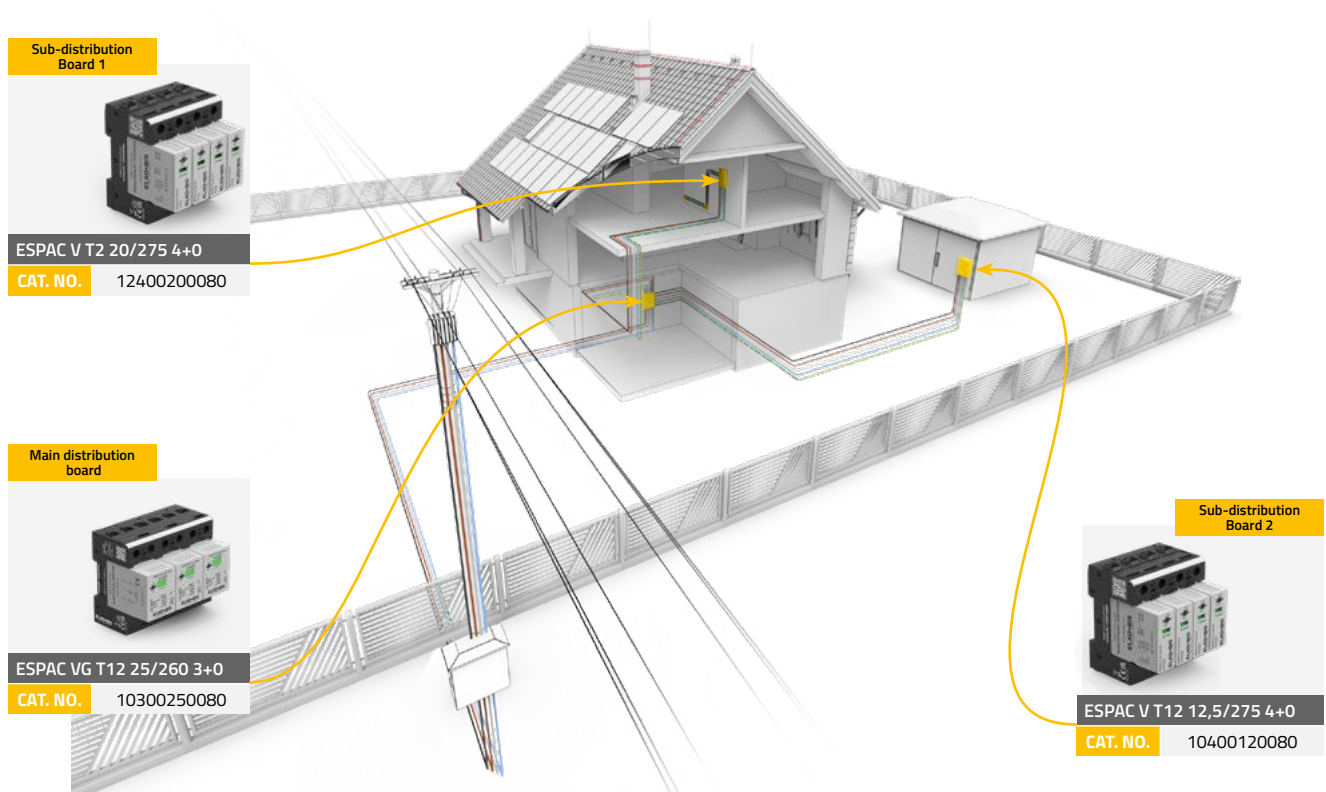
T1 $I_{imp} = 12,5$ kA

T2 $I_n = 20$ kA

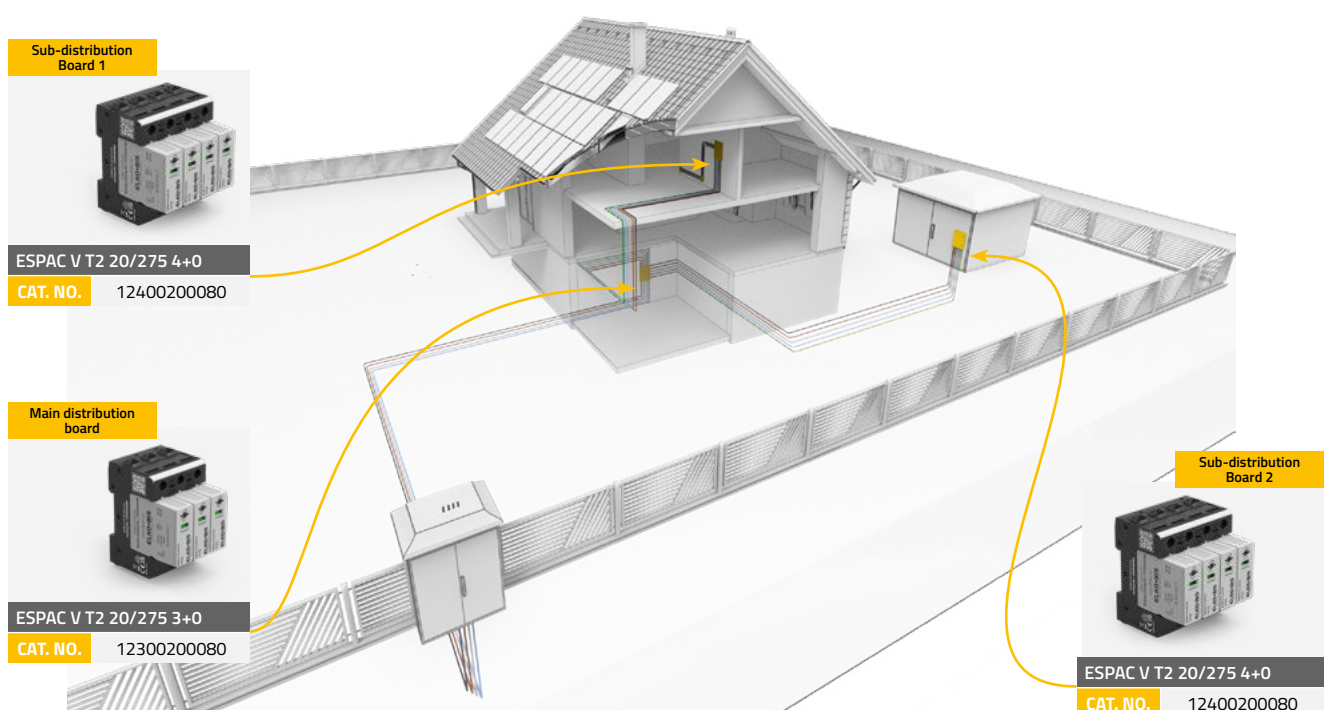


4.3. Building mock-ups showing exemplary selection of surge protective devices

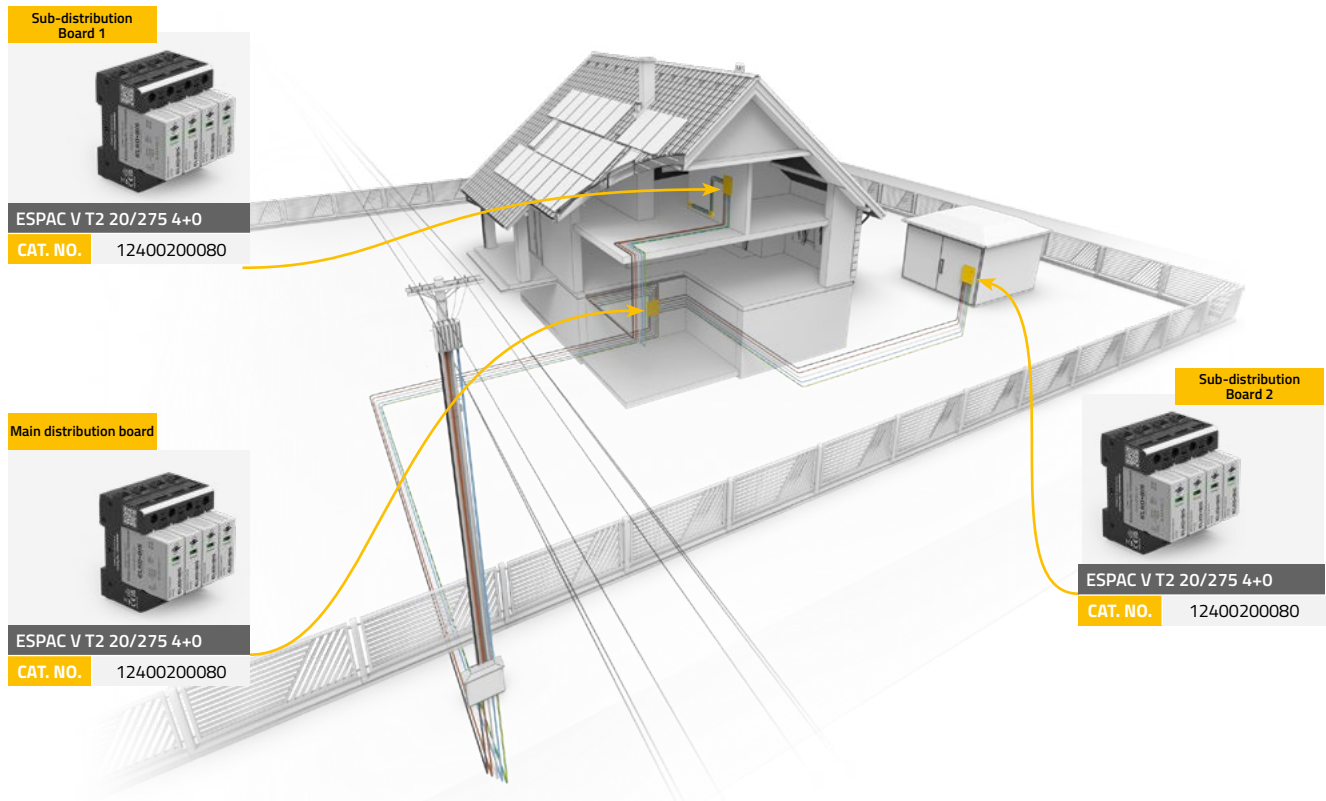
A single-family house in a built-up area with an LPS system and power supplied from a low-voltage overhead line. The TN-C-S network system has a point of separation in the building's main distribution board.



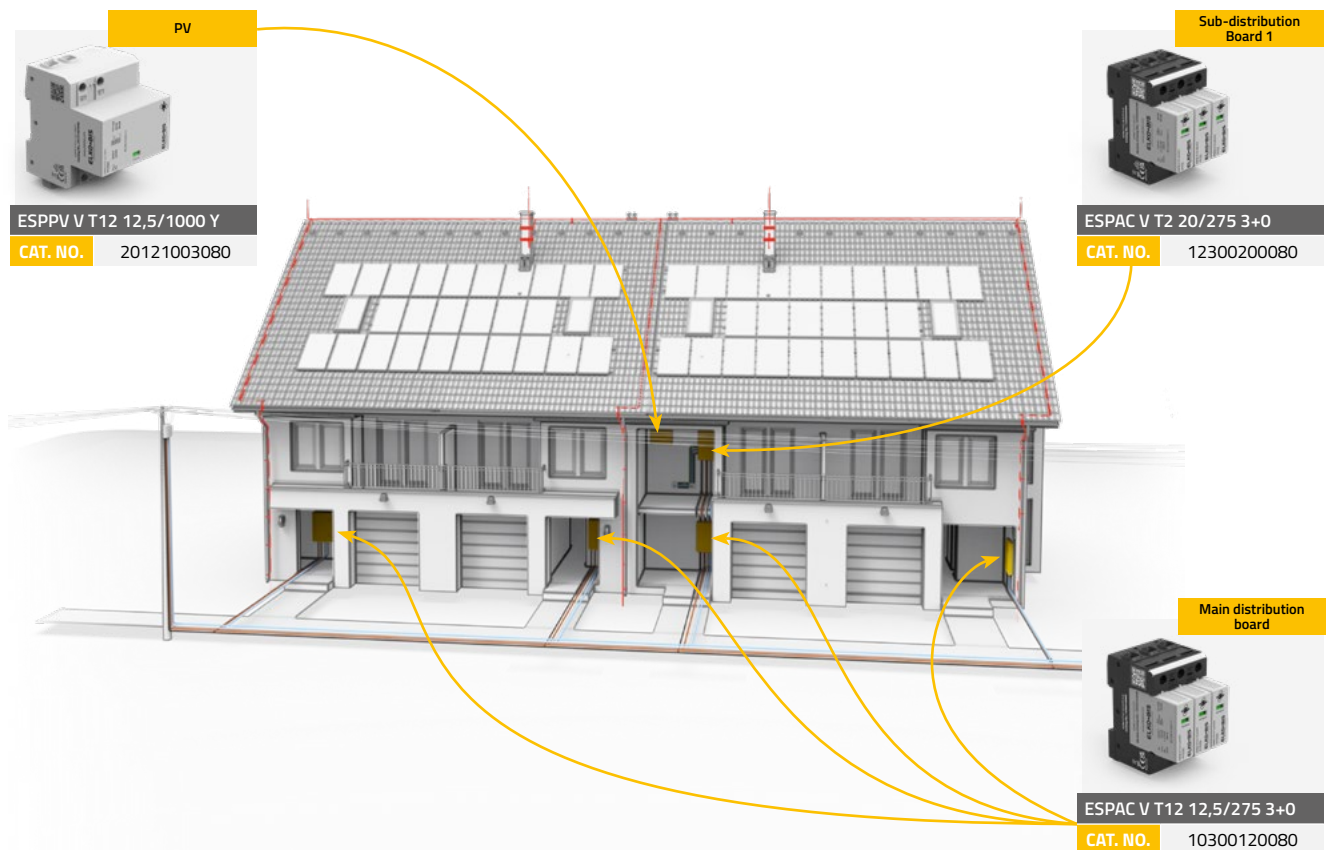
A single-family house in a built-up area without an LPS and powered by a cable line. TN-C-S network system with point of separation at the building's main distribution board.



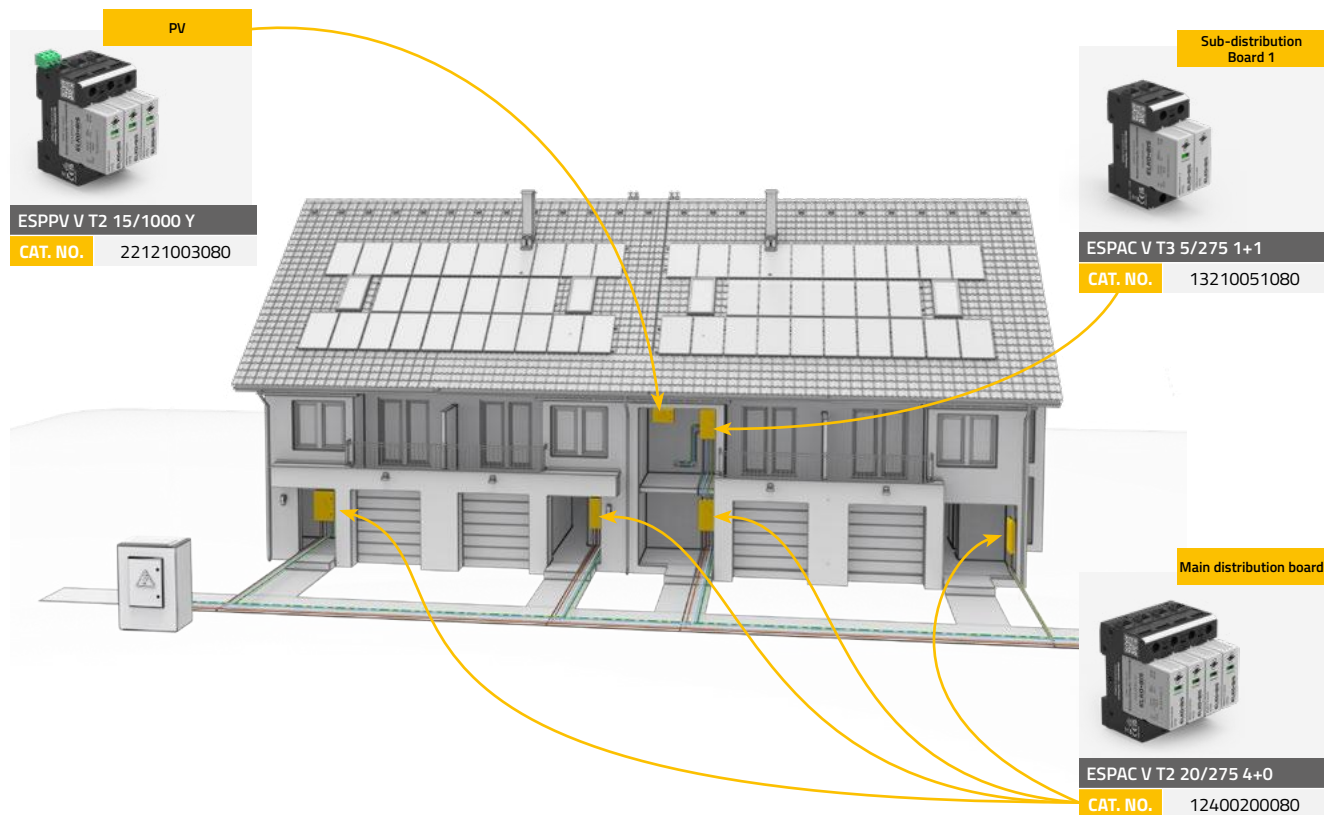
Single-family house in a built-up area without an LPS and powered by a low-voltage overhead line. TN-S network system.



