PD CLC/TS 61643-22:2016

BSI Standards Publication

Low-voltage surge protective devices

Part 22: Surge protective devices connected to telecommunications and signalling networks — Selection and application principles

bsi.

National foreword

This Published Document is the UK implementation of CLC/TS 61643-22:2016. It is derived from IEC 61643-22:2015. It supersedes DD CLC/TS 61643-22:2006 which is withdrawn.

The CENELEC common modifications have been implemented at the appropriate places in the text. The start and finish of each common modification is indicated in the text by tags Ⓒ Ⓒ.

The UK participation in its preparation was entrusted by Technical Committee PEL/37, Surge Arresters - High Voltage, to Subcommittee PEL/37/1, Surge Arresters - Low Voltage.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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European Committee for Electrotechnical Standardization
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European foreword

This document (CLC/TS 61643-22:2016) consists of the text of IEC 61643-22:2015 prepared by SC 37A "Low-voltage surge protective devices" of IEC/TC 37 "Surge arresters", together with the common modifications prepared by CLC/TC 37A "Low voltage surge protective devices".

This document supersedes CLC/TS 61643-22:2006.

CLCTS 61643-22:2016 includes the following significant technical changes with respect to CLC/TS 61643-22:2006:

a) Update the use of multiservice SPDs (Article 8)

b) Comparison between SPD classification of EN 61643-11 and EN 61643-21 (7.3.3)

c) Consideration of new transmission systems as PoE (Annex F)

d) EMC requirements of SPDs (Annex G)

e) Maintenance cycles of SPDs (Annex I)

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Endorsement notice

The text of the International Standard IEC 61643-22:2015 was approved by CENELEC as a European Standard with agreed common modifications.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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LOW-VOLTAGE SURGE PROTECTIVE DEVICES –

Part 22: Surge protective devices connected to telecommunications and signalling networks – Selection and application principles

FOREWORD

International Standard IEC 61643-22 has been prepared by subcommittee 37A: Low-voltage surge protective devices, of IEC technical committee 37: Surge arresters.

This second edition cancels and replaces the first edition published in 2004. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Update the use of multiservice SPDs (Article 8)

b) Comparison between SPD classification of IEC 61643-11 and IEC 61643-21 (7.3.3)

c) Consideration of new transmission systems as PoE (Annex F)

d) EMC requirements of SPDs (Annex G)

e) Maintenance cycles of SPDs (Annex I)

The text of this standard is based on the following documents:

FDIS	Report on voting
37A/273/FDIS	37A/277/RVD

Full information on the voting for the approval of this amendment can be found in the report on voting indicated in the above table.

A list of all parts in the IEC 61643 series, published under the general title *Low-voltage surge protector devices*, can be found on the IEC website.

The committee has decided that the contents of this amendment and the base publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This International Standard is a guide for the application of SPDs to telecommunications and signalling lines and those SPDs which have telecom or signalling SPDs in the same enclosure with power line SPDs (so called multiservice SPDs). Definitions, requirements and test methods are given in IEC 61643-21. The decision to use SPDs is based on an analysis of the risks that are seen by the network or system under consideration. Because telecommunications and signalling systems may depend on long lengths of wire, either buried or aerial, the exposure to overvoltages from lightning, power line faults and power line/load switching, can be significant. If these lines are unprotected, the resultant risk to information technology equipment (ITE) can also be significant. Other factors that may influence the decision to use SPDs are local regulators and insurance stipulations. This standard provides indications for evaluating the need for SPDs, the selection, installation and dimensioning of SPDs and for achieving coordination between SPDs and between SPDs and ITE installed on telecommunication and signal lines.

Coordination of SPDs assures that a proper interaction between them, as well as between an SPD and the ITE to be protected will be realized. Coordination requires that the voltage protection level, U_p, and let-through current, I_p, of the initial SPD does not exceed the resistibility of subsequent SPDs or the ITE.

In general, the SPD closest to the source of the impinging surge diverts most of the surge: a downstream SPD will divert the remaining or residual surge. The coordination of SPDs in a system is affected by the operation of the SPDs and the equipment to be protected as well as the characteristics of the system to which the SPDs are connected.

The following variables should be reviewed when attempting to attain proper coordination:

- waveshape of the impinging surge (impulse or AC);
- ability of the equipment to withstand an overvoltage/overcurrent without damage;
- installation, e.g. distance between SPDs and between SPDs and ITE;
- SPD voltage-protection levels.

The performance of an SPD and its coordination with other SPDs can be affected by exposure to previous transients. This is especially true for transients which approach the limit of the capacity of the SPD. If there is considerable doubt concerning the number and severity of the surges handled by the SPDs under consideration, it is suggested that SPDs with higher capabilities be used.

One of the direct effects of poor coordination may be bypassing of the SPD closest to the surge source, with the result that the following SPD will be forced to handle the entire surge. This can result in damage to that SPD.

Lack of proper coordination can also lead to equipment damage and, in severe cases, may lead to a fire hazard.

There are several technologies used in the design of the SPDs covered in this standard. These are explained in the main text and also in informative Annexes A and B.

LOW-VOLTAGE SURGE PROTECTIVE DEVICES –

Part 22: Surge protective devices connected to telecommunications and signalling networks – Selection and application principles

1 Scope

This part of IEC 61643 describes the principles for the selection, operation, location and coordination of SPDs connected to telecommunication and signalling networks with nominal system voltages up to 1 000 V r.m.s. a.c. and 1 500 V d.c.

This standard also addresses SPDs that incorporate protection for signalling lines and power lines in the same enclosure (so called multiservice SPDs).

2 Normative references

[C] The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 61643-21:2001 + A1:2009 +A2:2013, *Low voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signalling networks – Performance requirements and testing methods* (IEC 61643-21:2000 + A1:2008, modified +A2:2012)

EN 61643-11, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems - Requirements and test methods* (IEC 61643-11)

EN 61643-12, *Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles* (IEC 61643-12)

EN 62305-1:2011, *Protection against lightning – Part 1: General principles* (IEC 62305-1:2010, modified)

EN 62305-2:2012, *Protection against lightning – Part 2: Risk management* (IEC 62305-2:2010, modified)

EN 62305-3:2011 *Protection against lightning – Part 3: Physical damage to structures and life hazard* (IEC 62305-3:2010, modified)

EN 62305-4:2011 *Protection against lightning – Part 4: Electrical and electronic systems within structures* (IEC 62305-4:2010, modified)

EN 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test* (IEC 61000-4-5) [C]

3 Terms, definitions and abbreviations

For the purposes of this document, the following terms, definitions and abbreviations apply.

3.1 Terms and definitions

3.1.1
resistibility
ability of telecommunication equipment or installations to withstand, in general, without damage, the effects of overvoltages or overcurrents, up to a certain specified extent, and in accordance with a specified criterion

Note 1 to entry: This definition is derived from ITU-T K.44 [24][1].

3.1.2
multiservice surge protective device
MSPD
surge protective device providing protection for two or more services such as power, telecommunications and signalling in a single enclosure in which a reference bond is provided between services during surge conditions

3.2 Abbreviations

MSPD	Multiservice Surge Protective Device
POTS	Plain Old Telephone Service
VDSL	Very High Speed Digital Subscriber Line
ADSL	Asymmetric Digital Subscriber Line
PoE	Power over Ethernet

4 Description of technologies

4.1 General

The following is a short description of various surge protection component technologies. More details are available in Annexes A and B.

4.2 Voltage-limiting components

4.2.1 General

These shunt-connected SPD components are non-linear elements that limit overvoltages that exceed a given voltage by providing a low impedance path to divert currents. The continuous operating voltage (U_c), of the SPD is chosen to be greater than the maximum peak system voltage in normal operation. At the maximum system operating voltage, the SPD's leakage current shall not interfere with normal system operation.

Multiple components may be used to form assemblies. Connecting voltage-limiting surge protective components in series may results in higher voltage protection levels. Parallel component connection may increase the surge current capability of the assembly. For example, switching components will not share current, however clamping components may.

Some technologies, e.g. metal oxide varistors, have voltage-current characteristics that are inherently symmetrical for positive and negative voltage polarities. Such components are classified as symmetrical bi-directional. Components having positive and negative current-voltage characteristics with the same basic shape, but with significantly different characteristic values are classified as asymmetrical bi-directional.

Other technologies, e.g. PN semi-conductor components, typically have symmetrical voltage-current characteristics.

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1 Numbers in square brackets refer to the Bibliography.

4.2.2 Clamping components

These SPD components have continuous voltage-current characteristics. Generally, this will mean that the protected equipment will be exposed to a voltage above the SPD's threshold level for most of the voltage impulse duration. As a result, these SPD components will dissipate substantial energy during the overvoltage.

4.2.3 Switching components

These SPD components have a discontinuous current-voltage characteristic. At a designed voltage, they switch to a low-voltage state. In this low-voltage state, the energy absorbed is low compared to that of other SPDs that ”clamp” the voltage at a specific protection level. As a result of this switching action, protected equipment will be subjected to a voltage above the normal system voltage for only a very short time. If the system's operating voltage and current exceed the reset characteristics of the switching-type component, these components remain in the conducting state. Appropriate SPD selection and circuit design will allow the SPD to recover to a high resistance state under normal system voltage and currents.

4.3 Current-limiting components

4.3.1 General

To limit an overcurrent, the protection componenthas to stop or reduce the current flowing to the protected load. There are three possible methods: interruption, reduction or diversion. The majority of the technologies used for overcurrent protection are thermally activated, resulting in relatively slow response operating times. Until the overcurrent protection operates, the load, and possibly the SPDs, have to be capable of withstanding the surge.

4.3.2 Current-interrupting components

These components open the circuit path for the surge current to the SPD or ITE, (see Figure B.1). Sudden opening of a current-carrying circuit usually results in arcing, particularly if the current is at its peak. This arcing has to be controlled to prevent a safety hazard. After interruption, maintenance is required to restore service. One example of a current-interrupting component is a fuse.

4.3.3 Current-reducing components

These components reduce the current flow by effectively inserting a large series resistance with the load (see Figure B.4). An example of a current-reducing type used for this action is a self-heating positive temperature coefficient (PTC) thermistor. Overcurrents cause resistive heating of the PTC thermistor. When the thermistor's temperature exceeds its threshold temperature (typically 120 °C), this causes the thermistor resistance to change from Ohms to hundreds of kilo-Ohms, thereby reducing the current. The lower current, after changing to a high resistance, maintains the PTC thermistor's temperature, forcing the PTC thermistor to remain in the high resistance state. A thermistor dissipation of typically about 1 W is needed to maintain the temperature, e.g. 5 mA from a 200 V a.c. overvoltage. After the surge, the PTC thermistor cools and returns to a low resistance value (resets). Current reducing Electronic Current Limiters (see B.3.1.2) operate when the current exceeds a predetermined threshold and respond to lightning surges as well as a.c.

4.3.4 Current-diverting components

Current-diverting components effectively create a low impedance path in parallel with the load (see Figure B.2). Activation occurs due to temperature rise of the voltage-limiting type or load current sensing. Although the load is protected, the surge current in the network feed is the same or greater. After operation, maintenance may be required to restore service.

5 Parameters for selection of SPDs and appropriate tests from IEC 61643-21

5.1 General

This clause discusses the parameters of SPDs and their relevance to the operation of the SPDs and the normal operation of the networks to which they are connected. These parameter values can be used to form the basis for comparison amongst SPDs and also to provide guidance in their selection for signalling and power systems. Values for these parameters are available from SPD manufacturers and suppliers. Verification of the values, or obtaining them when not provided by suppliers, shall be performed using the tests and methods described in IEC 61643-21.

5.2 Normal service conditions

5.2.1 General

The SPD parameters shall be suitable for the intended environment.

5.2.2 Air pressure and altitude

Air pressure is 80 kPa to 106 kPa. These values represent an altitude of +2 000 m to –500m respectively.

5.2.3 Ambient temperature

Ambient temperature falls within the following ranges:

- normal range: -5 °C to + 40 °C

NOTE 1 This range normally addresses SPDs for indoor use. This corresponds to code AB4 in IEC 60364-5-51 [51].

- extended range: -40 °C t o +70 °C

NOTE 2 This range normally addresses SPDs for outdoor use in non weather-protected locations, class 3K7 in IEC 60721-3-3 [52].

- storage range: -40 °C to +70 °C

NOTE 3 Values outside this range will be specified by the manufacturer.

5.2.4 Relative humidity

Relative humidity falls within the following ranges:

- normal range: 5 % to 95 %

NOTE 1 This range normally addresses SPDs for indoor use. This corresponds to code AB4 in IEC 60364-5-51.

- extended range: 5 % to 100 %

NOTE 2 This range normally addresses SPDs for outdoor use in non weather-protected locations (e.g. SPD outside enclosure).

5.2.5 Abnormal service conditions

Exposure of the SPD to abnormal service conditions may require special consideration in the design or application of the SPD, and shall be called to the attention of the manufacturer.

5.3 SPD parameters that may affect normal system operation

The essential characteristics for the operation of SPDs having voltage-limiting or both voltage-limiting and current-limiting functions used in protecting telecommunication and signalling systems are as follows:

- maximum continuous operating voltage U_c;
- voltage protection level U_p;
- impulse reset;
- insulation resistance (leakage current);
- rated current.

SPDs shall conform to application-specific requirements. Some SPD parameters can influence the transmission characteristics of the network. These are listed below, as follows:

- capacitance;
- series resistance;
- insertion loss;
- return loss;
- longitudinal balance;
- near-end cross-talk (NEXT).

Therefore, SPDs may need to be tested using selected tests from IEC 61643-21. Annex D provides information about IT systems and some of their transmission characteristics that have to be taken into account when applying SPDs to these systems.

6 Risk management

6.1 General

The need for protective measures (e.g. protection with SPDs) for Information Technology Systems should be based on a risk assessment, considering the probability of overvoltage and overcurrent. The assessment of all parts of the Information Technology System shall attain a well coordinated protection of the whole network. This takes into account the consequences of the loss of service for the customer and network operator, the importance of the system (e.g. hospitals, traffic control), the electromagnetic environment at the particular site (probability of damages) and cost related to repair.

The decision to install protective measures shall be assessed based on

- the risk of damage to the network outside or inside the structure,
- the tolerable risk of damage.

For the structure and network inside the structure, the customer shall analyse these two values. For the network outside the structure, the network operator shall analyse them. As the weighting of risk components can lead to different protection results at the interconnection between the operator's network and private network (see Figure 1, “NT”-point), Table 1 gives a general overview of the responsibility for managing the protective measures.

Table 1 – Responsibility for managing the protective measures

Protection of the IT system	Responsibility
Installation outside the structure; operators' network Information technology equipment ITE (see NOTE)	Network operator/Service owner
Installation inside the structure; – private telecommunication network – Installation of an LPS – Installation of an effective earthing and bonding system – Information technology equipment ITE (see NOTE)	Building owner; Customer
Interconnection between operators' network and private network (NT) – Services SPDs, screens and metallic pipes: – Customer SPDs, screens and metallic pipes in private network	Network operator/Service owner Building owner; Customer
Additional protective measures based on risk assessment	Building owner; Customer
NOTE Resistibility requirements of Information technology equipment are given in the ITU-T K series recommendations. They are implemented by the ITE manufacturer by market demands.	

6.2 Risk analysis

Risk analysis takes into consideration the following electromagnetic phenomena:

- power induction;
- lightning discharges;
- earth potential rise;
- power contact.

