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SERIES K: PROTECTION AGAINST INTERFERENCE

**Protection of small-size telecommunication
installations with poor earthing conditions**

Recommendation ITU-T K.134

ITU-T



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Protection of small-size telecommunication installations with poor earthing conditions

Summary

Recommendation ITU-T K.134 provides engineering solutions for lightning protection and safety of small-size telecommunication installations under poor earthing conditions. These protection measures compromise alternatives due to restrictions of circumstance or expense. These protection measures are not common requirements for most circumstances and have defined conditions for certain applications. The selection of appropriate and feasible solutions is helpful to acquire the best technology to cost ratio.

Accompanying the miniaturization development trends of network termination units, more and more telecommunication installations, e.g., wire or wireless access units, are being installed in customer premises or other uncontrolled places. Compared with dedicated telecommunication buildings, these installation environments may be more complex and severe. Recommendations ITU-T K.66 and ITU-T K.120 provide bonding and earthing requirements for customer premises and miniature base stations, respectively. However, in some scenarios, it may be very difficult or expensive to satisfy these requirements. If ignored, there is a risk of equipment damage or human safety due to lightning strikes or electric shock.

History

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Keywords

Earthing, lightning protection, safety, small-size telecommunication installation.

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Recommendation ITU-T K.134

Protection of small-size telecommunication installations with poor earthing conditions

1 Scope

This Recommendation:

- provides engineering solutions for lightning protection and safety for small-size telecommunication installations under poor earthing conditions. These protection measures are not common requirements for most circumstances and have defined conditions for certain applications. If these installations have equivalent inherent capacity and function, the same results can be acquired;
- is not intended to replace traditional rules on bonding configurations and earthing. These protection measures compromise alternatives under poor earthing conditions due to restrictions of circumstance or expense;
- is intended to apply to installations powered by a.c. mains and comply with [IEC 60364 series] or national standards bodies on a.c. power installations;
- is intended to apply to installations powered by remote power output up to 400 VDC IT system and comply with [ETSI EN 302 099] and [ETSI EN 301 605].

The applied objects in this Recommendation are small-size telecommunication installations which are owned by network operators and controlled by skilled or trained personnel.

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 (2018), <i>Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents.</i> |
| [ITU-T K.66] | Recommendation ITU-T K.66 (2011), <i>Protection of customer premises from overvoltages.</i> |
| [ITU-T K.75] | Recommendation ITU-T K.75 (2016), <i>Classification of interface for application of standards on resistibility and safety of telecommunication equipment.</i> |
| [ITU-T K.85] | Recommendation ITU-T K.85 (2011), <i>Requirements for the mitigation of lightning effects on home networks installed in customer premises.</i> |
| [ITU-T K.95] | Recommendation ITU-T K.95 (2016), <i>Surge parameters of isolating transformers used in telecommunication devices and equipment.</i> |
| [ITU-T K.98] | Recommendation ITU-T K.98 (2014), <i>Overvoltage protection guide for telecommunication equipment installed in customer premises.</i> |
| [ITU-T K.120] | Recommendation ITU-T K.120 (2016), <i>Lightning protection and earthing of a miniature base station.</i> |

[IEC 60364 series]	IEC 60364-series, <i>Low-voltage electrical installations</i> .
[IEC 60364-4-41]	IEC 60364-4-41 (2005), <i>Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock</i> .
[IEC 61558-1]	IEC 61558-1:2017, <i>Safety of transformers, reactors, power supply units and combinations thereof – Part 1: General requirements and tests</i> .
[IEC 62305-2]	IEC 62305-2 (2010), <i>Protection against lightning – Part 2: Risk management</i> .
[IEC 62368-1]	IEC 62368-1:2018, <i>Audio/video, information and communication technology equipment – Part 1: Safety requirements</i> .
[ETSI EN 301 605]	ETSI EN 301 605 V1.1.1 (2013), <i>Environmental Engineering (EE); Earthing and bonding of 400 VDC data and telecom (ICT) equipment</i> .
[ETSI EN 302 099]	ETSI EN 302 099 V2.1.1 (2014), <i>Environmental Engineering (EE); Powering of equipment in access network</i> .

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 breakdown [b-IEC 61340-1]: Failure, at least temporarily, of the insulating properties of an insulating medium under electric stress.

3.1.2 distant power receiver [ETSI EN 302 099]: Power equipment electrically connected to a Remote Power Unit.

NOTE – Its function is to supply telecommunications equipment situated at the same location. It may be combined with the item of telecommunications equipment itself.

3.1.3 equipment class I [ITU-T K.66]: Equipment where protection against electric shock is achieved by:

- 1) using basic insulation; and also
- 2) providing a means of connecting to the protective earthing conductor in the building wiring those conductive parts that are otherwise capable of assuming hazardous voltages if the basic insulation fails.

3.1.4 equipment class II [ITU-T K.66]: Equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation are provided, there being no reliance on either protective earthing or installation conditions.

3.1.5 equipotential bonding [b-ITU-T Handbook]: An electrical connection putting various exposed conductive parts and extraneous conductive parts at a substantially equal potential.

Distinction is made between:

- the main equipotential bonding;
- supplementary equipotential bonding;
- earth-free equipotential bonding.

Equipotential bonding does not necessarily have to connect to earth.

3.1.6 impulse withstand voltage [b-IEC 60664-2-1]: Highest peak value of impulse voltage of prescribed form and polarity which does not cause breakdown of insulation under specified conditions.

3.1.7 inherent protection [b-ITU-T K.44]: Inherent protection is protection that is provided within the equipment either by virtue of its intrinsic characteristics, by specific design, or by suitable protection components.

3.1.8 insulation (electrical) [b-IEC 62477-1]: Electrical separation between circuits or conductive parts provided by clearance or creepage distance or solid insulation or combinations of them.

3.1.9 isolation transformer [b-IEC 60065]: Transformer with protective separation between the input and output windings

3.1.10 miniature base station [ITU-T K.120]: A type of radio base station (RBS) whose size and RF power are much smaller than typical macro-base station or DBS base stations.

3.1.11 multiservice surge protective device (MSPD) [ITU-T K.85]: A surge protective device (SPD) containing both telecommunications and mains protection. It may also include port protection for video or Ethernet.

3.1.12 remote powering (RP) [ETSI EN 302 099]: Power feeding of a telecommunications equipment by a remote power circuit.

NOTE – Such a circuit consists of a remote power unit, distribution wiring, and fed receivers.

3.1.13 remote power unit (RPU) [ETSI EN 302 099]: Power unit, connected to the mains or from a centralized power plant, which supplies distant telecommunications equipment.

3.1.14 surge isolating transformer (SIT) [b-IEC 61643-351]: Isolation transformer which has high impulse withstand voltage with/without electrostatic screen between input and output windings.

