

442.2.3 Requirements for calculation of limits

The requirements of Regulations 442.2.1 and 442.2.2 are deemed to be fulfilled for installations receiving a supply at low voltage from a system for distribution of electricity to the public.

To fulfil the above requirements co-ordination between the HV system operator and the LV system installer is necessary. Compliance with the above requirements mainly falls into the responsibility of the substation installer/owner/operator who needs also to fulfil requirements provided by IEC 61936-1. Therefore, the calculation for U_1 , U_2 and U_f is normally not necessary for the LV system installer.

Possible measures to fulfil the above requirements are, for example:

- (i) separation of HV and LV earthing arrangements
- (ii) change of LV system earthing
- (iii) reduction of earth resistance, R_E .

442.3 Power frequency stress voltage in case of loss of the neutral conductor in a TN or TT system

Consideration shall be given to the fact that, if the neutral conductor in a three-phase TN or TT system is interrupted, basic, double and reinforced insulation as well as components rated for the voltage between line and neutral conductors can be temporarily stressed with the line-to-line voltage. The stress voltage can reach up to $U = \sqrt{3} U_0$.

442.4 Power frequency stress voltage in the event of an earth fault in an IT system with distributed neutral

Consideration shall be given to the fact that, if a line conductor of an IT system is earthed accidentally, insulation or components rated for the voltage between line and neutral conductors can be temporarily stressed with the line-to-line voltage. The stress voltage can reach up to $U = \sqrt{3} U_0$.

442.5 Power frequency stress voltage in the event of short-circuit between a line conductor and the neutral conductor

Consideration shall be given to the fact that, if a short-circuit occurs in the low voltage installation between a line conductor and the neutral conductor, the voltage between the other line conductors and the neutral conductor can reach the value of $1.45 \times U_0$ for a time up to 5s.

443 PROTECTION AGAINST OVERVOLTAGES OF ATMOSPHERIC ORIGIN OR DUE TO SWITCHING

443.1 Scope and object

443.1.1 This section deals with protection of electrical installations against transient overvoltages of atmospheric origin transmitted by the supply distribution system and against switching overvoltages generated by the equipment within the installation.

NOTE 1: BS EN 62305 provides a comprehensive risk assessment based system for lightning protection. This includes protection for electrical and electronic systems using a number of methods such as surge protective devices.

NOTE 2: This section takes into consideration the technical intent of HD 60364-4-443:2006, which was not fully aligned to BS EN 62305. The IEC are currently reviewing Section 443 and realigning it with IEC 62305.

Protection according to this section can be expected if the relevant equipment product standards require at least the values of withstand voltage of Table 44.3 according to the overvoltage category of equipment in the installation.

NOTE 3: Transient overvoltages transmitted by the supply distribution system are not significantly attenuated downstream in most installations.

Where protection against overvoltages is by the use of surge protective devices (SPDs) they shall be selected and erected in accordance with Section 534.

Examples of equipment with various impulse withstand categories are given in Table 44.4.

NOTE 4: Some electronic equipment may have protection levels lower than Category I of Table 44.3 – see Section 534.

Direct lightning strikes on the low voltage lines of the supply network or on electrical installations are not taken into account (conditions of external influence AQ3). See also BS EN 62305.

This section does not cover overvoltages transmitted by data transmission systems. See BS EN 50174.

NOTE 5: When the need for power SPDs is identified, additional SPDs on other services such as telecom lines are also recommended. See BS EN 62305 and BS EN 61643.

443.2 Arrangements for overvoltage control

443.2.1 Where an installation is supplied by a low voltage system containing no overhead lines, no additional protection against overvoltage of atmospheric origin is necessary if the impulse withstand voltage of equipment is in accordance with Table 44.3.

A suspended cable having insulated conductors with earthed metallic covering is deemed to be an underground cable for the purposes of this section.

443.2.2 Where an installation is supplied by a low voltage network which includes overhead lines or where the installation includes an overhead line and in either case the condition of external influences AQ1 (≤ 25 thunderstorm days per year) exists, no additional protection against overvoltages of atmospheric origin is required if the impulse withstand voltage of equipment is in accordance with Table 44.3.

NOTE: Irrespective of the AQ value, protection against overvoltages may be necessary in applications where a higher reliability or higher risks (e.g. fire) are expected. See BS EN 62305.

443.2.3 Where an installation is supplied by or includes a low voltage overhead line, a measure of protection against overvoltages of atmospheric origin shall be provided if the ceramic level of the location corresponds to the condition of external influences AQ2 (> 25 thunderstorm days per year). The protection level of the surge protective device shall not exceed the level of overvoltage Category II given in Table 44.3.

443.2.4 As an alternative to the AQ criteria in Regulations 443.2.2 and 443.2.3, the use of surge protection may be based on a risk assessment method.

NOTE 1: As far as Section 443 is concerned, a simple method, based on the critical length d_c of the incoming lines and the level of consequences as described below.

The following are different consequential levels of protection:

- (i) Consequences related to human life, e.g. safety services, medical equipment in hospitals
- (ii) Consequences related to public services, e.g. loss of public services, IT centres, museums
- (iii) Consequences to commercial or industry activity, e.g. hotels, banks, industries, commercial markets, farms
- (iv) Consequences to groups of individuals, e.g. large residential buildings, churches, offices, schools
- (v) Consequences to individuals, e.g. small or medium residential buildings, small offices.

For levels of consequences (i) to (iii) protection against overvoltage shall be provided.

NOTE 2: There is no need to perform a risk assessment calculation for levels of consequences (i) to (iii) because this calculation always leads to the result that the protection is required.

For levels of consequences (iv) and (v) requirements for protection depend on the result of a calculation. The calculation shall be carried out using the following formula for the determination of the length d , which is based on a convention and called conventional length.

The configuration of the low voltage distribution line, its earthing, insulation level and the phenomena considered (induced coupling, resistive coupling) lead to different choices for d . The determination proposed below represents, by convention, the worst case.

NOTE 3: This simplified method is based on IEC 61662.

$$d = d_1 + d_2/k_g + d_3/k_t$$

By convention d is limited to 1 km:

where:

d_1 is the length of the low voltage overhead supply line to the structure, limited to 1 km

d_2 is the length of the low voltage underground unscreened line to the structure, limited to 1 km
The length of a screened low voltage underground line is neglected.

d_3 is the length of the high voltage overhead supply line to the structure, limited to 1 km
The length of the high voltage underground line is neglected.

$k_g = 4$ is the reduction factor based on the ratio on the influence of strikes between the overhead lines and underground unscreened cables, calculated for a resistivity of soil of 250 Ωm

$k_t = 4$ is the typical reduction factor for a transformer.

