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Recommendation

ITU-T K.143 (07/2023)

SERIES K: Protection against interference

Guidance on safety relating to the use of surge protective devices and surge protective components in telecommunication terminal equipment

Recommendation ITU-T K.143

Guidance on safety relating to the use of surge protective devices and surge protective components in telecommunication terminal equipment

Summary

It is necessary to clarify the electrical requirements for surge protective devices (SPDs) and surge protective components (SPCs) in order to realize both the resistibility and safety of telecommunication systems. Recommendation ITU-T K.143 analyses the influence on human safety of lightning measures bridging across insulation in equipment by surge suppressors. It provides guidance for the design of lightning protection and requirements on surge suppressor in equipment from the human safety standpoint. Requirements for SPDs/SPCs in multiservice surge protective devices external to the equipment and SPDs installed on lines in a building lie outside the scope of this Recommendation.

History*

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Keywords

Device, lightning protection, safety, SPC, SPD, surge suppressor, surge.

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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Introduction

A requirement on bridging between primary circuit and protective earth by surge suppressors in equipment is described in clause 5.5.7 of [IEC 62368-1]. However, the standard does not take into consideration lightning voltage larger than that considered in overvoltage category II, and it does not provide the requirements necessary for lightning protection of class II equipment without earthing in which bridging by surge suppressors is usually applied.

It is necessary to clarify the electrical requirements for surge suppressors to achieve both the resistibility and safety of telecommunication systems. This Recommendation analyses the influence of lightning measures including bridging by surge suppressors on human safety. This Recommendation gives guidance for the design of lightning protection and requirements of surge suppressors from the human safety standpoint.

Recommendation ITU-T K.143

Guidance on safety relating to the use of surge protective devices and surge protective components in telecommunication terminal equipment

1 Scope

This Recommendation provides guidance on how to ensure the safety of construction and maintenance personnel as well as customers of telecommunication systems in customer buildings and access networks when surge protectors are installed in telecommunication equipment.

The safety of persons on metallic access lines, in-home lines and terminal equipment lies within the scope of this Recommendation. The requirements for surge protective devices/surge protective components (SPDs/SPCs) in multiservice surge protective devices (MSPDs) external to the equipment and SPDs installed on lines in building lie outside the scope of this Recommendation, as does equipment in telecommunication centres and outdoor network equipment operating by remote or local power feeding.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T K.21] Recommendation ITU-T K.21 (2022), *Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents*.

[ITU-T K.64] Recommendation ITU-T K.64 (2020), *Safe working practices for outside equipment installed in particular environments*.

[ITU-T K.68] Recommendation ITU-T K.68 (2008), *Operator responsibilities in the management of electromagnetic interference by power systems on telecommunication systems*.

[ITU-T K.98] Recommendation ITU-T K.98 (2014), *Overvoltage protection guide for telecommunication equipment installed in customer premises*.

[IEC 60364-4-44] IEC 60364-4-44:2007:+AMD1:2015+AMD2:2018, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*.

[IEC 60479-1] IEC 60479-1:2022 *Effects of current on human beings and livestock – Part 1: General aspects*.

[IEC 61643-11] IEC 61643-11:2011, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*.

[IEC 62368-1] IEC 62368-1 Ed.4:2023, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*.

[IEC 62368-2] IEC TR 62368-2 Ed.3:2019, *Audio/video, information and communication technology equipment – Part 2: Explanatory information related to IEC 62368-1:2018*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 class I equipment [IEC 62368-1]: Equipment with basic insulation used as a basic safeguard, and with protective bonding and protective earthing used as a supplementary safeguard.

3.1.2 class II equipment [IEC 62368-1]: Equipment in which protection against electric shock does not rely on basic insulation only, but in which a supplementary safeguard is provided, there being no provision for protective earthing or reliance upon installation conditions.

3.1.3 class III equipment [IEC 62368-1]: Equipment in which protection against electric shock relies upon supply from ES1 and in which ES3 is not generated.

3.1.4 surge suppressor [b-IEC 60728-11]: Device designed to limit the surge voltage between two parts within the space to be protected, such as spark gap, surge diverter or semiconductor device.

3.1.5 TT power distribution system [b-ITU-T K.44]: A TT power distribution system has one point directly earthed, the parts of the equipment required to be earthed being connected at the user premises to earth electrodes that are electrically independent of the earth electrodes of the power distribution system.

3.1.6 IT power distribution system [b-ITU-T K.44]: An IT power system is isolated from earth, except that one point may be connected to earth through an impedance or a voltage limiter. The parts of the equipment to be earthed are connected to earth electrodes at the user premises.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 electrical energy source class 1, ES1: Class 1 electrical energy source with levels not exceeding ES1 limits under normal operating conditions and abnormal operating conditions that do not lead to a single fault condition and not exceeding ES2 limits under single fault conditions of a basic safeguard.

NOTE 1 – ES1 may be accessible to an ordinary person. ES1 effects are not painful on the body but may be detectable, and the ignition of combustible materials si not likely.

NOTE 2 – Paraphrased form the main body of [IEC 62368-1].

3.2.2 electrical energy source class 2, ES2: Class 2 electrical energy source with levels not exceeding ES2 limits under normal operating conditions, abnormal operating conditions and single fault conditions, but exceeding ES1 levels.

NOTE 1 – ES2 may be accessible to an instructed person. ES2 effects are painful on the body but not injurious. Ignition of combustible materials is possible, but limited growth and spread of fire is expected.

NOTE 2 – Paraphrased form the main body of [IEC 62368-1].

3.2.3 electrical energy source class 3, ES3: Class 3 electrical energy source with one or more parameters exceeding ES2 limits.

NOTE 1 – ES3 may be accessible to a skilled person. ES3 effects are injury to the body and ignition of combustible materials, with rapid growth and spread of fire likely.

NOTE 2 – Paraphrased from the main body of [IEC 62368-1].

3.2.4 TN-S power distribution system: Neutral earthed electrical supply system where, in part of the installation, the neutral conductor is also the protective earthing conductor, and in other parts there are separate neutral and protective earthing conductors.

NOTE – Based on the definition of "TN-S" in [b-ITU-T K Sup.7].

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC	Alternating Current
DC	Direct Current
ES1	Energy Source class 1
ES2	Energy Source class 2
ES3	Energy Source class 3
GDT	Gas Discharge Tube
HV	High Voltage
L	Line
LV	Low Voltage
MOV	Metal Oxide Varistor
MSPD	Multiservice Surge Protective Device
MV	Medium Voltage
N	Neutral
PE	Protective Earth
RMS	Root Mean Square
SPC	Surge Protective Component
SPD	Surge Protective Device
TOV	Temporary Overvoltage

5 Conventions

None.