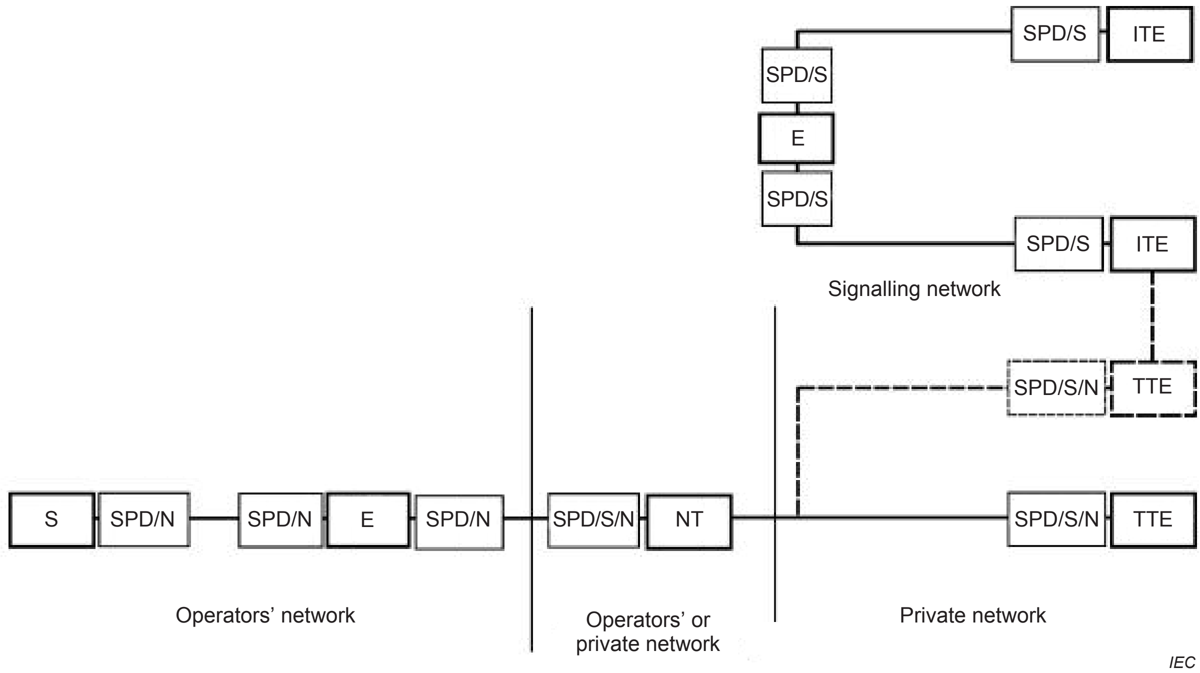
6.3 Risk identification

Risk identification takes into account economic aspects such as:

- costs (high repair costs of inadequately protected equipment versus no repair costs of adequately protected equipment, probability of occurrence of damaging electromagnetic phenomena);
- intended application;
- the protective measures in installations;
- continuity of the service;
- serviceability of the equipment (equipment installed in difficult-to-reach places, e.g. high mountains).

6.4 Risk treatment

Risk treatment considers reduction of damage to the whole of the communication network, i.e. all types of networks, public and private, including all kinds of transmission or terminal equipment. The installation of SPDs can be subject to requirements and/or restrictions given by the network operator, network authority and system manufacturer (see Figure 1 and Figure 2). For further information concerning risk management see Annex C.

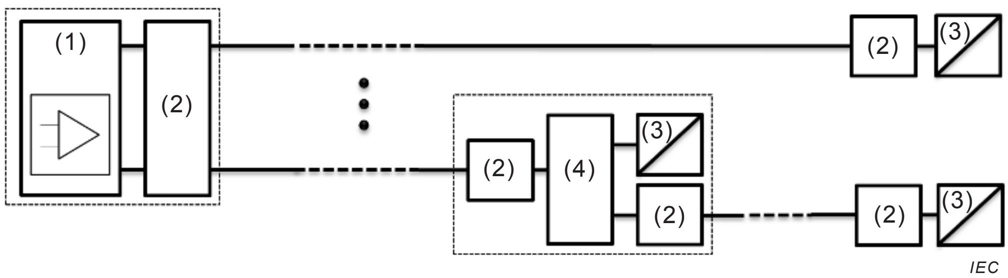


Telecommunications network

Key

SPD/N	SPD requirements/restrictions given by network operator/authority
SPD/S	SPD requirements/restrictions may be given by system manufacturer
SPD/S/N	SPD requirements/restrictions may be given by system manufacturer and network operator/authority
S	switching centre
E	equipment (e.g. multiplexer)
NT	network termination
ITE	information technology equipment or processing control
TTE	telecommunication terminal equipment

Figure 1 – SPD installation in telecommunications and signalling networks



Key

(1) ITE (e.g. Controller)

(2) SPDs requirements/restrictions may be given by customer or user

(3) ITE (e.g. Sensor/Actuator)

(4) Distributor

Figure 2 – Measurement and Control network (MCR)

7 Application of SPDs

7.1 General

When considering the application of SPDs to protect equipment connected to telecommunications and signalling networks, it is important to determine the probable overvoltage and overcurrent sources and how energy from these sources is coupled into these networks. These are shown in Figure 3. Figure 4 shows ways to reduce the amount of energy coupled into the network.

7.2 Coupling mechanisms

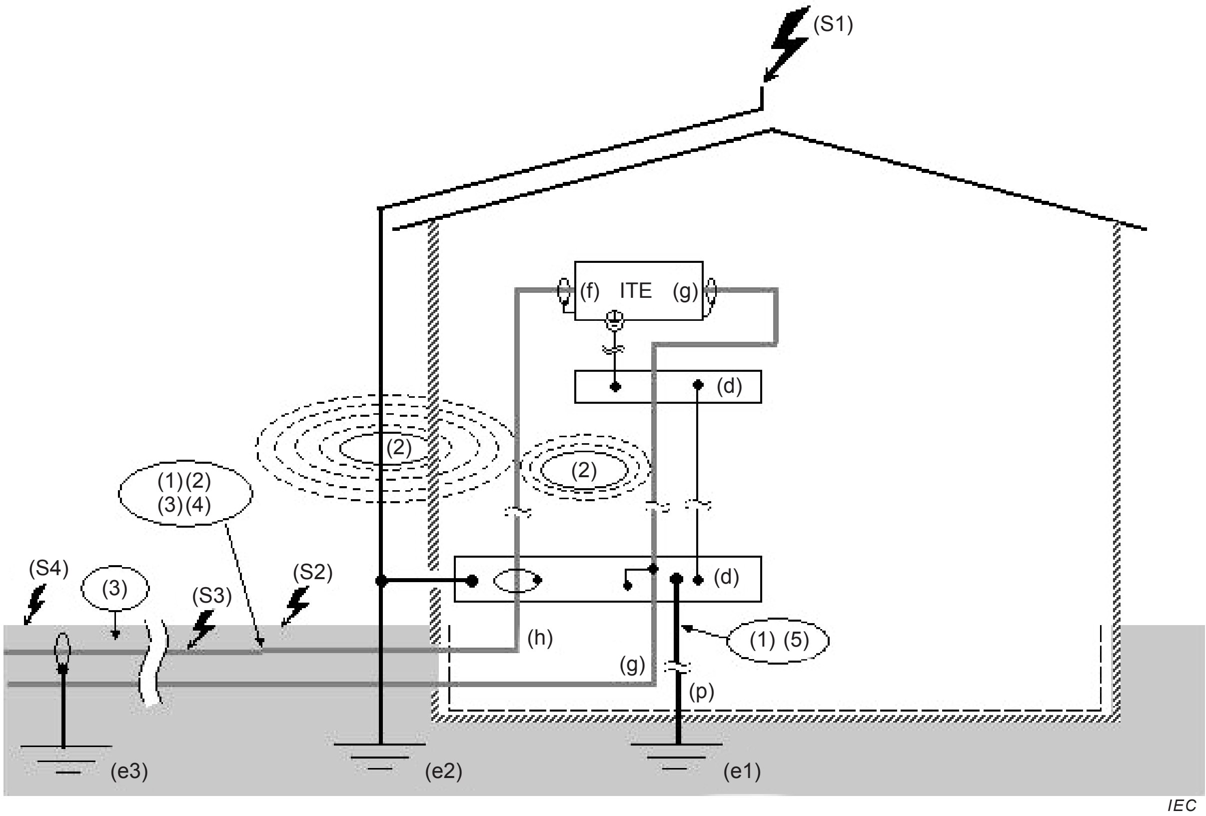
The major sources of transient that pose a threat to telecommunications and signalling systems are due to lightning and the electric power system. The means of coupling include a direct lightning strike to the structure and direct contact from the power system as well as capacitive, inductive and radiative coupling from both sources. A fourth coupling mechanism consists of earth potential rise which can also come from both sources.

Protective measures shall be coordinated with the system to be protected. Wherever protective measures are needed in a building, an equipotential bonding bar (EBB) shall be installed. A further important measure is to minimize the impedance of all bonding connections from the equipment to the building EBB. Metallic shields of cables, shall be continuously connected . It shall also be connected to the EBB, preferably directly or through an SPD (to avoid corrosion problems), at the ends of the cable. Another measure is to provide the incoming services with adequate SPDs so that transient overvoltages and overcurrents are reduced to system compatible levels. The SPDs shall be located as close as possible to a common entry area in the structure, e.g. a building or cabinet through which all incoming services enter. If some distance is required between protected equipment and the cable entrance area, particular attention shall be paid to minimizing the equipment bonding and SPD bonding conductor impedance.

Figure 3 depicts the way in which energy from lightning and a.c. sources is coupled into a structure containing the exposed equipment. It should be noted that while direct strikes result in the need for the more robust SPDs as seen in Table 2, they are also the most infrequent. The information contained in Clause 6, dealing with risk management, will provide guidance to understanding the figure and table. For the sake of simplicity, the figure illustrates direct lightning travelling down a single conductor. In reality, the system will have many down conductors and the direct lightning current will be shared among them. As a result of this current sharing, the magnitudes of surge voltages, by mechanisms of inductive coupling, would be subsequently reduced.

Figure 3 shows a typical structure with a lightning protection system (containing attachment terminals, a bonding network and an earthing system), in-coming services (possibly telephone or another telecommunications connections (h) and power (g)) as well as installed equipment. The figure incorporates single-point lightning protection bonding (d). This arrangement, which is recommended, sees all incoming services bonded on entry to the building to a single common earth point (main EBB). This common earth point is single-point connected to the lightning down-conductor and could have a separate earth for compliance with national requirements. All services entering the building should be connected to this earthing point to obtain an equipotential environment for all building systems. The figure also shows a local equipotential bonding arrangement at or near the building equipment (floor EBB). Within this arrangement, an equipotential environment is created for each floor, equipment room and possibly even an equipment rack by a common earth reference point at cable entry. All services entering the area are earth referenced to the point (either through surge protective devices or directly). This local equipotential bonding point is single-point connected to the main building bond and does not have a separate connection to earth. Examples of bonding arrangements in structures with multiple-point entries of external services are shown in IEC 62305-3:2010, E.6.2.2.

Table 2 shows the relationship between the source of transients and coupling mechanism (e.g. direct strike resistive coupling). The voltage and current waveshapes and test categories are selected from Table 3 of IEC 61643-21:2012.



Key

(d)	equipotential bonding bar (EBB)
(e1)	building ground
(e2)	lightning protection system ground
(e3)	cable shield ground
(f)	information technology/telecommunication port
(g)	power supply port
(h)	information technology/telecommunication line or network
(p)	earthing conductor
(S1)	direct lightning to the structure
(S2)	lightning near to the structure
(S3)	direct lightning to the telecommunication/power line
(S4)	lightning near to the telecommunication/power line
(1) … (5)	coupling mechanisms, see Table 2

Figure 3 – Coupling mechanisms

Table 2 – Coupling mechanisms

Source of transients	**Direct lightning to the structure (S1)**		**Lightning to ground near the structure (S2)**	**Direct lightning to the line (S3)**	**Lightning to ground near the line (S4)**	**AC influence**
Coupling	Resistive (1)	Induction (2)	Induction[a] (2)	Resistive (1, 5)	Induction (3)	Resistive (4)
Voltage wave-shape (µs)	–	1,2/50	1,2/50	–	10/700	50 Hz
Current wave-shape (µs)	10/350	8/20	8/20	10/350[c]	5/320	–
Preferred category[b]	D1	C2	C2	D1	B2	A2

NOTE (1) – (5) see Figure 3, coupling mechanisms.

a Also applies for capacitive/inductive couplings of switching in adjoining power supply networks.

b See Table 3 of EN 61643-21:2001 + A1:2009 + A2:2013.

c The simulated direct lightning strike test impulse is described by the IEC as a peak current value and total charge. A typical waveshape that can achieve these parameters is a double exponential impulse, 10/350 being used in this example.

7.3 Application, selection and installation of surge protective devices (SPDs)

7.3.1 Application requirements for SPDs

7.3.1.1 General

SPDs shall comply with IEC 61643-21 and with specifications that refer to the system to be protected.

For SPD applications in the public power supply system, other or additional requirements may apply, and will not be described in the following subclauses. The following subclauses deal with the application of SPDs in information technology systems inside structures.

7.3.1.2 Selection of SPDs for reducing lightning effects

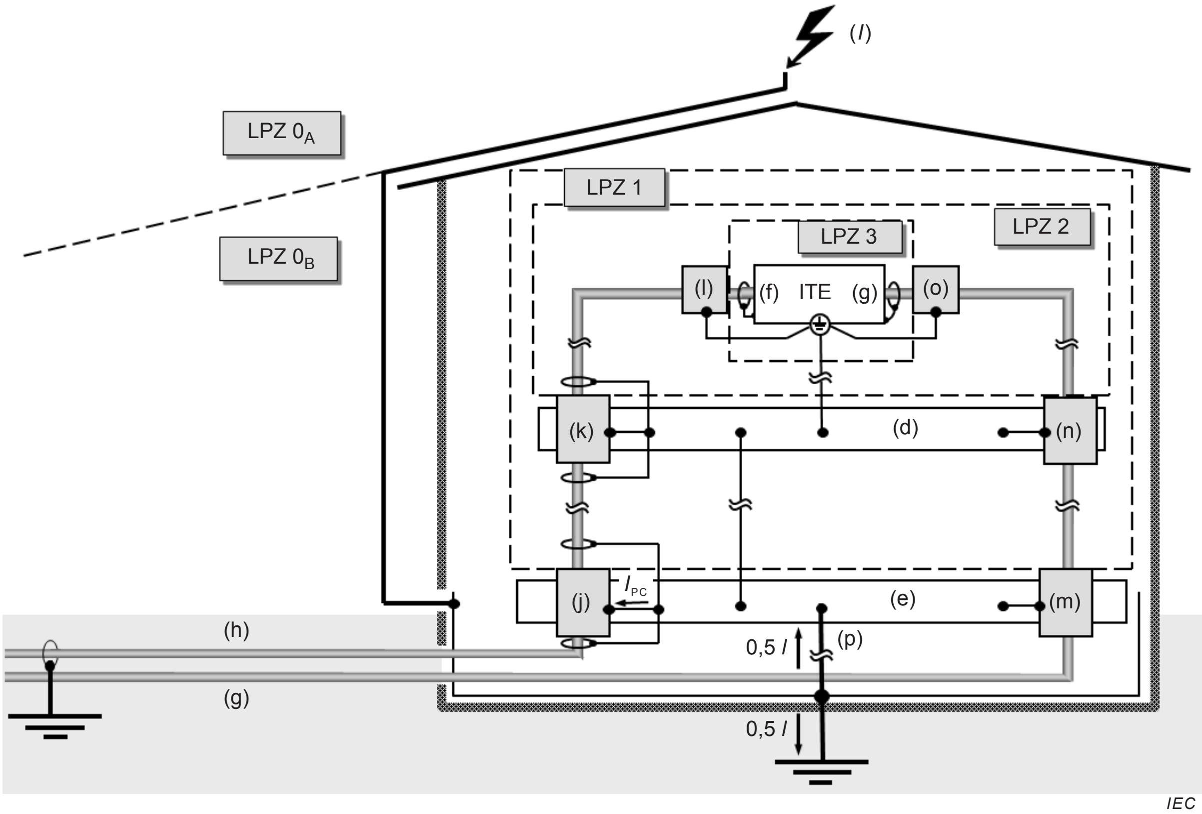
The action of limiting surges causes energy to be absorbed or reflected by the SPD. SPDs shall be selected in accordance with Table 3 of IEC 61643-21:2012, based on the risk assessment of IEC 62305-2 including details of peak pulse current and waveshape (for example 5 kA 8/20).