3.1.15 system [b-ITU-T Handbook]: An electrical system consisting of a single source of electrical energy and an installation. Types of system are identified as follows, depending upon the relationship of the source, and of exposed-conductive-parts of the installation, to Earth. Further details of these systems can be found in the document IEC 60364-4:

- **TN system:** a system having one or more points of the source of energy directly earthed, the exposed-conductive-parts of the installation being connected to that point by protective conductors.
- **TN-C system:** in which neutral and protective functions are combined in a single conductor throughout the system,
- **TN-S system:** having separate neutral and protective conductors throughout the system,
- **TN-C-S system:** in which neutral and protective functions are combined in a single conductor in part of the system.
- **TT system:** a system having one point of the source of energy directly earthed, and exposed-conductive-parts of the installation being connected to earth electrodes electrically independent of the earth electrodes of the source.
- **IT system:** a system having no direct connection between live parts and Earth, the exposed-conductive-parts of the electrical installation being earthed.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 enclosure live voltage detection: Function intended to detect whether or not a conductive enclosure is live.

3.2.2 poor earthing conditions: The actual situations which hinder the construction of valid earthing and bonding configurations compliant with the requirements of the relevant ITU-T K-series Recommendations, e.g., [ITU-T K.66] and [ITU-T K.120], due to the restriction of circumstance or expense.

3.2.3 small-size telecommunication installation (SSI): A telecommunication installation which meets the following conditions:

- the volume is small. The installation may contain a single equipment or a case, or a site with several interconnected equipment in close proximity;
- power consumption is low and usually less than 1 kW.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

LPS	Lightning Protection System
PE	Protective Earth
PEN	Protective Earth Neutral
RP	Remote Powering
RPU	Remote Power Unit
SIT	Surge Isolating Transformer
SPC	Surge Protective Component
SPD	Surge Protective Device
SSI	Small-Size telecommunication Installation
VDR	Voltage Dependent Resistor

5 Conventions

None.

6 General consideration

The concept and purpose of earthing is introduced in [b-ITU-T Handbook]. [ITU-T K.66] and [ITU-T K.120] also provide requirements on valid bonding and earthing for customer premises and miniature base stations, respectively. In some scenarios, it may be very difficult or expensive to satisfy these requirements. There may be a conflict between installation requirements of a small-size telecommunication installation (SSI) and their practical circumstances. If ignored, there is a risk of equipment damage or human safety due to lightning surges or electric shock.

Poor earthing conditions, often met in practice, are as follows:

- no earthing connection;
- long earthing conductor;
- high earth resistance.

In general, for the condition of no earthing connection, there may be electrical safety hazards and lightning protection issues. For the other two conditions, the possible issues are protection from lightning surges.

NOTE 1 – There are also electrical safety hazards when the resistance of the earthing conductor or earth resistance is extremely high, which is not considered in this Recommendation. For more information, refer to [IEC 60364 series].

These possible hazards are also related to other factors such as the type of equipment concerned with protection against electrical shock, the type of power feeding system, lightning risk level, etc. Considering the complexity of these scenarios, it is convenient and feasible to adopt additional engineering solutions for these SSIs according to local circumstances. The selection of appropriate

and feasible solutions depends on local conditions and is helpful when implementing the best technology to cost ratio.

Appropriate earthing conditions must be satisfied in the following scenarios:

- valid earthing conditions are required for functional (e.g., signalling or testing) purposes or electromagnetic compatibility (EMC) requirements;
- the SSI is located in a highly-exposed environment where there is a significant risk of a direct lightning strike to it or to the line immediately adjacent to it.

NOTE 2 – If there is an inconsistency between a requirement in this Recommendation and a requirement of the domestic laws and regulations relating to electrical safety, the requirement of the domestic laws and regulations shall apply.

7 Protection under no earthing connection

The risk derived from the absence of earthing connection is electric shock and lightning; these may lead to human injury and/or equipment damage. The selection of additional protection measures should consider the possible influence on lightning protection and safety according to practical conditions.

7.1 Protection for electric safety

7.1.1 Analysis of risk scenarios

The possible hazard concerning electric safety under no earthing connection is related to the type of equipment and power feeding system, as follows.

- Type of equipment concerning the precaution against electric shock.

The common types of SSIs are class I and class II. For class II equipment with non-metallic enclosures, the hazard of electric shock has nothing to do with poor earthing conditions. But for class I equipment and class II equipment with metallic enclosures, the influence of no earthing connection on safety should be considered.

- Type of power feeding system.

For a.c. TN systems, the protective earth (PE) or protective earth neutral (PEN) conductor is always laid along with live conductors, the earthing connection is easy to achieve in TN systems as long as it has been confirmed valid on site. However, if equipment is outside the main equipotential bonding network, e.g., some outdoor equipment powered by an adjacent building, the possible hazards of electric shock also exist in special conditions. Related information and requirements are introduced in Appendix I.

For a.c. TT and IT system, the earthing connection should be implemented through hard-wired conductors to local earth. If there are no earthing connections, the risk of electric shock shall be considered. Related information and requirement are introduced in Appendix II.

For up to 400 VDC systems, d.c. IT systems are generally used. Earthing connections should be implemented through hard-wired conductors to local earth. If there are no earthing connections, the risk of electric shock shall be considered. Related information and requirements are introduced in Appendix III.

7.1.2 Protection measures

When a reliable earthing connection is difficult to achieve, the following measures can be selected according to local conditions.

7.1.2.1 Adopting class II equipment

If requirements for mechanical strength or other relative abilities can be degraded, then class II equipment can be adopted.

The following design guidelines are suggested to avoid the hazard of electric shock:

- reinforced or double insulation shall be used between live parts and the enclosure, the detailed design requirements shall comply with class II equipment of [IEC 62368-1]; and
- equipment with metallic enclosures may be ‘live’ under some fault conditions. It is recommended to use enclosure live voltage detection to warn service personnel that there may be dangerous voltage on the enclosure; this is described in Annex A; and
- to protect an installation against a lightning surge, a surge protective device (SPD) or surge protective component (SPC) between live parts and the metallic enclosure is permitted. The SPD or SPC shall comply with the electric strength and the external clearance and creepage distance requirements with reinforced insulation, and the relevant IEC standard (e.g., IEC 61643 series). A voltage dependent resistor (VDR) alone, cannot be used to bridge reinforced or double insulation;
- it is also recommended to add an insulating surface on the metallic enclosure or other accessible conductive parts to avoid contact with the public.

7.1.2.2 Adding insulation

An SSI can be placed into an insulation case whose degree of protection level is not less than IPxxB or IP2X. This case should be locked or managed to ensure that the inner conducted parts cannot be handled by the public. The insulation case acts as double insulation and the entire case could be regarded as "class II equipment". All conducted parts in the case should be interconnected through local equipotential bonding. For detailed requirements refer to clause 412.2.2 in [IEC 60364-4-41].

To remind service personnel of the potential for electric shock in this case, the following warning sign and language shall be required to be placed on the equipment case.



IEC 60417-6042

"WARNING" or equivalent word or text, and

"HIGH TOUCH CURRENT" or equivalent text

"DISCONNECT SUPPLY ESSENTIAL BEFORE MAINTENANCE EQUIPMENT" or equivalent text.

The large area metallic parts of the service access area in the insulation case may be lived under some fault conditions, and enclosure live voltage detection may be used to warn service personnel that there may be dangerous voltage on the enclosure.