6 Conditions of telecommunication installations and overvoltages to be considered for safety requirement

6.1 Power, telecommunication and bonding lines connected to surge protective devices and equipment

6.1.1 Customer building

Figures 1, 2 and 3 are diagrams of power and telecommunication lines connected to SPDs, telecommunication equipment and bonding conductors, and are typical examples of TN-S, TT and IT power systems, respectively. Telecommunication equipment connected to particular power systems is classified into class I, class II and class III equipment in [IEC 62368-1] according to the protection measures applied against electric shock.

6.1.2 Access network installations

Optical fibre cables and metallic lines are used in the access network. Overvoltage and overcurrent on mains, such as surges induced by lighting or power fault, may propagate to metallic telecommunication lines or the metal parts of optical fibre cables in a building if arrestors operate in the building or equipment. In addition, overvoltages and overcurrent may conduct directly on mains due to lightning or earth fault on power transmission lines or they may flow to telecommunication lines due to earth potential rise. It is necessary to consider human safety in relation to the current and voltage path through these lines.

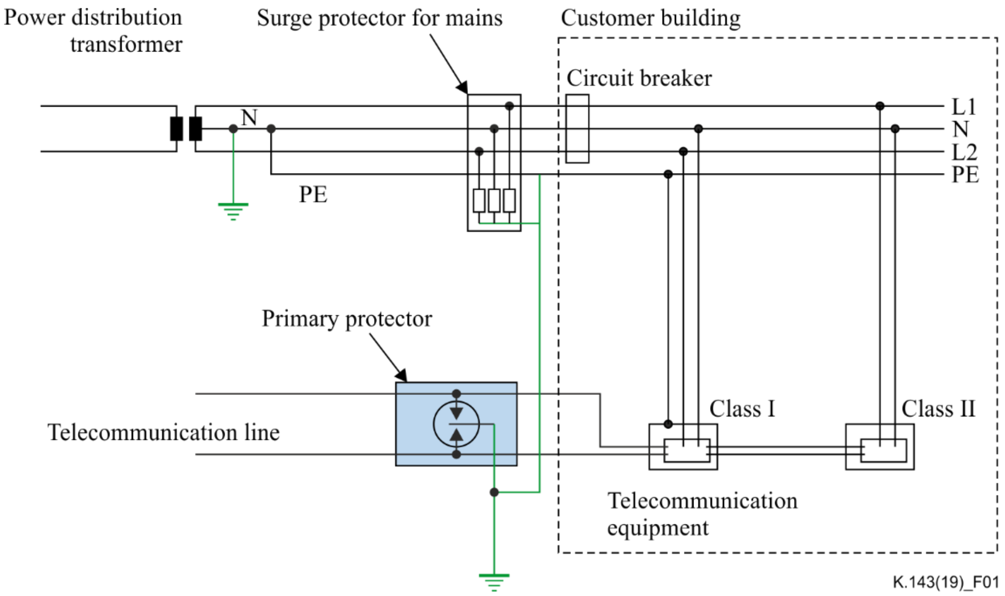

Figure 1 – SPD, equipment and wiring for a customer building using the TN-S system