When determining protection measures, protection requirements for each of the various protection locations (see Figure 4) shall be considered. Protection devices should be applied in a cascade arrangement at the zone interfaces (for management of lightning protection zones, consult IEC 62305-4).The zone concept is especially relevant when a physical LPS exists. For example, the first protection level (j, m), located at the entrance of the building, mainly serves to protect the installation against destruction. This protection should be designed and rated for such a threat. The output of this protection has a reduced surge energy that becomes the input to the subsequent downstream protection. The following protection levels (k, l and n, o) further reduce the surge level to a value that is acceptable for subsequent downstream protection or equipment (also see 7.3.1.3).

Figure 4 is an example of a lightning protection concept in accordance to IEC 62305-1.

Depending on the over-voltage/over-current threat levels and SPDs characteristics, a single SPD can be used to protect the equipment within a building. Several protection levels can be determined by means of a combination protection circuit in one SPD. Depending on equipment locations, a single SPD can be used to protect multiple zones within a building.

When cascading SPDs exist, the coordination conditions of Clause 9 should be considered.



Key

(d)	equipotential bonding bar (EBB) at the lightning protection zone (LPZ) boundary
(e)	Main Equipotential Bonding Bar (MEBB)
(f)	information technology/telecommunication port
(g)	power supply port/line
(h)	information technology/telecommunication line or network
I_{PC}	partial surge current of a lightning current
I	direct lightning current according to IEC 62305-1, which causes lightning partial currents I_{PC} within buildings via different coupling paths
(j), (k), (l)	SPD according to Table 3 (see also Table 3 of IEC 61643-21)
(m, n, o)	SPD according to test classes I, II and III of IEC 61643-11
(p)	earthing conductor
LPZ 0_A…3	lightning protection zone 0_A … 3 according to IEC 62305-1

Figure 4 – Example of a configuration of the lightning protection concept

7.3.1.3 Selection of SPDs to reduce transients

SPDs should be selected according to the cascading of the protection zones of 7.3.1.2 and Table 3. (Refer to Clause 9 for coordination.) For this purpose, the protection devices are selected in such a way that the limiting voltage indication U_p for the SPD is lower than the voltage value that has to be observed in the next SPD or ITE, (see Figure 5).

The selection with respect to lightning protection zones in Table 3 assumes that parts of the total lightning current *I* on the zone interface LPZ0 / LPZ1 are resistively coupled into the information technology system via the SPD (j) (partial lightning current I_{PC}) The resultant lightning wave shape which propagates in the information technology system will be modified by the system wiring and SPD operation. If the protection level of SPD (j) is higher than the equipment resistibility level, then install an additional SPD with an appropriate protection level which is coordinated with SPD (j). Alternatively, replace SPD (j) with an SPD which has a suitable protection level.

Surge currents, which are induced by the electromagnetic effects of a lightning stroke, or by let-through transients of pre-installed limiting installations (SPDs), are represented by the 8/20current waveform.

Voltages due to strokes close to information technology/telecommunication lines but remote from the ITE connected to these lines are represented with the 10/700 voltage waveform (refer to Table 9 of IEC 61643-21:2012).

Table 3 – Selection aid for rating SPDs for the use in (zone) interfaces according to EN 62305-1

Lightning protection zone EN 62305-1		LPZ 0/1	LPZ 1/2	LPZ 2/3
Requirements to SPDs (Category from Table 3, EN 61643-21)	SPD (j)*	D1 B2	---	---
	SPD (k)*	---	C2/B2	---
	SPD (l)*	---	---	C1
* SPD (j, k, l), see Figure 4.				
NOTE The range of surge values indicated under LPZ 2/3 includes typical minimum resistibility requirements and might be implemented into the equipment by market.				

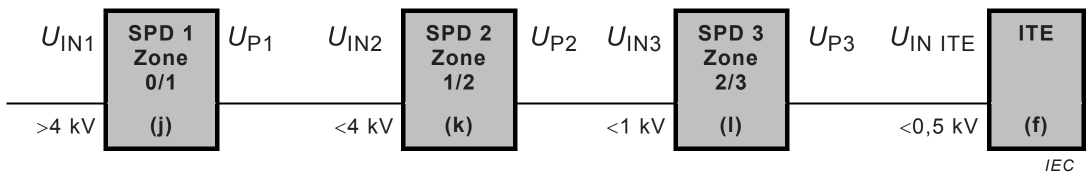


Figure 5 – Example of a configuration according to the zones (Figure 4)

Generally, the number of SPDs needed in order to achieve equipment protection determines the number of LPZ boundaries where SPDs are installed. Equipment protection can also be achieved by using a single SPD which utilizes a combination protection circuit as covered in 7.3.1.1.

The coordination conditions between the cascading protection devices (j) up to SPD 3 (l), according to Clause 9, should be considered.

7.3.1.4 Selection of SPDs for limiting low-frequency surge voltages

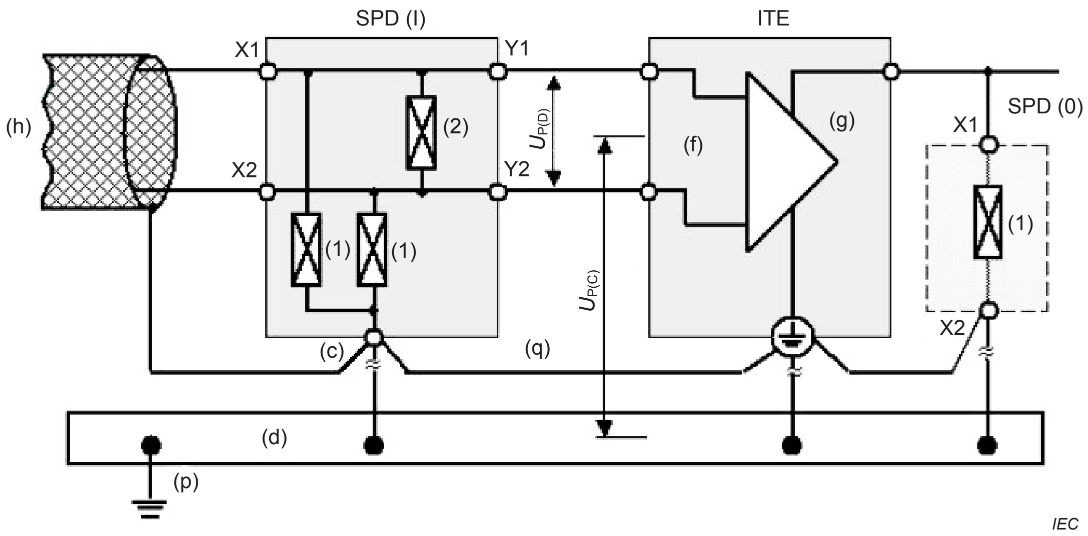
Where telecommunication lines are exposed to over-voltages from power line faults, the voltage of the lines relative to local earth potential should be limited by connecting SPDs between the line conductors and the earth terminal. The terminal equipment dielectric strength should be chosen, taking into account the breakdown voltage of the protective device and the impedance of the protector line to earth connection. Appropriate requirements should be chosen from the product family/product standards, i.e. ITU-T recommendations K.20, K.21

and K.45 [15, 16, 17]. The protection of telecommunication lines from power frequency surges can be achieved by the application of voltage limiting or switching SPDs.

7.3.1.5 Voltage-limiting compatibility of SPDs with respect to the system to be protected

It is important to ensure that the differential and common-mode voltage-limiting specifications of the SPD are matched to the protection requirements of the system (see Figure 6).

To achieve system compatibility, impulse coordination tests on equipment protected by SPDs should be carried out by the equipment manufacturer, as outlined in ITU-T Recommendations K.20, K.21 or K.45.



Key

(c) joint connection of an SPD, to which generally all common-mode, voltage-limiting surge voltage components refer within the SPD

(d) equipotential bonding bar (EBB)

(f) information technology/telecommunication port

(g) power supply port

(h) information technology/telecommunication line or network

(I) SPD according to Table 3 (see also Table 3 of IEC 61643-21)

(o) SPD for power supply

(p) earthing conductor

(q) necessary connection (as short as possible)

$U_{P(C)}$ common-mode, voltage limited to the protection level

$U_{P(D)}$ differential mode voltage limited to the protection level

X1, X2 terminals of an SPD, between which the limiting components (1, 2) are allocated respectively, to which the unprotected side of an SPD is connected

Y1, Y2 terminals of an SPD on the protected side

(1) surge voltage protection component according to the IEC 61643-3xx series for limiting common-mode voltages ([3], [5], [6], [7])

(2) surge voltage protection component according to the IEC 61643-3xx series for limiting differential-mode voltages ([3], [5], [6], [7])

Figure 6 – Example of protection measures against common-mode voltages and differential mode voltages of the data (f) and supply voltage input (g) of an ITE

7.3.2 SPD installation cabling considerations

7.3.2.1 General

The installation should minimize the wiring voltage drop in the leads/connections.

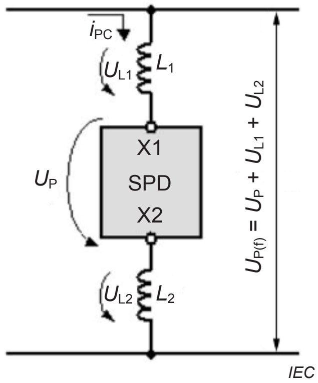
The following measures, together with a low protection level for U_p, make up the basic rules for avoiding any additional voltage rises during the limiting process due to incorrect wiring (coupling, looping, cable inductance), and thus an effective voltage-limiting effect is achieved.

An effective voltage-limiting effect is achieved by

- installing the SPD as close as possible to the equipment (see 7.3.2.3);
- avoiding long leads and minimizing unnecessary bending between the terminals X1, X2 of the SPD (see Figure 7) and where the protection is applied. The allocation corresponding to Figure 8 is optimal.

7.3.2.2 Two-terminal SPD

Figures 7 and 8 represent two possible ways to install a two-terminal SPD. The second installation removes secondary effects of protector lead length.



Key

L_1, L_2 conductor inductance of a lead

U_{L1}, U_{L2} at the allocated inductance "*L*", normal mode voltages induced by the d*i*/d*t* of the surge current I_{PC} referred to the total conductor length or a length unit

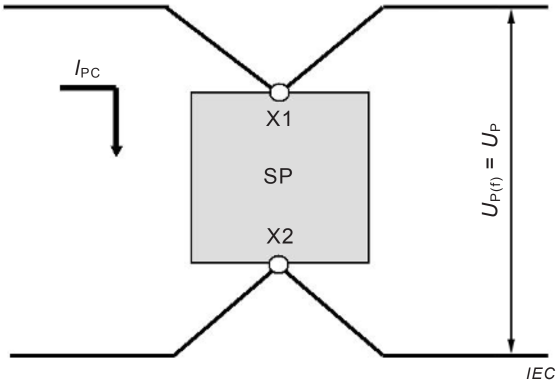
X1, X2 terminals of an SPD, between which the limiting components (1, 2 see Figure 6) are allocated with respect to the unprotected side of an SPD

I_{PC} partial surge current of a lightning current

$U_{p(f)}$ voltage (effective protection level) at the input (f) of the ITE resulting from the protection level U_p and the voltage drop along the connecting conductor between the protection device and the equipment to be protected. It should be noted that U_{L1} and U_{L2} = 0 V before the SPD starts conducting and for the switching type SPD, U_p becomes the residual voltage when the SPD starts conducting.

U_p voltage at the output of an SPD (protection level)

Figure 7 – Influence of voltages U_{L1} and U_{L2} on protection level U_P caused by inductance of the leads



Key

X1, X2 terminals of an SPD between which the limiting components (see Figure 6) are allocated with respect to the unprotected side of an SPD

I_{PC} partial surge current of a lightning current

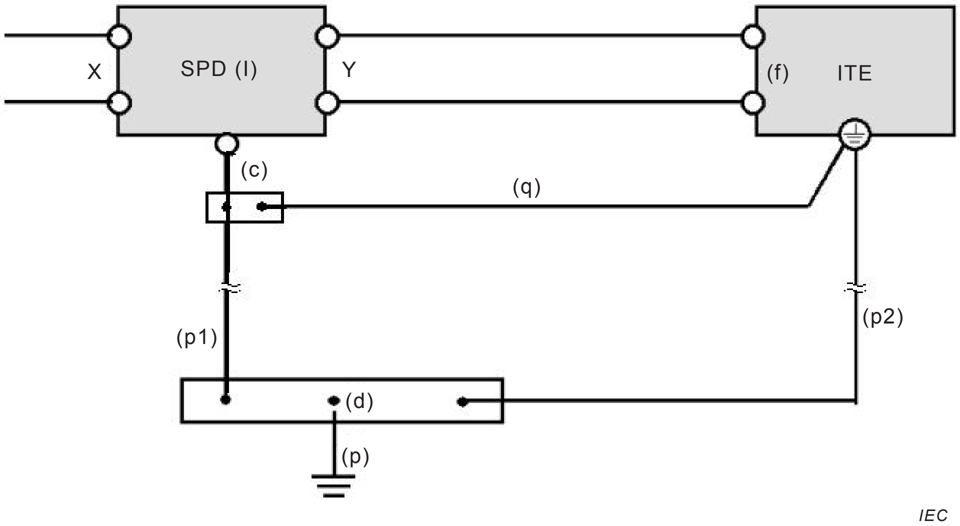
$U_{P(f)}$ voltage at the input (f) of the equipment to be protected (effective protection level) resulting from the protection level and the connecting line between the protection device and the equipment to be protected

U_P voltage at the output of an SPD (protection level)

Figure 8 – Removal of the voltages U_{L1} and U_{L2} from the protector unit by connecting leads to a common point

7.3.2.3 Three, five or multi-terminal SPD

An effective voltage-limiting outcome requires a system-specific observation which has to consider various conditions between the protective device and the ITE.



Key

(c) common reference termination of an SPD, to which generally all common-mode, voltage-limiting surge voltage components refer within the SPD

(d) equipotential bonding bar (EBB)

(f) information technology/telecommunication port

(l) SPD according to Table 3 (see also Table 3 of IEC 61643-21)

(p) earthing conductor

(p1),(p2) earthing conductor (as short as possible). For a remote powered ITE, (p2) may not exist.

(q) necessary connection (as short as possible)

X, Y terminals of an SPD between which the limiting components (1, 2, see Figure 6) are allocated with respect to the unprotected port of an SPD

Figure 9 – Necessary installation conditions of a three, five or multi-terminal SPD with an ITE for minimizing the interference influences on the protection level

Additional measures:

- Do not run the cable to the protected port together with the cable to the unprotected port.
- Do not run the cable to the protected port together with the earth conductor (p).
- The connection of the protected side of the SPDs to the ITE to be protected shall be made as short as possible, or shielded.

7.3.2.4 Effects of lightning-induced overvoltages on systems inside buildings

Lightning-induced overvoltages can be present inside buildings, coupled into the internal network, by means of mechanisms described in 7.2. These overvoltages are generally common mode, but may also appear as differential mode. Insulation breakdown and/or ITE component failure can occur as a result of these overvoltages.

To limit these effects, SPDs should be installed in accordance with Figure 6.

Other measures that may be taken are as follows:

- equipotential bonding (q) between SPD and ITE to reduce the common mode voltage (see Figure 9);
- use of twisted pair lines to reduce differential mode voltage;
- use of shielded lines to reduce common mode voltage;

- for the calculation basis on various loop configurations, see IEC 62305-4:2010, Annex A.

7.3.3 Comparison between SPD classification of IEC 61643-11 and IEC 61643-21

The selection of the SPD surge current is based on partitioning of lightning current of the services (e.g. power, data, telecommunication) and can be calculated for lightning strikes according to IEC 62305-1:2010, Annex E or based on Table 4.

Table 4 shows an example of the relationship between the test classes and categories of Power- and signalling-SPDs which are installed at the LPZ borders.