Protection is required if: $d > d_c$

where:

- d is the conventional length in km of the supply line of the considered structure with a maximum value of 1 km
- d_c is the critical length in km, equal to $1/N_g$ for level of consequences (iv) and equal to $2/N_g$ for level of consequences (v), where N_g is the frequency of flashes per km² per year.

If this calculation indicates that a surge protective device (SPD) is required, the protection level of these protective devices shall not be higher than the level of overvoltage Category II given in Table 44.3.

443.2.5 Deleted by BS 7671:2008 Amendment No 1

443.2.6 Where required or otherwise specified in accordance with this section, overvoltage protective devices shall be located as close as possible to the origin of the installation.

TABLE 44.3 – Required minimum impulse withstand voltage, U_w

Nominal voltage of the installation V	Required minimum impulse withstand voltage kV^1			
	Category IV (equipment with very high impulse voltage)	Category III (equipment with high impulse voltage)	Category II (equipment with normal impulse voltage)	Category I (equipment with reduced impulse voltage)
230/240 277/480	6	4	2.5	1.5
400/690	8	6	4	2.5
1000	12	8	6	4

¹ This impulse withstand voltage is applied between live conductors and PE.

TABLE 44.4 – Examples of various impulse category equipment

Category	Example
I	Equipment intended to be connected to the fixed electrical installation where protection against transient overvoltage is external to the equipment, either in the fixed installation or between the fixed installation and the equipment. Examples of equipment are household appliances, portable tools and similar loads intended to be connected to circuits in which measures have been taken to limit transient overvoltages.
II	Equipment intended to be connected to the fixed electrical installation e.g. household appliances, portable tools and similar loads, the protective means being either within or external to the equipment.
III	Equipment which is part of the fixed electrical installation and other equipment where a high degree of availability is expected, e.g. distribution boards, circuit-breakers, wiring systems, and equipment for industrial uses, stationary motors with permanent connection to the fixed installation.
IV	Equipment to be used at or in the proximity of the origin of the electrical installation upstream of the main distribution board, e.g. electricity meter, primary overcurrent device, ripple control unit.

534 DEVICES FOR PROTECTION AGAINST OVERVOLTAGE

For further information see Appendix 16.

534.1 Scope and object

This section contains provisions for the application of voltage limitation to obtain insulation coordination in the cases described in Section 443, BS EN 60664-1, BS EN 62305-4 and BS EN 61643 (CLC/TS 61643-12). Protection against malfunction of electrical and electronic equipment due to overvoltages is not covered in this section. Protective measures against malfunction of such equipment are detailed in the BS EN 61643 series (CLC/TS 61643-12). BS EN 62305-4 and CLC/TS 61643-12 deal with the protection against the effects of direct lightning strokes or strokes near to the supply system. Both documents describe the selection and the application of surge protective devices (SPDs) according to the lightning protection zones (LPZ) concept. The LPZ concept describes the installation of Type 1, Type 2 and Type 3 SPDs.

SPDs, specific isolating transformers, filters or a combination of these may be used for protection against overvoltages.

These requirements are for the selection and erection of:

- (i) SPDs for electrical installations of buildings to obtain a limitation of transient overvoltages of atmospheric origin transmitted via the supply distribution system and against switching overvoltages
- (ii) SPDs for the protection against transient overvoltages caused by direct lightning strokes or lightning strokes in the vicinity of buildings protected by a lightning protection system.

These requirements do not take into account surge protective components which may be incorporated in the appliances connected to the installation. The presence of such components may modify the behaviour of the main surge protective device of the installation and may need an additional coordination.

These requirements also cover protection against overcurrent due to SPD failure and the consequences of that failure.

NOTE 1: For example, failure can be due to mains supply faults or due to the SPD reaching the end of its life.

These requirements apply to a.c. power circuits.

NOTE 2: Overvoltages of atmospheric origin and electrical switching events can affect metallic data, signal and telecommunication lines. Protection measures for these systems are detailed within CLC/TS 61643-22.

534.2 Selection and erection of surge protective devices

534.2.1 Use of SPDs

Where required by Section 443 or otherwise specified, SPDs shall be installed:

- (i) near the origin of an installation, or
- (ii) in the main distribution assembly nearest the origin of an installation.

NOTE 1: Annex E of CLC/TS 61643-12 provides examples of application of the risk analysis as described in Section 443.

When two or more SPDs are used on the same conductor, they shall be coordinated and as such are referred to as coordinated SPDs. In accordance with BS EN 62305-4, protection of electrical and electronic systems within structures requires coordinated SPDs.

Where required and in accordance with BS EN 62305-4 or otherwise specified, SPDs shall be installed at the origin of an installation.

NOTE 2: Depending on the voltage stress, Type 1 or Type 2 SPDs may be used at the origin whilst Type 2 or Type 3 are also suited for location close to the protected equipment to further protect against switching transients generated within the building.

NOTE 3: Type 1 SPDs are often referred to as equipotential bonding SPDs and are fitted at the origin of the installation to specifically prevent dangerous sparking which could lead to fire or electric shock hazards. A lightning protection system which only employs equipotential bonding SPDs provides no effective protection against failure of sensitive electrical and electronic systems.

Additional SPDs are required to protect sensitive and critical equipment (for example hospital equipment and fire/security alarm systems). Such SPDs shall be coordinated with the SPDs installed upstream and be installed as close as practicable to the equipment to be protected. Where SPDs are required in accordance with Section 443 or BS EN 62305-4, consideration shall be given to the installation of SPDs on other incoming networks (such as metallic telecommunication and signalling services).

534.2.2 Connection of SPDs

Where required by Regulation 534.2.1, SPDs at or near the origin of the installation shall be connected between specific conductors according to Table 53.2.

Where the equipment to be protected has a sufficient overvoltage withstand or is located close to the main distribution board, one SPD assembly may be sufficient if it provides sufficient modes of protection.

NOTE 1: Sensitive electronic equipment requires both common mode protection (conductors with respect to earth e.g. line and earth, neutral and earth) as well as differential mode protection (between live conductors, e.g. line and neutral).

The SPD assembly shall be installed as close as possible to the origin of the installation and shall have sufficient surge withstand capability for this location.