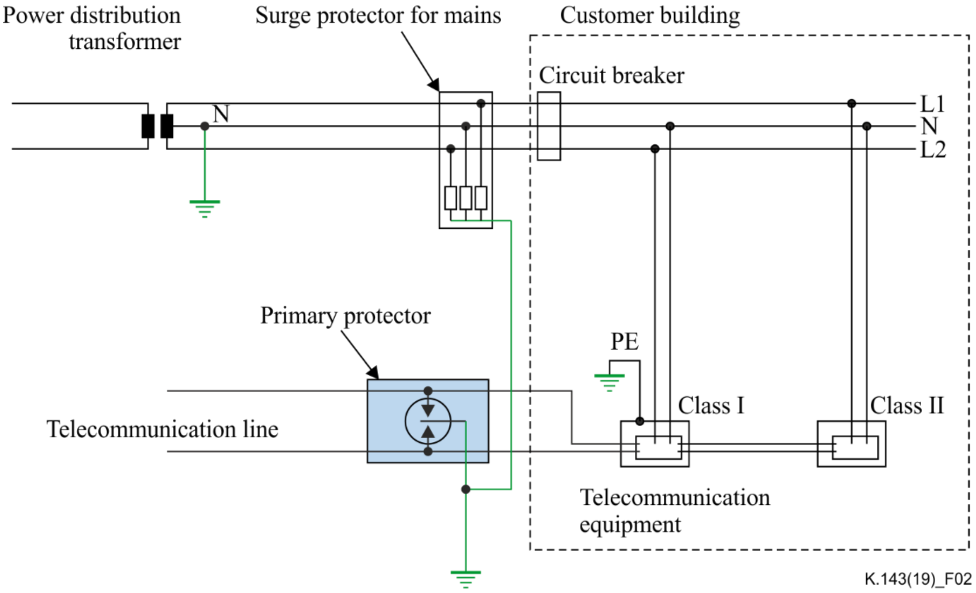

Figure 2 – SPD, equipment and wiring for a customer building using the TT system

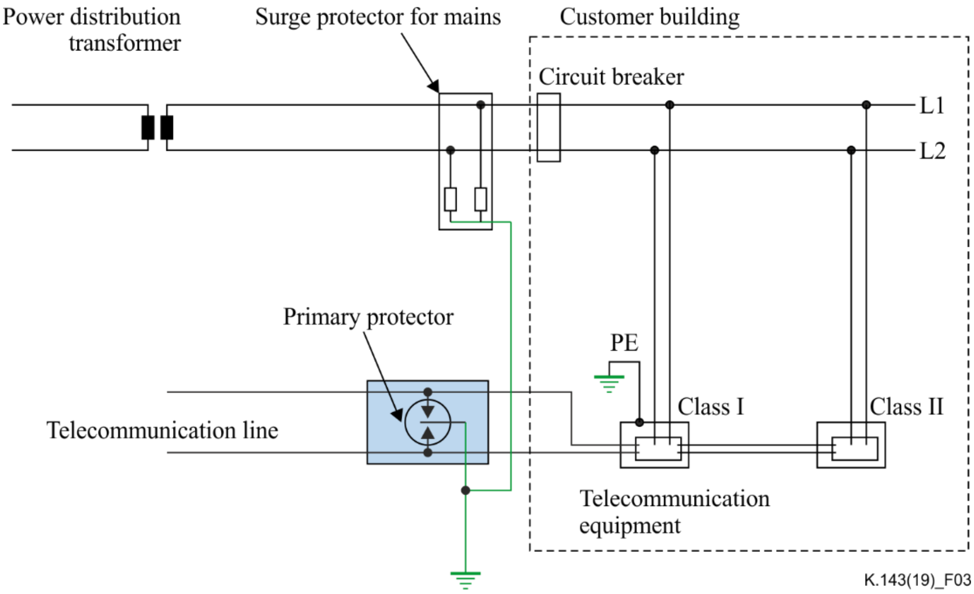

Figure 3 – SPD, equipment and wiring for a customer building using the IT system

6.2 Causes of electrical human hazards

6.2.1 Mains voltage

1) Degradation of telecommunication equipment insulation

Insulation is provided among the primary circuit, the external circuit and the enclosure of the telecommunication equipment, so that hazardous current does not flow to a human body. The supply current may flow from primary to telecommunication line and the current may cause fire or human hazards for users or installation construction or maintenance personnel if the insulation breakdown occurs. Insulation degradation may continue after insulation breakdown caused by overvoltages on mains and telecommunication lines.

The strength of the insulation is required by [IEC 62368-1]. Also, the resistibility of equipment incorporating surge suppressors is specified by [ITU-T K.21].

2) Power contact

An accident can occur in which the power supply line and the communication line are brought into contact and the insulation is damaged; then the power supply line conductor might come into direct contact with the telecommunication line. This could cause overheating, fire hazard and hazard to the human body through continuous flow of hazardous voltage and current from the power supply line to the telecommunication line.

3) Temporary overvoltages due to faults in power systems

Temporary overvoltages (TOVs) can appear on live to neutral (L-N) and live to protective earth (L-PE) in mains conductors as a result of a fault in the low-voltage (LV) system. Also, TOVs can appear on N-PE and L-PE in mains due to a fault in the high (medium) voltage power system (see Figure 4).

For faults on high-voltage/medium-voltage (HV/MV) power systems, countermeasures have been taken to detect the failure current and shut off the power supply to the HV system. Also, in order to limit a potential rise of the N conductor of the mains, the N terminal of the power distribution transformer is connected to the earth, and the upper limit of the earth resistance is specified. When the earthing resistance is higher than the limit, the safety condition is not satisfied, since the potential rise of the PE becomes higher and the delay time to shut off the power supply longer; see Figure 4.

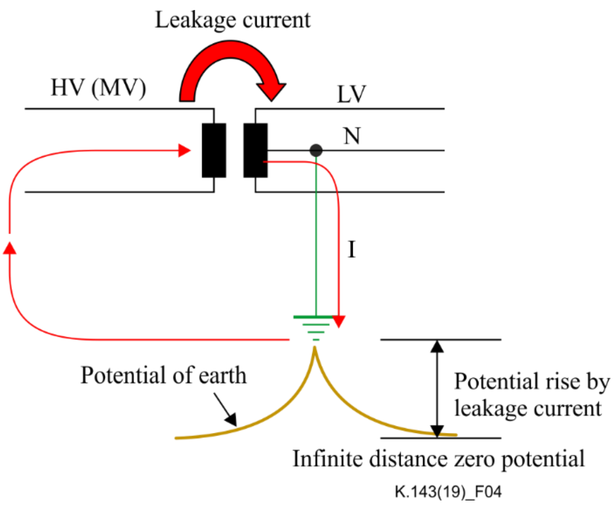

Figure 4 – Power fault in a high-voltage system at a distribution transformer

The stress for equipment connected to LV mains is referred to as a TOV in [IEC 60364-4-44]. The maximum voltage of the TOV is U_0 + 1 200 V for up to 5 s and U_0 + 250 V for longer periods, where U_0 is the nominal AC root mean square (RMS) line voltage to earth in TN and TT systems. In an IT system, it is nominal AC RMS voltage between the line conductor and the N conductor or the midpoint conductor, as appropriate.

In systems without an N conductor, U_0 shall be the line-to-line voltage.

More stringent limits are required in some countries, such as Japan; see Table 1.

Table 1 – Permissible power-frequency stress voltage in Japanese TT system

Duration of earth fault in a high-voltage system t (s)	**TOV RMS in low-voltage installations** U (V)
$t > 2$	$U_0 + 150$
$2 \geq t > 1$	$U_0 + 300$
$1 \geq t$	$U_0 + 600$
NOTE – U_0: nominal AC RMS line voltage to earth.	

6.2.2 Lightning surge

1) Lightning surges on low-voltage power distribution lines

The occurrence rate for lightning surges on LV power distribution lines in Japan is shown in Figure 5. Lightning surges are produced by direct strikes and induction to the power lines.

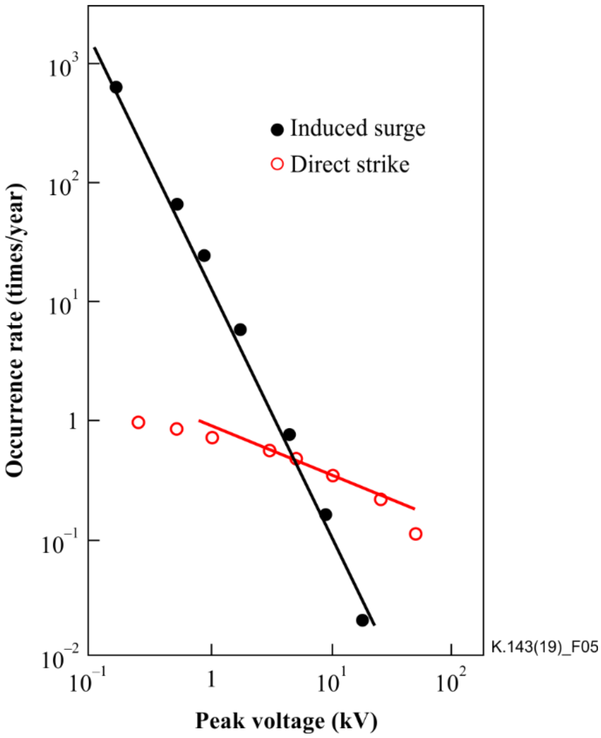

Figure 5 – Occurrence rate for lightning voltage on low-voltage power distribution lines

2) Lightning surges on telecommunication lines

The occurrence rate for lightning surges on telecommunication lines is shown in Figure 6. The solid line shows calculated value at the subscriber end and the dotted line shows the value at the telecommunication centre. The plots indicate measured value. Surge voltage exceeding 10 kV appears on telecommunication lines at the subscriber end.