Table 4 – Relationship between SPD classification of IEC 61643-21 and IEC 61643-11

LPZ zones	Category of SPD in acc. to IEC 61643-21
0/1	D1
1/2	C2
2/3	C1

LPZ zones	Test class of SPD in acc. to IEC 61643-11
0/1	I
1/2	II
2/3	III

8 Multiservice surge protective devices

The conventional practice of applying surge protective devices (SPDs) at the building entry point of an AC/DC power or telecommunications service may not be sufficient to protect surge sensitive equipment clusters such as computer workstations and multi-media centers. Internal surges can appear on the signalling cables due to inductive coupling within the building cable-network, SPD current diversion into the earthing system and differences in earthing electrode potential. A multiservice SPD supplements the existing protection by providing local protection to the equipment cluster. Services are routed through the multiservice SPD, which protects the services at the cluster to a common reference point and mitigates circulating surge currents in the cluster earth interconnections.

These devices consist of a combination of protection circuits in a single enclosure for at least two different services, which limits the surge voltages to the equipment and provides equipotential bonding between the different services. The surge voltage protection circuits of combined protective devices shall comply with the requirements of IEC 61643-11 for the power supply circuit, and with IEC 61643-21 for the telecommunications/signalling circuits. Multiservice Surge Protective Device called MSPD.

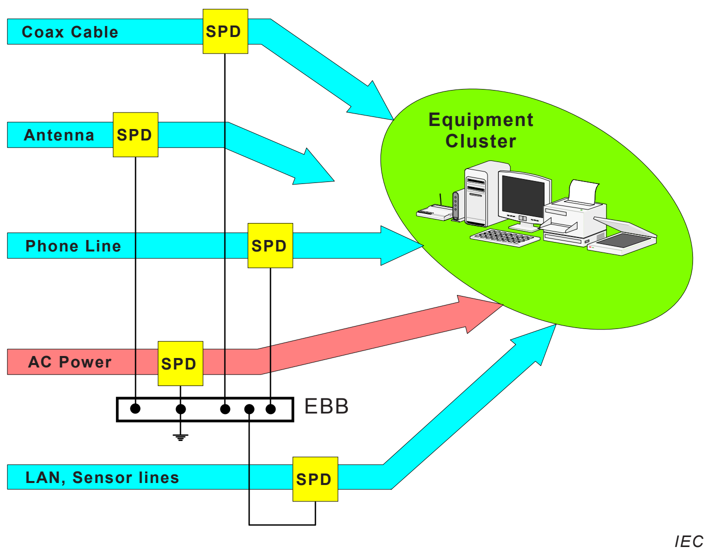


Figure 10 – Individual SPDs

There can be wiring practices, resulting in magnetically induced surges into the building wiring, ground potential rises and imperfect bonding between the services of power and telecommunications. The MSPD, has been developed to protect equipment and localized equipment clusters from these problems as shown in Figure 10, where the equipment cluster is connected to many services.

A key feature of the MSPD design and construction is the bonding between SPDs for the individual services. This minimizes the voltage differences between the services, see Figure 11.

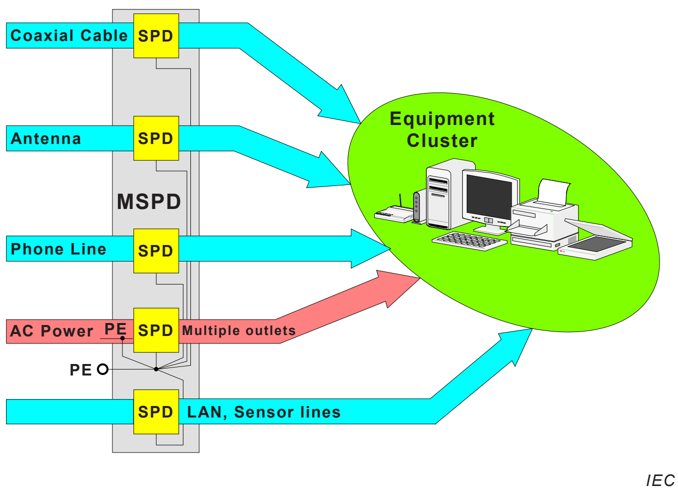
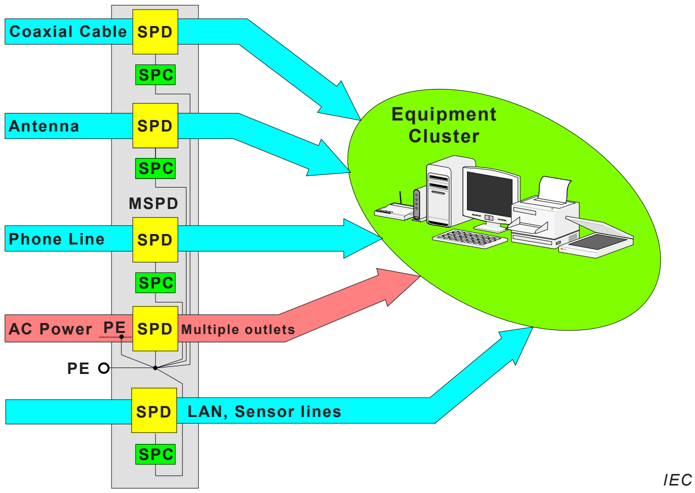


Figure 11 – MSPD with PE connection option

Depending on the application an earthing terminal might be necessary.

MSPD bonding verification consists of applying a surge between the individual services, their grounds or both, then measuring the ground current let-through on the protected side of the MSPD.

Sharing the reference point may be accomplished within the device either by a direct bond, Figure 11, or through a suitable component, Figure 12, such as an SPC (surge protective component) which maintains isolation during normal conditions but provides an effective bond during the occurrence of a surge in one or both systems. These SPCs may be incorporated in the SPD.



a Sharing the reference point may be accomplished within the device either by a direct bond or through a suitable device, such as an SPD which maintains isolation during normal conditions but provides an effective bond during the occurrence of a surge in one or both systems.

Figure 12 – MSPD with transient bonding SPCs to PE terminals

Sharing the reference point may be accomplished within the device either by a direct bond or through a suitable device, such as an SPD which maintains isolation during normal conditions but provides an effective bond during the occurrence of a surge in one or both systems.

The MSPD shall be located close to the equipment to be protected (Computer, Telephone etc.). In accordance with IEC 62305 they will be used in LPZ 1-2 or LPZ 2-3.Therefore the MSPD will not be designed to handle direct lightning currents which will occur in Zone 0-1. Table 5 shows the relationship between LPZ and the requested test categories of MSPDs.

Table 5 – Relationship between LPZ and the requested test categories of MSPDs

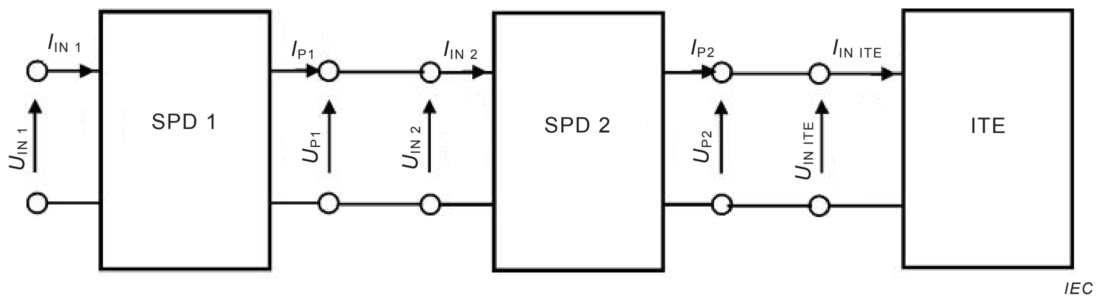
Lightning protection zone	Test Category of SPDs in acc. to IEC 61643-21	Test class of SPDs in acc. to IEC 61643-11
LPZ 0/1	Not applicable	Not applicable
LPZ 1/2	C2	II
LPZ 2/3	C1	III

In addition to the voltage limiting function of the mains- and data-port the MSPD has to fulfil the transmission and installation properties of the communication / data interface which it supports.

9 Coordination of SPDs/ITE

To ensure that two cascaded SPDs or an SPD and an ITE to be protected are coordinated during overvoltage conditions, the output protective levels from SPD 1 shall not exceed the input resistibility levels of SPD 2 or the ITE for all known and rated conditions.

The coordination of two cascaded SPDs is achieved if the following criteria are fulfilled: $U_p < U_{IN}$ and $I_p < I_{IN}$ (Figure 13). If these coordination conditions are not achieved, a coordination may be realized via a decoupling element which might have to be determined by a measurement.



Key

U_{IN2}; $U_{IN\ ITE}$	open-circuit voltage of the generator used for resistibility verification
I_{IN2}; $I_{IN\ ITE}$	short-circuit current of the generator used for resistibility verification
U_P	voltage protection level
I_P	let-through current

NOTE In the case of one port SPDs an additional voltage drop on the shunt connected leads should be considered.

Figure 13 – Coordination of two SPDs

In the case of one port SPDs an additional voltage drop on the shunt connected leads should be considered. An example in IEC 61643-12 covers this by reducing U_W (voltage withstand) by 20 %.

Since an SPD contains at least one non-linear voltage limiting device, the protective open-circuit output voltage will be a distorted version of the applied (open-circuit) overvoltage from the test generator. This makes a general statement regarding a “blackbox” SPD coordination difficult. It is safest to use SPDs recommended by the manufacturer. The manufacturer is able to evaluate how coordination can be achieved or can be determined by testing. To coordinate SPDs with ITE the requirements/information/test reports of the ITE manufacturers will be required.

Annex A
(informative)

Voltage-limiting components

A.1 Clamping components

A.1.1 General

These shunt-connected clamping components are non-linear elements that limit overvoltages that exceed a given voltage by providing a low impedance path to divert currents (Figure A.1).

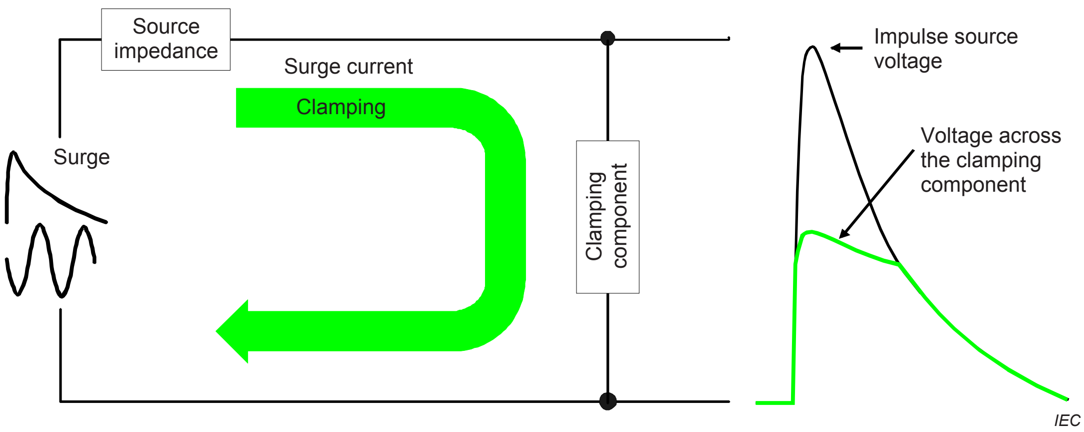


Figure A.1 – Behaviour of clamping components

A.1.2 Metal oxide varistor (MOV)

An MOV is a non-linear resistor made from metal oxides. Over most of the voltage-limiting range, the MOV voltage increases non-linearly with increasing current. At the highest current levels, the material bulk resistance predominates, making its characteristic practically linear.

MOV components are available with U_c voltages of about 5 V and upwards, usually with a tolerance of about ±10 %. Under high impulse current conditions, the MOV limiting voltage can increase significantly. This can help in coordination of cascaded SPDs, but the downstream equipment may be exposed to high-voltage levels.

The MOV has a short response time, making it suitable for limiting fast transient voltages. It also has a high thermal capacity and can dissipate quite high amounts of energy. Exposure to many rated current impulses or to a few exceeding the componentsrating will degrade the MOV. This degradation causes a decrease of U_c and shall be taken into account in the application of these components.

MOV components exhibit high capacitance. This characteristic will limit its use in some high-frequency applications.

A.1.3 Silicon semi-conductors

A.1.3.1 General

These components are formed from single or multiple PN junctions.

Generally, these components have a relatively low energy handling capability and are temperature sensitive. They are used where a rapid voltage-limiting capability is required and they can provide voltage-limiting values of 1 V and upwards.

A.1.3.2 Forward biased PN junction

A forward biased PN has a forward voltage (V_f) of about 0,5 V. Over most of the voltage-limiting range, the diode current increases rapidly with increasing applied voltage. Under high current conditions, the forward voltage V_f may increase to 10 V or higher.

Under rapidly rising applied voltage conditions, the diode may exhibit some voltage overshoot. This overshoot (forward recovery voltage, V_{frm}) may be greater than the high current forward voltage. In the forward biased polarity, the diode has a relatively high capacitance. This capacitance is dependent on the signal and DC bias levels. If the diode is used with reverse bias, the capacitance is decreased. Assemblies of these components connected in series for higher operating voltage will also have significantly reduced capacitance because of the series connection.

A.1.3.3 Avalanche breakdown component (ABD)

ABDs are reversed bias PN junctions, with threshold or breakdown voltages ranging from about 7 V upwards. Over most of its operating current range, the typical ABD terminal voltage changes little with current.

The ABD has a very short response time, making it suitable for limiting rapidly rising transient voltages. The capacitance of an ABD is inversely proportional to the breakdown voltage and is also inversely proportional to the applied voltage, either from signal or d.c. operating voltage.

The single junction ABD is unidirectional. To make a bi-directional component, a second, reverse-poled ABD is connected in series with the first. In either polarity, the component acts as an avalanche ABD in series with a forward biased diode. These two components can be integrated into a single NPN or PNP structure in chip form.

A.1.3.4 Zener diode

Reverse biased PN junctions in Zener breakdown have breakdown voltages of approximately 2,5 V to 5,0 V. Unlike the ABD, the Zener terminal voltage increases considerably with current. This increase may be as high as twice the breakdown voltage.

A.1.3.5 Punch-through diode

Punch-through diodes are NPN or PNP structures. They utilize the widening of the centre region depletion layer with increasing applied voltage to achieve conductivity between the space charge regions of the two PN junctions. Breakdown voltages as low as 1 V are possible. The punch-through diode was introduced as a low voltage, low capacitance replacement for Zener diodes.

A.1.3.6 Foldback diode

Foldback diodes are NPN or PNP structures that utilize transistor action to create a re-entrant or ”foldback” voltage-limiting characteristic. Once the breakdown voltage is reached, the terminal voltage rapidly drops with increasing current to approximately 60 % of the breakdown voltage. Higher currents will cause the voltage to increase. Compared to an ABD with the same breakdown voltage, the foldback has a lower limiting voltage.

The amount of ”foldback” is dependent on the breakdown voltage. For 10 V components, the amount of foldback is very small.

A.2 Switching components

A.2.1 General

These shunt-connected switching components are non-linear elements that limit overvoltages that exceed a given voltage by providing a low impedance path to divert currents (Figure A.2).