7.1.2.3 Using an isolation transformer for electrical separation

7.1.2.3.1 Rational

Using an isolation transformer for electrical separation is a valid protection measure against indirect contact electric shock. Figure 1 shows a typical layout. When a contact fault of single phase to conducted parts occurs, because the secondary side of the transformer is floating and the fault current (I_d) would flow back to the transformer (T) through the contact resistance (R_E) and the very small capacitance to earth (C), the fault current and the fault voltage (U_t) on the conducted part is very low and electric shock can be avoided to the most extent.

The length of the wiring system served by an isolation transformer shall not exceed 50 m. Flexible cables and cords shall be visible throughout any part of their length susceptible to mechanical damage.

Any equipment with a metallic enclosure may be "live" under some fault conditions; it is recommended to use enclosure live voltage detection to warn service personnel that there is a possibility of dangerous voltage on the enclosure, and/or to install a residual current device, which opens the circuit at 10 mA, on the secondary side of the isolation transformer.

To remind service personnel of the potential risk of electric shock in some cases, a warning sign and language as described in clause 7.1.2.2 shall be required.

When there is a fault between two phases, the circuit would be disconnected by the disconnection device due to high fault current.

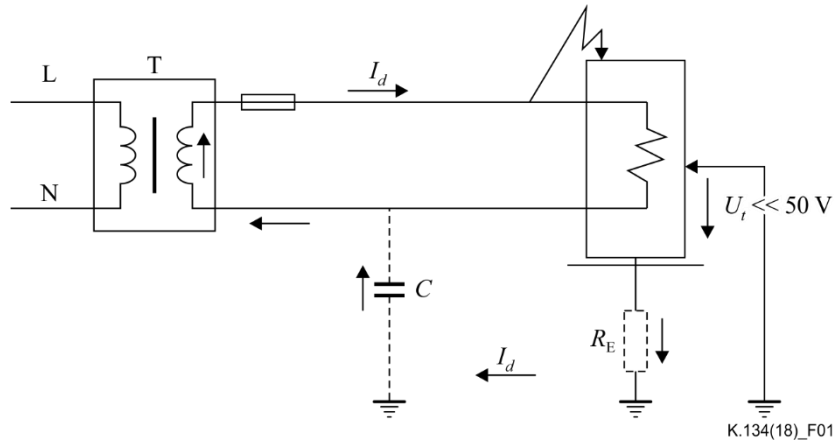


Figure 1 – A typical layout using an isolation transformer for electrical separation

NOTE – 1) The installation location of equipment shall be selected to avoid the risk of possible contact with other live conductors;

2) The isolation transformer should conform with the requirements for Class II transformer which are regulated in [IEC 61558-1].

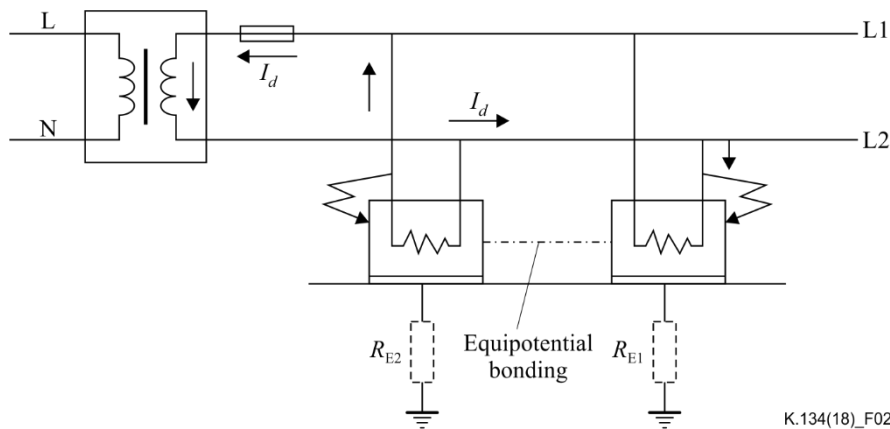
7.1.2.3.2 Protection methods for small systems

An isolation transformer can also serve a small system including several equipment and not be connected to local earth. When the L_1 (or L_2) conductor of one piece of equipment makes contact with the enclosure while the L_2 (or L_1) conductor of another piece of equipment contacts the enclosure, the power supply of both pieces of equipment is not interrupted. An electric shock may happen if service personnel accidentally come in contact with both equipment enclosures simultaneously. Therefore, the risk of electric shock shall be considered.

The available solutions for this hazard is as follows:

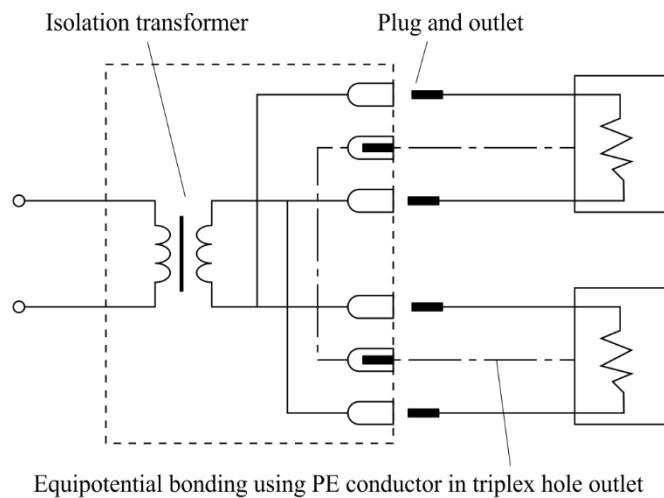
If equipment is interconnected through local equipotential bonding without earthing, protection against electric shock can be achieved. Equipotential bonding without earthing can be implemented through hard-wired conductors or via the PE conductor of the triplex hole outlet at the secondary side of the transformer. Typical layouts are shown in Figures 2 and 3.

Additionally, it is recommended to use enclosure live voltage detection to warn service personnel that there is dangerous voltage on the enclosure.



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Figure 2 – A typical layout for serving equipment through hard-wired conductors as equipotential bonding



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Figure 3 – A typical layout for serving equipment through the PE conductor of the triplex hole outlet as equipotential bonding

7.2 Lightning protection

7.2.1 Protection against lightning

The need for lightning protection is determined by performing a risk assessment according to [IEC 62305-2], which compares the risk value R , as the sum of all risk components, with the tolerable risk value R_T . In this Recommendation, the risk of loss of human life (R_1) and the risk of loss of service (R_2) are considered.

The related information about the installation environment should first be investigated to perform a risk assessment. The main factors to be considered are as follows:

- the geographical environment where the SSI is installed, e.g., urban environment, suburban environment or rural environment, as defined in [IEC 62305-2];
- the lightning ground flash density, or roughly the keraunic level;
- the lightning protection zone (LPZ) where the SSI is installed;
- the type of telecommunication network, e.g., buried or aerial cable, screened or unshielded cable, cable shield installed or not installed;
- the type of power network, e.g., buried or aerial cable, screened or unshielded cable, cable shield installed or not installed, neutral bonded or not bonded to PE;

- the type of structure construction e.g., timber, brick or reinforced concrete;
- whether or not protection measures have been used at the structure or by the services;
- equipment resistibility level.