If lightning strikes are anticipated on the telecommunication line or in the vicinity thereof, danger shall be avoided by stopping all work that involves accessing the telecommunication line both outdoors and indoors. In addition, members of the public are protected by insulation and earthing of equipment enclosures.

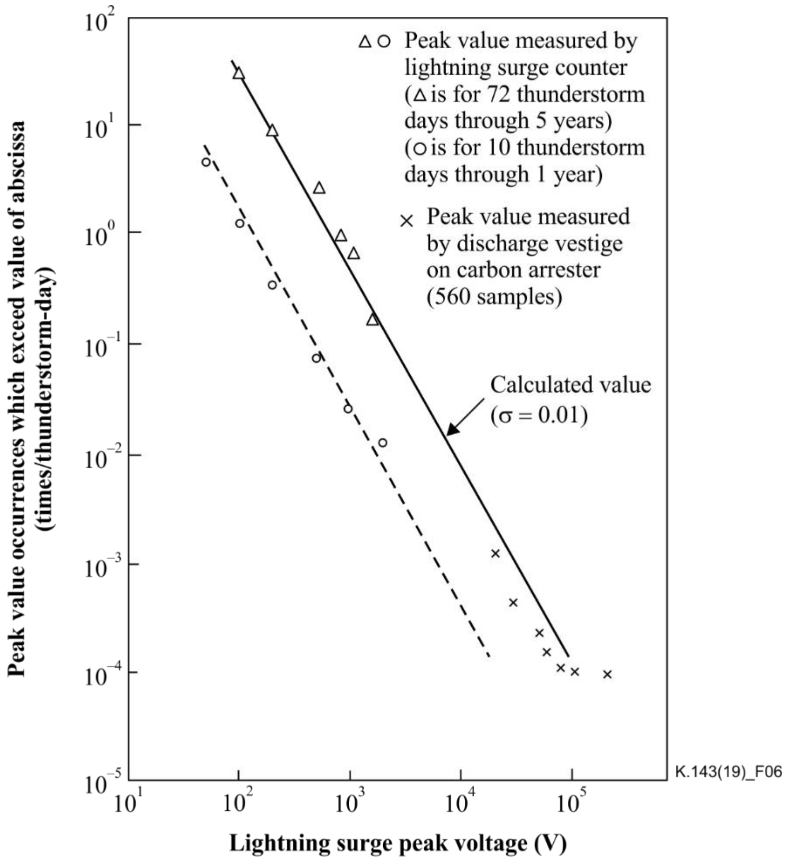

Figure 6 – Occurrence rate for lightning voltage on telecommunication line

6.2.3 Power-frequency induction from power transmission line

Large current flows at the time of occurrence of an earthing fault in a HV power transmission line; such a flow becomes an induction source and high common mode voltage may be induced in the telecommunication line. To ensure the safety of construction and maintenance personnel working on or around telecommunication lines, induced voltage is limited by shielding and through utilization of arresters to a level that does not cause ventricular fibrillation in a person who might directly touch the telecommunication line.

The limit value of the power induction voltage (longitudinal voltage) is specified in [ITU-T K.68]. The values in Table 2 are specified for the condition under which the resistance value of the current path can be kept high (typical situation). The values in Table 3 are specified for a case where the resistance value in the current path is likely to be low due to clothing becoming damp due to perspiration, etc., in hot and humid climatic conditions (severe situation).

Since induction of hazardous voltages from HV power transmission lines is caused mainly by earth fault current generated by insulation sparks caused by lightning strikes on it, construction or maintenance personnel should stop works on outdoor installations when a local lightning strike is predicted in order to avoid a dangerous situation.

Table 2 – Limits relating to danger in the case of electromagnetic interference produced by AC power plants in fault conditions: Typical situations

Reference fault duration *t* [s]	**Induced voltage RMS** [V]
$t \leq 0.10$	2 000
$0.10 < t \leq 0.20$	1 500
$0.20 < t \leq 0.35$	1 000
$0.35 < t \leq 0.50$	650
$0.50 < t \leq 1.00$	430
$1.00 < t \leq 3.00$	150
$3.00 < t$	60
NOTE – Table 18 of [ITU-T K.68].	

Table 3 – Limits relating to danger in the case of electromagnetic interference produced by AC power plants in fault condition: Severe situations

Reference fault duration *t* [s]	**Induced voltage RMS general** [V]	**Induced voltage RMS when current paths through chest or hip need not be considered** [V]
$t \leq 0.06$	430	650
$0.06 < t \leq 0.1$	430	430
$0.1 < t \leq 1.0$	300	300
$t > 1.0$	60	60
NOTE – Table 19 of [ITU-T K.68].		

6.3 Hazards relating to accessible parts on installations and equipment

6.3.1 Accessible parts in a telecommunication system and its installations

Figures 7, 8 and 9 show places where a maintenance person or a customer may make contact with conductors in a telecommunication system and its installations using TN-S, TT and IT systems, respectively. Brief descriptions for accessible parts, labelled (A) to (E2), are as follows.