SPDs at or near the origin of the installation shall be connected at least between the following points:

- (i) If there is no direct connection between the neutral conductor and protective conductor at or near the origin of the installation:

between each line conductor and either the main earthing terminal or the main protective conductor, and between the neutral conductor and either the main earthing terminal or the protective conductor, whichever route is the shorter - Connection Type 1 (CT 1), see Figure 53.1

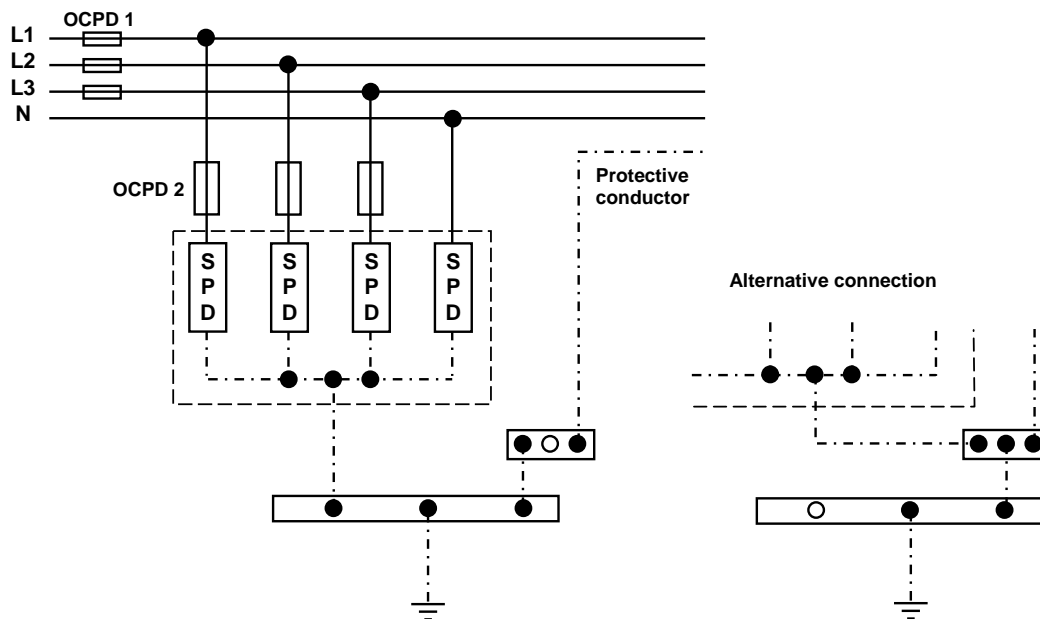
or alternatively,

between each line conductor and the neutral conductor and between the neutral conductor and either the main earthing terminal or the protective conductor, whichever route is the shorter – Connection Type 2 (CT 2) see Figure 53.2.

NOTE 2: If a line conductor is earthed, it is considered to be equivalent to a neutral conductor for the application of this regulation.

NOTE 3: It is recommended that the power and signalling cabling enter the structure to be protected in close proximity and are bonded together at the main earthing terminal.

Fig 53.1 – Connection Type 1 (CT 1)



OCPD = overcurrent protective device

Fig 53.2 – Connection Type 2 (CT 2)

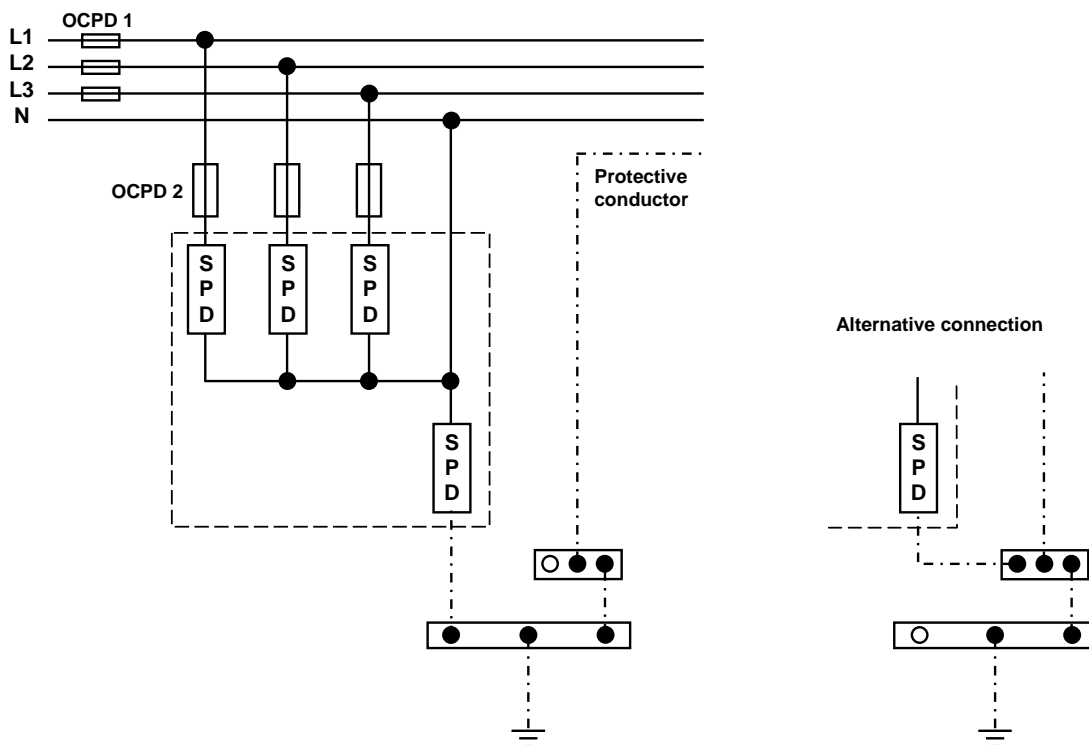


TABLE 53.2 – Modes of protection for various LV systems

SPDs connected between:	TN-C-S, TN-S or TT		IT without distributed neutral
	Installation in accordance with		
	CT 1	CT 2	
Each line conductor and neutral conductor	+	•	N/A
Each line conductor and PE conductor	•	N/A	•
Neutral conductor and PE conductor	•	•	N/A
Each line conductor and PEN conductor	N/A	N/A	N/A
Line conductors	+	+	+

• = SPD required, N/A = not applicable, + = optional, in addition, CT = Connection Type

NOTE 1: If more than one SPD is connected on the same conductor, it is necessary to ensure co-ordination between them.

NOTE 2: The number of modes of protection depends on the type of equipment to be protected (for example if the equipment is not connected to earth, line or neutral to earth protection may not be necessary), the withstand of the equipment in accordance with each mode of protection, the electrical system structure and earthing and the characteristics of the incoming surge. For example, protection between line/neutral and protective conductor or between line and neutral are generally sufficient, and protection between line and line is not used generally.

Consideration shall be given to the installation of additional SPDs at other locations. Sensitive and critical equipment requires protection in both common and differential modes to ensure further protection against switching transients.

534.2.3 Selection of surge protective devices (SPDs)

SPDs shall be selected in accordance with the following regulations.

534.2.3.1 Selection with regard to voltage protection level (U_p)

534.2.3.1.1 The impulse withstand voltage of the equipment (or impulse immunity of critical equipment) to be protected and the nominal voltage of the system shall be considered in selecting the preferred voltage protection level (U_p) value of the SPD.

SPDs shall be selected to provide a voltage protection level lower than the impulse withstand capability of the equipment or, in some cases where the continuous operation of the equipment is critical, lower than the impulse immunity of the equipment.