The risk of loss of human life (R_1) for telecommunication equipment users or maintenance personnel is normally only required to be considered when there is a significant risk of a direct lightning strike to the SSI or a direct strike to one of the services near the SSI. When the risk R_1 is less than the tolerable risk R_{T1} , the SSI is considered inherently protected against direct lightning. When $R_1 > R_{T1}$, valid earthing via a connection to a lightning protection system (LPS) and the corresponding SPDs are normally the best measures to be adopted.

To minimize the risk of damage to equipment, the risk of loss of service (R_2) should be evaluated and compared to the tolerable risk of loss of service value $R_{T2} = 10^{-3}$ or a lower value according to the decision of the network operator. Even when $R_1 < R_{T1}$, R_2 should be evaluated in accordance with [IEC 62305-2]. [ITU-T K.85] also provides assessment methods and examples of R_2 for equipment installed in customer premises.

When the risk R_2 is less than the tolerable risk R_{T2} , the protection for electric safety is only considered, the corresponding measures are introduced in clause 7.1.

When $R_2 > R_{T2}$, protection is recommended and the knowledge of the risk component values guides the protection designer in selecting the most adequate protective measures to protect the equipment. The selection of protection measures depends on the convenience of valid earthing and a comparison of expenses. For protection measures under valid earthing refer to [ITU-T K.66], [ITU-T K.120] and other relative recommendations. The protection measures under no earthing connection are introduced in clause 7.2.2.

At times, to avoid an excessive workload resulting from risk assessment where there are large numbers of sites in a project, a simplified approach for the evaluation of the lightning risk level according to installation scenarios is also adopted. For relative information refer to [ITU-T K.120].

7.2.2 Protection measures under no earthing connection

A lightning surge along the connected metal lines needs to be withstood via an insulation barrier, or by bypassing via SPDs or SPCs, to attain reliable protection for SSIs. The absence of an earthing connection means there is no safe path to bleed the lightning surge; this may cause damage to equipment or injury to personnel when the insulation barrier breaks down due to the lightning overvoltage.

Using isolation protection to block the surge and prevent the breakdown between ports of the SSI or its surroundings is an appropriate solution under no earthing connection. However, when considering the restrictions of volume and expense, the isolation level of the isolation protection is not enough to bear the overvoltage derived from a direct lightning hit. The lightning risk introduced in clause 7.2.1 and the configuration of ports of an SSI should be considered.

The SSI can be viewed as a "black box" with a variety of ports. For information on the classification of external and internal ports, refer to [ITU-T K.75]. A mains port is always an external port. The most important item for lightning protection of SSIs is the protection between these ports. The implementation of isolation protection for an SSI depends on the configuration of ports.

For an SSI with a single port (a.c. mains), if the type of equipment is class II or a high level of isolation to surroundings is ensured, only the transverse overvoltage for the external port needs to be considered; if not, isolation measures may be required to prevent possible flashover to its surroundings. A common measure is adding a power surge isolating transformer (SIT) or insulation. Figure 4 provides an illustration for the protection of an SSI with a single port.

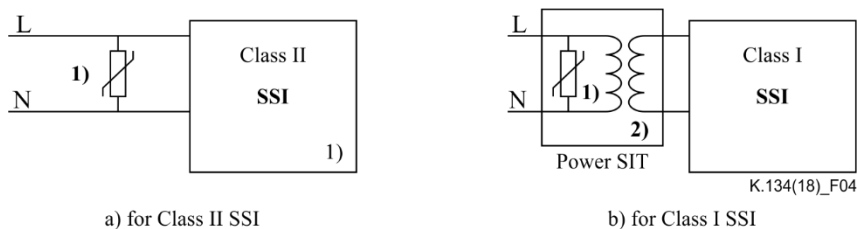


Figure 4 – Illustration for protection of an SSI with a single port (a.c. mains)

NOTE – 1) When the differential surge is expected to exceed the inherent resistibility of equipment or the SIT, the differential protection is needed;

2) The power SIT needs to conform the corresponding requirements in clause 7.1.2.3 simultaneously.

For a multi-port SSI, the isolation level between ports and the surroundings should be ensured and the transverse overvoltage for the external ports needs to be attenuated. If the inherent level is not sufficient or the external cables have a hazard of power contact or induction, isolation measures should be adopted. A common measure is adding power SIT, signal SIT or using optical-electric transfer isolation. Figure 5 provides an illustration for the protection of a multi-port SSI.

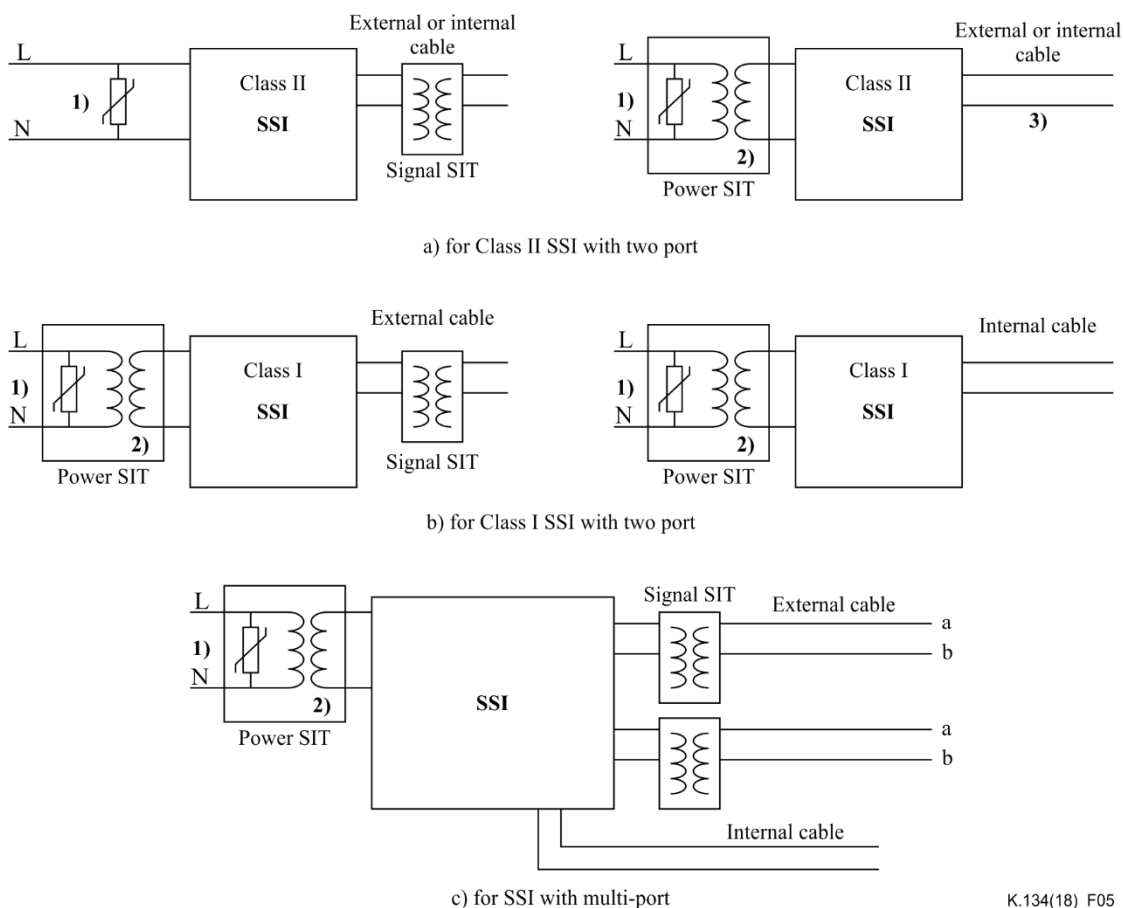


Figure 5 – Illustration for protection of a multi-port SSI

NOTE – 1) When the differential surge is expected to exceed the inherent resistibility of equipment or the SIT, the differential protection is needed;

2) The power SIT needs to conform the corresponding requirements in clause 7.1.2.3 simultaneously;

3) If the external cable has the risk of power contact or induction, the signal SIT is needed.