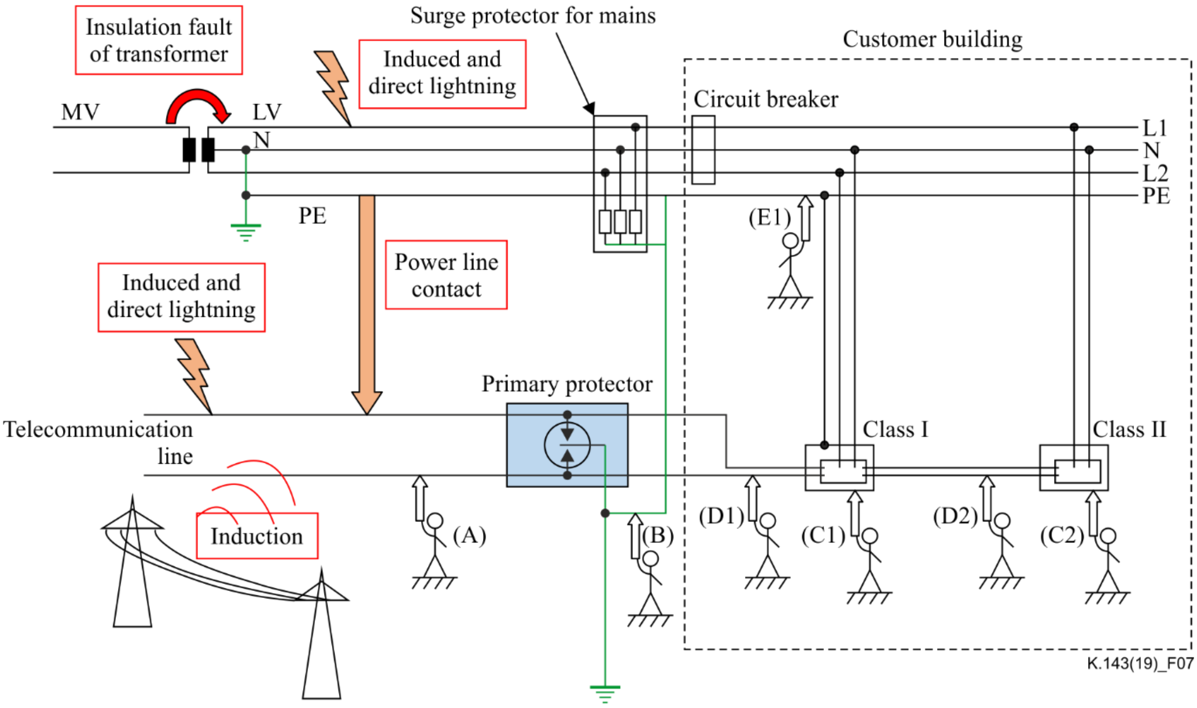

Figure 7 – Example of accessible parts in a customer building using the TN-S system

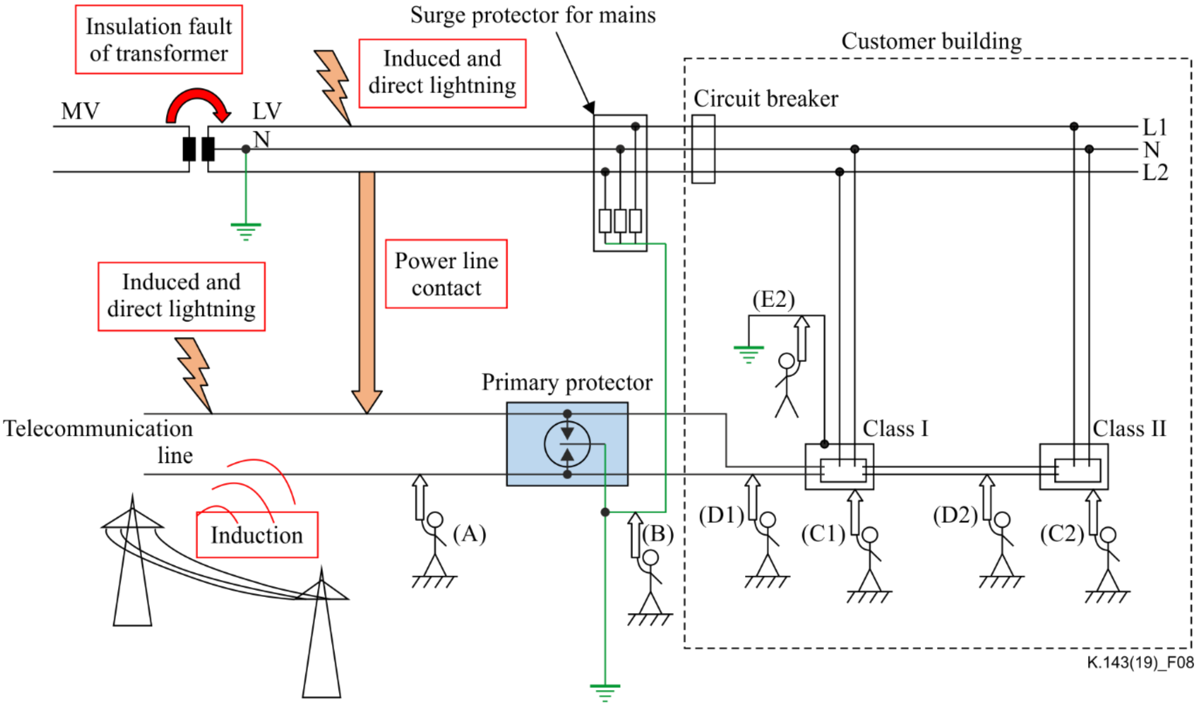

Figure 8 – Example of accessible parts in a customer building using the TT system

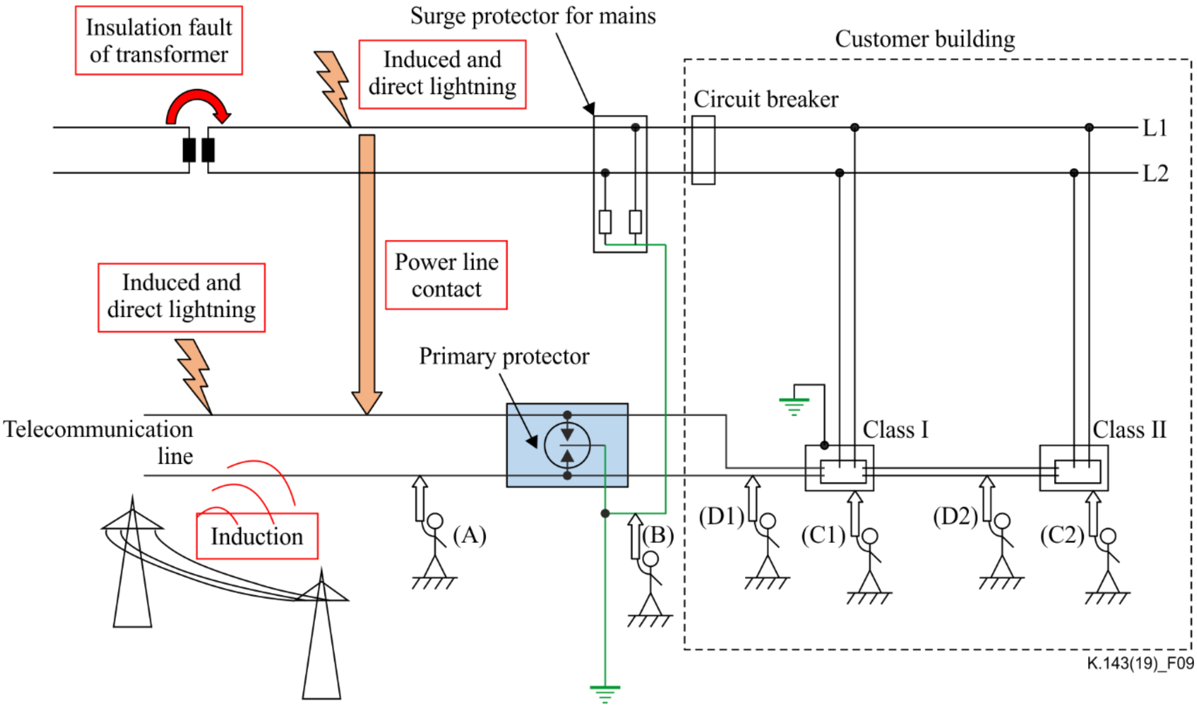

Figure 9 – Example of accessible parts in a customer building using the IT system