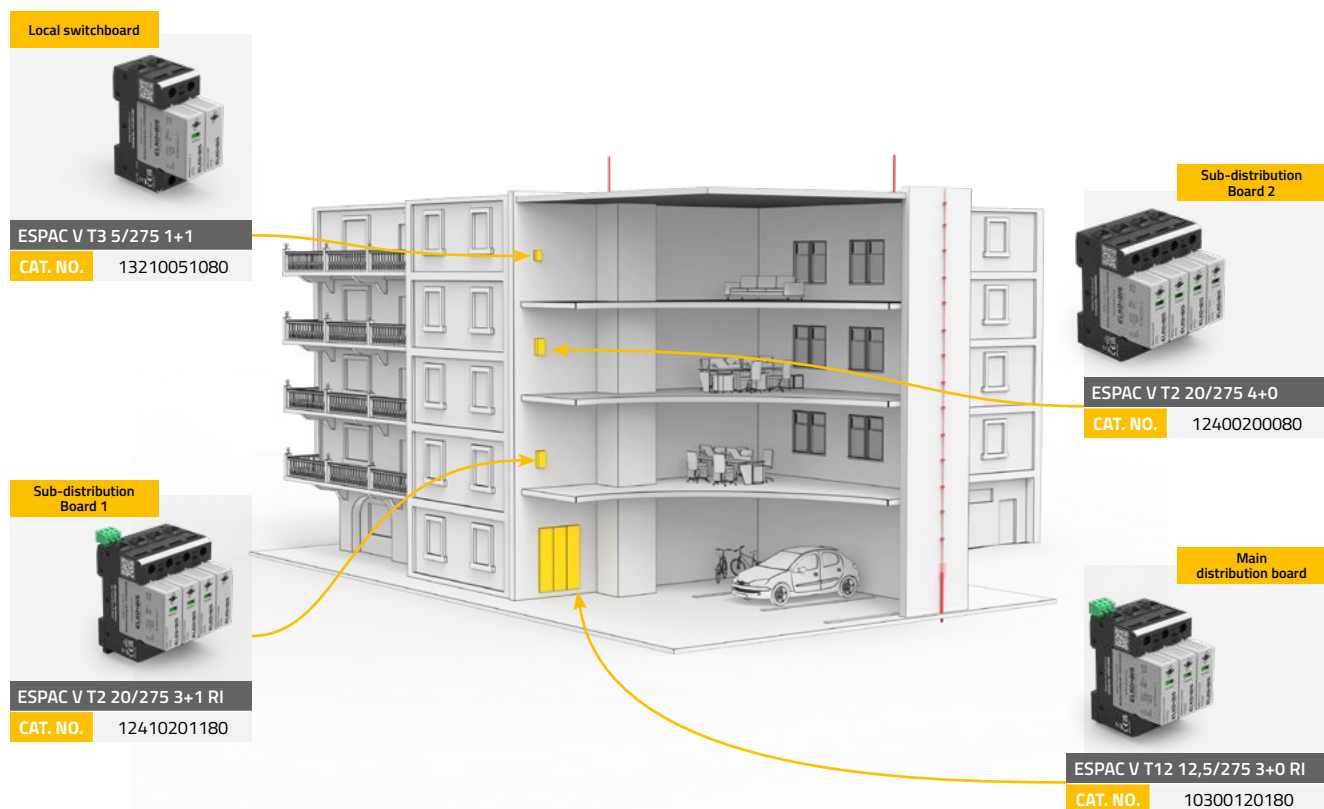
Terraced houses with LPS and overhead line power supply. TN-C network system.



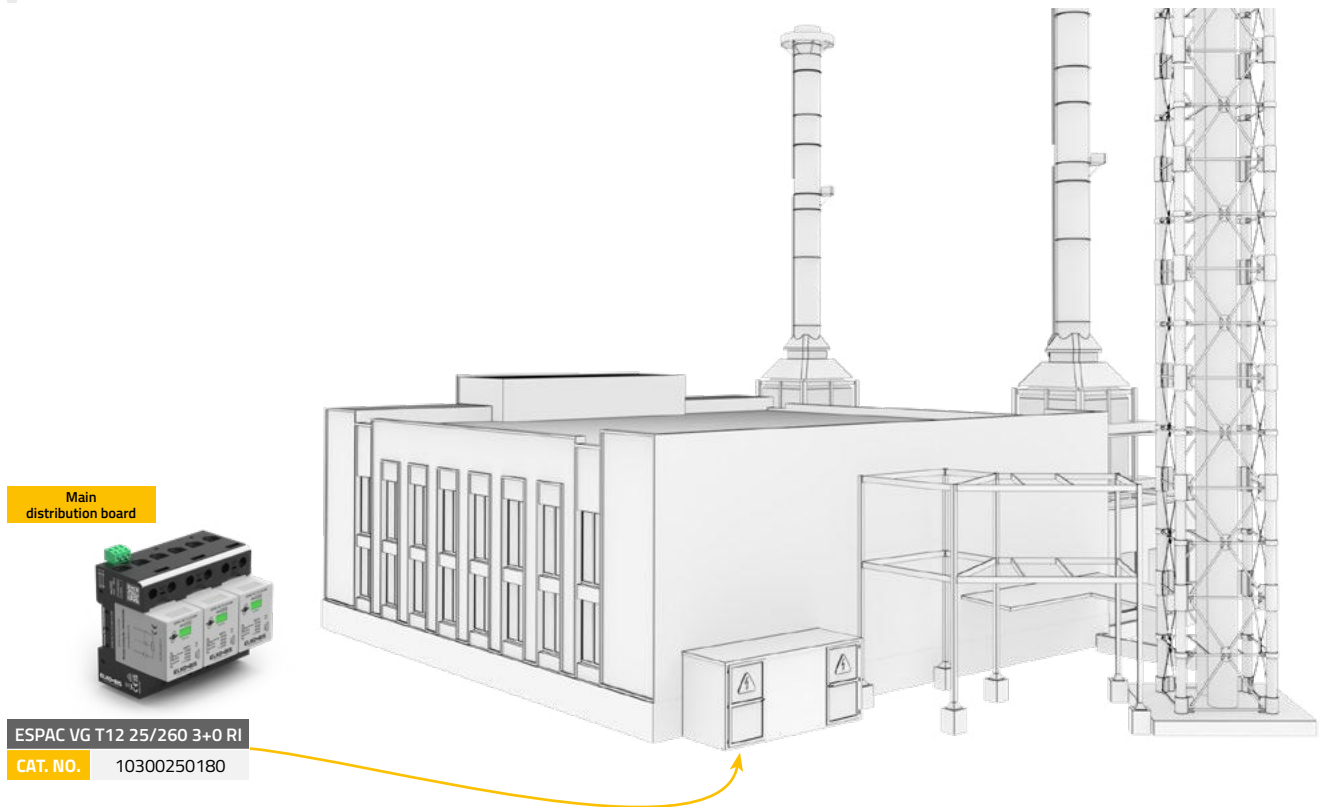
Terraced houses without LPS, with cable power supply. TN-S network.



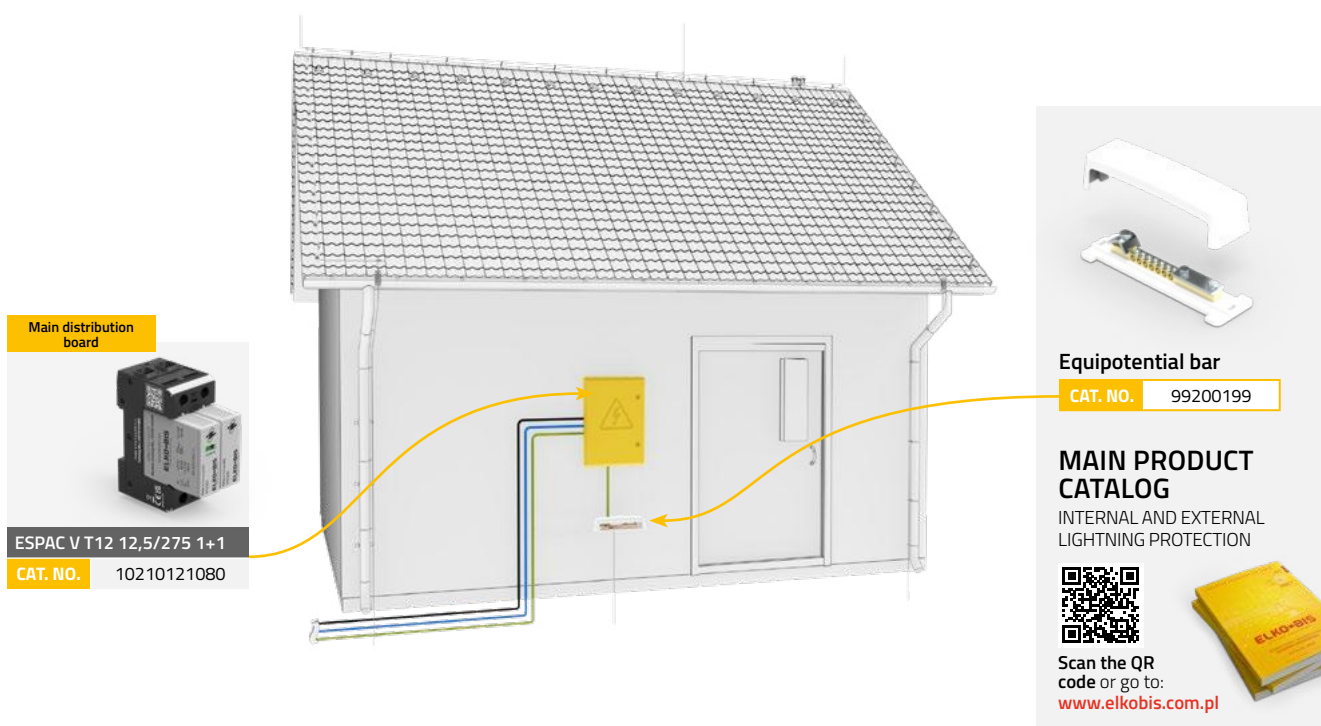
Apartment building with a class III or IV LPS. TN-C-S network system.



Industrial building with LPS. TN-C network system.



Garage, workshop, tool room or other small utility building - single-phase installation.



Industrial facility combined with commercial and office space. TN-S network system.