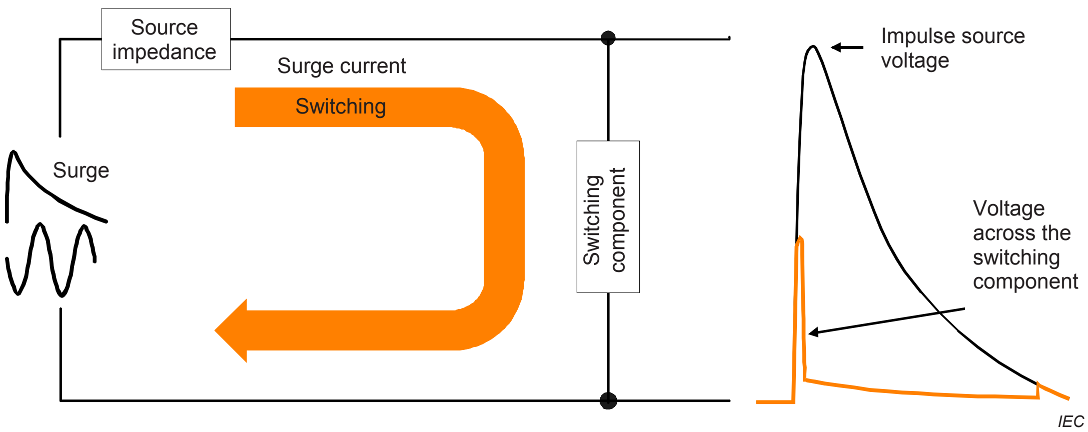


Figure A.2 – Behaviour of switching components

A.2.2 Gas discharge tube (GDT)

Gas discharge tubes consist of two or more metal electrodes separated by a gap of the order of 1 mm or less and held by a ceramic or glass cylinder. Noble gas mixtures at pressures above and below atmospheric fill the interior. When a slowly rising voltage across the gap reaches a value determined primarily by the electrode spacing, gas pressure and gas mixture, an ionization process begins. This process rapidly leads to the formation of an arc between the electrodes with the residual voltage across the component dropping to a value typically less than 30 V. The voltage at which this process occurs is defined as the sparkover (breakdown) voltage of the component.

If the applied voltage (e.g. transient) rises rapidly, the time taken for the ionization/arc formation process may allow the transient voltage to exceed the value required for breakdown in the previous paragraph. This voltage is defined as the impulse breakdown voltage and is generally a positive function of the rate-of-rise of the applied voltage (transient).

Because of their switching action and rugged construction, gas tubes exceed other components in current-carrying capability. Many types of gas tubes can easily carry surge currents as high as 10 kA peak, 8/20 surges.

The construction of gas discharge tubes is such that they have very low capacitance, generally less than 2 pF. This allows their use in many high-frequency circuit applications.

When GDTs (gas discharge tubes) operate, they may generate high-frequency radiation which can influence sensitive electronics. It is therefore wise to place GDT circuits at a certain distance from the electronics. The distance depends on the sensitivity of the electronics and how well the electronics are shielded. Another method to avoid the effect is to place the GDT in a shielded enclosure.

A.2.3 Air gaps

These components are similar to gas discharge tubes in their operation. The difference lie in their construction and the fact that, as their name implies, ambient air is the gas that separates the electrodes. Construction differences include a much smaller gap, generally of the order of 0,1 mm, and carbon rather than metal electrodes. Dust and moisture from the ambient air and graphite dust resulting from the arcing process combine to quickly reduce the useful life of these components. Also, dust particles can actually bridge the gap resulting in a variable resistance that may make a noisy line in telecom applications.

Since atmospheric pressure air is used as the gas dielectric, the lowest practical breakdown voltage for these components is typically 350 V. This compares with about 70 V for gas discharge tubes. Because of the small gap length, however, the impulse ratio or ratio of impulse breakdown to breakdown voltage is lower for air gaps than for gas discharge tubes. Millions of these components are in use today and are still being produced in some quantity.

A.2.4 Thyristor surge suppressor (TSS) – Fixed voltage types (self-gating)

A fixed voltage thyristor surge suppressor (TSS) utilizes the breakdown voltage of the inner NP junction to set the threshold voltage (see A.1.3.3, A.1.3.4 and A.1.3.6). This voltage is set during TSS manufacture. Above a certain breakdown current, the NPNP structure regenerates and switches to a low-voltage condition. The peak value of breakdown voltage is called the breakover voltage ($V_{(BO)}$). For the TSS to switch off, the current provided by the protected system must be below the TSS holding current parameter.. All the TSS parameters are temperature sensitive and this should be taken into consideration when applying SPDs using this technology.

Bi-directional TSS components can be symmetrical or asymmetrical. Unidirectional TSS components will only switch in one polarity. In the other polarity, the TSS may block current flow or conduct large current if a diode (PN junction) has been integrated in parallel. These unidirectional types provide benefits for certain applications.

The multiple PN junctions of the TSS do reduce the overall capacitance; values in the tens to hundreds of picoFarads are common. As with all PN junction devices, the capacitance is dependent on d.c. bias and signal amplitude. The breakdown voltage is dependent on current rise. A power frequency voltage is used to determine the slow rate breakover voltage. Under fast rates of rise, the impulse breakover voltage may be 10 % to 20 % higher.

When the TSS operates, it may generate high-frequency oscillation, which can influence sensitive electronics. Care should be taken when applying this type of protection to minimize coupling into adjacent electronics.

A.2.5 Thyristor surge suppressor (TSS) – Gated types

A voltage-controlled TSS uses a gate connection to the central P or N regions of the NPNP structure. Connecting the gate to an external reference sets the TSS threshold voltage to a similar value. This form of TSS is used where it is desirable to limit the overvoltage close to the external reference value. The external reference may be the supply voltage of the equipment electronics. P-gate types provide negative voltage protection and N-gate types provide positive voltage protection. Bi-directional and unidirectional components are available.

Annex B
(informative)

Current-limiting components

B.1 General

There are two types of current limiter; non-resetting (B.2), requiring manual intervention or power-down to restore system operation, and self-resetting (B.3), which reverts to its non-operating state either almost immediately after overcurrent stops or after a certain time period.

B.2 Non-resetting current limiters

B.2.1 General

These current limiters can be two-terminal series components, which interrupt the circuit current flow (B.2.1), or three-terminal components that divert the current away from the protected circuit (B.2.2)

B.2.2 Series current-interrupting components

B.2.2.1 General

These components are series elements which normally conduct the circuit current. An overcurrent condition causes the components to open the circuit, interrupting the current flow, as shown in Figure B.1. SPD or protected load must provide a low impedance path in order for the series current limiter to function.

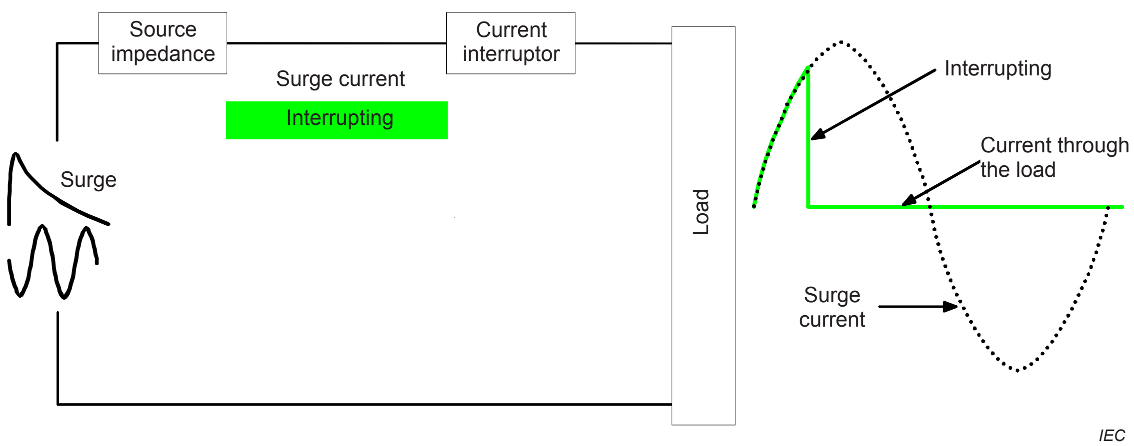


Figure B.1 – Behaviour of current interrupting components

B.2.2.2 Fusible resistor

B.2.2.2.1 General

These components are linear resistors which incorporate an overcurrent fusing function. The fusing function may be directly incorporated in the resistor technology or as a separate element integrated with the component. The overcurrent causes component overheating and the resultant temperature rise causes an open circuit.

B.2.2.2.2 Thick film resistors

These components are made by depositing resistive tracks onto a ceramic substrate. Laser trimming is used for accurate adjustment of the resistance values. In some cases, one side of the substrate may have two power resistors, matched for balanced line applications, and the other side may have an array of resistors for other system applications.

The layout and thermal mass of thick film resistors means that the resistance is insensitive to impulse energies. These components are used primarily to provide current interruption under long-term a.c. overcurrent conditions. They are sometimes termed pulse-absorbing resistors.

The heat developed under a.c. overcurrent conditions causes a severe thermal gradient in the ceramic substrate. If the gradient becomes excessive, the substrate fragments, breaking the resistive tracks interrupting the current flow.

In some cases, a series solder alloy thermal fuse link is added to reduce the long-term fusing low-current characteristic.

B.2.2.2.3 Wirewound fusible resistors

These components are wirewound resistors, often non-inductively wound, which incorporate a fuse or a solderable spring or link.

B.2.2.3 Fuses

Fuses are self-acting break elements for protection of electrical circuits against overcurrent. The current flow is interrupted by the melting of the fuse wire in which the current flows.

B.2.2.4 Thermal fuses

These components are sometimes known as thermal cut-out devices (TCO). They provide protection against overload by interrupting the current due to ambient temperature increases. They can be found in non-resetting and resetting types.

B.2.3 Shunt current-diverting limiters

B.2.3.1 General

Operation of these components effectively places a short across the load, as shown in Figure B.2. Operation occurs due to temperature rise of the component or load-current sensing.

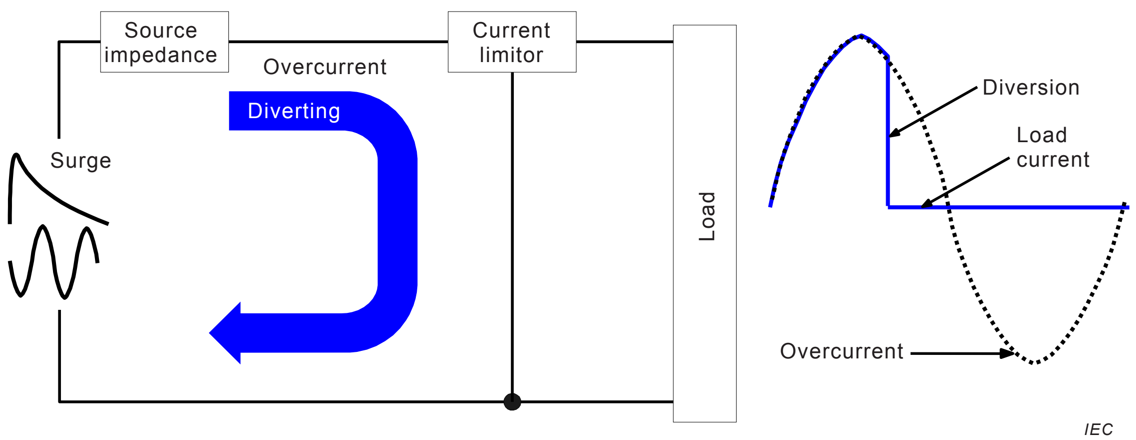


Figure B.2 – Behaviour of current-diverting component

B.2.3.2 Heat coils

Ⓒ Heat coils are thermally activated mechanical components with normally a series and shunt connection on the line being protected. Their function is to divert current at the circuit connection point, thereby preventing this current from flowing through the protected equipment, as shown in Figure B.3. Normally they are constructed using a grounding contact held in its non-operative position by solder. A heat source, generally a coil of resistance wire and a spring, force the grounding contact to ground when the solder melts.

The source of heat is the unwanted line current flowing through the coil of resistance wire. The resistance of communication-type heat coils is typically 4,0 Ω, with a range between 0,4 Ω and 21 Ω. The contact arrangement is such that once the heat coil contacts are closed (operated) the current flows to earth directly and bypasses the coils.

Heat coils are normally single-operating component. There is no means to restore the line to its operating state other than the replacement of the item containing the heat coil. Heat coils have been designed that are manually resettable, not requiring replacement of the SPD. Their use is generally restricted for application in areas where induced currents from 50 Hz power systems are frequent.

It is also possible to construct current-interrupting heat coils, which open circuit as a result of overcurrent.

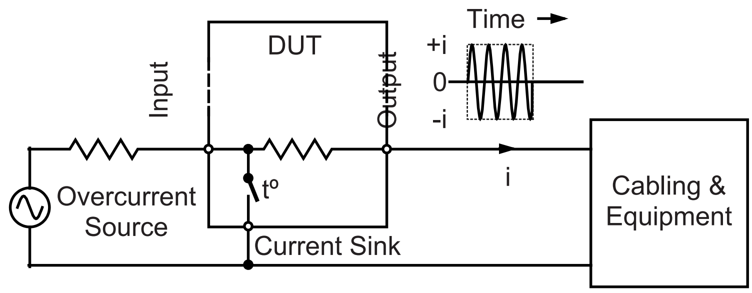


Figure B.3 – Thermally operated (heat coil) three-terminal shunt current limiter Ⓒ

B.2.3.3 Thermal Switch

These switches are thermally activated mechanical components mounted on the voltage-limiting component (normally a GDT). They are typically non-resetting components . There are three common activation technologies: melting plastic insulator, melting solder pellet or a disconnect device.

Melting occurs as a result of the temperature rise of the voltage-limiting components thermal overload condition, when exposed to a continuous current flow. When the switch operates, it shorts out the voltage-limiting components, typically to ground, and, conducts the surge current previously flowing through the voltage-limiting component.

- A plastic-melting based switch, consists of a spring with a plastic insulator that separates the spring contact from the leads of the voltage-limiting component. When the plastic melts, the spring contacts all leads and shorts out the voltage-limiting component.
- A solder pellet-melting based switch, consists of a spring mechanism that separates the line conductor(s) from the ground conductor by a solder pellet. In the event of a thermal overload condition the solder pellet melts and shorts out the voltage-limiting component.
- A disconnect switch typically uses a spring assembly that is held in the open position by a soldered connection and will short out the voltage-limiting componentwhen its switching temperature is reached. When the solder melts, the switch is released and shorts out the voltage limiting component.

B.3 Self-resetting current limiters

B.3.1 General

These current limiters can be two-terminal series components, which interrupt the circuit current flow (B.3.2.1), or three-terminal components that divert the current away from the protected circuit (B.3.2.2)

B.3.2 Series current-reducing components

B.3.2.1 General

These components are series elements, which normally conduct the circuit current. An overcurrent condition causes the components to increase their resistance, thus reducing the current flow.

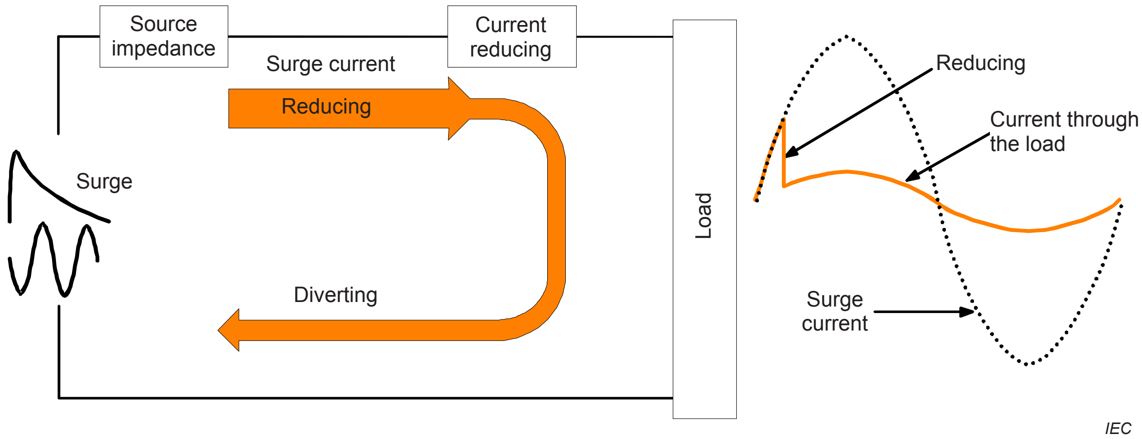


Figure B.4 – Behaviour of current-reducing components (thermally operated type)

B.3.2.2 Thermally operated series current-reducing limiters

B.3.2.2.1 General

Positive temperature coefficient thermistors (PTCs), are commonly used as current-reducing components, as shown in Figure B.5. A PTC is a resistive element, which undergoes a resistance increase of many orders of magnitude (tripping) when its body temperature is increased beyond a specific trip temperature (typically 130 °C). On cooling down to a reference temperature (normally 25 °C) the PTC resistance is reduced to a value similar to that before tripping. PTCs are normally used in the directly (internally) heated mode; circuit current flow through the PTC causes device heating and temperature rise. The heating from impulse currents is usually too small to cause PTC tripping. Higher values of current will give shorter times for tripping to occur (PTC response time). When tripped, the high PTC resistance reduces the circuit current to a low value. If the power source has sufficient voltage, the PTC will stay in a high voltage, low current tripped condition. When the disturbing voltage stops, the PTC will cool and revert to a low resistance value. PTCs are rated for maximum (untripped) inrush current and a (tripped) voltage, beyond which the PTC may be damaged.