(A) This is an outdoor facility for a telecommunication line, where construction or maintenance workers may come into contact with metallic parts of the lines. However, it is not permitted for ordinary persons to touch these parts. Workers may also touch other conductive parts at zero potential at infinity simultaneously. Risk reduction is attempted through safety working procedures, such as leakage voltage checking using a detector. Work practices to be applied while working on live telecommunication circuits are described in [ITU-T K.64].

(B) There is a terminal board for the introduction of the telecommunication line to the building and there are terminals for a primary protector. Construction and maintenance workers may come into contact with these parts; however, it is not permitted for ordinary persons to touch them. A worker may touch other conductive parts that are not bonded to the PE outside the building. During a work carried out at outdoor facilities, risk reduction is attempted through safe working procedures such as leakage voltage checking using a detector.

(C1) and (C2) These are enclosure surfaces of telecommunication equipment and persons often touch these parts. The enclosures of class I equipment are earthed and those of class II equipment are separated from the primary circuit by enhanced insulation or double insulation.

(D1) This is an indoor part of a telecommunication subscriber line. Contact with the conductors in order to cut and connect the line is limited to construction and maintenance workers. Ordinary persons may only touch the outer surfaces of wire insulation, plugs or connector surfaces. However, metallic parts are not accessible to them since modular connector (RJ-11) is used.

(D2) This part is the wiring for internal connection links between internal ports of telecommunication equipment. Contact with the conductors in order to cut and connect the lines is limited to construction and maintenance persons. Ordinary persons may touch the outer surfaces of wire insulation or plug or connector surfaces. Whether metallic parts can be accessed depends on the types of connectors utilized for the system.

(E1) This is a protective earthing (PE) terminal or bonding in the TN system. PE and N conductors are connected in the TN system and the contact with the PE wiring conductors is limited to construction and maintenance persons for the indoor power line. The conductor of the PE is connected to the plug of the class I device at the indoor outlet. Whether an ordinary person may access the PE terminal of the outlet depends on the shape of the outlet (PE is accessible at the CEE7/3 outlet for type F and CEE7/5 outlet for type E). Potential differences may appear between PE terminals (conductors) when impedance of the bonding conductor is not sufficiently low.

(E2) This is an earthing (PE) terminal or wiring in a TT system. Connection between the PE and the N conductor is not permitted. Wiring of the PE is insulated, but some types of PE terminals, such as screw type terminals, are accessible.

6.3.2 Impacts on safety of contact points and current path

The current in a human body may flow between a conductive part of a telecommunication installation and another conductor. The influence on the human body depends on the potential difference between the two conductive parts, contact parts of the human body (current path in a body), and resistance within and outside the body. (Figures 7 to 9 illustrate the case when the contact parts of a human body are a hand and a foot, for example.)

The degree of hazard depends on the value of current and its path in the human body, as described in [IEC 60479-1].

Further, one end of the current path can be a floor, a surrounding metal conductor or the like; and there are two cases: they are a) bonded or b) not bonded to a PE to create equipotential bonding. In the TN-S system, the PE is connected to N and the potential of the N appears at the PE terminal.

Figure 10 shows two cases: a) a person who is in contact with the metallic enclosure of the communication system and is standing on a floor with the same electrical potential as the PE; b) a person who is standing on a floor at a local earthing potential independent of the PE (e.g., zero potential at infinity). When the arrester operates and the current flows to the earthing of the PE, the potential of the PE rises by its earthing resistance. In this case, a hazardous situation can occur when the ground potential of the PE rises and the person standing on the local earthing potential is touching the metallic enclosure of class I equipment.

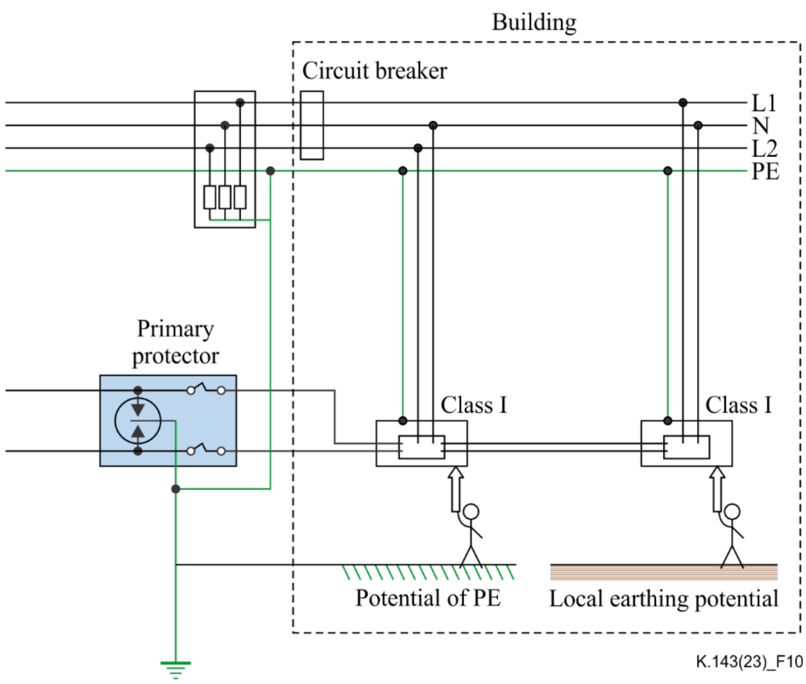

Figure 10 – Difference of potential at standing point

7 Safety requirements relating to surge suppressors in telecommunication equipment

7.1 Surge suppressors bridging telecommunication line and earthing

Surge suppressors that bridge the separation between ES1 or ES2 circuitry intended to be connected to external circuits and earth shall comply with the requirements specified in clause 5.4.11.2 of [IEC 62368-1].