SPDs with lower voltage protection levels provide better protection. However, consideration shall be given to the effects of temporary overvoltages on an SPD (or built-in surge protective component) having an excessively low protection level. SPDs shall be selected which will protect equipment from failure, remain operational during surge activity and withstand most temporary overvoltage conditions.

The voltage protection level (U_p) of SPDs shall be selected in accordance with impulse withstand voltage Category II of Table 44.3. If BS EN 62305-2 requires SPDs for the protection against overvoltages caused by direct lightning strokes, the protection level of these SPDs shall also be selected in accordance with impulse withstand voltage Category II of Table 44.3. In installations operating at 230/400 V, the protection level of the installed SPD shall not exceed 2.5 kV, as the SPD's connecting leads have additional inductive voltage drop across them (see Regulation 534.2.9). It may therefore be necessary to select an SPD with a lower voltage protection level.

If the distance between the SPD and equipment to be protected (protective distance) is greater than 10 m, oscillations could lead to a voltage at the equipment terminals of up to twice the SPD's voltage protection level. Consideration shall be given to the provision of additional coordinated SPDs, closer to the equipment, or the selection of SPDs with a lower voltage protection level.

534.2.3.1.2 Where SPDs are connected as in Figure 53.2 the voltage protection level (U_p) required shall be met by the serial combination of the two SPDs between line and neutral and between neutral and the protective conductor.

Where the voltage protection level required cannot be obtained with a single SPD, additional SPDs, which are coordinated, shall be installed to ensure the required voltage protection level.

To protect sensitive and critical equipment, consideration shall be given to the installation of additional coordinated SPDs selected in accordance with impulse withstand voltage Category I (1.5 kV) of Table 44.3.

NOTE 1: Annex D of CLC/TS 61643-12 provides application examples of selecting SPDs and choice of protection level U_p .

534.2.3.2 Selection with regard to continuous operating voltage (U_c)

The maximum continuous operating voltage U_c of SPDs shall be equal to or higher than that required by Table 53.3.

TABLE 53.3 – Minimum required U_c of the SPD dependent on supply system configuration

SPDs connected between:	TN-C-S, TN-S or TT	IT without distributed neutral
Line conductor and neutral conductor	1.1 $U_{\alpha \text{ spd}}$	N/A
Each line conductor and PE conductor	1.1 $U_{\alpha \text{ spd}}$	Line to line voltage (Note 2)
Neutral conductor and PE conductor	$U_{\alpha \text{ spd}}$ (Note 2)	N/A
Each line conductor and PEN conductor	N/A	N/A
<p>N/A = not applicable</p> <p>NOTE 1: $U_{\alpha \text{ spd}}$ is the nominal a.c. rms line voltage of the low voltage system to Earth.</p> <p>NOTE 2: These values are related to worst-case fault conditions, therefore the tolerance of 10 % is not taken into account.</p> <p>NOTE 3: In extended IT systems, higher values of U_c may be necessary.</p>		

534.2.3.3 Selection with regard to temporary overvoltages (TOVs)

SPDs shall be selected and erected in accordance with manufacturers' instructions.

NOTE: The loss of neutral is not covered by these requirements. Although there is currently no specific test in BS EN 61643-11, SPDs are expected to fail safely.

534.2.3.4 Selection with regard to nominal discharge current (I_{nspd}) and impulse current (I_{imp})

534.2.3.4.1 SPDs shall be selected according to their withstand capability, as classified in BS EN 61643-11 for power systems and in BS EN 61643-21 for telecommunication systems.

The nominal discharge current I_{nspd} of the SPD shall be not less than 5 kA with a waveform characteristic 8/20 for each mode of protection.

534.2.3.4.2 For Connection Type 2 (CT 2), the nominal discharge current I_{nspd} for the SPD connected between the neutral conductor and the protective conductor shall be not less than 20 kA with a waveform characteristic 8/20 for three-phase systems and 10 kA with a waveform characteristic 8/20 for single-phase systems.

Type 1 SPDs shall be installed where a structural lightning protection system is fitted or the installation is supplied by an overhead line at risk of direct lightning strike.

The lightning impulse current I_{imp} according to BS EN 61643-11 shall be calculated according to BS EN 62305-4.

Where Type 1 SPDs are required, the value of I_{imp} shall be not less than 12.5 kA for each mode of protection, if I_{imp} cannot be calculated.

534.2.3.4.3 For Connection Type 2 (CT 2) installations, the lightning impulse current I_{imp} for the SPD connected between the neutral conductor and the protective conductor shall be calculated in accordance with BS EN 62305-4. If the current value cannot be established, the value of I_{imp} shall be not less than 50 kA for three-phase systems and 25 kA for single-phase systems.

534.2.3.4.4 When a single SPD is used for protection according to both BS EN 62305-4 and Section 443, the rating of I_{nspd} and of I_{imp} shall comply with the requirements of Regulation 534.2.3.4.3.

534.2.3.5 Selection with regard to the prospective fault current and the follow current interrupt rating

The short-circuit withstand of the combination SPD and overcurrent protective device (OCPD), as stated by the SPD manufacturer shall be equal to or higher than the maximum prospective fault current expected at the point of installation.

NOTE 1: The OCPD may be either internal or external to the SPD.

When a follow current interrupt rating is declared by the manufacturer, it shall be equal to or higher than the prospective line to neutral fault current at the point of installation.

NOTE 2: Follow current interrupt rating is only applicable to certain voltage switching devices such as spark gaps and gas discharge tubes.

SPDs connected between the neutral conductor and the protective conductor in TT or TN systems, which allow a power frequency follow current after operation (e.g. spark gaps) shall have a follow current interrupt rating greater than or equal to 100 A.

In IT systems, the follow current interrupt rating for SPDs connected between the neutral connector and the protective conductor shall be the same as for SPDs connected between line and neutral.

534.2.3.6 Co-ordination of SPDs

SPDs shall be selected and erected such as to ensure coordination in operation.

534.2.4 Protection against overcurrent and consequences of SPD's end of life

Protection against SPD short-circuits is provided by OCPDs (see Figures 53.1 and 53.2) which shall be selected according to the recommended ratings given in the manufacturer's SPD instructions.

OCPD2 may be omitted if the characteristics of OCPD1 meet the requirements given in the manufacturer's instructions.

534.2.5 Fault protection integrity

Fault protection shall remain effective in the protected installation even in case of failures of SPDs.

In TN systems, automatic disconnection of supply shall be obtained by correct operation of the overcurrent protective device on the supply side of the SPD.

In TT systems this shall be obtained by either:

- (i) the installation of SPDs on the load side of an RCD (see Figure 16A.2 in Appendix 16), or
- (ii) the installation of SPDs on the supply side of an RCD (see Figure 16A.3 in Appendix 16).