ESPPV V T12 12,5/1000 Y RI

CAT. NO. 20121003180



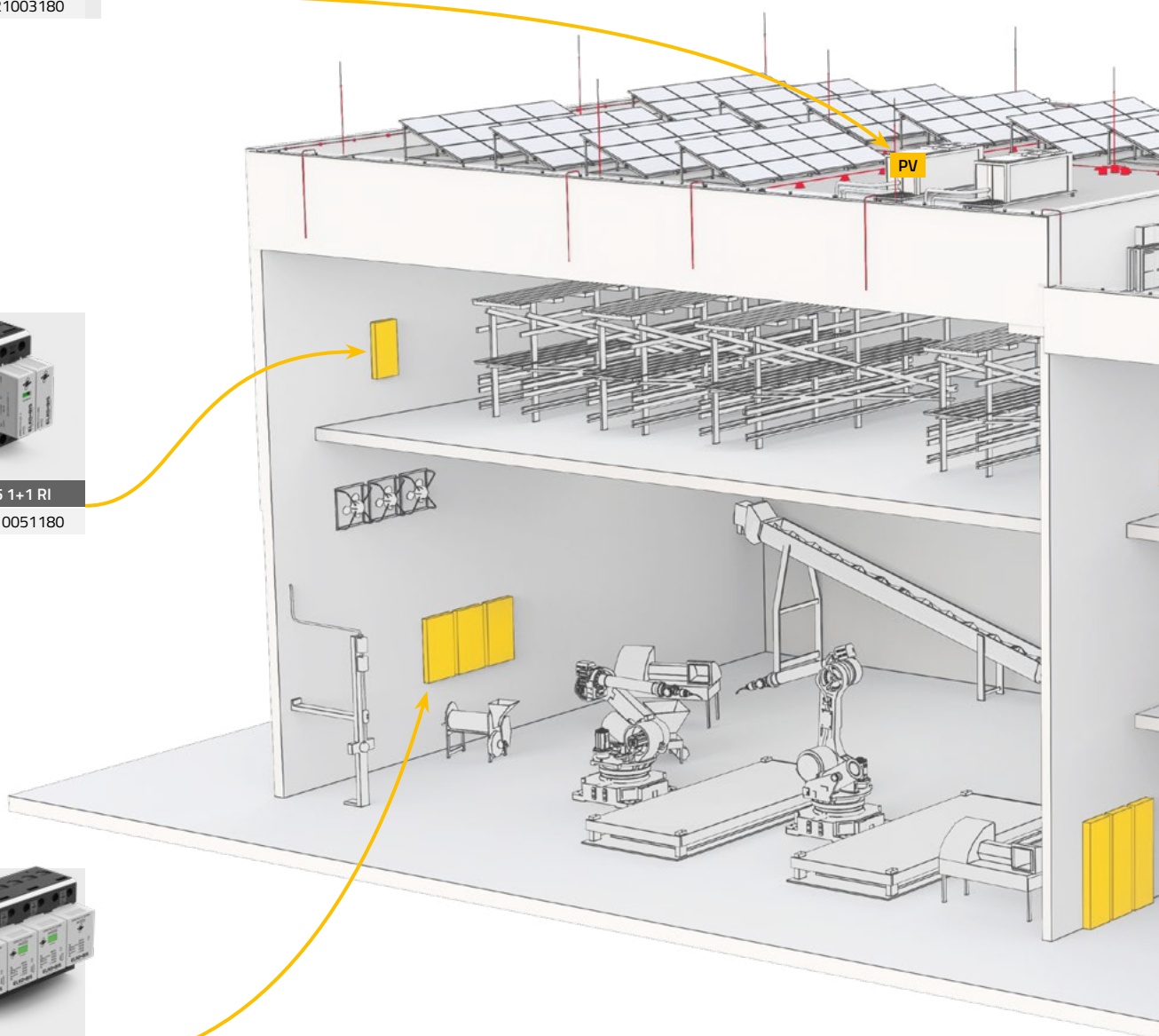
ESPAC V T3 5/275 1+1 RI

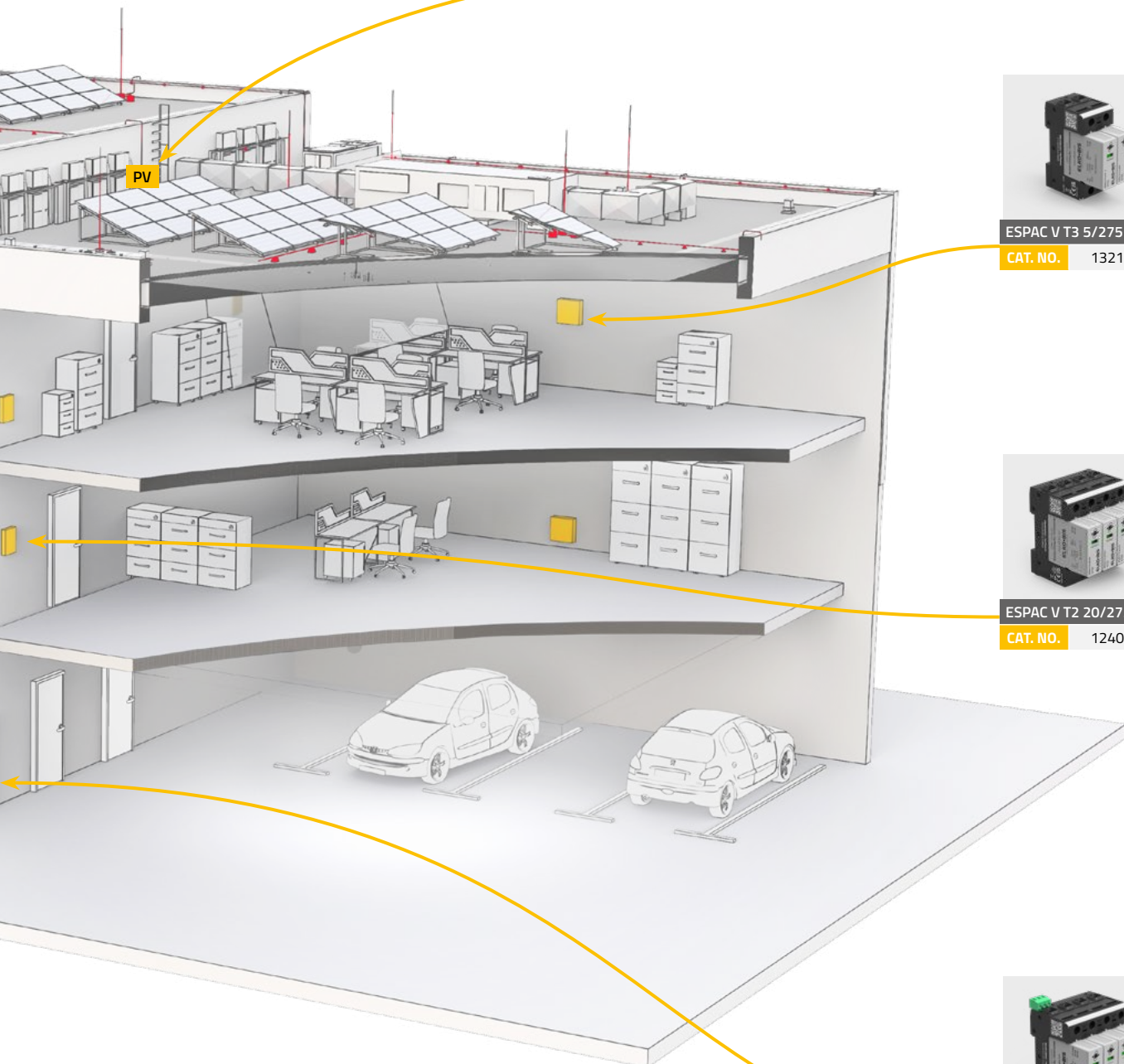
CAT. NO. 13210051180



ESPAC VG T12 25/260 3+1 RI

CAT. NO. 10410251180





4.4 Suggestions for selecting surge protection in electrical installations of various buildings

Type of building:						
Single-family houses, administrative buildings, technological facilities, industrial facilities						
Network System	Building main distribution board		Building sub-distribution board		Local switchboard - supplementary protection	
	Cat. No.	Name	Cat. No.	Name	Cat. No.	Name
3-phases TN-C	10300250080	ESPAC VG T12 25/260 3+0	12300200080	ESPAC V T2 20/275 3+0		
			12300200180	ESPAC V T2 20/275 3+0 RI		
			distance > 50			
			10300120080	ESPAC V T12 12,5/275 3+0		
	10300250180	ESPAC VG T12 25/260 3+0 RI	10300120180	ESPAC V T12 12,5/275 3+0 RI		
			distance > 100			
			10300250080	ESPAC VG T12 25/260 3+0		
			10300250180	ESPAC VG T12 25/260 3+0 RI		
3-phases TN-S	10400250080	ESPAC VG T12 25/260 4+0	12400200080	ESPAC V T2 20/275 4+0	distance > 5 m	
			12400200180	ESPAC V T2 20/275 4+0 RI	surge protection for TH 35 rail:	
			distance > 50			
			10400120080	ESPAC V T12 12,5/275 4+0	13210051080	ESPAC V T3 5/275 1+1
	10400250180	ESPAC VG T12 25/260 4+0 RI	10400120180	ESPAC V T12 12,5/275 4+0 RI	(up to 63 A)	
			distance > 100		13210051180	ESPAC V T3 5/275 1+1 RI
			10400250080	ESPAC VG T12 25/260 4+0		
			10400250180	ESPAC VG T12 25/260 4+0 RI		
3-phases TN-C-S	10300250080	ESPAC VG T12 25/260 3+0	12400200080	ESPAC V T2 20/275 4+0		
			12400200180	ESPAC V T2 20/275 4+0 RI		
			distance > 50			
			10400120080	ESPAC V T12 12,5/275 4+0		
	10300250180	ESPAC VG T12 25/260 3+0 RI	10400120180	ESPAC V T12 12,5/275 4+0 RI		
			distance > 100			
			10400250080	ESPAC VG T12 25/260 4+0		
			10400250180	ESPAC VG T12 25/260 4+0 RI		

Type of building:						
Apartment buildings with 12 or more apartments (SPD located in housing estate buildings)						
Network System	Main building distribution board		Building sub-distribution board		Local switchboard - supplementary protection	
	Cat. No.	Name	Cat. No.	Name	Cat. No.	Name
3-phases TN-C			10300120080	ESPAC V T12 12,5/275 3+0	distance > 5 m	
			10300120180	ESPAC V T12 12,5/275 3+0 RI		
3-phases TN-S			10400120080	ESPAC V T12 12,5/275 4+0	surge protection for TH 35 rail:	
			10400120180	ESPAC V T12 12,5/275 4+0 RI		
3-phases TN-C-S	PEN separation point in the main distribution board of the building		10300120080	ESPAC V T12 12,5/275 3+0	13210051080	ESPAC V T3 5/275 1+1
			10300120180	ESPAC V T12 12,5/275 3+0 RI	(up to 63 A)	
1-phase TN-C			10210251180	ESPAC VG T12 25/260 1+1 RI	13210051180	ESPAC V T3 5/275 1+1 RI
1-phase TN-S			10200120080	ESPAC V T12 12,5/275 2+0		
			10200120180	ESPAC V T12 12,5/275 2+0 RI		

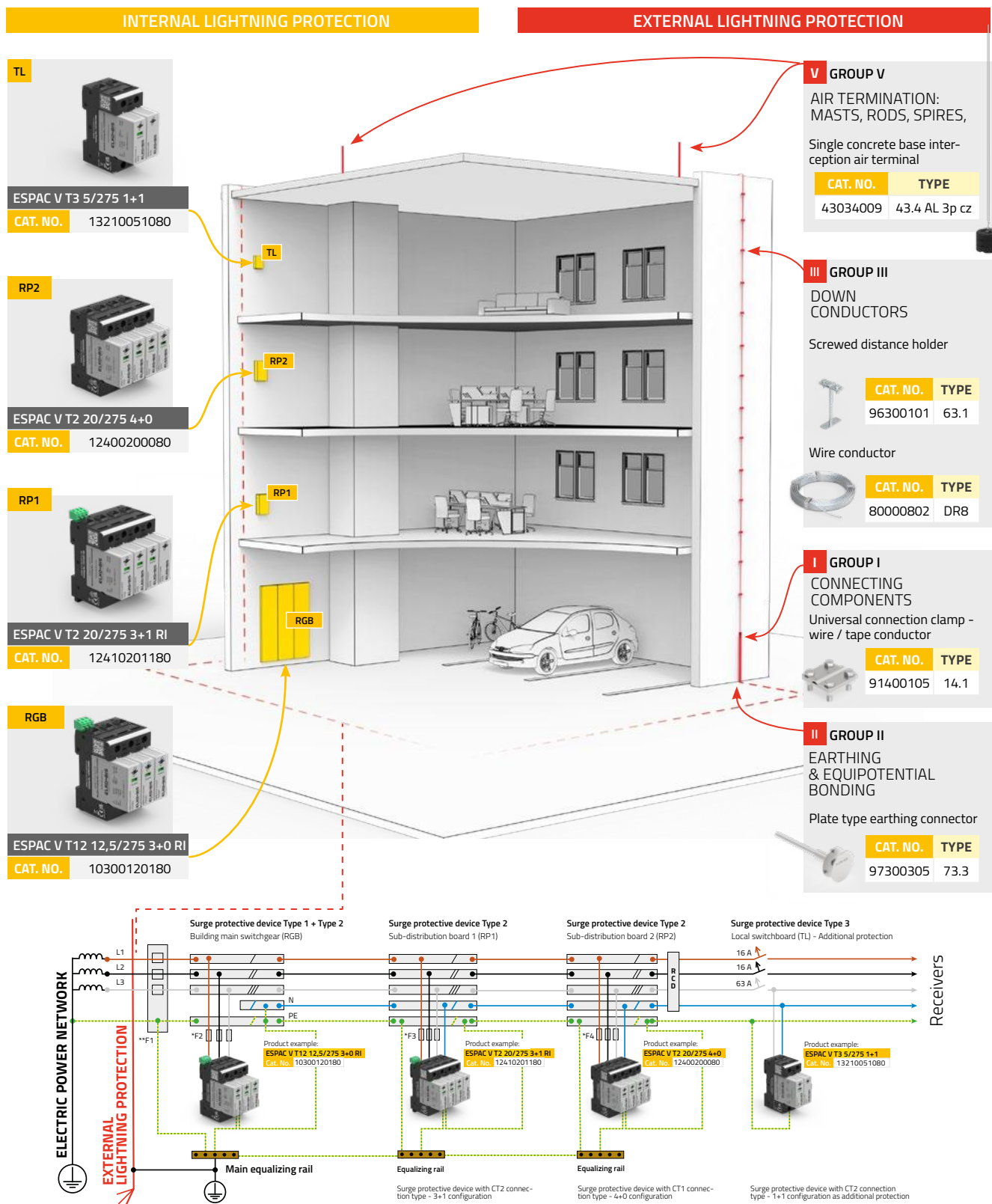
Type of building:						
Demanding facilities (facilities – plants classified as explosion-hazardous, chemical plants, facilities of very high importance)						
Network System	Building main distribution board		Building sub-distribution board		Local switchboard - supplementary protection	
	Cat. No.	Name	Cat. No.	Name	Cat. No.	Name
3-phases TN-C	10300250080	ESPAC VG T12 25/260 3+0	12300200080	ESPAC V T2 20/275 3+0	distance > 5 m	
			12300200180	ESPAC V T2 20/275 3+0 RI		
			distance > 50			
			10300120080	ESPAC V T12 12,5/275 3+0		
	10300250180	ESPAC VG T12 25/260 3+0 RI	10300120180	ESPAC V T12 12,5/275 3+0 RI		
			distance > 100			
			10300250080	ESPAC VG T12 25/260 3+0		
			10300250180	ESPAC VG T12 25/260 3+0 RI		
3-phases TN-S	10400250080	ESPAC VG T12 25/260 4+0	12400200080	ESPAC V T2 20/275 4+0	surge protection for TH 35 rail:	
			12400200180	ESPAC V T2 20/275 4+0 RI		
			distance > 50			
			10400120080	ESPAC V T12 12,5/275 4+0		
	10400250180	ESPAC VG T12 25/260 4+0 RI	10400120180	ESPAC V T12 12,5/275 4+0 RI		
			distance > 100		13210051080	ESPAC V T3 5/275 1+1
			10400250080	ESPAC VG T12 25/260 4+0	(up to 63 A)	
			10400250180	ESPAC VG T12 25/260 4+0 RI	13210051180	ESPAC V T3 5/275 1+1 RI
3-phases TN-C-S	PEN separation point in the main distribution board of the building		12400200080	ESPAC V T2 20/275 4+0		
			12400200180	ESPAC V T2 20/275 4+0 RI		
			distance > 50			
			10400120080	ESPAC V T12 12,5/275 4+0		
	10300250080	ESPAC VG T12 25/260 3+0	10400120180	ESPAC V T12 12,5/275 4+0 RI		
			distance > 100			
	10300250180	ESPAC VG T12 25/260 3+0 RI	10400250080	ESPAC VG T12 25/260 4+0		
			10400250180	ESPAC VG T12 25/260 4+0 RI		

Type of building:								
Buildings with single-phase technological installations								
Network System	Building main distribution board		Building sub-distribution board		Local switchboard - supplementary protection			
	Cat. No.	Name	Cat. No.	Name	Cat. No.	Name		
1-phase TN-C	10100250080	ESPAC VG T12 25/260 1+0	12100200080	ESPAC V T2 20/275 1+0				
			12100200180	ESPAC V T2 20/275 1+0 RI				
			distance > 50					
			10100120080	ESPAC V T12 12,5/275 1+0				
	10100250180	ESPAC VG T12 25/260 3+0 RI	10100120180	ESPAC V T12 12,5/275 1+0 RI				
			distance > 100					
			10100250080	ESPAC VG T12 25/260 1+0				
			10100250180	ESPAC VG T12 25/260 1+0 RI				
				distance > 5 m				
1-phase TN-S	10200250080	ESPAC VG T12 25/260 2+0	12200200080	ESPAC V T2 20/275 2+0	surge protection for TH 35 rail:			
			12200200180	ESPAC V T2 20/275 2+0 RI				
			distance > 50					
			10200120080	ESPAC V T12 12,5/275 2+0			13210051080	ESPAC V T3 5/275 1+1
	10200250180	ESPAC VG T12 25/260 2+0 RI	10200120180	ESPAC V T12 12,5/275 2+0 RI	(up to 63 A)			
			distance > 100		13210051180	ESPAC V T3 5/275 1+1 RI		
			12200200080	ESPAC V T2 20/275 2+0				
			12200200180	ESPAC V T2 20/275 2+0 RI				
1-phase TN-C-S	PEN separation point in the main distribution board of the building		12200200080	ESPAC V T2 20/275 2+0				
			12200200180	ESPAC V T2 20/275 2+0 RI				
			distance > 50					
			10200120080	ESPAC V T12 12,5/275 2+0				
	10100250080	ESPAC VG T12 25/260 1+0	10200120180	ESPAC V T12 12,5/275 2+0 RI				
			distance > 100					
			10100250180	ESPAC VG T12 25/260 1+0 RI	10200250080	ESPAC VG T12 25/260 2+0		
					10200250180	ESPAC VG T12 25/260 2+0 RI		

5. Reduction of overvoltages in LPZ zones

The principle of zone voltage reduction involves gradually reducing the overvoltage level to a safe value that will not damage the receivers. To achieve a safe overvoltage

value, the entire structure is divided into individual zones, and a surge protective device is installed at the boundary between the zones.



Rule 1 – maintain a certain length of connecting cables.