7.2 Surge suppressors bridging mains and earthing

Surge suppressors used between a mains circuit at ES3 voltage and PE shall comply with the requirements specified in clause 5.5.7 of [IEC 62368-1].

7.3 Surge suppressors bridging between primary circuit and telecommunication line

Necessity and technical discussion about bridging between the primary circuit and telecommunication line can be found in [IEC62368-2].

Where a surge suppressor is used between the circuits connected to mains and an external circuit classified as ID1 in Table 13 of [IEC 62368-1], e.g., a telecommunication line, in class II equipment without earthing, the following requirements apply: The ES1 or ES2 circuits in the equipment shall be separated from the conductor connected to external circuit. Impulse test of 1.5 kV 10/700 and steady state test of 1.0 kV (AC peak or DC voltage), described in 5.4.10.1 in [IEC 62368-1], are required for this purpose.

An example of circuit configuration of a surge suppressor in this condition is shown in Figure 11.

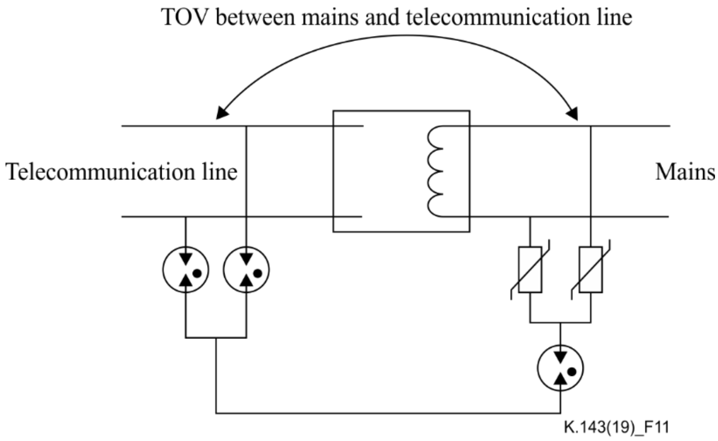

Figure 11 – Example of circuit configuration of an SPD

The part of the circuit to which the surge suppressor is connected shall not be accessible. It shall be checked by inspection or test probe.

Where a surge suppressor is used between the circuit connected to mains and the external circuit as indicated by ID number 1 in Table 13 of [IEC 62368-1], it shall consist of varistor(s) and gas discharge tube(s) connected in series, where the following applies.

7.3.1 Requirement for a surge suppressor relating to TOV

The surge suppressor bridging between primary and external circuits shall not operate when a DC voltage of U_{TOV2}, simulating a TOV condition, is applied between the primary circuit and the external circuit in equipment.

For power systems complying with [b-IEC 60364 series]:

for single phase less than 120 V, U_{TOV2} = 2 000 V for single phase lower or equal to 230 V, U_{TOV2} = 2 500 V

For power systems in USA and Japan:

for a nominal voltage of the mains lower than or equal to 400 V, U_{TOV2} = 1 500 V

This value is derived from the peak voltages of TOV in the respective country.

7.3.2 Requirement on surge suppressor when it has a single fault

A surge suppressor usually consists of combination of SPCs including metal oxide varistors (MOVs) and gas discharge tubes (GDTs). The surge suppressor bridging between the mains and an external circuit shall not operate at normal mains voltage including the voltage fluctuation, even if any one of the SPCs constituting the surge suppresser is short-circuited.

The voltage fluctuation of the mains voltage is in many countries less than 10% of the nominal mains voltage. For safety reasons a 10% margin is added to the maximum fluctuation of the mains voltage. The maximum voltage is set to 120% of the nominal mains voltage for the calculation of the minimum operation voltage of the surge suppressor under single fault condition of the same.

The value 120% of the nominal mains voltage is the same as the test voltage for ICX in G.16 of [IEC 62368-1].

The peak voltage of the AC mains voltage at the maximum of the fluctuation U_{peak2} is calculated as $U_{peak2} = \Delta U_0 \times 1.2 \times 1.414$.

The calculated values for major mains voltages in the world are listed in Table 4.

Table 4 – The value of U_{peak2} for major mains voltages

U_0	$U_0 \times 1.2$	$U_{peak2} = U_0 \times 1.2 \times 1.414$ (Round up)
100	120	170
115	138	196
120	144	204
200	240	340
220	264	374
230	276	391
240	288	408
400	480	679

The operation voltage of the SPC shall be specified not to operate at U_{peak2} as shown in Table 4, considering the variations in SPC production (ΔU_{sp}) and change of the rated operating voltage due to the SPC ageing over the expected life of the equipment (ΔU_{sa}).

The minimum rated operating voltage U_{op} of each component shall be determined taking into account variations in production and ageing as follows:

$$U_{op} = U_{spd} + \Delta U_{sp} + \Delta U_{sa}$$

where:

U_{spd} is the operating voltage of each component designed not to operate at U_{peak2}, even if any one of the SPCs constituting the surge suppresser is short-circuited

ΔU_{sp} is the maximum variation of the operating voltage due to variations in SPC production, obtained by subtracting minimum operating voltage from rated operating voltage

ΔU_{sa} is the maximum variation of the operating voltage due to the SPC ageing over the expected life of the equipment, obtained by subtracting the decreased operating voltage after ageing from rated operating voltage. ΔU_{sa} shall be zero if the operating voltage does not decrease.

Equipment including the surge suppressor shall comply with the resistibility requirements of the enhanced level in [ITU-T K.21].

7.4 Coordination between SPDs

In a customer building, SPDs are installed on the entry portions of cables to the building, and wiring between entry point and equipment may have an MSPD. The major part of the energy of incoming overvoltages, including lightning surges, is reduced at the SPD installed at the cable entry. However, if coordination among these SPDs, MSPD and surge suppressor in telecommunication equipment is not well set up, the SPD at the cable entry does not operate and the equipment may be damaged.

The SPD conforming to [IEC 61643-11] is recommended at the cable entry to a building. An MSPD is used to compensate deficiency of the resistibility of the equipment. If the operation voltages of the SPDs at the entry portions of cables to the building and/or MSPD at wiring are too high, coordination of SPDs cannot be obtained. Therefore, the operation conditions of SPDs in the building shall be determined in light of the coordination condition.

Details of coordination of SPDs are described in [ITU-T K.98]. However, it is difficult to determine the coordination condition for the equipment since the specification of the SPD at the cable entry cannot be determined and controlled correctly.

Larger stress of overvoltage may be applied to telecommunication equipment when PE is not bonded well, especially in TT and IT systems, since the potential rise of earthing of SPDs is large. Therefore, it is recommended that the equipment have "enhanced level" resistibility as specified in [ITU-T K.21].