Owing to the possibility of the failure of an SPD between neutral and protective conductors,

- (iii) the conditions of Regulation 411.4.1 shall be met, and
- (iv) the SPD shall be installed in accordance with Regulation 534.2.2, Connection Type 2 (CT 2).

In IT systems, no additional measure is required.

534.2.6 SPD installation in conjunction with RCDs

Where SPDs are installed in accordance with Regulation 534.2.1 and are on the load side of a residual current device, an RCD having an immunity to surge currents of at least 3 kA 8/20, shall be used.

NOTE 1: S-type RCDs satisfy this requirement.

NOTE 2: In the case of surge current higher than 3 kA 8/20, the RCD may trip causing interruption of the power supply.

534.2.7 Not used

534.2.8 SPD status indication

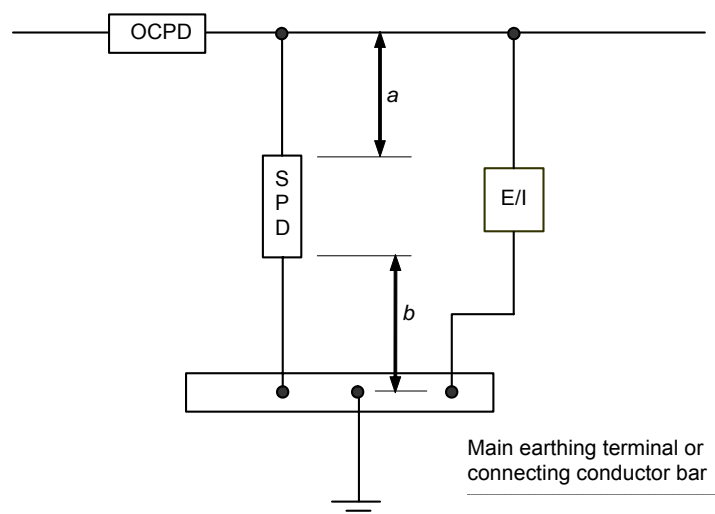
Indication that the SPD no longer provides overvoltage protection shall be provided by a status indicator local to the SPD itself and/or remote, to provide electrical, visual or audible alarms.

534.2.9 Critical length of connecting conductors

To gain maximum protection the supply conductors shall be kept as short as possible, to minimize additive inductive voltage drops across the conductors. Current loops shall be avoided (see Figure 53.3). The total lead length ($a + b$) should preferably not exceed 0.5 m, but shall in no case exceed 1.0 m. Where an SPD is fitted in-line (see Figure 53.4), the protective conductor (length c) should not exceed 0.5 m in length, and in no case shall exceed 1.0 m.

NOTE: To keep the connections of SPDs as short and inductance as low as possible, SPDs may be connected to the main earthing terminal or to the protective conductor, e.g. via the metallic enclosures of the assembly being connected to the protective conductor.

Fig 53.3 – Example of a shunt installation of SPDs at or near the origin of the electrical installation

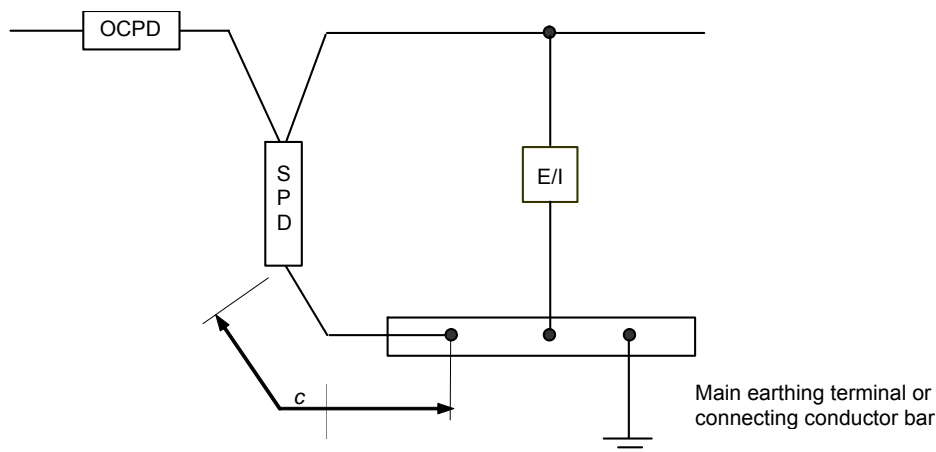


OCPD = overcurrent protective device

SPD = surge protective device

E/I = equipment or installation to be protected against overvoltages

Fig 53.4 – Example of an in-line installation of SPDs at or near the origin of the electrical installation



OCPD = overcurrent protective device

SPD = surge protective device

E/I = equipment or installation to be protected against overvoltages

NOTE: The line terminal on the SPD must be capable of carrying the load current.

534.2.10 Cross-sectional area of connecting conductors

The connecting conductors of SPDs shall either:

- (i) have a cross-sectional area of not less than 4 mm² copper (or equivalent) if the cross-sectional area of the line conductors is greater than or equal to 4 mm², or
- (ii) have a cross-sectional area not less than that of the line conductors, where the line conductors have a cross-sectional area less than 4 mm².

Where there is a structural lightning protection system, the minimum cross-sectional area for Type 1 SPDs shall be 16 mm² copper, or equivalent.

535 DEVICES FOR PROTECTION AGAINST UNDERVOLTAGE

A device for protection against undervoltage shall be selected and erected so as to allow compliance with the requirements of Section 445.

536 CO-ORDINATION OF PROTECTIVE DEVICES

536.1 General

Where co-ordination of series protective devices is necessary to prevent danger and where required for proper functioning of the installation, consideration shall be given to selectivity and/or any necessary back-up protection.

Selectivity between protective devices depends on the co-ordination of the operating characteristics of two or more protective devices such that, on the incidence of fault currents within stated limits, only the device intended to operate within these limits does so (see Regulation 536.5).

The rated breaking capacity of a protective device shall be not less than the maximum prospective short-circuit or earth fault current at the point at which the device is installed unless back-up protection is provided. A lower breaking capacity is permitted if another protective device (a back-up protective device) having the necessary breaking capacity is installed on the supply side and the characteristics of the devices are suitably co-ordinated such that the energy let-through of the upstream device does not exceed that which can be withstood without damage by the downstream device (see Chapter 43).