To effectively protect receivers against surges, it's important to remember the voltage protection level. U_p – voltage protection level [kV]. This is a parameter of the surge protection device that determines the effectiveness of limiting the voltage at its terminals during the flow of discharge current.

This parameter is determined by checking the ratio of the voltage level to the continuous operating voltage U_c . As this ratio increases, the level of insulation protection of the protected devices decreases. If a single surge protective device does not meet the required U_p parameter level, an additional arrester or arresters should be used in a cascade.

For AC surge protective devices, the U_p parameter value is usually specified for the connections: L – N. For DC surge arresters, two U_p parameter values are usually specified for the connections:

(+) – (-) and (+/-) – PE.

The protection level U_p and the voltage drop on the power supply lines ΔU must not exceed the withstand voltage at the receiver terminals.

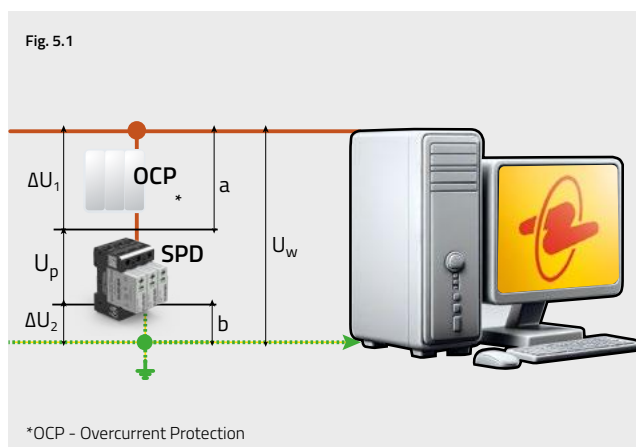
It is clear from Fig. 5.1 that the total protection level is obtained by adding partial voltage drops, and such a sum cannot exceed 80% of the withstand voltage U_w at the receiver terminals.

$$U_w > U_p + \Delta U_1 + \Delta U_2$$

U_w – withstand voltage

U_p – voltage protection level

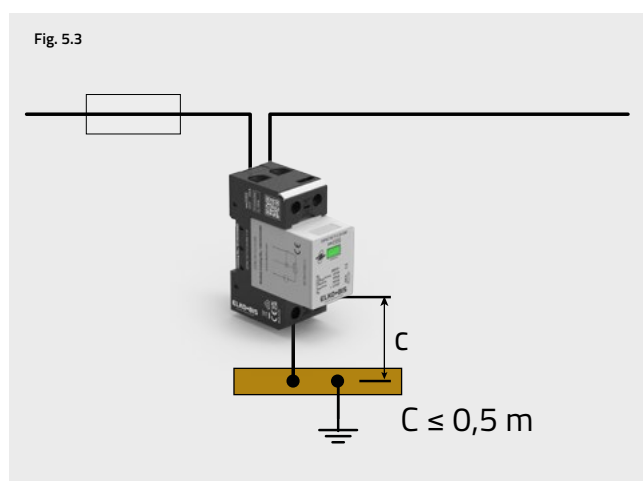
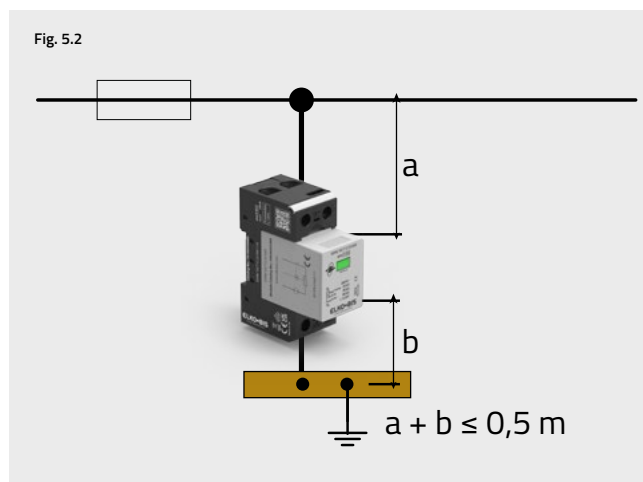
$\Delta U_1, \Delta U_2$ – voltage drops on conductors



The impedance of power supply cables for high-frequency currents is approximately 1 μH per 1 m of cable length. The voltage drop in this cable is described by the formula:

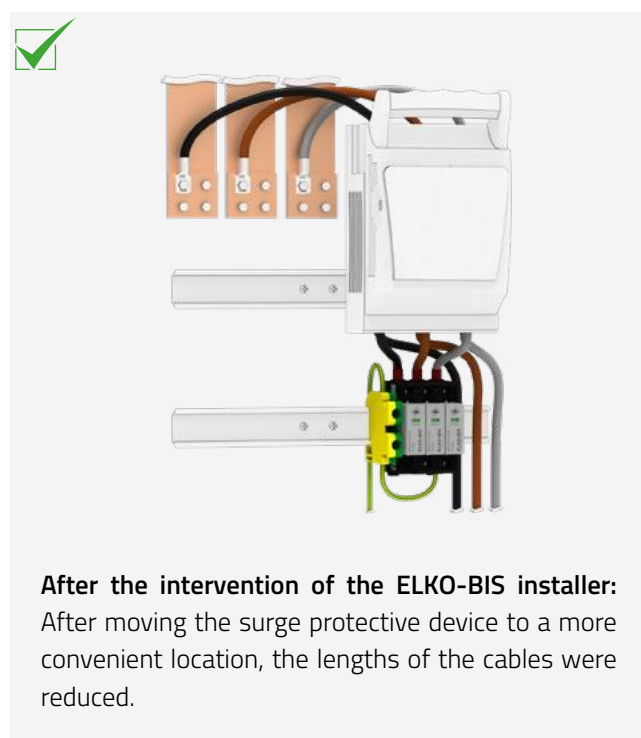
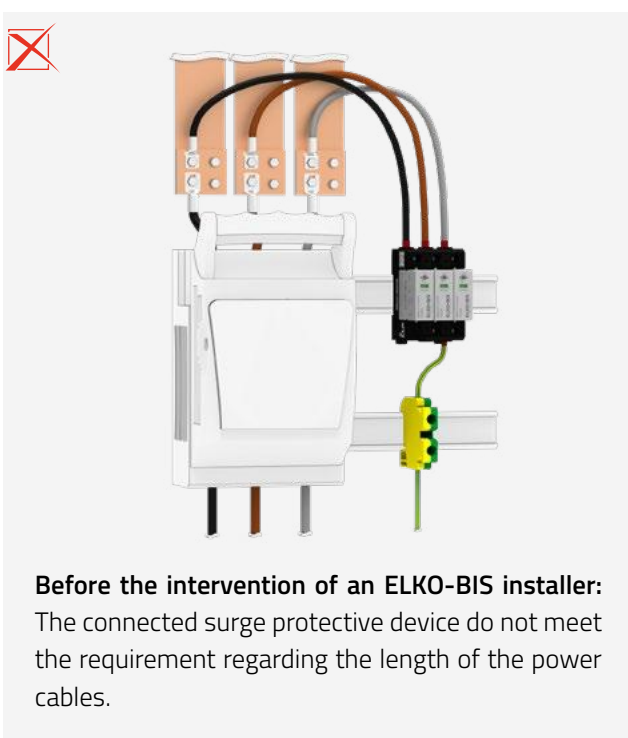
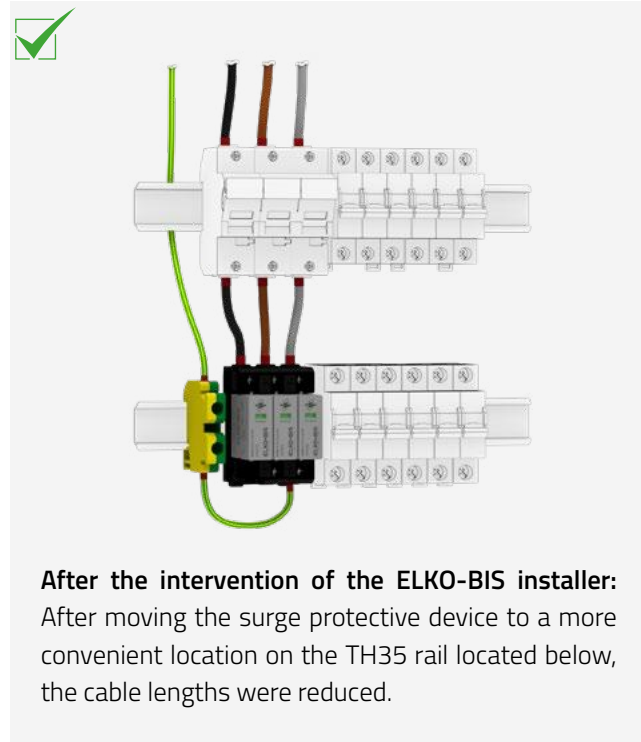
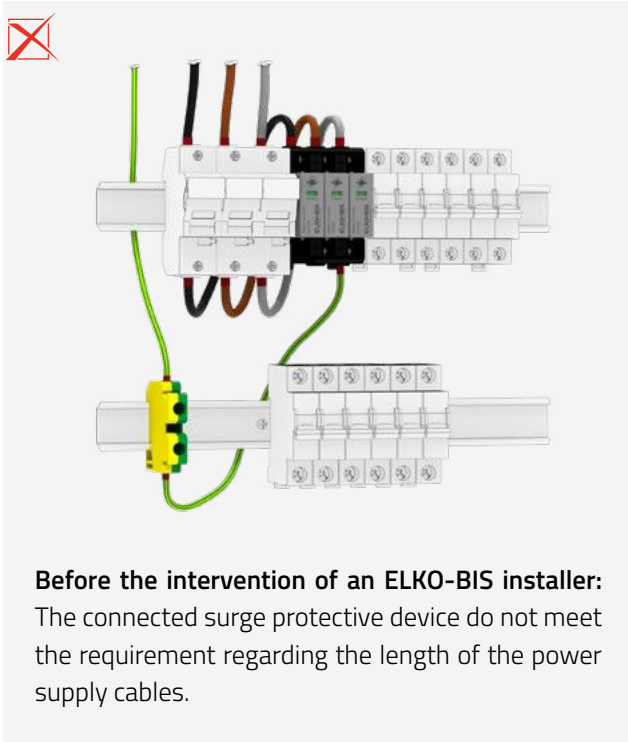
$$U_w = L \times di/dt$$

With a pulse slope and rise time of 1 $\text{kA}/\mu\text{s}$, the voltage is reduced by 1000 V per meter of cable, which should be included in the surge arrester's voltage protection level. With a total power supply cable length of 0,5 m, 500 V will be added to the protective voltage level U . Therefore, the length of the power supply cables must be as short as possible and should not exceed a total length of 0,5 m, as shown in the following diagrams, which illustrate connection options.



ATTENTION! The following graphical representations of electrical installations are for illustrative purposes only and refer only to the installation method of surge protective devices. They do not address the issue of short-circuit protection. Selection of the appropriate short-circuit protection for a surge arrester should be based on the tables included in our product materials (such as the PRODUCT CATALOG, the „SURGE ARRESTERS“ CATALOG, and other materials presenting the ELKO-BIS offer) available at <https://elkobis.com.pl/en/baza-wiedzy-elkobis/>

The following two figures illustrate how the required cable length of $\leq 0,5$ m for connecting a surge protective device can be met in practice.



Rule 2 - selection of surge protection based on technical conditions.

A surge protective device, which is the main surge protection for a facility, should be installed in the building's main distribution board to quickly eliminate any surges entering the power lines and prevent them from negatively impacting the devices installed in the distribution

board. Always select a surge arrester that is compatible with the network system and the number of phase conductors in the electrical installation.

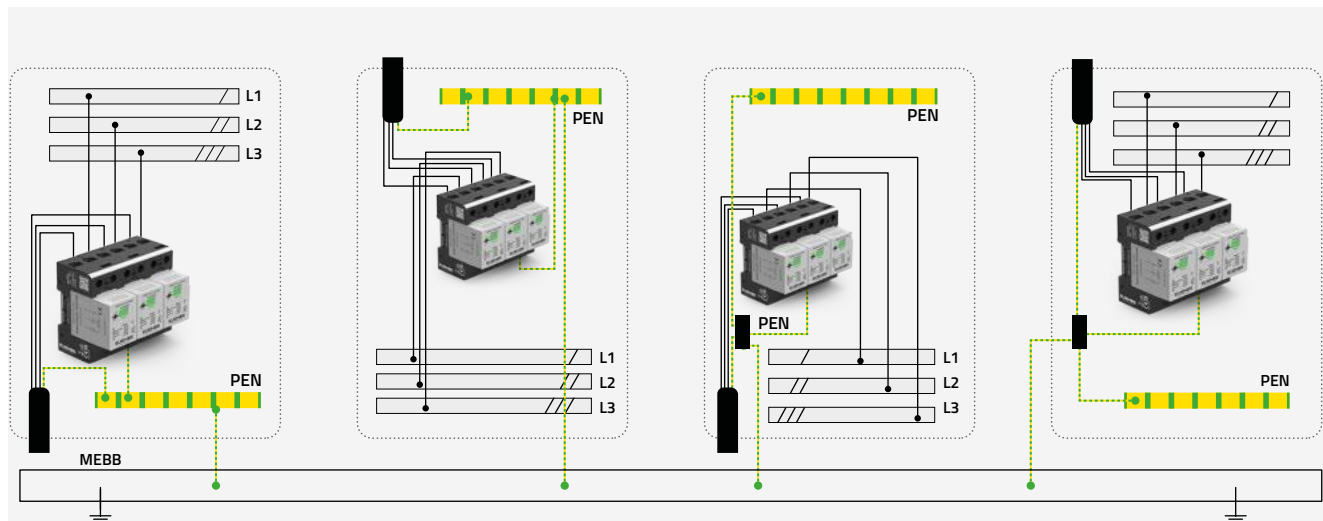
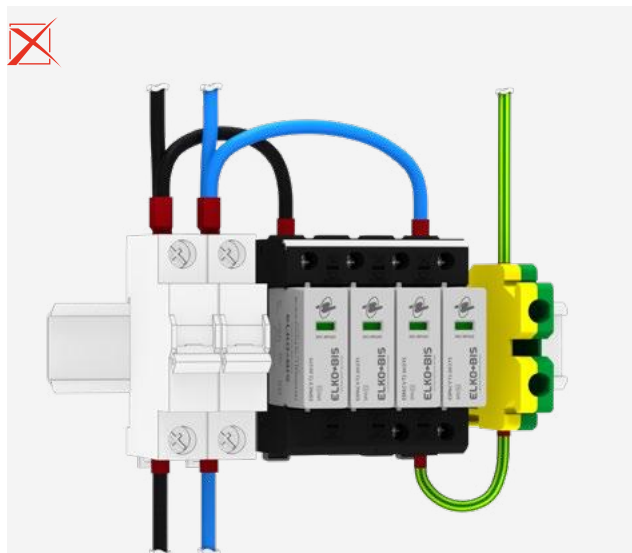
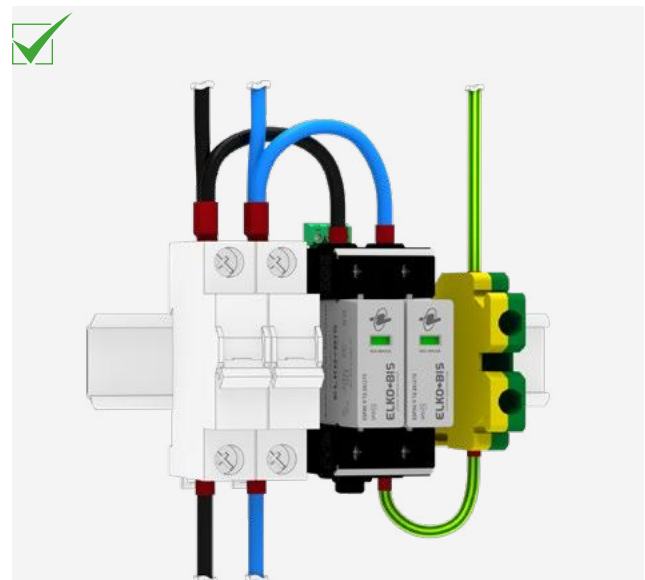


Fig. 5.4

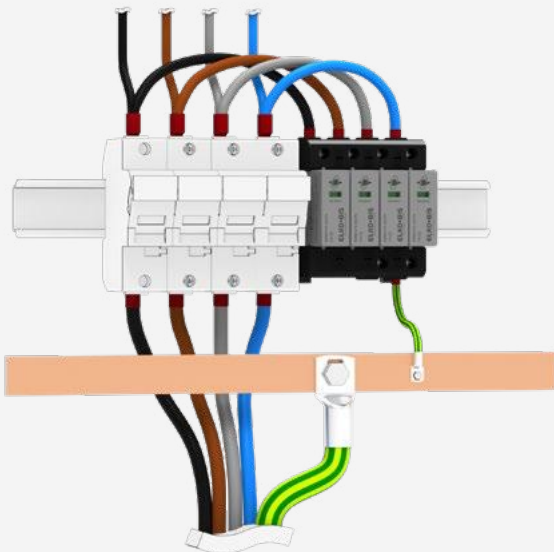
Diagram showing how to connect ESPAC VG T12 25/260 3+0 in a TN-C network system.