The relative requirements about the surge parameters of signal SIT could refer to [ITU-T K.95].

In any case, equipotential bonding within the SSI should be ensured. A metal-free optical-fibre cable is recommended, if possible. If an optical-fibre cable with a metallic component or metallic sheath is used, the metallic component or sheath should be isolated with other metal parts.

The rated impulse withstand voltage for these isolation measures is required to be not less than 10 kV (1.2/50 us). In field applications, some protection measures, e.g., the power SIT and insulation case, are easy to implement in order to provide a higher isolation level (e.g., 30 kV or even higher), which can meet the requirement of higher reliability or applying in some severe circumstances.

NOTE – A power isolation transformer should also have enough insulation level or valid measures to ensure electric safety under fault conditions when a breakdown happens.

8 Protection under long earthing conductor

8.1 Consideration of hazards

[ITU-T K.66] provides requirements for the maximum length of an earthing conductor, which are shown in Table 2.

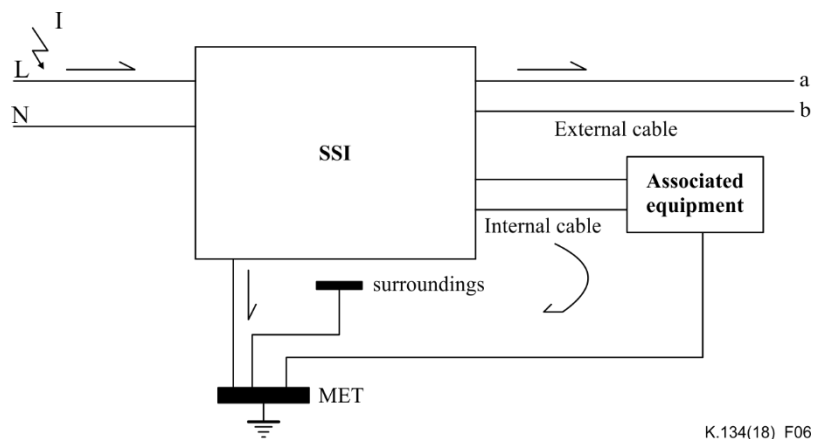
Table 2 – Requirements for the maximum length of an earthing conductor

NOTE – Table 2 taken from [ITU-T K.66].

Mechanism	Maximum length/resistance
Direct strikes	1.5 m
Induced surges	10 m
Power induction/power contact	1 Ω (< 50 V a.c. @ 2 times 24 A a.c.)

When the earthing conductor of an SSI is long, the possible hazards, which are illustrated through an example in Figure 6, would be:

- the overvoltage drop on the long earthing conductor is so high that there is a big potential difference between the SSI and its surroundings, which maybe lead to a flashover;
- the bleeding of lightning current would be influenced and the conducted surge along external wires may shift to other vulnerable ports and associated interconnected equipment. Some simulation results under defined conditions for this scenario are provided in [ITU-T K.98] and also demonstrate this influence.



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Figure 6 – Illustration of the hazards under a long earthing conductor

8.2 Protection measures

For scenarios with long earthing conductors, implementing protection measures need to consider the lightning risk level, configuration of ports and local circumstances. Common protection measures are shown as follows.

1) Optimization through local equipotential bonding

Figure 7 shows an example of optimization through local equipotential bonding. The sub-bar is installed close to the SSI and is interconnected with the associated equipment and metal surroundings, which reduces the potential difference and eliminates the risk. However, local equipotential bonding cannot reduce pressure on the external port.

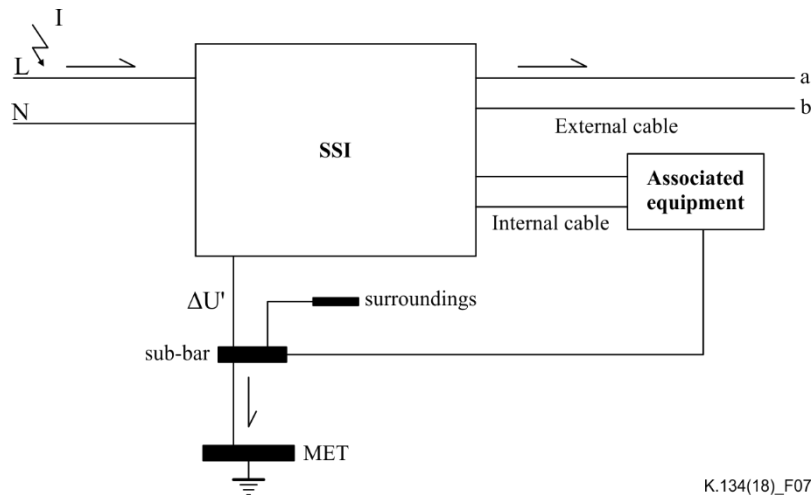


Figure 7 – Illustration of local equipotential bonding

2) Adding SPDs on vulnerable ports

Adding SPDs on vulnerable ports of the SSI and the interconnected equipment can improve endurance capacity of the ports. The coordination between SPDs and inherent protection should be ensured. For more information, refer to [ITU-T K.66] and [ITU-T K.85].

This method cannot reduce the potential difference between the SSI and its surroundings.

3) Adding SITs to block the conducted surge

The use of external SITs can reduce the magnitude of a conducted surge current to a very small level (capacity current), which prevents the hazards caused by long earthing conductors. For more information about this application, refer to clause 7.2.2 of this Recommendation and [ITU-T K.126]. Figure 8 shows an illustration of using SITs.

SITs cannot bear the overvoltage derived from a direct lightning strike. Thus, this method shall not be used in highly exposed environments where there is a significant risk of a direct lightning strike to it or to the line immediately adjacent to it.