Annex A

Transmission of TOV

(This annex forms an integral part of this Recommendation.)

When a fault event occurs at the HV to LV distribution transformer, the TOV appears at LV line. The event conditions are illustrated in Figure 44.A1 of [IEC 60364-4-44]) and listed in Table 44.A1 of [IEC 60364-4-44]. Simulating TOV conditions is typically done by increasing the LV supply by 1 200 V for up to 5 s and by 250 V for longer periods.

Figure A.1 shows the transmission route of the TOV in a TN system. The TOV passes through the PE line to the user building and extends to the PE of equipment. Then the TOV proceeds to the telecommunication line through the SPD between PE and the telecommunication line in the equipment. The TOV is not significantly reduced, because the earthing resistance R_A of the PE at the user building is not sufficiently low compared to R_E and R_B at the power distribution transformer.

The surge suppressor between the PE and the telecommunication line does not stop the TOV since the operation voltage is lower than the TOV. The lower limit of the operation voltage is $U_{op} = U_{peak} + \Delta U_{sp} + \Delta U_{sa}$ according to clause 5.4.11 of [IEC 62468-1], where U_{peak} should be higher than 180 V for a nominal voltage of mains lower than 130 V, and 360 V for a nominal voltage higher than 130 V.

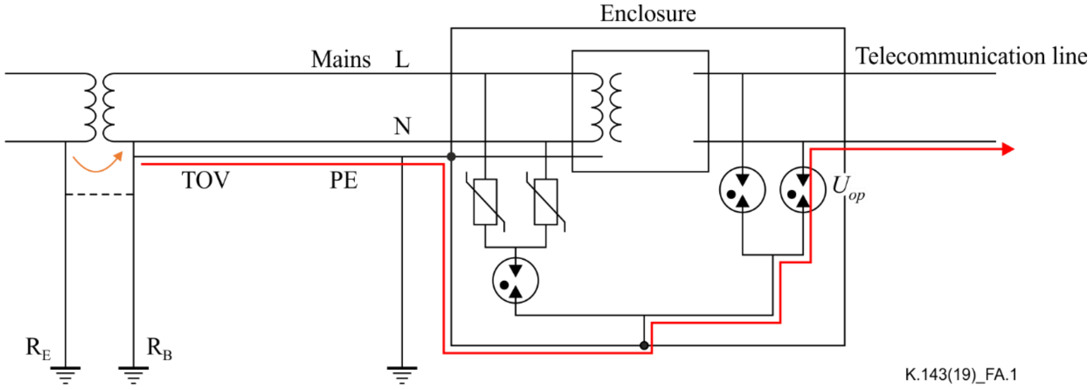

Figure A.1 – Transmission route of TOV in TN system

Figures A.2 and A.3 show transmission of a TOV in a TT system and an IT system, respectively.

A TOV goes from the N and L line of the mains to the telecommunication line through the surge suppressor. The TOV can be stopped by the surge suppressor if the operation voltage of the surge suppressor is designed according to clause 7.3.

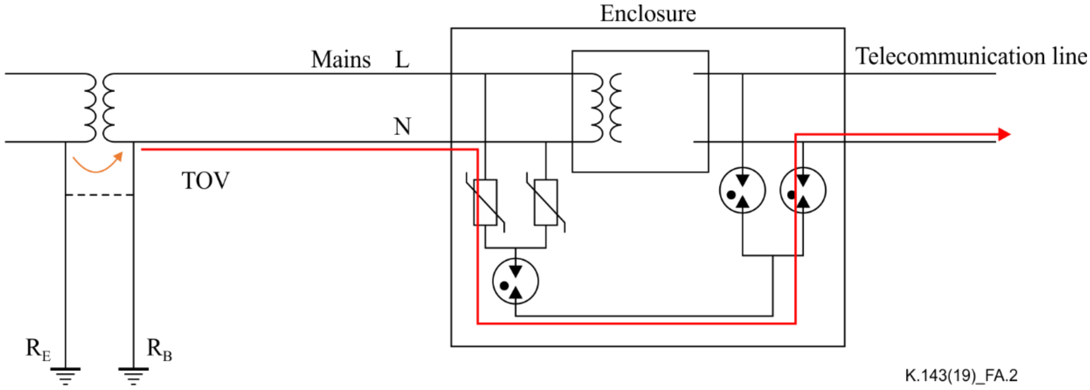

Figure A.2 – Transmission route of a TOV in a TT system

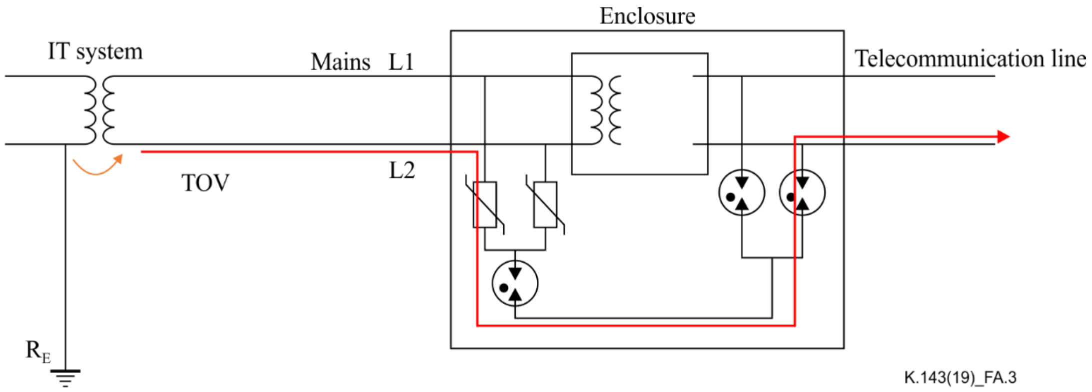

Figure A.3 – Transmission route of a TOV in an IT system

Bibliography

[b-ITU-T K.44] Recommendation ITU-T K.44 (2019), *Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation*.

[b-ITU-T K Sup.7] ITU-T K-series Recommendations – Supplement 7 (2017), *ITU-T K.44 – AC supply configurations*.

[b-IEC 60364 series] IEC 60364 series, *Low-voltage electrical installations*.

[b-IEC 60728-11] IEC 60728-11, ed. 3.0:2010, *Cable networks for television signals, sound signals and interactive services – Part 11: Safety*.

[b-IEC 61643-12] IEC 61643-12:2020, *Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles*.

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