Before the intervention of the ELKO-BIS installer:
A 4+0 surge protective device was connected to the power supply in a single-phase distribution board, which makes no sense at all due to the smaller number of phases (one) in this installation.



Before the intervention of the ELKO-BIS installer:
A 4+0 surge protective device was connected to the power supply in a single-phase distribution board, which makes no sense at all due to the smaller number of phases (one) in this installation.

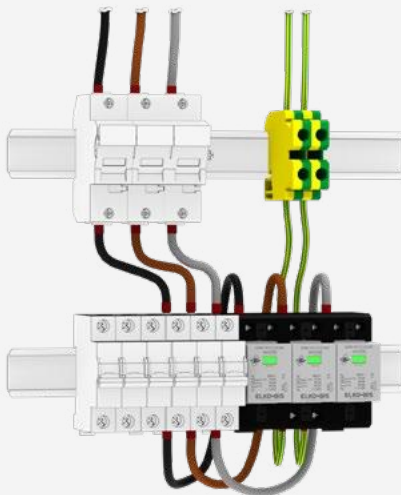


In this case, the electrical installation was three-phase. The Elko-Bis installer, decided to use an ESPAC V T2 20/275 4+0 surge protective device as surge protection for this distribution board. The device's installation method and selection are perfectly accurate.

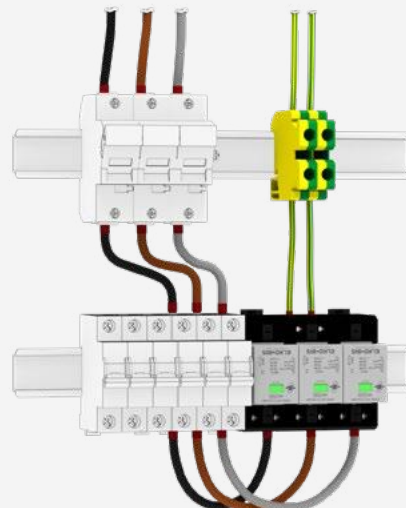
Rule 3 - Minimize loop length.

To minimize induced overvoltages in the loop and significantly reduce their effects on other devices and connected equipment in the switchboard, the area of the

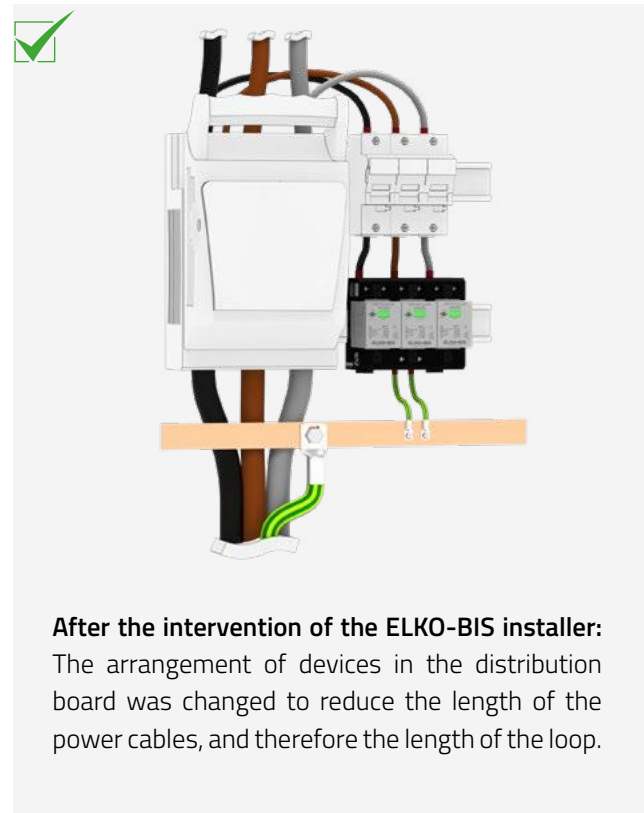
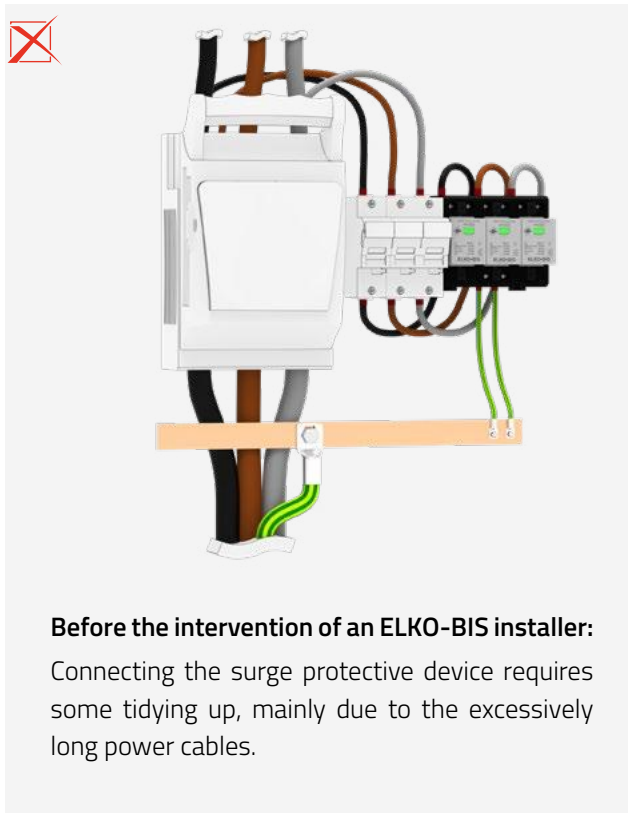
loop consisting of L, N, and PE conductors must be as small as possible. The principle of minimizing loop length is shown below.



Before the intervention of an ELKO-BIS installer: connecting the surge protective device requires some tidying up, mainly due to the excessively long power cables.



After the intervention of the ELKO-BIS installer: After rotating the surge protective device, the lengths of the power cables were reduced (therefore, the loop is smaller), and the cable routing was executed in a clear manner.



ATTENTION! The above graphical representations of electrical installations are for illustrative purposes only and only cover the installation of surge protective devices. They do not address short-circuit protection (back-up protection).

Rule 4 - routing cables in the distribution board

When routing cables in a distribution board, it is always necessary to separate protected and unprotected cables. It is essential to maintain the greatest possible distance between them (over 30 cm). If this distance cannot be maintained, a protective barrier should be placed

between them. If crossing protected and unprotected cables is unavoidable, the crossing should be at a right angle to prevent interference pulses from being induced in the protected cables.

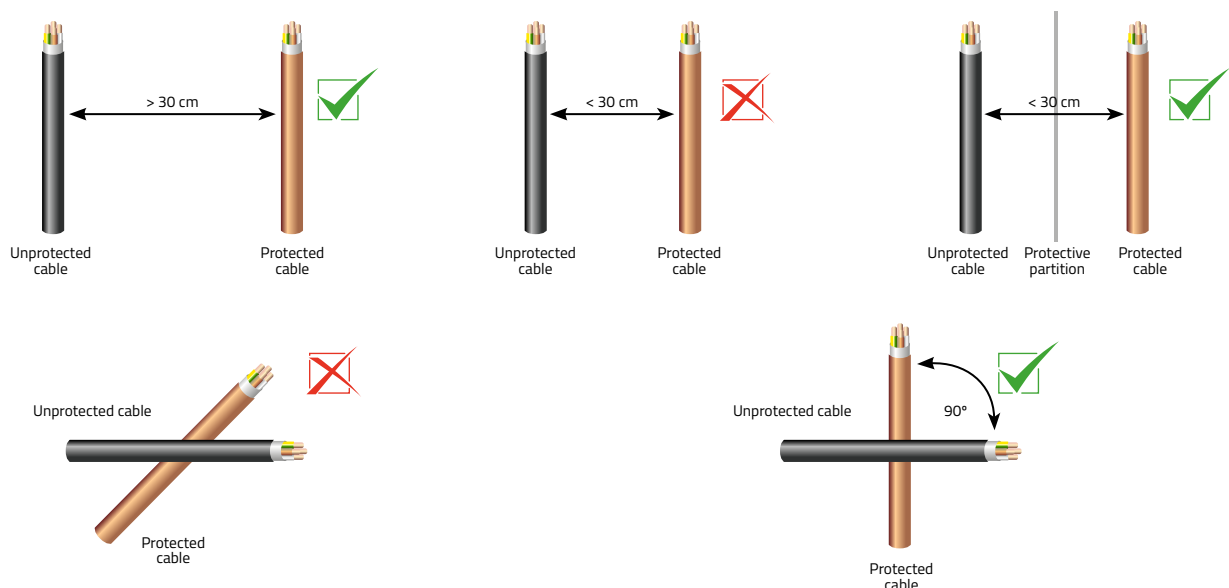


Fig. 5.5 Suggested method of routing cables in the distribution board.

5.1 Coordination of surge protective devices in a cascade

To ensure proper operation of individual SPD protection levels, specific distances must be maintained between them. The general solution is shown in the figures below. Fig. 5.6 shows incorrect coordination between individual surge protective devices. If the coordination distances between individual protection levels cannot be maintained, the distance can be increased by using a coupling

impedance. Coupling impedances must be adapted to the current flowing through the circuit. The current can be determined based on the protection values of the given circuit. It is important to ensure that Type 1, Type 2, and Type 3 surge arresters are coordinated with each other – ideally without the use of additional coupling impedance.

L - distance in meters

> - greater than
< - smaller than

>> - much greater than
<< - much smaller than

≥ - greater/equal
≤ - smaller/equal

Fig. 5.6

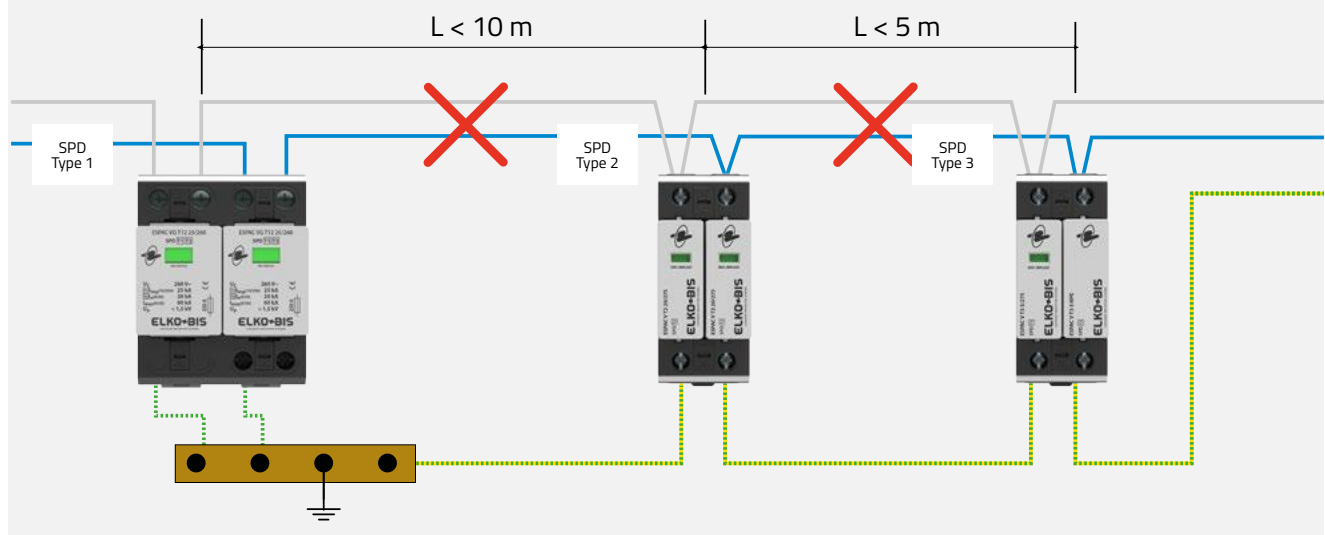
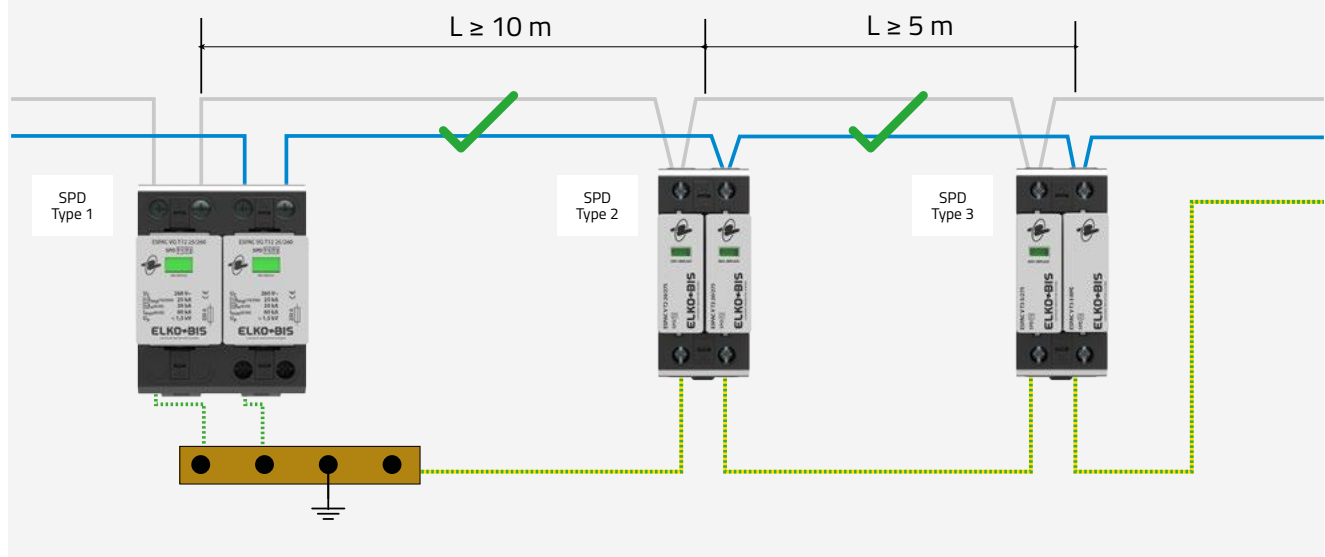


Fig. 5.7



The following figures show the coordination of Type 1 and Type 2 surge protective devices. The ESPAC VG T12 25/260 2+0 arrester was used as a Type 1 SPD, and the ESPAC V T2 20/275 1+1 arrester was used as a Type 2 SPD. It is not necessary to maintain a distance greater than 10 m between them, as they are mutually coordinated and can be mounted side by side, as shown in Figure 5.8 below.