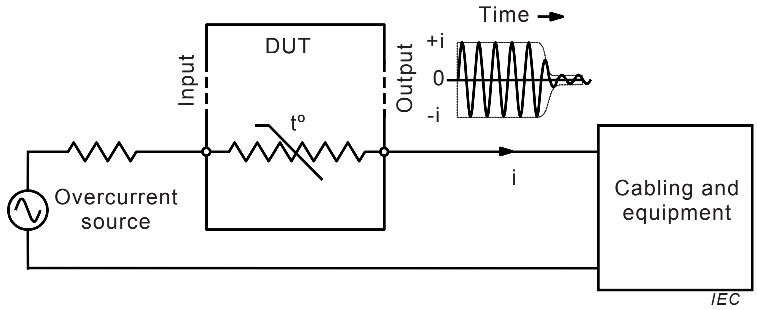


Figure B.5 – Thermally operated (PTC thermistor) two-terminal series current limiting component

B.3.2.2.2 Polymer PTC

These PTCs are typically made from a polymer mixed with a conductive material, normally graphite. They are typically available in resistance values from 0,01 Ω to 10,0 Ω. The untripped resistance value is reasonably constant with temperature. After tripping and cooling, the resistance may be 10 % to 20 % higher than the original value. Unmatched PTC resistance changes after tripping can cause an imbalance in telecommunication systems.

Polymer PTCs have a lower thermal capacity than ceramic PTCs. This tends to give them shorter tripping times.

B.3.2.2.3 Ceramic PTC

These PTCs are typically made from ferroelectric semi-conductor materials and are generally available in resistance values from 10 Ω to 50 Ω. Over most of the untripped temperature range, the resistance slightly decreases with increasing temperature. After tripping and cooling, the resistance returns to a value close to the original value, making matched ceramic PTCs suitable for balanced line applications.

Under impulse conditions the ceramic PTC effective resistance decreases with voltage level, possibly by 70 % of the zero current value.

B.3.2.3 Electronic current limiters (ECL)

These series-connected electronic components have a low resistance for current levels up to a threshold current after which it transitions to a high resistance state. In operation the peak let-through current is the threshold current, as shown in Figure B.6. Current flows in the circuit until the threshold current level is reached. Under a.c. conditions the current consists of current pulses around the zero crossings. Being current, rather than temperature sensitive, ECLs will limit lightning surge currents as well as power frequency currents for low impedance loads. Unlike PTC thermistors, very little power is required to hold the ECL in the high resistance condition. Being electronic, the component characteristics are not affected by multiple surges, provided the maximum voltage rating is not exceeded. The rapid response time allows the automatic coordination of cascaded SPDs and SPD to ITE under impulse and a.c. surge conditions.

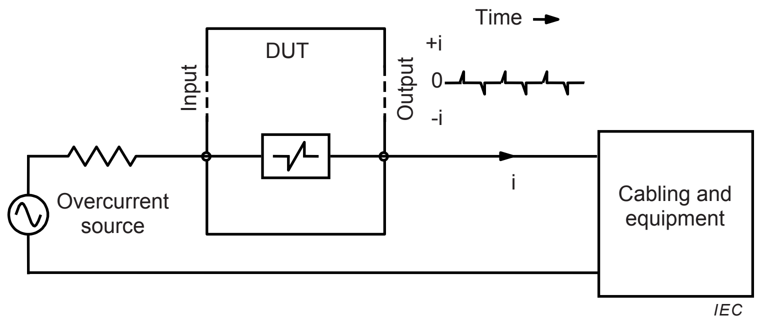


Figure B.6 – Two-terminal series electronic current limiting component

B.3.3 Shunt current-diverting components

B.3.3.1 General

Operation of these self-resetting components effectively places a short across the circuit. Operation occurs when the circuit current exceeds a predetermined threshold level.

B.3.3.2 Electronic Current-triggered limiting components

A TRIAC-type thyristor is has sufficient speed to be effective under a.c. conditions. To rapidly respond to lightning type surges a parallel combination of P-gate and N-gate thyristors is required. The gate and its adjacent protection terminal are connected in series with the circuit, making the circuit current flow through the gate. Switching and resultant current diversion occurs when the circuit current exceeds the gate current triggering value, as shown in Figure B.7. Current flows to the protected item until the threshold current level is exceeded. Under a.c. conditions the protected item current consists of current pulses around the zero crossings. The potential difference across the gate and adjacent protection terminal is about 0,6 V at the trigger current value.

In practice, the gate current trigger value may be lower than the normal circuit current. To avoid premature triggering, the circuit current for switching can be increased by bypassing some current through a low value resistor (usually 1 Ω to 10 Ω) connected across the gate and appropriate main terminal.

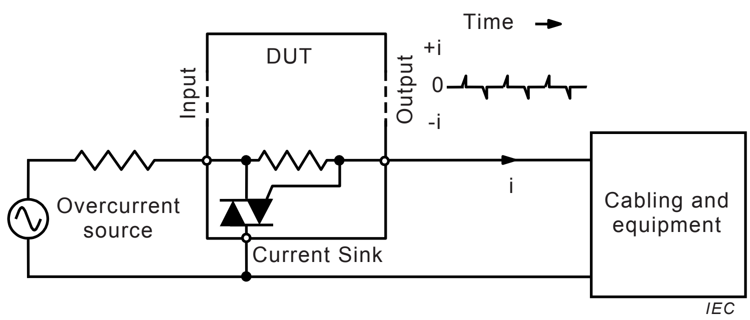


Figure B.7 – Electronic (gated bidirectional thyristor) three-terminal shunt current limiting component

Annex C
(informative)

Risk management

C.1 Risk due to lightning discharges

C.1.1 Risk assessment

The risk assessment of possible damage due to lightning consists of assessment of the following quantities related to the location under consideration:

- lightning flash density;
- earth resistivity;
- nature of installation (buried, aerial, shielded or unshielded cable);
- resistibility of equipment to be protected.

Completion of this assessment will determine whether or not protective measures, e.g. SPDs, are required.

Loss of telecommunications service may occur due to one or more of the following:

- damage to the telecommunication line
- damage to the telecommunication network equipment
- damage to telecommunication equipment installed in structures (both network operator and customer owned equipment)

If they are, the selection of these measures will be based on the information gained as well as initial and maintenance cost. Further information and calculation methods are mentioned in the bibliography.

C.1.2 Risk analysis

C.1.2.1 General

The purpose of a risk analysis is to reduce the expected risk of loss of service (R'_2) due to lightning to a value which is equal to or lower than the tolerable risk of damages (R_T) (see ITU-T K.72 [30].

However, if $R'_2 > R_T$, protective measures are required in order to reduce R_p.

The risks of damage are those caused to telecommunication and signal lines (e.g. insulation breakdown) and connected equipment:

R'_V: Risk component related to direct lightning flashes to telecommunication network causing physical damage of telecommunication line due to mechanical and thermal effects of lightning current.

R'_Z: Risk component related to indirect flashes near the telecommunication line entering the structure or near the structure causing failure of line insulation caused by overvoltages induced on telecommunication lines.

R'_B: Risk component related to direct lightning flashes to the structure, to which the telecommunication network is connected causing failure of line insulation caused by overvoltages or by thermal effects of lightning current flowing along the line.

The expected risk of loss of service, R'_2, in a telecommunication network is given by the following equation:

$$R'_2 = R'_V + R'_B + R'_Z$$

The evaluation of need for protection is done by the comparison of the risk R'_2 with the tolerable risk R_T with the sum of the estimated expected frequencies of damages per year and the expected downtime of service in hours for the customer.

Risk evaluation deals with the risk of damage to the cables, such as perforation of the insulation or melting of conductors, and/or damage to the equipment connected to the cables which causes interruption or degradation of service below acceptable limits.

C.1.2.2 Risk criteria

Minimum resistibility characteristics of the cables and the connected equipment shall be assumed as risk criteria.

- The minimum cable resistibility between any two metallic conductors is assumed to be the following:
  - 1,5 kV for a paper insulated cable;
  - 5 kV for a plastic insulated cable, which includes terminal blocks.
- Equipment connected at the ends of or installed along telecommunication or signal lines is expected to withstand the following minimum impulse common mode overvoltages:
  - 1 kV 10/700, as required by ITU-T Rec. K.20 for equipment at the telecommunication centre end;
  - 1,5 kV 10/700, as required by ITU-T Rec. K.21 and K.45 equipment at the subscriber’s building end or along the line.
- In other cases (signalling networks), the applicable EMC standard (IEC 61000-4-5) shall be used.

C.1.2.3 Evaluating procedure

A procedure that may be followed to evaluate the need for protection is shown in Figure C.1.

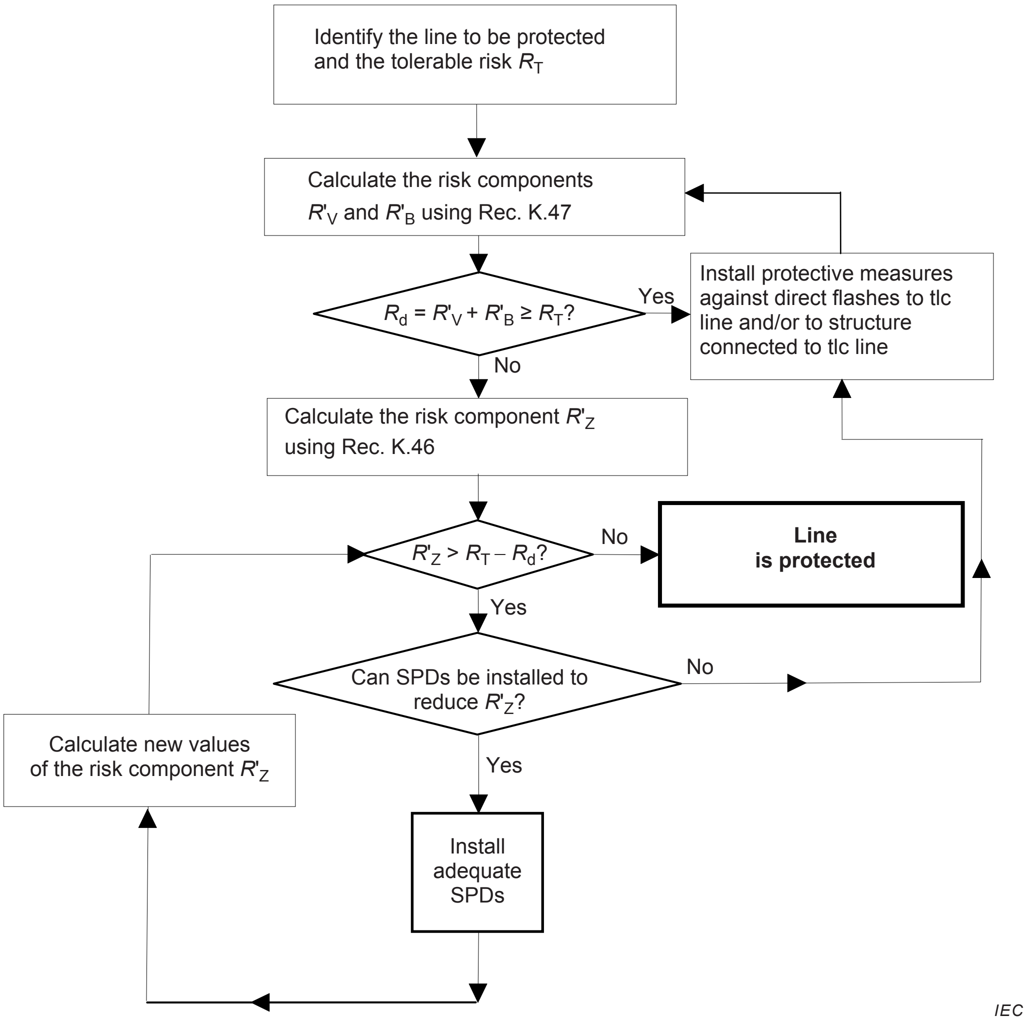


Figure C.1 – Risk evaluation procedure

C.1.3 Risk treatment

For telecommunications or signal lines, the following protective measures, which can also be combined, are considered:

- use of surge protective devices (SPD);
- installation of buried cables instead of aerial cables, i.e. to improve the installation factor of the different line sections;
- shielding, i.e. to improve the shielding factor of the line. Select shielded instead of unshielded cable, replace cables that have reduced shielding factors;
- increased cable resistibility, e.g. choice of cable with plastic-insulated conductors instead of cable with paper-insulated conductors, in combination with the use of SPD;
- route redundancy.

Use of the above-mentioned protective measures reduces the risk of damage:

– to the cable insulation;

– to equipment connected to the telecommunication or signal line.

When the cable types and the installation conditions of the different line sections cannot be changed, the use of SPDs are the only available method to protect the equipment.

C.2 Risk due to power line faults

C.2.1 General

The risk of overvoltages in telecommunications and signalling networks due to fault conditions in power line systems (power supply and traction systems) is dependent on

- distance from the telecommunications or signal line to the line of the power system,
- earth resistivity,
- voltage level and type of power system.

Earth faults in power systems cause large unbalanced currents to flow along the power line, inducing overvoltages into adjacent telecommunications or signal lines which follow a parallel course. The overvoltages may rise to several kilovolts and have durations of 200 ms to 1 000 ms (occasionally even longer) according to the fault-clearing system used on the power line. Calculation methods for overvoltages due to power line faults are given in IEC 61643-12 Ed.1.0 Annex E.

C.2.2 AC power systems

Exact calculation for fault conditions in a.c. overhead power systems are not necessary when both conditions of Table C.1 are fulfilled.

Table C.1 – AC overhead power systems

Environment	Earth resistivity Ωm	Distance m
Rural	≤3 000	>3 000
Rural	>3 000	>10 000
Urban	≤3 000	>300
Urban	>3 000	>1 000

Exact calculation for fault conditions in a.c. underground electric cables are not necessary when both conditions of Table C.2 are fulfilled.

Table C.2 – AC underground electric cables

Environment	Earth resistivity Ωm	Distance m
Rural	≤3000	>10
Rural	>3 000	>100
Urban	n.a.	>1

C.2.3 DC power systems

Exact calculation for fault conditions in d.c. overhead power systems are not necessary when both conditions of Table C.3 are fulfilled.

Table C.3 – DC overhead power systems

Environment	Earth resistivity Ωm	Distance m
Rural	≤3 000	>400
Rural	>3 000	>700
Urban	≤3 000	>40
Urban	>3 000	>70

Exact calculation for fault conditions in d.c. underground electric cables are not necessary when both conditions of Table C.4 are fulfilled.

Table C.4 – DC underground electric cables

Environment	Earth resistivity Ωm	Distance m
Rural	≤3 000	>10
Rural	>3 000	>100
Urban	n.a.	>1

Annex D
(informative)

Transmission characteristics related to IT systems

D.1 General

Annex D provides data about IT system transmission characteristics that have to be considered when selecting SPDs. Depending on the application, the SPD can be tested using relevant tests from IEC 61643-21. The installation of SPDs may be subject to additional requirements and/or restrictions given by the network operator, network authority and system manufacturer (see Clause 6).