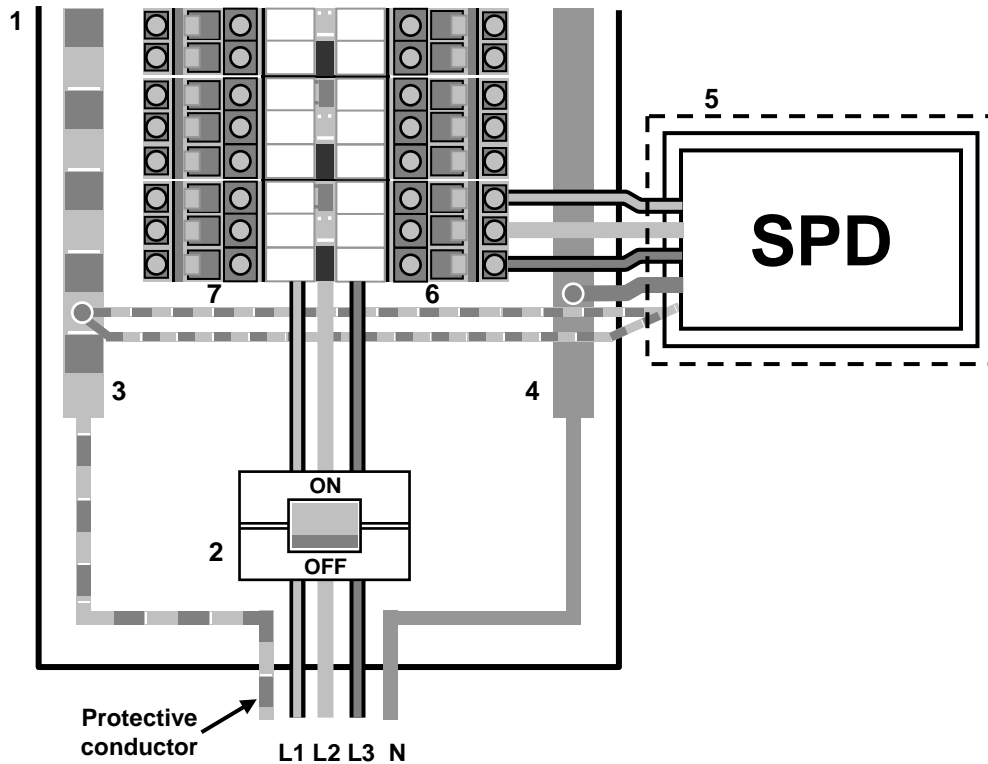
NOTE: Back-up protection on the load side of a protective device is acceptable only if the risk of a fault in the circuit between the two protective devices in series is negligible.

APPENDIX 16 (Informative)

Devices for protection against overvoltage

Typical installation of a surge protective device (SPD) in a power distribution board for a TN-S system.

Fig 16A.1 – SPD connected to the first overcurrent protective device (OCPD) to the incoming supply



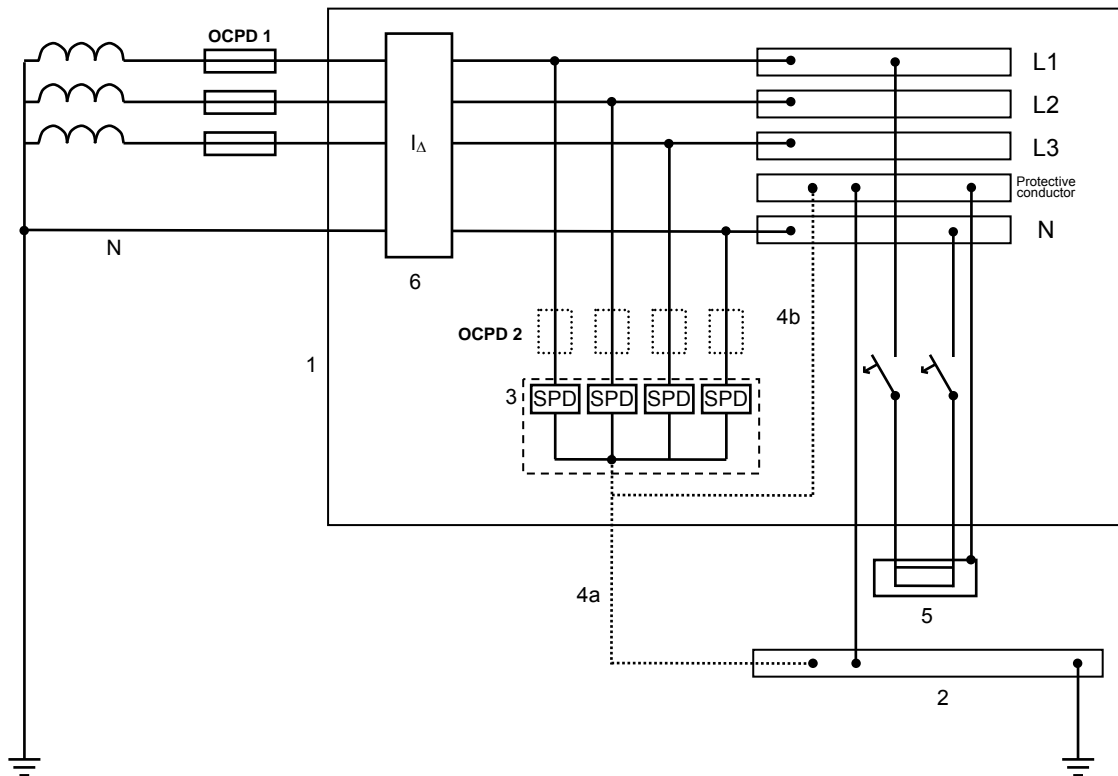
Key :

- 1 distribution board
- 2 main switch
- 3 earthing bar
- 4 neutral bar
- 5 enclosure for SPD
- 6 first OCPD
- 7 alternative first OCPD

NOTE: The OCPD provides a convenient means to protect the SPD and a means of isolation. As there is insufficient room within the distribution board the SPD is mounted in a separate enclosure for electrical safety. This enclosure is mounted directly alongside the distribution board to ensure the connecting leads are kept short. An additional local bonding connection is made to further minimize voltage drop on the connecting leads.

Installation of surge protective devices in TT systems, Connection Type 1 (CT 1)

Fig 16A.2 – SPDs on the load side of an RCD [according to Regulation 534.2.5(i)]