For proper operation of the given levels of SPD Type 2 and SPD Type 3 surge protection, minimum distances must be observed. The general design of multi-level surge protection is shown in Fig. 5.8 and Fig. 5.9, and incorrect coordination is shown in Fig. 5.6. If the coordination distance cannot be maintained in a cascade between SPD Type 2 and SPD Type 3, the distance can be increased further using coupling impedances.

Fig. 5.8

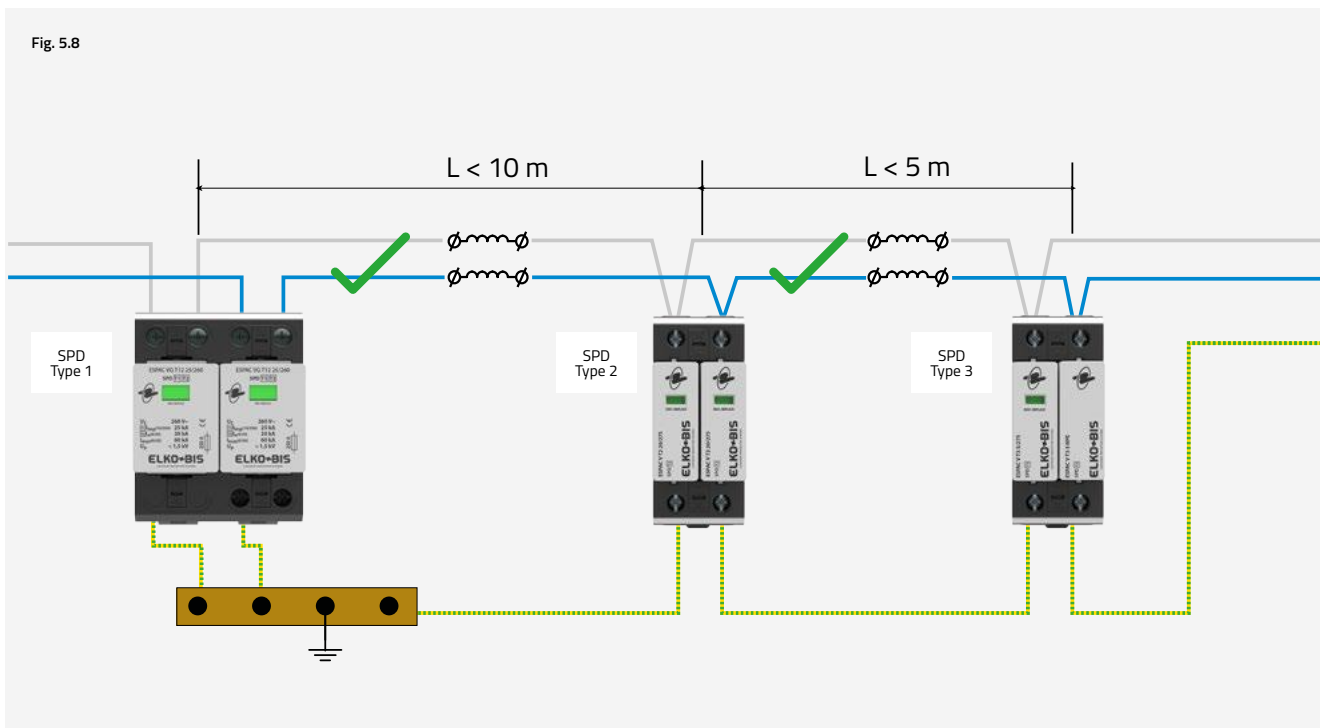
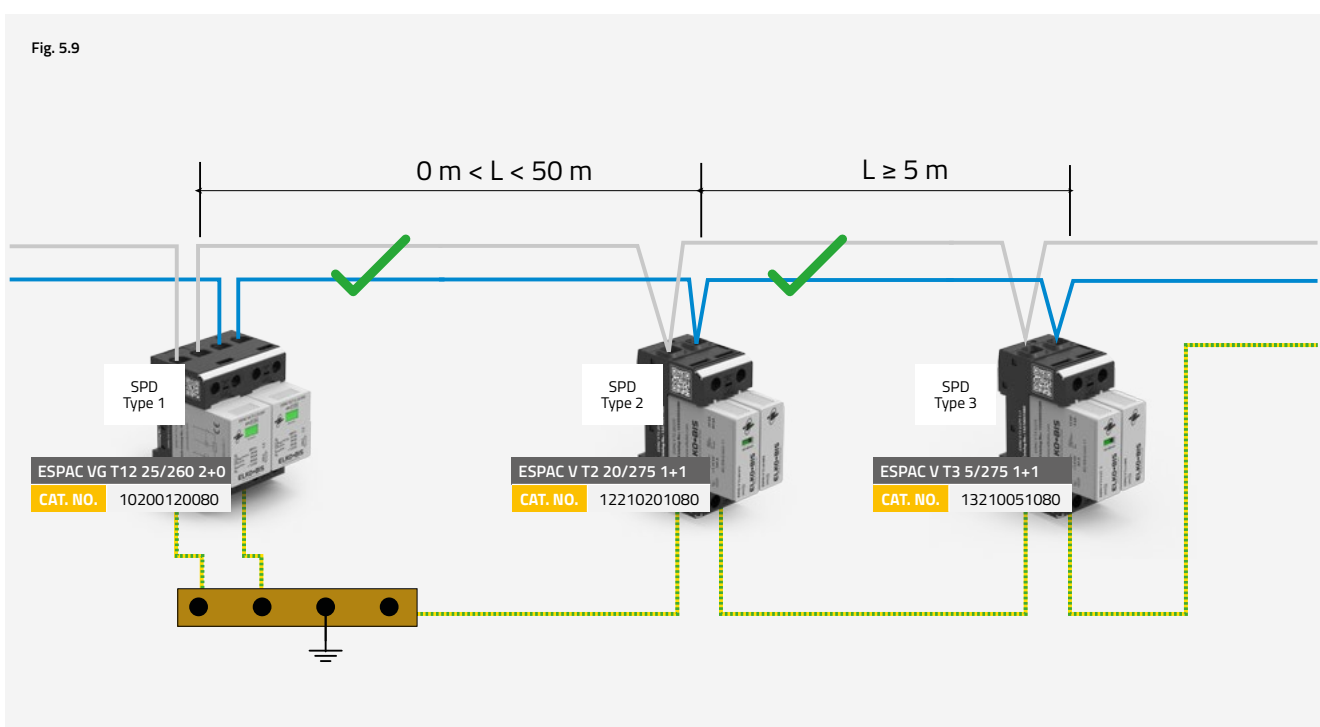


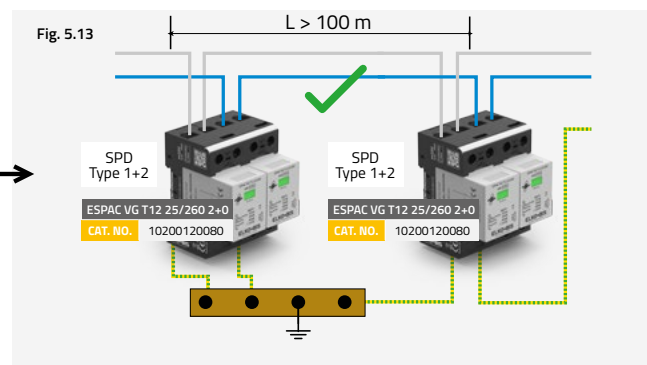
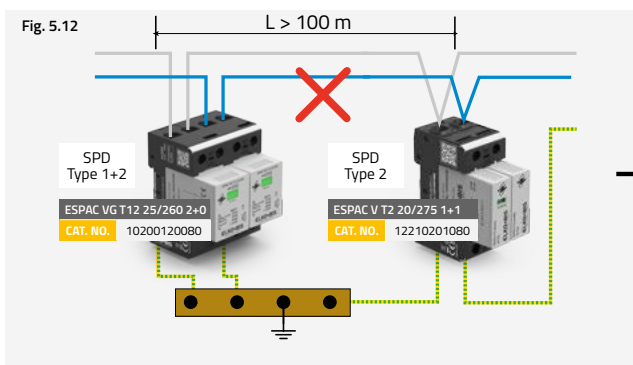
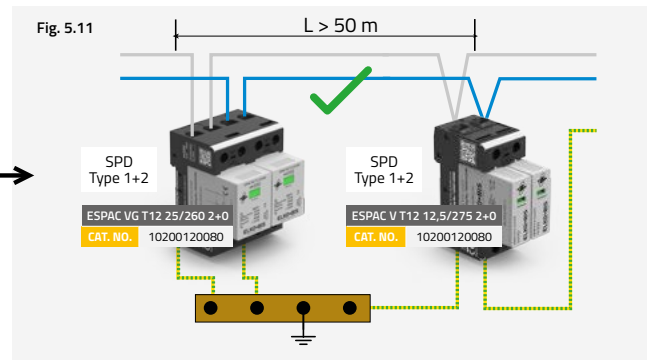
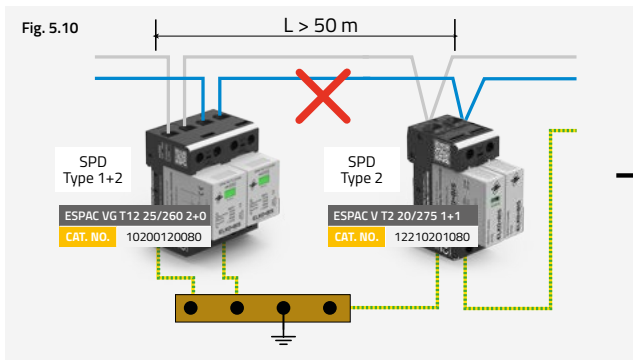
Fig. 5.9



Relationship between distance and surge protective device selection

In practice, situations arise where the devices to be protected are connected directly to the building's main distribution board, and the sub-distribution board is usually located several dozen meters away. In such cases, it is recommended to install an additional Type 1 + Type 2 surge protective device in the sub-distribution board

to eliminate overvoltages. Integrated surge protective devices - Type 1 + Type 2, characterized by the ability to discharge not only the lightning current - I_{imp} (10/350 μ s), but also the rated discharge current - $I_n = 30$ kA (8/20 μ s). This type of surge arrester can function as both a Type 1 and Type 2 SPD.



Protective distance for receivers

To protect loads, a surge protective device should be installed as close as possible to the receiver. If the distance between the SPD and the protected device is too great, voltages may appear on the line due to oscillations, which can damage the connected load or cause insulation breakdown in both the power supply and the load. These oscillations can even double the protective voltage U_p .

This doubling effect occurs when the input impedance is high. If the distance between the SPD and the protected device is $L \leq 10$ m, interference from oscillations does not need to be considered. If the distance is long ($L \gg 10$ m - much greater than 10 m), remember to install an additional SPD.

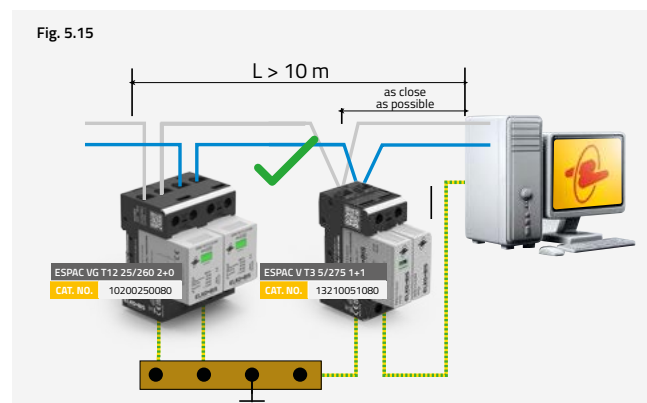
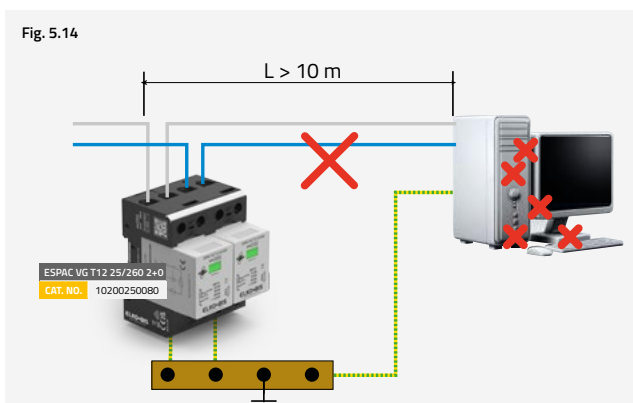


Fig. 5.16

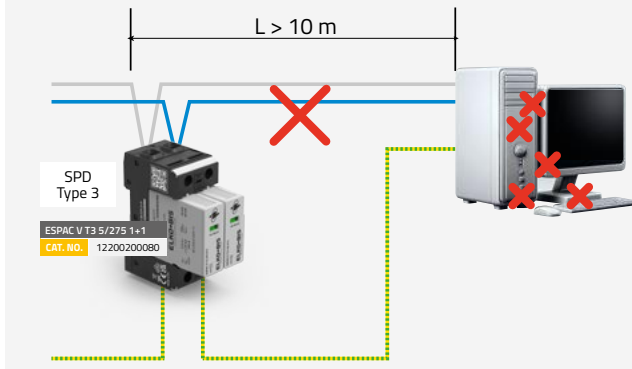
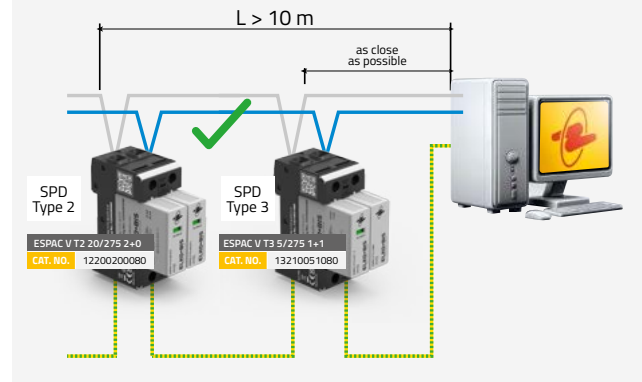


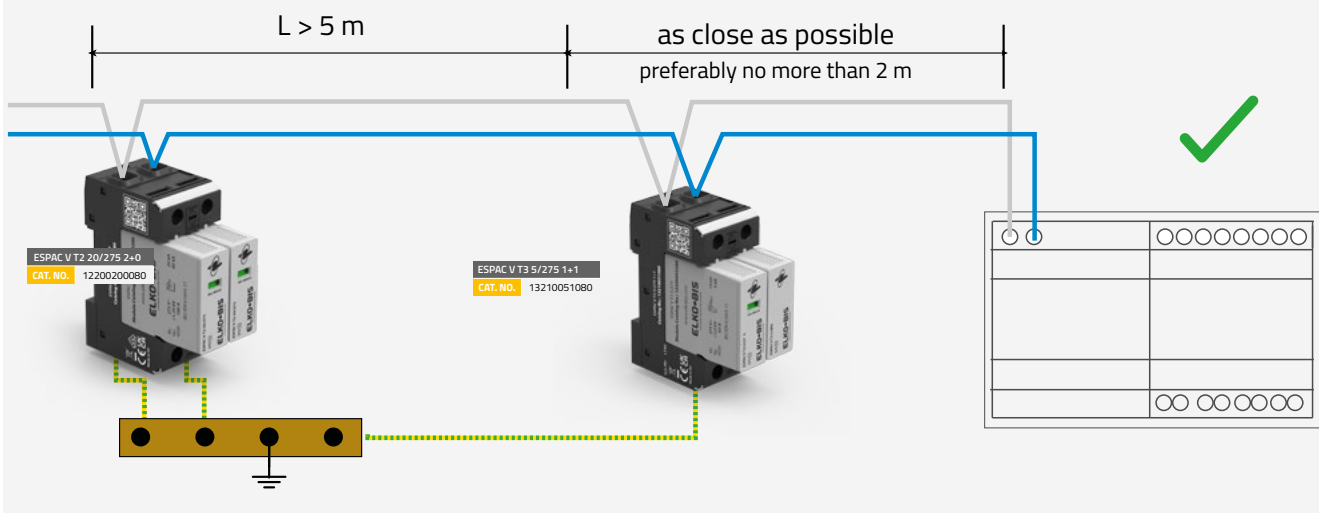
Fig. 5.17



In practice, the protective distance of surge arresters is always reduced by voltages induced by lightning currents or switching loads connected in the loop circuit. Therefore, the distance between SPDs and receivers should never exceed 5 m. This is particularly important when protecting highly sensitive electronic devices, such as electronic security systems, electronic fire alarm systems, PLCs, and other processor-controlled systems, which are also susceptible to induced switching overvoltages. Transient overvoltages of very short duration (μ s) and low pulse

amplitude (hundreds of volts) would reach the receivers, which may not destroy them, but could cause processor interruption, damage or erasure of memory chips, or degrade device functionality. Therefore, in such cases, an additional Type 3 SPD should be installed to protect sensitive receivers.