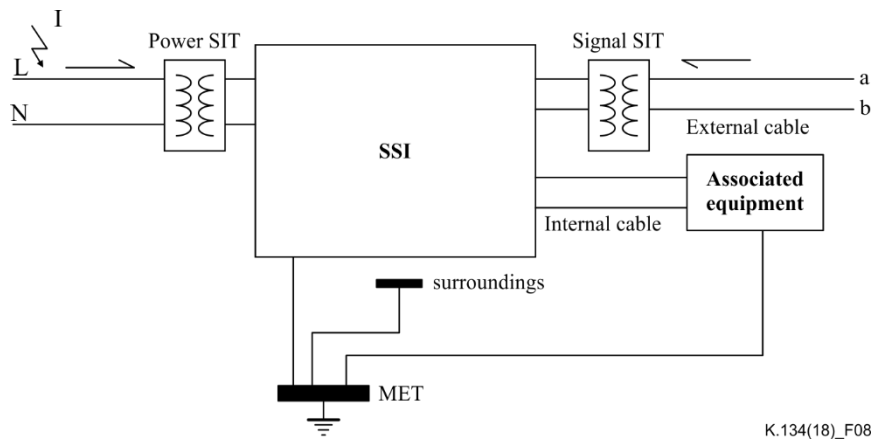


Figure 8 – Illustration of using SITs

4) Using enclosure live voltage detection to alarm for possible danger

Any equipment with metallic enclosure may be ‘live’ under some fault conditions. Enclosure live voltage detection should be used to warn service personnel that there is dangerous voltage on the enclosure.

9 Protection under high earth resistance

For lightning protection, the function of the earth network is to provide a valid bleeding path for lightning current and decrease the risk to personnel due to touch and step voltages. The architecture of the earth network seems more important than the specific values of earth resistance. It is also difficult to establish definite requirements about earth resistance, but lower earth resistance is preferred. High earth resistance leads to more pressure for primary protection for external cables from a direct lightning strike. However, it is unreasonable to attempt to achieve lower earth resistance without regard for the expense to implement protection.

For an SSI located in a low exposure environment, the influence of earth resistance is very small and equipotential bonding is more important.

For an SSI located in highly exposed environment, the implementation of earth network shall first meet the requirements regulated in [ITU-T K.66] and [ITU-T K.120]. If earth resistance is high, the capacity of primary protection for external cables should be confirmed to be sufficient. Detailed information can be found in Annex E of [b-IEC 62305-1]. In most cases, it is not recommended to intentionally decrease earth resistance for low-cost SSIs.

Annex A

Enclosure live voltage detection

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

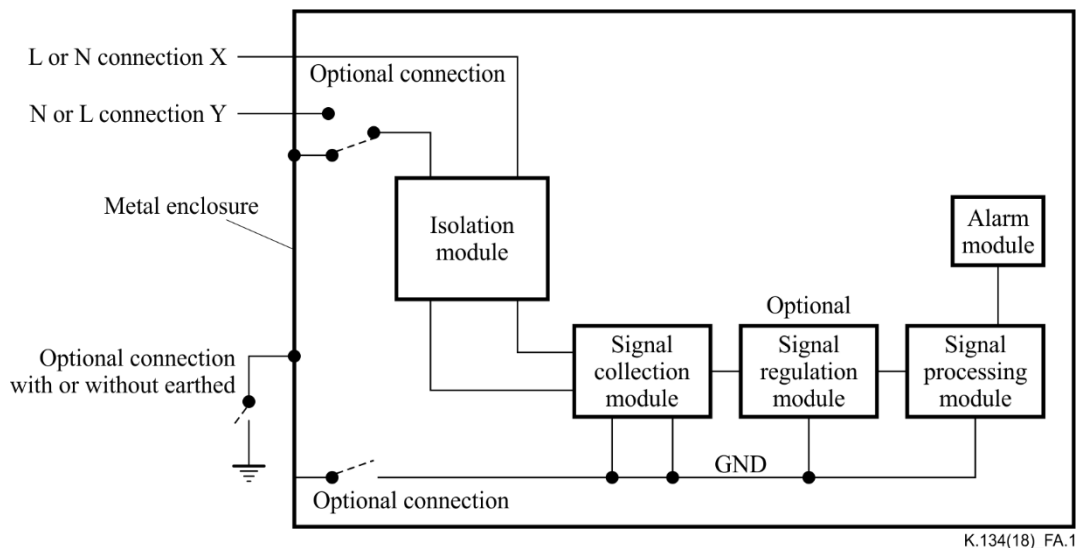
Enclosure live voltage detection is used to detect dangerous voltage caused by insulation impedance degradation or breakdown between any input live conductor or circuit and the metallic enclosure of the equipment.

Enclosure live voltage detection consists of an isolation module, a voltage signal collection (or division) module, a signal regulation module (optional), a signal processing (or comparison) module, and an alarm (local or remote) module, as shown in Figure A.1.

The isolation module shall comply with the electric strength and the clearance and creepage distance requirements of double or reinforced insulation detailed in [IEC 62368-1].

Enclosure live voltage detection shall provide a local or remote alarm on the equipment to remind service personnel that there is dangerous voltage on the equipment.

Enclosure live voltage detection shall not rely on the earthing of equipment within metallic enclosures.



K.134(18)_FA.1

Figure A.1 – Enclosure live detection function diagram

Example:

The enclosure live voltage detection circuit contains a detection circuit and a detection method.

The enclosure live voltage detection circuit consists of an isolation module, a voltage signal collection module, a signal regulation module, a signal processing module, and a remote alarm module.

The isolation module is used to isolate hazardous live parts, it uses two high-impedance isolation modules with symmetrical impedance.

The signal collection module is used to sample the voltage U_x that is the ratio voltage between a live conductor and the metallic enclosure, it uses R_1 and R_2 of equal resistance value to divide voltage, U_x is a differential voltage between the voltage at both ends of the R_1 and the voltage at both ends of the R_2 multiplied by a certain proportion.

The signal regulation module is used to regulate the voltage to match the signal processing, it adjusts the signal to a level within an acceptable range of the signal processing module to protect the signal processing module from overvoltage or negative voltage damage.

The signal processing module is used to calculate the value of $\frac{U_x}{U_{in}}$, and judge if the device is faulty according to the detection method. U_{in} is the ratio input voltage that the input voltage of the equipment is multiplied by a certain proportion, and is necessary in the detection method. The signal of U_{in} should be connected to the signal processing module.

The principle detection method is to compare $\frac{U_x}{U_{in}}$ with a setting value or range, when the result meets the setting conditions it indicates that the device is faulty.

The faults include at least one of the cases as below:

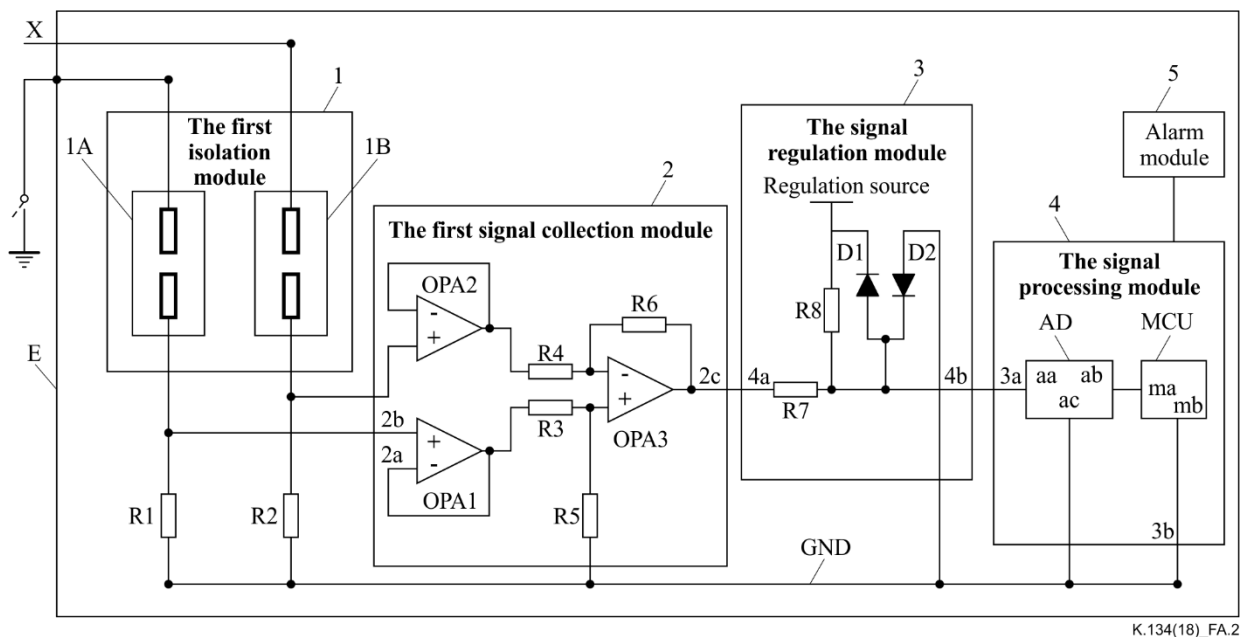
- 1) the metallic enclosure of equipment is lived;
- 2) the phase conductor and neutral conductor are reversed.

A detailed circuit diagram is shown in Figure A.2.

Note:

X is connected to a target live conductor,

E is a metallic enclosure of equipment with or without earthing.



K.134(18)_FA.2

Figure A.2 – Circuit diagram for enclosure live voltage detection

Appendix I

Possible hazards of electric shock for SSIs in a.c. TN system

(This appendix does not form an integral part of this Recommendation.)

When an SSI is outside the main equipotential bonding network, e.g., some outdoor equipment powered by an adjacent building, the conducted fault voltage along PE or PEN conductors may lead to accidental electric shock. The fault voltage can be produced due to various reasons. In the example demonstrated in Figure I.1, the L conductor is in contact with the earth and the power supply is uninterrupted. For example, if the L conductor falls into a pond. Due to the restriction of the earth resistance of fault point (R_E) and the power transformer (R_B), the fault current (I_d) is small. If the value of R_B and I_d are assumed to be $4\ \Omega$ and $20\ \text{A}$, the persistent fault voltage (U_f) along PE or PEN conductors is $80\ \text{V}$. For the equipment within the main equipotential bonding network in the building, there is no hazard of electric shock. But for equipment outside the main equipotential bonding network, the persistent fault voltage can lead to an accident. Although there is an RCD on the circuit for the building, it cannot cut off this fault because there is no trigger current. When the earth resistance of the power transformer (R_B) is very small or there are many customers which have repetitive earthing in parallel with R_B , these hazards would be decreased.

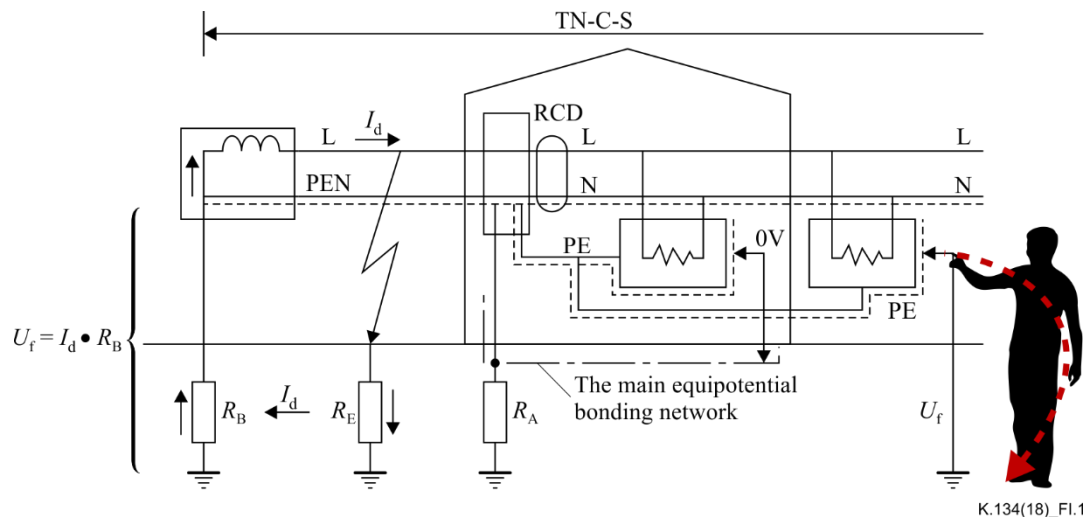


Figure I.1 – Example of possible hazards of electric shock in a.c. TN system

The available solutions for these hazards include:

- a local earthing TT system for the outdoor equipment, which is shown in Figure I.2; or
- class II equipment as described in clause 7.1.2.1, which is shown in Figure I.3; or
- an insulation case as described in clause 7.1.2.2; or
- an isolation transformer as described in clause 7.1.2.3 as electrical separation, which is shown in Figure I.4.

NOTE – For the first solution, a local earthing connection is needed. The relative requirements can refer to the TT system in [IEC 60364 series]. But in some scenarios, it may be very difficult or expensive to satisfy these requirements.