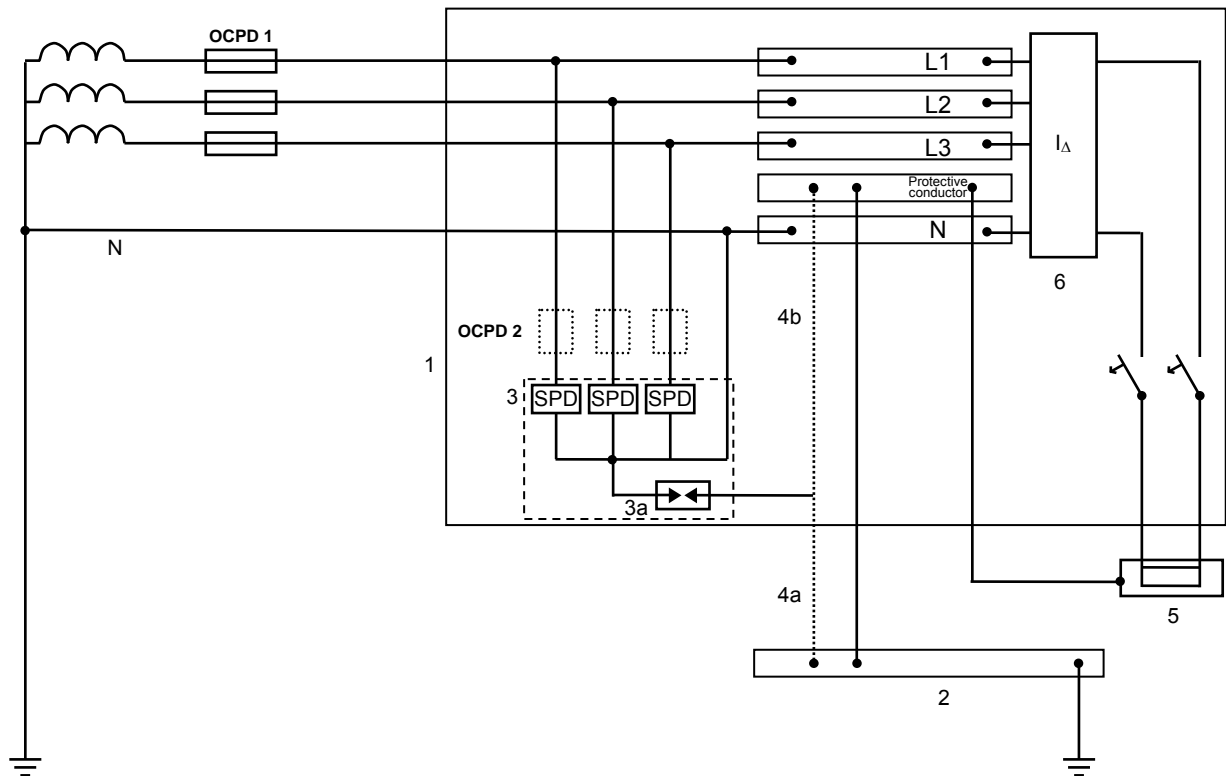


Key

- | | |
|---|--|
| <ul style="list-style-type: none"> 1 Distribution board 2 Main earthing terminal or bar 3 Surge protective devices ensuring a protection level in accordance with overvoltage Category II 4 Earthing connection of surge protective devices, either 4a or 4b, whichever is the shorter route 5 Current-using equipment 6 Residual current protective device (RCD) | <ul style="list-style-type: none"> OCPD 1 Overcurrent protective device at the origin of the installation OCPD 2 Overcurrent protective device |
|---|--|

Installation of surge protective devices in TT systems, Connection Type 2 (CT 2)

Fig 16A.3 – SPDs on the supply side of an RCD [according to Regulation 534.2.5(ii)]



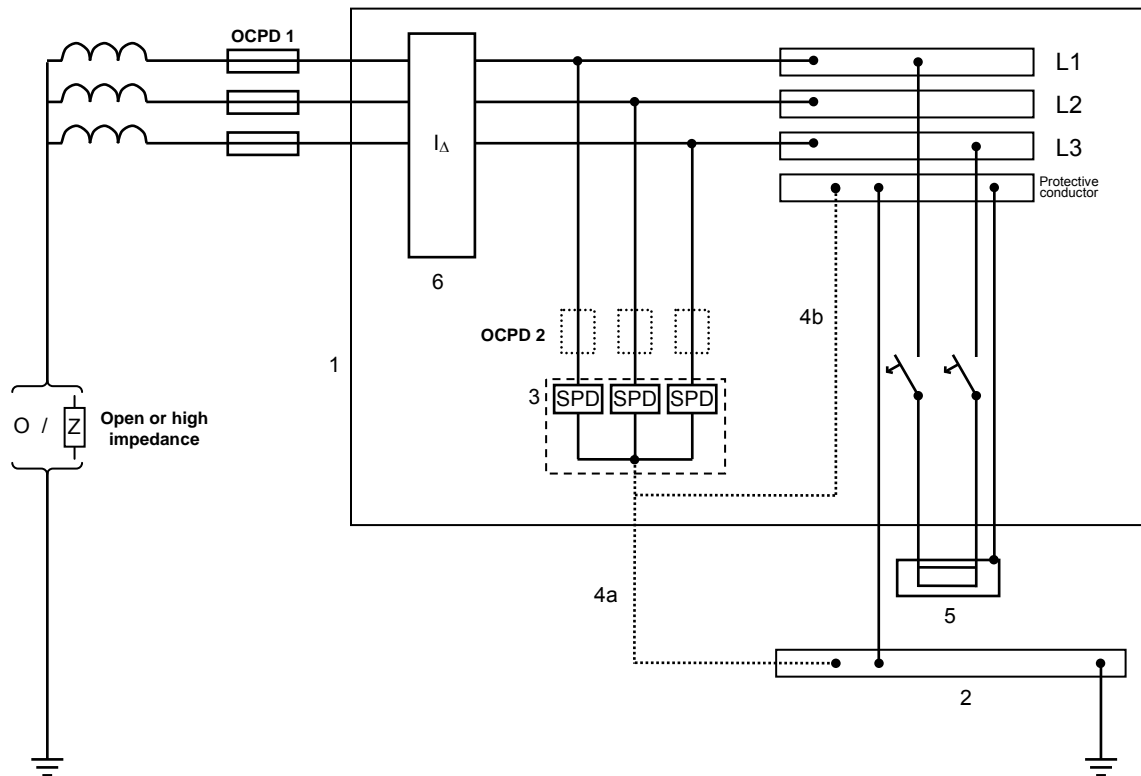
Key

- | | |
|----|--|
| 1 | Distribution board |
| 2 | Main earthing terminal or bar |
| 3 | Surge protective devices |
| 3a | Surge protective device (SPDs 3 and 3a in series ensuring a protection level in accordance with overvoltage Category II) |
| 4 | Earthing connection of surge protective devices, either 4a or 4b, whichever is the shorter route |
| 5 | Current-using equipment |
| 6 | Residual current protective device (RCD) installed downstream of the surge protective devices |

- | | |
|--------|---|
| OCPD 1 | Overcurrent protective device at the origin of the installation |
| OCPD 2 | Overcurrent protective device |