Fig. 5.18



6. Summary table of basic technical parameters of ELKO-BIS surge protective devices.

	CATALOG NUMBER	Name	U _n [V]	U _{c/cpv} [V]	I _{imp} [kA]	I _n [kA]	I _{max} [kA]	U _p [kV]	I _{sccr/scpv} [kA]	
1	10100250080	ESPAC VG T12 25/260 1+0	230	260	25	30	60	1,5	50	
2	10200250080	ESPAC VG T12 25/260 2+0	230	260	25	30	60	1,5	50	
3	10300250080	ESPAC VG T12 25/260 3+0	230	260	25	30	60	1,5	50	
4	10400250080	ESPAC VG T12 25/260 4+0	230	260	25	30	60	1,5	50	
5	10100250180	ESPAC VG T12 25/260 1+0 RI	230	260	25	30	60	1,5	50	
6	10200250180	ESPAC VG T12 25/260 2+0 RI	230	260	25	30	60	1,5	50	
7	10300250180	ESPAC VG T12 25/260 3+0 RI	230	260	25	30	60	1,5	50	
8	10400250180	ESPAC VG T12 25/260 4+0 RI	230	260	25	30	60	1,5	50	
9	10210251180	ESPAC VG T12 25/260 1+1 RI	230	260	25	30	60	1,5	50	
10	10410251180	ESPAC VG T12 25/260 3+1 RI	230	260	25	30	60	1,5	50	
11	10100120080	ESPAC V T12 12,5/275 1+0	230	275/350	12,5	30	60	1,5	50	
12	10200120080	ESPAC V T12 12,5/275 2+0	230	275/350	12,5	30	60	1,5	50	
13	10300120080	ESPAC V T12 12,5/275 3+0	230	275/350	12,5	30	60	1,5	50	
14	10400120080	ESPAC V T12 12,5/275 4+0	230	275/350	12,5	30	60	1,5	50	
15	10100120180	ESPAC V T12 12,5/275 1+0 RI	230	275/350	12,5	30	60	1,5	50	
16	10200120180	ESPAC V T12 12,5/275 2+0 RI	230	275/350	12,5	30	60	1,5	50	
17	10300120180	ESPAC V T12 12,5/275 3+0 RI	230	275/350	12,5	30	60	1,5	50	
18	10400120180	ESPAC V T12 12,5/275 4+0 RI	230	275/350	12,5	30	60	1,5	50	
19	10210121080	ESPAC V T12 12,5/275 1+1	230	275	12,5	25	60	1,5	50	
20	10410121080	ESPAC V T12 12,5/275 3+1	230	275	12,5	30	60	1,5	50	
21	10210121180	ESPAC V T12 12,5/275 1+1 RI	230	275	12,5	25	60	1,5	50	
22	10410121180	ESPAC V T12 12,5/275 3+1 RI	230	275	12,5	30	60	1,5	50	
23	12100200080	ESPAC V T2 20/275 1+0	230	275/350	-	20	40	1,35	50	
24	12200200080	ESPAC V T2 20/275 2+0	230	275/350	-	20	40	1,35	50	
25	12300200080	ESPAC V T2 20/275 3+0	230	275/350	-	20	40	1,35	50	
26	12400200080	ESPAC V T2 20/275 4+0	230	275/350	-	20	40	1,35	50	
27	12100200180	ESPAC V T2 20/275 1+0 RI	230	275/350	-	20	40	1,35	50	
28	12200200180	ESPAC V T2 20/275 2+0 RI	230	275/350	-	20	40	1,35	50	
29	12300200180	ESPAC V T2 20/275 3+0 RI	230	275/350	-	20	40	1,35	50	
30	12400200180	ESPAC V T2 20/275 4+0 RI	230	275/350	-	20	40	1,35	50	
31	12210201080	ESPAC V T2 20/275 1+1	230	275	-	20	40	1,35	50	
32	12410201080	ESPAC V T2 20/275 3+1	230	275	-	20	40	1,35	50	
33	12210201180	ESPAC V T2 20/275 1+1 RI	230	275	-	20	40	1,35	50	
34	12410201180	ESPAC V T2 20/275 3+1 RI	230	275	-	20	40	1,35	50	
35	12300102180	ESPAC V T2 20/600 3+0 RI	400-690	760	-	20	40	3,4	25	
36	13210051080	ESPAC V T3 5/275 1+1	230	275	-	5	-	1	-	
37	13210051180	ESPAC V T3 5/275 1+1 RI	230	275	-	5	-	1	-	
38	20121003080	ESPPV V T12 12,5/1000 Y	-	1050	-	20	40	3,8	20	
39	20121003180	ESPPV V T12 12,5/1000 Y RI	-	1050	-	20	40	3,8	20	
40	20121503080	ESPPV V T12 12,5/1500 Y	-	1500	-	20	40	5,4	20	
41	20121503180	ESPPV V T12 12,5/1500 Y RI	-	1500	-	20	40	5,4	20	
42	22120703080	ESPPV V T2 20/700 Y	-	750	-	20	40	3,6	10	
43	22120703180	ESPPV V T2 20/700 Y RI	-	750	-	20	40	3,6	10	
44	22121003080	ESPPV V T2 15/1000 Y	-	1020	-	15	40	4	10	
45	22121003180	ESPPV V T2 15/1000 Y RI	-	1020	-	15	40	4	10	

	CATALOG NUMBER	Name	t_a [ns]	U_{oc} [kV]	I_{cw} [kA]	Overcurrent protection	Network system	Remote indication	Modular width
	10100250080	ESPAC VG T12 25/260 1+0	100	20	-	250 A gL/gG	TN-S, TN-C, TN-C-S	NO	2 modules (36 mm)
	10200250080	ESPAC VG T12 25/260 2+0	100	20	-	250 A gL/gG	TN-S, TN-C, TN-C-S	NO	4 modules (72mm)
	10300250080	ESPAC VG T12 25/260 3+0	100	20	-	250 A gL/gG	TN-C	NO	6 modules (108 mm)
	10400250080	ESPAC VG T12 25/260 4+0	100	20	-	250 A gL/gG	TN-S, TN-C-S	NO	8 modules (144 mm)
	10100250180	ESPAC VG T12 25/260 1+0 RI	100	20	-	250 A gL/gG	TN-S, TN-C, TN-C-S	YES	2 modules (36 mm)
	10200250180	ESPAC VG T12 25/260 2+0 RI	100	20	-	250 A gL/gG	TN-S, TN-C, TN-C-S	YES	4 modules (72mm)
	10300250180	ESPAC VG T12 25/260 3+0 RI	100	20	-	250 A gL/gG	TN-C	YES	6 modules (108 mm)
	10400250180	ESPAC VG T12 25/260 4+0 RI	100	20	-	250 A gL/gG	TN-S, TN-C-S	YES	8 modules (144 mm)
	10210251180	ESPAC VG T12 25/260 1+1 RI	100	20	-	250 A gL/gG	TT, TN-S, TN-C, TN-C-S	YES	4 modules(72mm)
	10410251180	ESPAC VG T12 25/260 3+1 RI	100	20	-	250 A gL/gG	TT, TN-S, TN-C-S	YES	8 modules(144 mm)
	10100120080	ESPAC V T12 12,5/275 1+0	25	-	-	160 A gL/gG	TN-S, TN-C, TN-C-S	NO	1 module (18 mm)
	10200120080	ESPAC V T12 12,5/275 2+0	25	-	-	160 A gL/gG	TN-S, TN-C, TN-C-S	NO	2 modules (36 mm)
	10300120080	ESPAC V T12 12,5/275 3+0	25	-	-	160 A gL/gG	TN-C	NO	3 modules (54 mm)
	10400120080	ESPAC V T12 12,5/275 4+0	25	-	-	160 A gL/gG	TN-S, TN-C-S	NO	4 modules(72 mm)
	10100120180	ESPAC V T12 12,5/275 1+0 RI	25	-	-	160 A gL/gG	TN-S, TN-C, TN-C-S	YES	1 module (18 mm)
	10200120180	ESPAC V T12 12,5/275 2+0 RI	25	-	-	160 A gL/gG	TN-S, TN-C, TN-C-S	YES	2 modules (36 mm)
	10300120180	ESPAC V T12 12,5/275 3+0 RI	25	-	-	160 A gL/gG	TN-C	YES	3 modules (54 mm)
	10400120180	ESPAC V T12 12,5/275 4+0 RI	25	-	-	160 A gL/gG	TN-S, TN-C-S	YES	4 modules (72 mm)
	10210121080	ESPAC V T12 12,5/275 1+1	25	-	-	160 A gL/gG	TT, TN-S, TN-C, TN-C-S	NO	2 modules(36 mm)
	10410121080	ESPAC V T12 12,5/275 3+1	25	-	-	160 A gL/gG	TT, TN-S, TN-C-S	NO	4 modules (72 mm)
	10210121180	ESPAC V T12 12,5/275 1+1 RI	25	-	-	160 A gL/gG	TT, TN-S, TN-C, TN-C-S	YES	2 modules (36 mm)
	10410121180	ESPAC V T12 12,5/275 3+1 RI	25	-	-	160 A gL/gG	TT, TN-S, TN-C-S	YES	4 modules (72 mm)
	12100200080	ESPAC V T2 20/275 1+0	25	-	-	160 A gL/gG	TN-S, TN-C, TN-C-S	NO	1 module (18 mm)
	12200200080	ESPAC V T2 20/275 2+0	25	-	-	160 A gL/gG	TN-S, TN-C, TN-C-S.	NO	2 modules (36 mm)
	12300200080	ESPAC V T2 20/275 3+0	25	-	-	160 A gL/gG	TN-C	NO	3 modules (54 mm)
	12400200080	ESPAC V T2 20/275 4+0	25	-	-	160 A gL/gG	TN-S, TN-C-S	NO	4 modules (72 mm)
	12100200180	ESPAC V T2 20/275 1+0 RI	25	-	-	160 A gL/gG	TN-S, TN-C, TN-C-S	YES	1 module (18 mm)
	12200200180	ESPAC V T2 20/275 2+0 RI	25	-	-	160 A gL/gG	TN-S, TN-C, TN-C-S.	YES	2 modules (36 mm)
	12300200180	ESPAC V T2 20/275 3+0 RI	25	-	-	160 A gL/gG	TN-C	YES	3 modules (54 mm)
	12400200180	ESPAC V T2 20/275 4+0 RI	25	-	-	160 A gL/gG	TN-S, TN-C-S	YES	4 modules (72 mm)
	12210201080	ESPAC V T2 20/275 1+1	25	-	-	160 A gL/gG	TT, TN-S, TN-C, TN-C-S	NO	2 modules (36 mm)
	12410201080	ESPAC V T2 20/275 3+1	25	-	-	160 A gL/gG	TT, TN-S, TN-C-S	NO	4 modules (72 mm)
	12210201180	ESPAC V T2 20/275 1+1 RI	25	-	-	160 A gL/gG	TT, TN-S, TN-C, TN-C-S	YES	2 modules (36 mm)
	12410201180	ESPAC V T2 20/275 3+1 RI	25	-	-	160 A gL/gG	TT, TN-S, TN-C-S	YES	4 modules (72 mm)
	12300102180	ESPAC V T2 20/600 3+0 RI	100	-	-	100 A gL/gG	IT	YES	3 modules (54 mm)
	13210051080	ESPAC V T3 5/275 1+1	25	10	5	63 A gL/gG or C 63 A	TN-S, TN-C, TN-C-S, TT	NO	2 modules(36 mm)
	13210051180	ESPAC V T3 5/275 1+1 RI	25	10	5	63 A gL/gG or C 63 A	TN-S, TN-C, TN-C-S, TT	YES	2 modules(36 mm)
	20121003080	ESPPV V T12 12,5/1000 Y	25	-	-	-	-	NO	4 modules (72 mm)
	20121003180	ESPPV V T12 12,5/1000 Y RI	25	-	-	-	-	YES	4 modules (72 mm)
	20121503080	ESPPV V T12 12,5/1500 Y	25	-	-	-	-	NO	4 modules(72 mm)
	20121503180	ESPPV V T12 12,5/1500 Y RI	25	-	-	-	-	YES	4 modules (72 mm)
	22120703080	ESPPV V T2 20/700 Y	25	-	-	-	-	NO	3 modules (54 mm)
	22120703180	ESPPV V T2 20/700 Y RI	25	-	-	-	-	YES	3 modules (54 mm)
	22121003080	ESPPV V T2 15/1000 Y	25	-	-	-	-	NO	3 modules (54 mm)
	22121003180	ESPPV V T2 15/1000 Y RI	25	-	-	-	-	YES	3 modules (54 mm)



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7. FREQUENTLY ASKED QUESTIONS

1. Are varistors and spark gaps nonlinear elements? Are spark gaps and varistors semiconductors?

Yes, both the varistor and the spark gap are non-linear elements.

- A varistor has a nonlinear voltage-current characteristic – at low voltage, it conducts a very small current (leakage current), but after exceeding a certain voltage threshold, its resistance rapidly decreases and it begins to conduct a large current (e. g. lightning current to ground). It is used to protect electronic systems against overvoltages.
- The spark gap also has nonlinear characteristics. It does not conduct current until the breakdown voltage is exceeded, after which a spark discharge (ignition) occurs and a rapid current flow occurs.
- A varistor is a semiconductor, while a spark gap is not. A varistor is made of semiconductor materials, most often zinc oxide (ZnO) with the addition of other ceramic fillers. It is therefore a semiconductor element.
- A spark gap is not a semiconductor. It's a gaseous or vacuum electrotechnical element in which an electrical discharge occurs between electrodes. It does not rely on semiconductor phenomena, but on dielectric breakdown.

2. What is the point of using surge protective devices?

Surge protective devices are used to protect electrical and electronic devices from the effects of surges (sudden voltage increases and discharge currents), which can lead to damage to devices, fires, or system disruptions.

The main purposes of using surge arresters:

- Protection against atmospheric overvoltages (atmospheric discharges) - when lightning strikes, for example, a power line or its vicinity, it can generate a surge that propagates throughout the network. Surge protective devices discharge such impulses to ground.
- Protection against switching surges - surges can also occur as a result of sudden switching on or off of devices. Surge protective devices protect against these disturbances.
- Increased reliability and service life of protected electrical and electronic devices. Even short-term, low-energy surges can lead to component degradation over time. Surge protective devices reduce the risk of failure.
- Meeting standards and regulations. In many installations (e.g., residential, industrial, or telecommunications buildings), the use of surge protective devices is required by standards such as IEC 61643 and IEC 60364-4-44.

Read more: page 3

3. Which surge protective device should I choose to protect my electrical installation in a TN-S network? The LPL class for this building is set at I.