D.2 Telecommunications systems

Table D.1 – Transmission characteristics for telecommunications systems in access networks

System	**Bit rate** MBit/s up to	**Bandwidth** kHz up to	**Channels**	**Standard(s)**	***Z*** Ω	**Maximum allowed attenuation** dB@kHz	**Remarks**
POTS	–	3,4 (16)	–		Z_L (com-plex)	Various	Analogue
PCMx	0.784	~ 600	up to 12 × 64 kBit/s	ITU-T G.961 [32], ETSI TS 101 135 [11], ETSI TS 102 080 [13]	135	up to 31@150	
ISDN PMXA	2.	~ 5 000	30 × 64 kBit/s 1 × 64 kBit/s	ITU-T G.962 ANSI T1.601-1999 (R2004)	130	40@1 000	(used worldwide except US)
ISDN PMXA	1.5	~ 5 000	23 × 64 kBit/s 1 × 64 kBit/s	ITU-T G.963 ANSI T1.601-1999 (R2004)	130	40@1 000	(used in the US)
ISDN-BA	0.160	~ 120	2 × 64 Kbit/s + 1 × 16 kBit/s	ITU-T G.961 [32] ETSI TS 102 080 Annex B [13]	150	32@40	EURO-ISDN physical identical
SDSL	2.3	~ 800	Various	ETSI TS 101 524 [14]	135	Various	
HDSL	2.3	~1 000	12-32 × 64 kBit/s	ETSI TS 101 135 [11]	135	31, 27 or 22@150	
ADSL	8	~1 104	Various	ITU-T G.992.1 Annex B [33]	100	Various	ADSL-over-POTS
ADSL2	16	~1 104	Various	ITU-T G.992.3 [34]	100	Various	ADSL-over-POTS
ADSL2+	25	~2 208	Various	ITU-T G.992.5 [36]	100	Various	ADSL-over-POTS or over ISDN
VDSL	30	~12 000	Various	ITU-T G.993.1 [37]	135	Various	
VDSL2	100	~30 000	Various	ITU-T G.993.2 [38]	135	Various	
g.fast	1000	106MHz	Various	ITU G.9701	100	Various	

D.3 Signalling, measurement and control systems

Table D.2 – Transmission characteristics of IT systems in customer premises

System	Bit rate Mbit/s	Class	NEXT a) dB	Standard(s)	Z Ω	Maximum allowed attenuation [a] [dB] at kHz	Remarks
Ethernet (100 Base T)	100	D (5)	27,1@100 MHz	ISO/IEC 8802-5 [41]	100	24 @ 100 MHz	Max. length 100 m
Gigabit Ethernet (1 000 Base T)	1 000	D (5e) or E (6)	30,1@100 MHz	EN 50173-1 [39]	100	24 @ 100 MHz	Max. length 100 m
High speed Ethernet (10G Base T)	10 000	EA (6A)	27,9@ 500 MHz	ISO / IEC 11801 Ed.2 [44]	100	49,3 @ 500 MHz	Max. length 100 m / shielded
ATM	155	D (5)	27,1@100 MHz	EN 50173-1 [39]	100	24 @ 100 MHz	Max. length 100 m
Token ring	16	C (3)	19,3@16 MHz	ISO/IEC 8802-5 [41] EN 50173-1 [39]	150	14,9 @ 16 MHz	Max. length 100/150 m

[a] Channel performance

Further transmission parameters, described in EN 50173, are as follows:

Return loss, PSNEXT, PSACR, ELFEXT and PSELFEXT7.2.2, Measurement and control.

D.4 Cable TV systems

Table D.3 – Transmission characteristics of cable TV systems

System	Bandwidth MHz	Return loss dB f > 50 MHz	Minimum return loss dB at 50 MHz at system outlet (customer)	Standard(s)	Z Ω	Max. allowed attenuation dB/100 m at 450 MHz (depending on cable type)	Remarks
Broadband TV distribution network	47 to 450	From ≤ 24 dB to 1dB/octave to ≤ 26 dB to 1dB/octave (depending on cable type)	≤20 dB to 1,5 dB/octave	National (DE)	75	2,9 dB 4,1 dB 6,2 dB 12,2 dB	Carrier signal level at system outlet min. 47 – 77 dB max.
Broadband TV distribution network	47 to 862	from ≤24 dB to 1dB/octave to ≤26 dB to 1dB/octave (depending on cable type)	To be determined	National EN 50083-1 [42]	75	2,9 dB 4,1 dB 6,2 dB 12,2 dB	

Annex E
(informative)

Coordination of SPDs/ITE

E.1 General

The factors discussed in Clause 9 make it impossible to give a generalized approach to ”black box” SPD coordination. For the user, the safest approach is to have the manufacture(s) recommend appropriate SPDs. The manufacturer, who knows the SPD circuits, may be able to calculate if coordination is achieved or whether it may have to resort to testing. If the user knows the SPD circuits he may also be able to calculate if coordination is achieved. As there are so many configurations involved in a generalized analysis, such calculations are not covered here.

The following analysis of ”black box” SPD coordination is based on linear assumptions which lead to a conservative and non-optimal design. It assumes that SPD electrical parameters are available, either from the manufacturer or from testing. Some types of SPD will require testing for both common-mode and differential overvoltage conditions. There are three steps:

- Determine the input terminal resistibility voltage and current waveforms for SPD2.
- Determine the output protective voltage and current waveforms for SPD1.
- Compare SPD1 and SPD2 values.

The test procedure for the protective open-circuit output voltage, U_p, is described in 5.2.1.3 of IEC 61643-21:2012. A future amendment of IEC 61643-21 will describe the test-procedure for protective short circuit output current I_P.

E.2 Determination of U_{IN} and I_{IN}

Coordination between SPD1 and SPD2 can be achieved by using IEC 61643-21.

Coordination between SPD2 and ITE may be possible if $U_{IN\ ITE}$ and $I_{IN\ ITE}$ are available from the ITE manufacturer or a relevant ITE product standard. It is assumed that the ITE withstands the protective levels U_{P2} and I_{P2} produced by SPD2 under rated conditions. The ITE impedance may vary considerably under protective conditions, so the extremes of loading for the output terminals of SPD2 shall be considered under open-circuit and short-circuit conditions.

When SPD2 is tested at its rated impulse values, the voltage and current resistibility waveforms will be developed at the input terminals of SPD2. There are two sets of waveforms for each rated condition; one for open-circuit output and the other for short-circuit output. The coordination verification process is shown in Figure E.1.

E.3 Determine the output protective voltage and current waveforms for SPD1

The purpose of SPD1 is to increase the resistibility of the system and will be rated for the same tests as SPD2 but at higher voltage levels. When SPD1 is tested at its rated impulse values, the voltage and current protective waveforms will be developed at the output terminals of SPD1. There are two sets of waveforms for each rated condition; one for open-circuit output and the other for short-circuit output. It may be advisable to check SPD1 at lower voltage test levels to ensure that the protective levels produced at the rated conditions are the maximum that can occur.

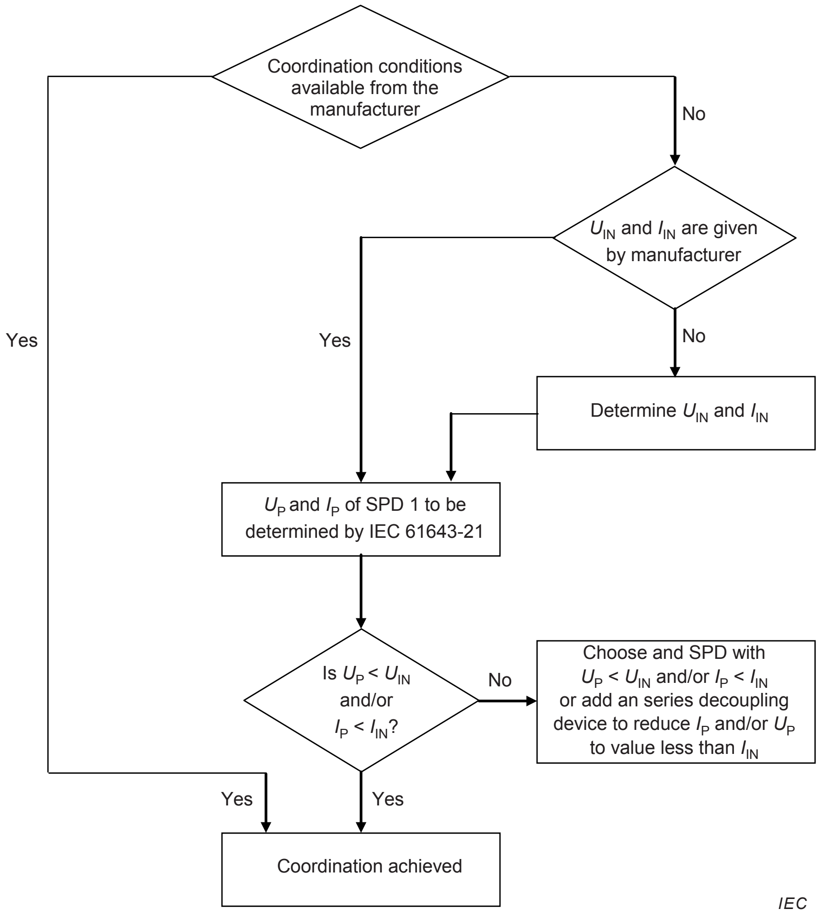


Figure E.1 – Coordination verification process

To ensure that two cascaded SPDs are coordinated during overvoltage conditions, the output protective levels from the SPD 1 shall not exceed the input resistibility levels of SPD 2 for all known and rated conditions (see Figure E.1).

E.4 Compare SPD1 and SPD2 values

Coordination is achieved when all the following conditions are met:

– $U_p < U_{In}$;

– $I_p < I_{in}$;

- U_p waveform is enclosed by the U_{In} waveform;
- I_p waveform is enclosed by the I_{In} waveform.

If the protective waveforms are enclosed by the corresponding resistibility waveforms then time coordination is achieved. At this peak level and time, coordination is achieved. However, some components are sensitive to rate of change (e.g. TSS have a d*i*/d*t* rating) and coordination may fail as a result. This level of detail is beyond the scope of this approach.

E.5 Necessity of verification of the coordination by testing

Any of the following conditions would require verification by testing the combination of SPD1 and SPD2:

– $U_p > U_{In}$;

– $I_p > I_{In}$;

- U_p waveform is longer than the U_{In} waveform;
- I_p waveform is longer than the I_{In} waveform.

The verification by testing is not necessary if the coordination conditions are given by the manufacturer (see Figure E.1).

Annex F
(informative)

Protection of Ethernet systems

F.1 Power over Ethernet (PoE)

The original Power over Ethernet standard IEEE 802.3af 2003 could deliver some 13 W to the powered device (PD) from the power sourcing equipment (PSE). IEEE 802.3af was effectively withdrawn by its incorporation into IEEE 802.3 2008.

The higher power PoE standard IEEE 802.3at 2009 (PoE Plus, PoE+) increased the maximum delivered power to 25.5 W at the PD. To avoid confusion, IEEE 802.3at calls up to 13 W Type 1 PoE and the 25.5 W Type 2 PoE.

Powering is done over two of the four twisted pairs in an Ethernet cable. Figure F.1 shows the two powering options; Mode A and Mode B. The voltage, current and power conditions are shown in Figure F.1 are for Type 2 PoE. Table F.1 shows voltage, current, resistance and power levels for Type 1 PoE and Type 2 PoE.

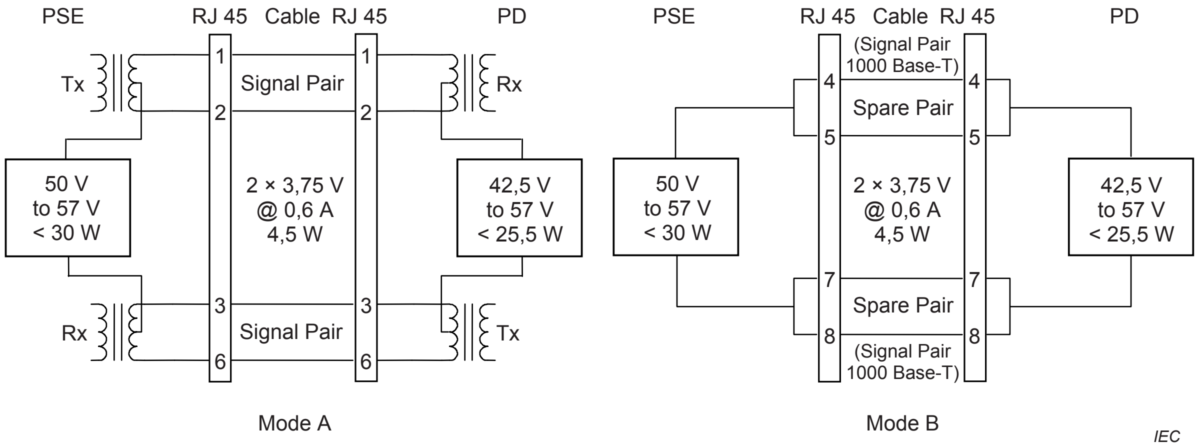


Figure F.1 – PoE powering modes

Table F.1 – Comparison of Type 1 (PoE) and Type 2 PoE+) powering values

Parameter	Unit	Type 1	Type 2
Available power at PD	W	13	25.5
Maximum power sourced by PSE	W	15.4	30
PSE output voltage range	V	44 to 57	50 to 57
PD input voltage range	V	37 to 57	42.5 to 57
Cable loop maximum DC current per pair	A	0.35	0.6
Cable loop maximum pair resistance	Ω	20	12.5
Cable loop maximum power loss	W	2.45	4.5

NOTE In case of short circuit at the PD the PSE will switch off the load current.

F.2 Withstand capabilities and SPD coordination

To protect an ITE a coordination of the protection level of an SPD and the withstand capability of the ITE is necessary. This means in both modes (common and differential mode) the protection level has to be lower than the withstand capability of an ITE. It should also be considered that there exists additional voltage drop on the leads of the SPD (see 7.3.2.1) which increases the protection level.

Ethernet ports are usually designed to withstand a common mode impulse (e.g. X1-C) of 1 kV as listed in ITU-T K.21. In this case the Up of an SPD should be lower than 1kV. There are cases where Ethernet ports have a lower withstand than 1 kV. In this case the U_p of an SPD has to be coordinated with this lower withstand capability of the ITE.

The withstand capability of differential mode is mostly not known and therefore the protection level should be as close as possible to the maximum operating voltage of the signal.

F.3 Common mode to differential mode surge conversion by switching devices

F.3.1 General

Inherently the surges on twisted pair wires are common mode. Differential surges on twisted pair wires are generally assumed to be generated by joint or insulation breakdown of a single wire or, more commonly, asynchronous operation of switching SPDs protecting the wire pair.

Figure F.2 shows two situations; a two-electrode GDT on each wire and a single chamber three electrode GDT. The longitudinal surge on the twisted pair wires (wire 1 and wire 2) is converted to a differential surge (green voltage) by asynchronous SPD operation. The two-electrode GDT design will often result in higher and longer differential surges than the three-electrode GDT design (transverse voltage).

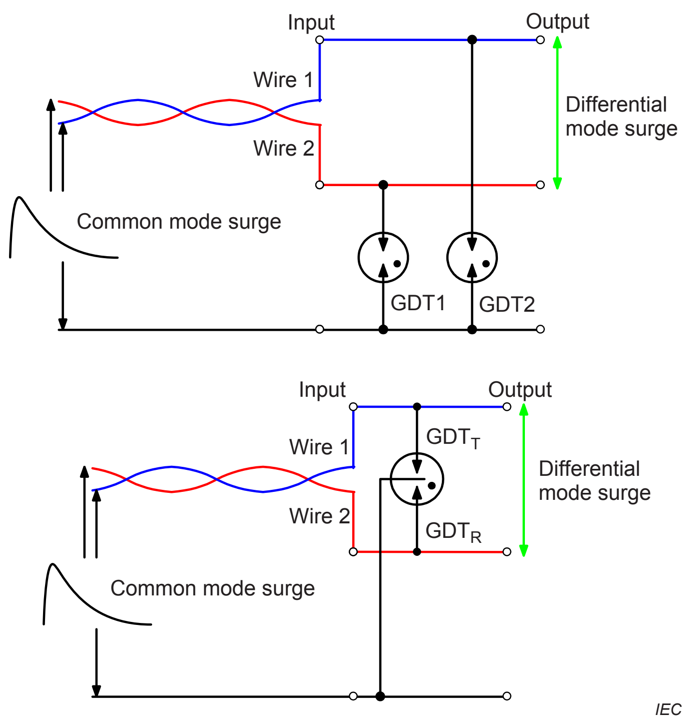


Figure F.2 – Common mode to differential mode surge conversion by asynchronous SPD operation

Figure F.3 shows the longitudinal surge waveforms on the twisted pair wires (wire 1 and wire 2) being converted to a differential surge (green trace) by asynchronous SPD operation.