Installation of surge protective devices in IT systems

Fig 16A.4 – SPDs on the load side of an RCD



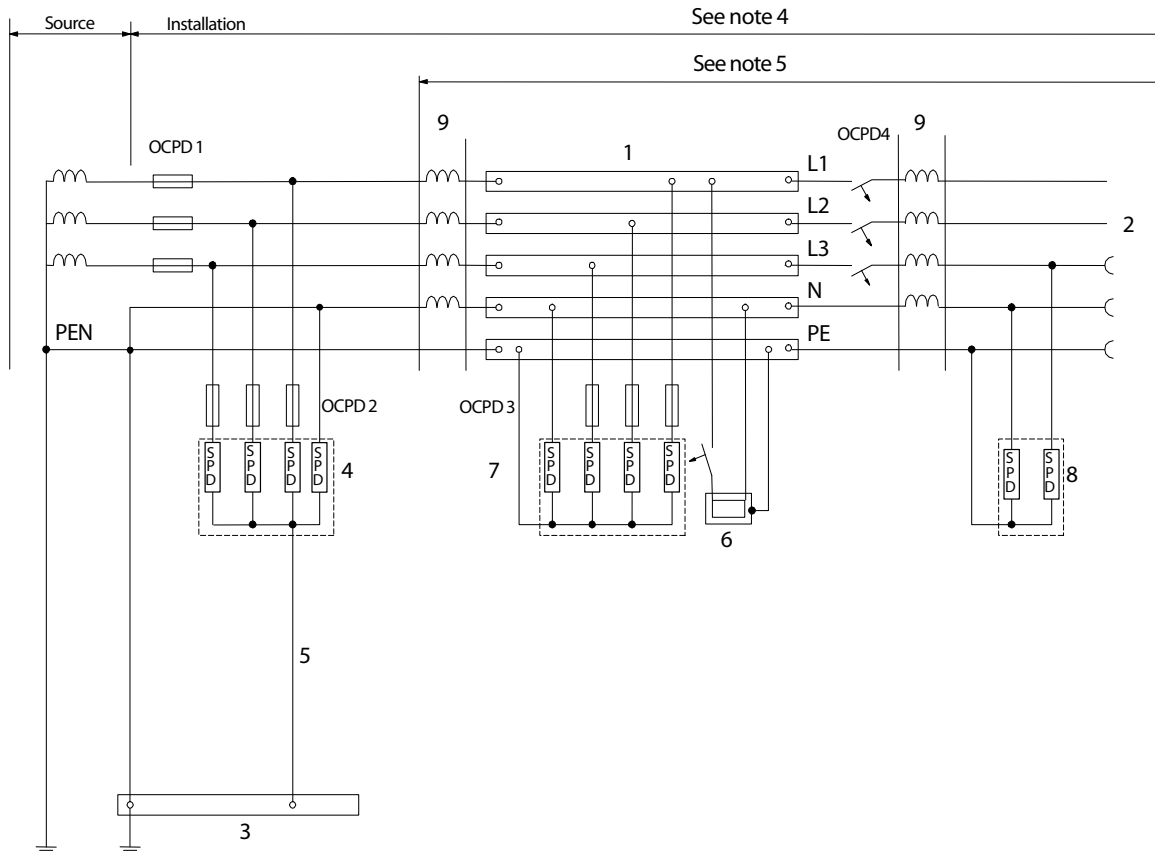
Key

- | | |
|---|--|
| 1 | Distribution board |
| 2 | Main earthing terminal or bar |
| 3 | Surge protective devices ensuring a protection level in accordance with overvoltage Category II |
| 4 | Earthing connection of surge protective devices, either 4a or 4b, whichever is the shorter route |
| 5 | Current-using equipment |
| 6 | Residual current protective device (RCD) installed upstream of the surge protective devices |

- | | |
|--------|---|
| OCPD 1 | Overcurrent protective device at the origin of the installation |
| OCPD 2 | Overcurrent protective device |

Installation of Types 1, 2 and 3 SPDs, for example in TN-C-S systems

Fig 16A.5 – Installation example of Type 1, 2 and 3 coordinated SPDs



Key

- | | |
|---|---|
| 1 | Distribution board |
| 2 | Distribution outlet |
| 3 | Main earthing terminal or bar |
| 4 | Surge protective device, Type 1 |
| 5 | Earthing connection (earthing conductor) of surge protective device |
| 6 | Fixed equipment to be protected |

- | | |
|---|---|
| 7 | Surge protective device, Type 2 |
| 8 | Surge protective device, Type 2 or Type 3 |
| 9 | Decoupling element or line length |
- NOTE:** If the cable length between the SPD types is short (refer to manufacturers' data), a decoupling element is employed to provide inductance for correct SPD co-ordination
- OCPD 1, 2, 3, 4 Overcurrent protective devices

NOTE 1: For further information reference should be made to CLC/TS 61643-12.

NOTE 2: SPDs 4 and 7 (or 7 and 8) can be combined in a single SPD.

NOTE 3: SPDs may require additional modes of protection for sensitive equipment.

NOTE 4: BS EN 62305-4 covers the protection of electrical and electronic systems within structures against lightning.

NOTE 5: Section 443 of BS 7671 deals with the protection of electrical installations against transient overvoltages of atmospheric origin, transmitted by the supply distribution system and against switching overvoltages generated by the equipment within the installation.

Typically, Type 1 SPDs are used at the origin of the installation, Type 2 SPDs are used at distribution boards and Type 3 SPDs are used near terminal equipment. Combined Type SPDs are classified with more than one Type, e.g. Type 1+2, Type 2+3. Type 1 SPDs are only used where there is a risk of direct lightning current.

The most important aspect in selecting an SPD is its limiting voltage performance (protection level U_p) during the expected surge event, and not the energy withstand (e.g. I_{imp}) which it can handle. An SPD with a low protection level will ensure adequate protection of the equipment, while an SPD with a high energy withstand may only result in a longer operating life.

TABLE 16A – Information on SPD classification

SPD according to BS EN 62305	SPD according to BS EN 61643-11
SPD tested with I_{imp}	Type 1
SPD tested with I_n	Type 2
SPD tested with a combination wave	Type 3

SPD tested with I_{imp} (BS EN 62305-4)

SPDs which withstand the partial lightning current (with a typical waveform 10/350 μ s) require a corresponding impulse test current I_{imp} .

NOTE 1: For power lines, a suitable test current I_{imp} is defined in the Class I test procedure of BS EN 61643-11.

SPD tested with I_n (BS EN 62305-4)

SPDs which withstand induced surge currents with a typical waveform 8/20 μ s require a corresponding impulse test current I_{nspd} .

NOTE 2: For power lines a suitable test current I_{nspd} is defined in the Class II test procedure of BS EN 61643-11.

SPD tested with a combination wave (BS EN 62305-4)

SPDs that withstand induced surge currents with a typical waveform 8/20 μ s and require a corresponding impulse test current I_{sc} .

NOTE 3: For power lines a suitable combination wave test is defined in the Class III test procedure of BS EN 61643-11 defining the open-circuit voltage U_{oc} 1.2/50 μ s and the short-circuit current I_{sc} 8/20 μ s of a 2 Ω combination wave generator.