In a TN-S network, surge protective devices with a CT1 connection type and a 4+0 configuration (10400250080 ESPAC VG T12 25/260 4+0) or a CT2 connection type and a 3+1 configuration (10410251180 ESPAC VG T12 25/260 3+1 RI) are typically used in three-phase electrical installations.

In single-phase installations, surge protective devices with a CT1 connection type and a 2+0 configuration (10200250080 ESPAC VG T12 25/260 2+0) or a CT2 connection type and a 1+1 configuration (10210251180 ESPAC VG T12 25/260 1+1 RI) can be used.

Two single-pole surge protective devices (10100250080 ESPAC VG T12 25/260 1+0) can also be used. In this case,

the building is LPL I rated, hence the need to use surge protective devices with a lightning discharge current (Iimp) of 25 kA. Cascade protection can also be selected and completed with the proposed solutions by adding a Type 2 surge arrester in the three-phase sub-distribution board (12400200080 ESPAC V T2 20/275 4+0) and a Type 3 surge protective device in the single-phase local distribution board (13210051080 ESPAC V T3 5/275 1+1) to the surge protection, provided the appropriate installation distances for the surge protective devices in the cascade are maintained.

Read more: page 6

4. Which surge protective device should I choose to protect my electrical installation in a TN-C network? The LPL class for this building is set at IV.

In a TN-C network, surge protective devices with a CT1 connection type and a 3+0 configuration are typically used (10300120080 ESPAC V T12 12,5/275 3+0) for three-phase electrical installations. For single-phase installations, surge protective devices with a CT1 connection type and a 2+0 configuration (10200120080 ESPAC V T12 12,5/275 2+0) or a CT2 connection type and a 1+1 configuration (10210121080 ESPAC V T12 12,5/275 1+1) can be used.

Two single-pole surge protective devices (10100120080 ESPAC V T12 12,5/275 1+0) can also be used. In this case, the building is LPL IV class, hence the need to use

surge protective device with a lightning discharge current (I_{imp}) of 12,5 kA.

The proposed solutions can also be combined with cascade protection by adding a Type 2 surge protective device in the three-phase sub-distribution board (12300200080 ESPAC V T2 20/275 3+0) and a Type 3 surge protective device in the single-phase local distribution board (13210051080 ESPAC V T3 5/275 1+1) to the surge protection provided the appropriate installation distances for the arresters in the cascade are maintained.

Read more: page 7

5. Which surge protective device should I choose to protect my electrical installation in a TT network? The building does not have a lightning protection system (LPS).

In a TT network, surge protective devices with the CT2 connection type and a 3+1 configuration (12410201080 ESPAC V T2 20/275 3+1) are typically used in three-phase electrical installations. It is recommended to use a surge arrester with a rated discharge current of at least 10 kA. CT2 surge protective devices have a special design that combines varistor elements with a spark gap, ensuring galvanic separation of the PE conductor from other conductors. The 3+1 surge protective device configuration also protects against a possible short circuit between the neutral conductor (N) and the protective conductor (PE). Shorting the phase conductors (L1, L2, L3) with the protective conductor (PE) without simultaneously shorting the neutral conductor (N) is not possible in this type of surge arrester. A short circuit in the surge protective device between the phase conductor (L) and the neutral conductor (N) will cause a large current to flow, which, provided the electrical installation is properly designed, will automatically disconnect the power supply within the time specified in the IEC 60364-4-41

standard. It is also important to install a surge protective device upstream of the differential protection to avoid unnecessary tripping during proper operation of the electrical installation. In single-phase installations, surge arresters with a CT2 connection type and a 1+1 configuration (12210201080 ESPAC V T2 20/275 1+1) should be used.

In this case, the building does not have a lightning protection device (LPS), and the power supply is provided via a cable line, so a Type 2 surge protective device can be used as the main surge protection. The proposed solutions can also be combined with cascade protection by adding a Type 2 surge protective device in the three-phase sub-distribution board (12400200080 ESPAC V T2 20/275 4+0) and a Type 3 surge protective device in the single-phase local distribution board (13210051080 ESPAC V T3 5/275 1+1) to the surge protection system if the appropriate distances for installing surge protective devices in the cascade are maintained.

Read more: page 7

6. Which surge protective device should you choose as additional protection for expensive electronic devices susceptible to the negative effects of surges?

Type 3 surge protective devices are used in electrical installations to protect electrical and electronic end devices against overvoltages that may occur as a result of:

- switching operations,
- indirect lightning strikes,
- interference generated by other electrical devices.

Elko-Bis recommends using Type 3 surge protective devices to protect sensitive and expensive electronic devices: 13210051080 ESPAC V T3 5/275 1+1 and 13210051180 ESPAC V T3 5/275 1+1 RI. Remember to install the Type 3 SPD as close as possible to the protected devices.

Read more: page 30

7. Does a surge protective device need to be grounded?

The surge protective device must be grounded. This is crucial for its proper and safe operation.

Why is this necessary?

Surge current discharge – the purpose of a surge protective device is to discharge excess energy to ground. If it is not grounded, it will not be possible to discharge the surge current, this energy will not be effectively dissipated and may cause damage to the installation or equipment.

Safety of people and equipment – lack of grounding may cause overvoltage to affect other installation components, increasing the risk of electric shock or damaging electronic devices.

Compliance with standards – the requirement to ground surge protective devices is clearly defined in the standards: IEC 61643-11 and IEC 60364-5-53.

8. What are the most important standards regulating the use of surge protective devices?

The use of surge protective devices in electrical installations is regulated by several key standards – both national and international:

PN-EN 61643-11

Title: Low-voltage surge protective devices – Part 11: Surge protective devices connected to AC low-voltage power systems – Requirements and test methods

The standard specifies the technical parameters, classification, requirements, and test methods for SPDs. It divides SPDs into Types 1, 2, and 3:

- Type 1 – for protection against direct lightning strikes;
- Type 2 – for protection of internal installations against switching and induced overvoltages;
- Type 3 – for protection of terminal electronic devices.

IEC 60364-4-44

Tytuł: Title: Low-voltage electrical installations — Part 4-44: Protection for safety — Protection against voltage disturbances and electromagnetic disturbances

It contains requirements for protecting installations against overvoltages, including:

- when the use of SPDs is mandatory;
- in which cases they can be omitted (for example, risk analysis);
- it is established that protection is mandatory when overvoltages can cause: a life-threatening situation

(e.g., hospitals), disruption to public facilities (e.g., data centers), or significant economic losses.

IEC 60364-5-53:2001/A2:2015

Title: Low-voltage electrical installations – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control

It specifies the principles for the selection, placement, and installation of SPDs. It includes guidelines for:

- Surge Protective Device type depending on the application;
- installation location;
- grounding requirements.

IEC 62305 (series) – Protection against lightning

It applies to general lightning protection (LPS – Lightning Protection System). It is relevant when the SPD is part of a larger lightning protection system. The standard consists of several parts:

62305-1: Protection against lightning – Part 1: General principles

62305-2: Protection against lightning – Part 2: Risk management

62305-3: Protection against lightning – Part 3: Physical damage to structures and life hazard

62305-4: Protection against lightning – Part 4: Electrical and electronic systems within structures

9. How to check if the surge protective device is working properly?

To check if the surge protective device is working properly, you can do the following:

Checking the status indicator (visual indicator) – Most SPDs have a window or color marker that indicates the device's service life: green – the SPD is working properly; red – the SPD is damaged (the replaceable module or device should be replaced). The indicator is usually located on the front of the module – this is the quickest way to make an initial assessment.

Checking replaceable modules: Remove the replaceable module (if you have the authorization and the electrical installation is turned off); check the visual indicator and inspect the entire module; if damaged, replace only the module, not the entire device.

Measurement of insulation resistance or SPD tripping threshold voltage (after consultation with a qualified electrician) – only an authorized person can measure the electrical parameters of surge arresters:

- SPD tester / ignition voltage meter – checks whether the SPD will trip at the correct moment (usually above a voltage level of 250 V when applied between the L (phase) and PE (protective) conductors).
- Leakage current / insulation resistance measurement – allows for assessing the SPD's (varistor) service life.
- Checking other protection devices that work with the SPD (fuses, circuit breakers)

Sometimes it is not the surge protective device that's faulty, but the upstream protection. Make sure the protection has not tripped and the SPD circuit has not tripped. Check the continuity of the protective earth (PE) and neutral (N) conductors, as well as the condition of the electrical connections, including the terminals of the protective devices.

Checking the connected protective conductor (PE): Make sure the wires are securely fastened, check the continuity of the protective conductor (PE) and measure the grounding resistance.

10. Can I install a surge protective device myself?

It is not recommended to install a surge protective device (SPD) yourself unless you are an electrician and have the appropriate qualifications. Installation of a surge arrester should be performed by an electrician with a valid E-Qualification Certificate up to 1 kV.

A user without authorization can purchase a surge protective device and prepare the installation site; prepare the installation instructions to be handed over to an electrician; and check whether a surge arrester must be installed in the facility (commission a risk analysis).

11. In the case of surge protective devices used to protect photovoltaic installations, which of the connection arrangements of these arresters is the best and why: U, V or Y?

U configuration

The so-called „bipolar“ system protects only + and –. The surge protective device is connected between + and – (without connections to the protective conductor). No protection from ground.

Advantages:

- Inexpensive, easy to install.
- Sufficient for systems without grounding (IT network).

Disadvantages:

- Does not protect from ground; it may be ineffective in the event of overvoltages resulting from lightning strikes. Not recommended for use in electrical installations with a lightning protection system (LPS).

Applications:

- Small PV systems without a lightning protection system, with an isolated inverter (IT network).

V configuration

It consists of two current paths protected by nonlinear elements: one is located between the + and the PE protective conductor, the other between the – and the PE protective conductor. There is a terminal for the PE protective conductor (the third current path, not protected by a nonlinear element).

Advantages:

- Protection from earth (PE) – especially in the event of lightning discharges. Recommended in systems with LPS (lightning protection of the building).

Disadvantages:

- No nonlinear element protecting the current path of the PE protective conductor.
- Requires grounding and appropriate design.
- May not provide protection between poles (if they are sensitive to potential differences between + and –).

Applications:

- Electrical installations with LPS, large PV farms, and industrial facilities.

Y configuration

All three current paths, i.e., the +, –, and PE connections, are protected by separate non-linear elements to ensure maximum surge protection.

Advantages:

- Most comprehensive protection: between poles and against ground.
- Effective in both isolated and grounded systems.
- Minimizes the risk of damage to the inverter and electronic loads.

Disadvantages:

- Expensive due to the larger number of non-linear elements.

Applications:

- Recommended in modern PV systems with transformerless inverters.
- Recommended in systems with LPSs of various sizes and surge-sensitive electronic loads.

Read more: page 14

Comparison of U, V and Y configurations for DC SPDs:

Cecha	Configuration U	Configuration V	Configuration Y
Electrical connections	+ ↔ –	+ ↔ PE, – ↔ PE	+ ↔ –, + ↔ PE, – ↔ PE
Protection between poles (+/–)	✓ Yes	✗ No	✓ Yes
Protection against earth (PE)	✗ No	✓ Yes	✓ Yes
Overall effectiveness	⚠ Low	Medium	High
Grounding required	✗ No	✓ Yes	✓ Yes
Use with LPS?	✗ No	✓ Yes	✓ Yes
Application	Very small PV farms	PV farms with LPS	All PV farms
Cost	Lowest	Medium	Medium/high

12. What happens if I do not use a surge protective device in my photovoltaic installation?

If, after conducting a risk analysis, it is determined that a surge protective device does not necessarily need to be installed in a given DC electrical installation, then possible negative scenarios regarding the impact of surges on the installation should also be taken into account:

- possible damage to the inverter,
- possible damage to the PV modules,
- damage to other electrical devices in the building, especially their power supplies (surges can also affect the AC installation).

Read more: page 4

13. Is the use of surge protective devices in PV installations mandatory?

According to the IEC 60364-7-712 standard, surge protective devices are required in the following cases:

- when a building with a photovoltaic installation also has a lightning protection system (LPS);
- when the risk analysis indicates the need for surge protective devices;

- when the photovoltaic system is installed above 10 m from ground level

In practice, the use of surge protective devices is recommended in every PV installation.

Read more: page 14

14. Does a surge protective device affect the performance of an electrical installation?

No. The surge protective device only operates in the event of an overvoltage.

On a day-to-day basis, it does not significantly affect the operation of other components of the electrical installation – both other protection devices and electrical receivers. An exception may be the leakage current in surge arresters with a non-linear element in the form

of a varistor. In some network systems (for example, TT systems), it may cause unwanted tripping of the differential protection, but only in the case of incorrect installation and the selection of an inappropriate surge protective device.

15. Is the surge protective device covered by warranty?

Yes, for all Elko-Bis surge arresters this is a 3-year period.

Wear and tear of the device due to overvoltage, voltage interruption, or voltage limiting is not covered by the warranty. The warranty covers manufacturing defects and premature wear and tear of the device during normal

operation under normal operating conditions – for example, excessive varistor leakage current during the SPD protection warranty period.

16. I would like to replace the surge protective device in my installation. I have a surge arrester from a certain company, but I would like to replace it with a surge arrester from a different company. Can I do this?

Selecting and installing a replacement surge protective device from a different manufacturer is possible and permitted, but there are several important aspects to consider when making such a replacement:

- A replacement surge protective device should always be selected with the same technical parameters as the previous one or better. A surge arrester should be selected that will function properly in a given electrical installation, also taking into account its network system and other requirements. The replacement should be consistent with the information contained in the leading standards that apply to surge arresters. It is best to seek

the assistance of a technician to analyze such a replacement;

- the surge protective device should be installed by an electrician with an E-qualification certificate;
- If a larger electrical installation is being considered, for example in an industrial plant or a large commercial/office building, then the replacement of the surge protective device should also be based on the design of the electrical installation for such a facility.

17. Does the length of the cables connected to the surge protective device affect the effectiveness of this protective device?

Yes, longer wiring can increase voltage, reducing the effectiveness of surge protection.

Correct installation with optimal cable lengths is presented in this Installer's Guide on page 30.

[Read more: page 30](#)

18. Should the surge protective device be replaced after each trip?

No. Elko-Bis surge protective devices are designed to discharge lightning currents multiple times.

This is evidenced by the VDE and ECU certificates for the ESPAC and ESPPV families of modular surge protective devices. Replacement of the arrester module or the entire

device (if it does not have replaceable modules) should begin when the optical indicator changes color from green to red.

19. What do waveforms like 8/20 μ s and 10/350 μ s mean and how are they related?

Lightning-induced surge currents are characterized by rapidly rising „leading peaks“ and long, decaying „tails.“ The first number in each example surge waveform above represents the time it takes for the surge to reach 90% of its peak value, and the second number represents the time it takes for the surge to decay from its peak value to

its half-peak value. These times are measured in microseconds, although convention does not require this unit to appear after the waveform. The ratio of these different waveforms is a complex function based on energy integral.

[Read more: page 5](#)

20. How to deal with frequently recurring switching overvoltages?

The majority of all transient overvoltages (as much as 80%) are generated within the facility. These types of transients are typically characterized by lower energy and recurrence because they arise from the cyclical switching on and off of various loads within the facility. It is important to understand where these transient overvoltages may be originating and to ensure the appropriate

level of surge protection at that location. To protect the facility against switching overvoltages, the ESPAC V T2 20/275 and ESPAC V T3 5/275 surge protective devices series are recommended.

CE 3kV
Made in EU

ESPPV VT2 15/1000
Module Catalog No.: 22531003280

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ELKO-BIS
LIGHTNING PROTECTION SYSTEMS

U_{ov}	510 V~	$PV \square I_{in}$	15 kA
U_p	<2,0 kV	I_{max}	40 kA
IEC/EN 61643-31			

ELKO-BIS

LIGHTNING PROTECTION SYSTEMS

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