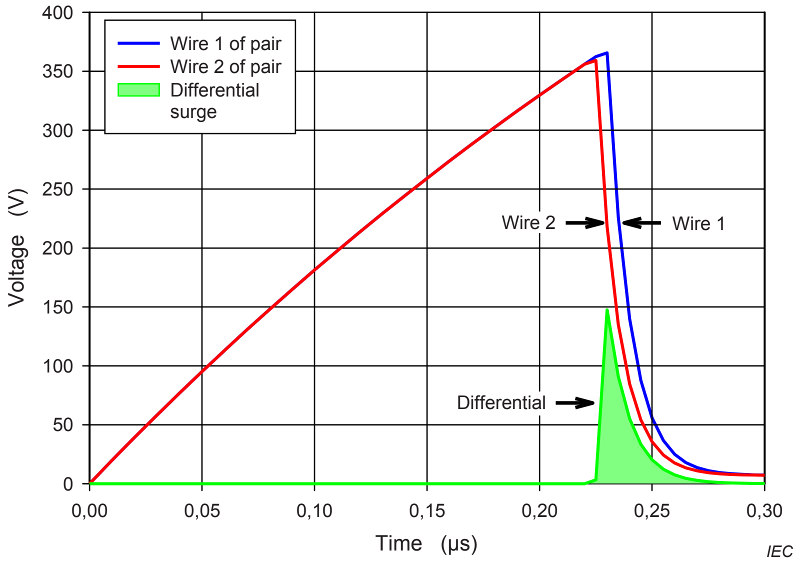


Figure F.3 – Differential surge generated by asynchronous SPD operation on a longitudinal surge

F.3.2 Differential mode voltage reduction by inter-wire protection

The differential surge can be reduced when a SPD use additional protection (e.g. breakdown diodes) between the lines (wire 1 and wire 2). Figure F.4 shows such a circuit. The peak differential voltage will be limited to the diode clamping voltage, see Figure 5.

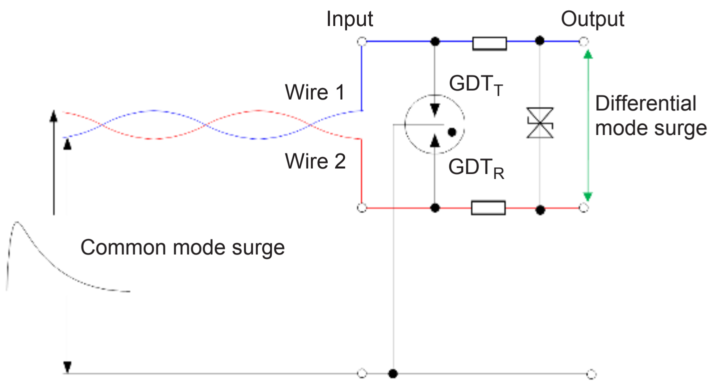


Figure F.4 – SPD circuit with inter-wire protection to limit the differential surge

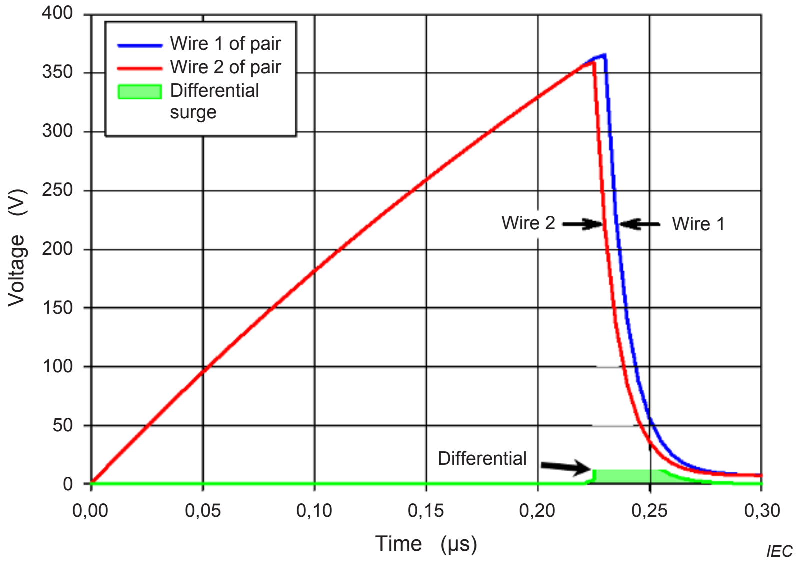


Figure F.5 – Differential surge voltage limited by inter-wire protection

F.3.3 Differential mode voltage reduction by single switching element

By using a single switching element and a bridge of steering diodes the differential surge can be reduced to the difference in the forward voltages of diodes D4 and D6 for positive surges and D3 and D5 for negative surges (Figure F.6, F.7). The bridge diode technique can be extended to protect multiple twisted wire pairs by adding four diodes (corresponding to D3 to D6) for each additional twisted pair. The diode bridge technique for multiple twisted pairs will also result in low levels of differential surge voltage between cable pairs.

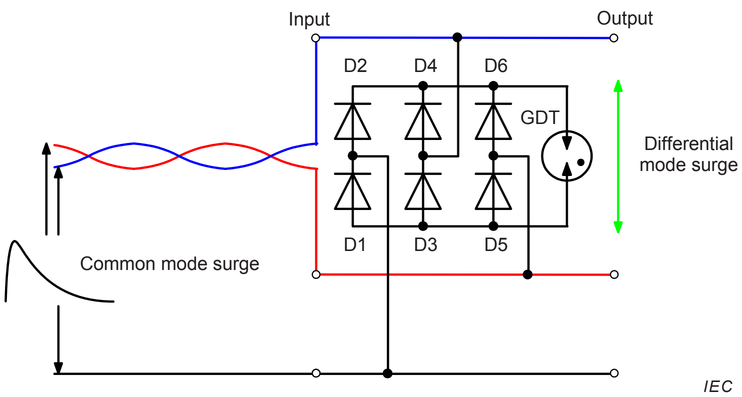


Figure F.6 – SPD using a single switching element and a steering diode bridge

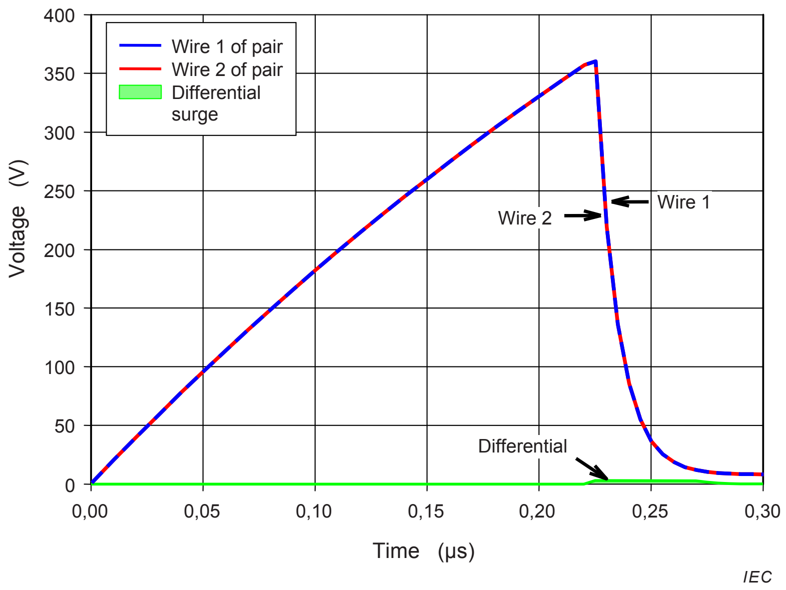


Figure F.7 – Differential surge voltage reduced by single switching element and steering diode bridge

Annex G
(informative)

EMC impact of SPDs

G.1 General

Electromagnetic compatibility (EMC) means the ability of equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. The addition of SPDs shall not decrease this EMC, and shall not degrade the intended function of the system as described in the product standards for the system.

G.2 Electromagnetic immunity

In high frequency systems the SPD may modify the line balance, wiring configuration and/or shielding effectiveness resulting in the need for system immunity testing.

SPDs compliant to IEC 61643-21 are unlikely to cause line unbalance.

G.3 Electromagnetic emission

In a quiescent state (non suppressing mode) an SPD does not create electromagnetic disturbances and no SPD emission tests are required. In high frequency systems the SPD may modify the line balance, wiring configuration and/or shielding effectiveness resulting in the need for system emission testing.

In an operating state (suppressing mode) the combination of SPDs and the system wiring may emit transient electromagnetic fields, due to surge currents, that adversely impact the operation of the system. Switching type SPDs can create an additional transient electromagnetic field during the switching action to the low voltage state (seeFigure A.2).

Annex H
(informative)

Definition of internal port
(Source: ITU-T K.44)

An equipment port can only be classified as an internal port if all of the following apply:

- it is only connected to intra building cables,
- the cable is connected to an internal port of the associated equipment,
- the equipment and the associated equipment have the same earth reference or the equipment is floating,
- the port will not be connected to an external port of the associated equipment,
- the port does not provide a service which the customer may extend to an another building (e.g. a POTs, Ethernet or Video port),
- the port will not have a conductive connection to a cable which leaves the building via other equipment (e.g. via a splitter)

Any port not complying with the requirements for an intra system port or an internal port is an external port.

Annex I
(informative)

Maintenance of SPDs for Information Technology

I.1 General requirements

Protective measures of the telecommunication and signalling networks and/or of telecommunication structures (e.g., exchange building and remote sites) are the result of the protection need evaluation before construction or in the event of changes to the plant, and they are integral part of a protected system.

All protective measures have to be documented to prove that they correspond to the obligation to exercise due care. Protective measures have to be inspected to ensure that they can perform a required function. All measuring results have to be documented and, together with the inspection protocols, are to be kept for as long as the protective measure exists. They have to be compared with the results of previous inspections (see Note 2). This proves if the results differ fundamentally from earlier values, then the reasons for the deviation need to be determined and solved.

Subsequent protective measures or the inspection of the existing ones might become necessary in the following cases:

- repeated appearance of damage caused by electrical sources;
- later erection of exposed structures;
- later erection or changes to electric power plants/traction systems;
- change of the operating currents in existing power plants/traction systems;
- upon customer or authority request.

The maintenance of the interconnection of cable screens and the earthing of the screen including equipotentialization of the system depends on the cabling.

NOTE Measuring results may be influenced by the ambient conditions.

I.2 Maintenance responsibilities

The operator of the telecommunication and signalling network is responsible for the protection of the plant within the network.

The building owner is responsible for the overall safety of the installation within the building, providing a bonding terminal, EBB or access to the MEBB (Figure 4) to enable the earthing of the protective measures.

The customer is responsible for the protection of his (private) network in his property.

All parties are responsible for the effectiveness and documentation of the protective measures in their premises.

I.3 Maintenance of SPDs

I.3.1 General

The decision to protect a structure against lightning with an LPS, as well as the selection of the protection measures, shall be performed according to IEC 62305-2.

The considered protection measures for structures include the structure itself and the installations inside the structure. The LPS e.g. conforms to the design based on the IEC 62305-3 standard.

I.3.2 Visual inspection

The visual inspection includes the inspection of the earthing system.

In addition, the following inspections have to be carried out at accessible parts of the network:

- visible damage or indications of irreversible functions of SPDs;
- indications that the SPDs are in working order;
- new installations added after the last inspection that might increase the risk (e.g., masts or antennas in the neighbourhood of the telecommunication system or supplied structures).
- after alterations or repairs, or when it is known that the structure has been struck by lightning.

I.3.3 Complete inspection

The complete inspection includes the visual inspection.

In addition, the following inspections have to be carried out:

- functional performance of SPDs;
- for monitored SPDs (remote signalling), the functionality of the supervisory apparatus (e.g., remote control) has to be checked.

The function test of SPDs could be carried out as a field test, substituting the out of range SPDs, or by periodic replacement.

I.3.4 Examining periods

The protective measures should be inspected periodically according to Table I.1 or table I.2.

Table I.1 – Maximum period between inspections of lightning protective measures covered by IEC 62305-3

Protection level	Visual inspection (years)	Complete inspection (years)	Critical situations [a] [b] complete inspection year
I and II	1	2	1
III and IV	2	4	1

a Lightning protection systems utilized in applications involving structures with a risk caused by explosive materials should be visually inspected every 6 months. Electrical testing of the installation should be performed once a year. An acceptable exception to the yearly test schedule would be to perform the tests on a 14 to 15 month cycle where it is considered beneficial to conduct earth resistance testing over different times of the year to get an indication of seasonal variations.

b Critical situations could include structures containing sensitive internal systems, office blocks, commercial buildings or places where a high number of people may be present.

NOTE For more information on maintenance and inspection of an LPS see clause E.7 of IEC 62305-3:2010 .

Table I.2 – Maximum period between inspections of lightning protective measures covered by ITU-T K.69 [28]

Item to be inspected	Visual inspection (years)	Complete inspection (years)
Protective measures	3	6 (note)
NOTE Information on some network operators' experiences for reasonable examining periods for GDTs and on tests for field survey is given in Appendix I. The test of function of SPDs and the examining period could be subject to manufacturers' requests		

Annex J
(informative)

Earth potential rise (EPR)

J.1 General

A voltage potential through the earth or across the earth surface results when a current of any magnitude or frequency flows through the local resistivity of the earth. Electrical damage to communications equipment and interfaces occurs when there is a large difference in earth potential due to earth potential rise (EPR), within a local grounded site containing communications equipment or between local and remote sites containing communications equipment that are connected by wire-line communications circuits and shields.

J.2 Causes of EPR

Ⓒ Power related EPR is caused by a low frequency, 50 Hz fault current flowing through a ground grid or the earth via a distribution line power cross to a tree or other earthing paths or utility switching of power lines. The duration of this event may last from fractions of a second to many minutes.

Lightning related EPR is caused by a fast rising current of many kA with rise times in nano seconds to micro seconds and pulse widths in micro seconds to milli seconds flowing through a ground grid or the earth.

Electrified railways also cause EPR. Ⓒ

J.3 Influence of soil resistivity

The magnitude of EPR depends on the magnitude of the current and the local soil resistivity and resulting impedance to earth. The resistivity of the surrounding soil is dependent upon its composition, temperature, humidity and electrolyte content as well as current magnitude (soil ionization) and varies from several to more than 1 000 of Ohm-m.

J.4 Fibre optics

Replacing metallic conductors with fibre optic conductors is an excellent means of reducing EPR related damages. Proper power surge protection and proper locate wire / tension member termination is required.

Annex K
(informative)

References and examples of risk management based on IEC 62305-2

To calculate the risk of damages to equipment, IEC 62305-2 gives detailed information. the following list shows interesting paragraphs of calculation and examples:

- Annex B of IEC 62305-2:2010 describes an assessment of probability P_X of damage.
- Annex C of IEC 62305-2:2010 describes an assessment of amount of loss L_X.
- Annex E of IEC 62305-2:2010 shows examples of risk management at country house, an office building, a hospital and an apartment block.

The presented analysis assumes all incoming services are metallic conductors.

In the case of non metallic conductors e.g. optical fibre it is necessary to be aware that distribution services within the building may be metallic. For this situation ITU-T K.92 provides information about EMC environment. To improve the resistibility measures as listed in C.1.3 (Risk treatment) of this document should be considered.

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