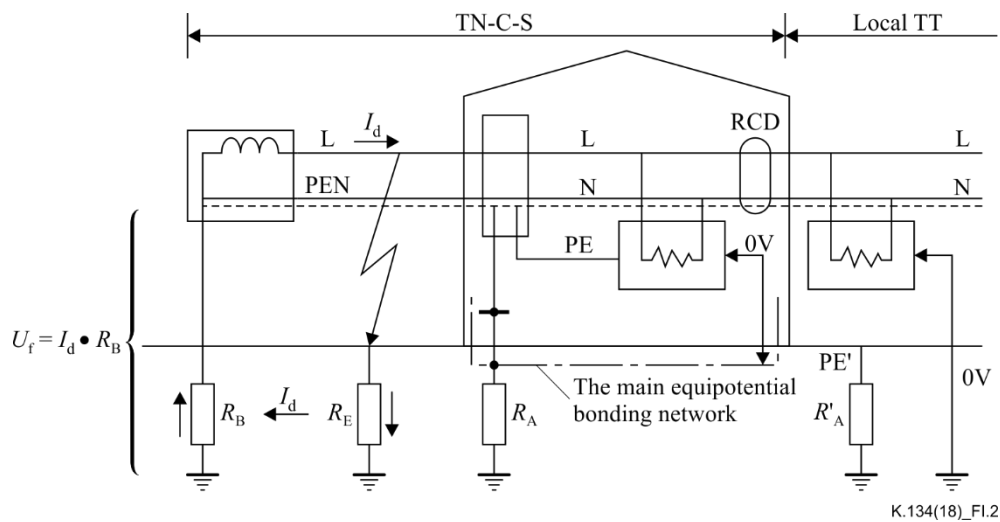


Figure I.2 – Solution of building a local a.c. TT system for outdoor equipment

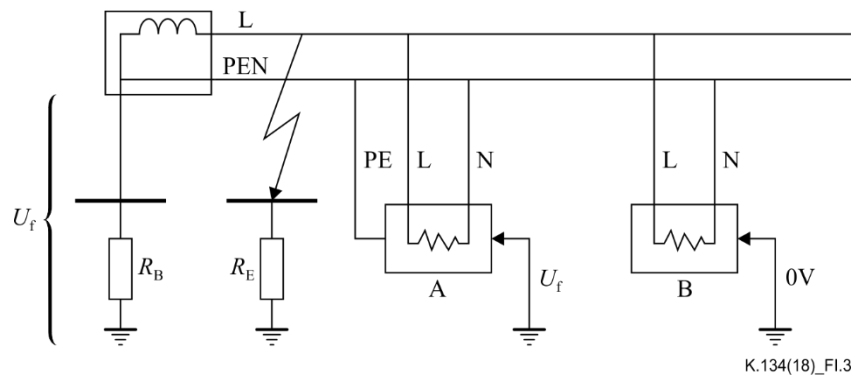


Figure I.3 – Solution of adopting a class II equipment as electrical separation

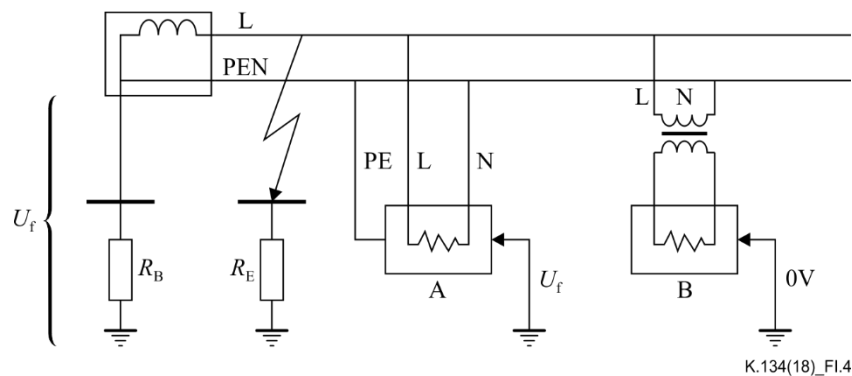


Figure I.4 – Solution of adopting an isolation transformer as electrical separation

Appendix II

Possible hazards of electric shock for SSIs in a.c. TT or IT system

(This appendix does not form an integral part of this Recommendation.)

If class I equipment is powered by an a.c. TT system and is not connected to local earth, the equipment within the metallic enclosure may be lived under a single fault condition, and the risk of electric shock shall be considered. This is shown in Figure II.1.

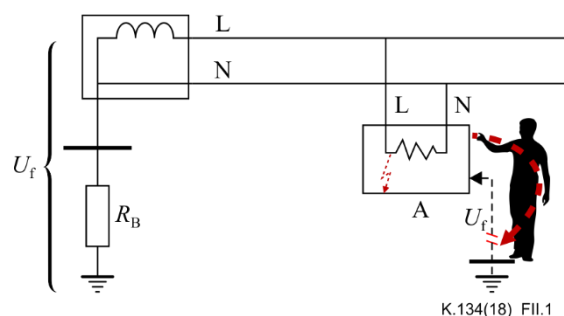


Figure II.1 – Example of possible hazards of electric shock in a.c. TT system

If class I equipment are powered by an a.c. IT system not connected to local earth, the L (or N) conductor contact with the earth and the power supply does not interrupt, for example, if the L (or N) conductor falls into a pond or its insulation is damaged. The equipment within the metallic enclosure may be lived under a single fault condition, and the risk of electric shock shall be considered. This is shown in Figure II.2.

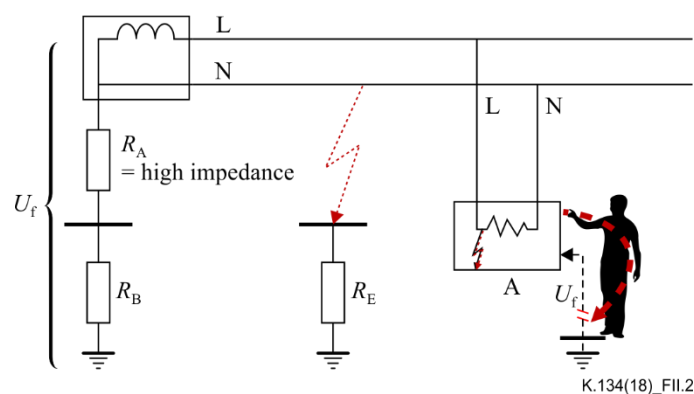


Figure II.2 – Example of possible hazards of electric shock in a.c. IT system

The available solutions for these hazards include:

- class II equipment as described in clause 7.1.2.1; or
- an insulation case as described in clause 7.1.2.2; or
- for the equipment powered by a TT system, an isolation transformer as described in clause 7.1.2.3 as electrical separation; or
- for equipment within a metallic enclosure powered by a TT and IT system, an enclosure live voltage detection as described in Annex A.

Appendix III

Possible hazards of electric shock for SSIs powered by up to 400 VDC IT system

(This appendix does not form an integral part of this Recommendation.)

If class I equipment (distant power receiver/SSI) is powered by a d.c. IT system (remote power unit (RPU)) and is not connected to local earth, the power supply does not interrupt when the + (or –) conductor contacts the earth in the case of an earth fault or insulation breakdown. The metallic enclosure may be lived under a single fault condition, and the risk of electric shock shall be considered, as shown in Figure III.1.

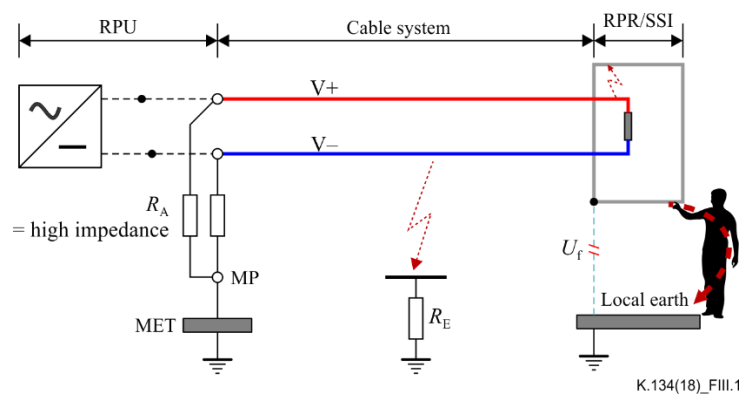


Figure III.1 – Example of possible hazards of electric shock in d.c. IT system

If several pieces of class I equipment (RPR/SSI) are powered by a d.c. IT small system (RPU) and are not connected to local earth, when one equipment has a + (or –) conductor in contact with the enclosure and the other equipment also has a – (or +) conductor in contact with the enclosure, both pieces of equipment do not interrupt the power supply. If, for example, two body parts of a service person accidentally contact both enclosures forming an electric shock circuit, then the risk of electric shock shall be considered, as shown in Figure III.2.

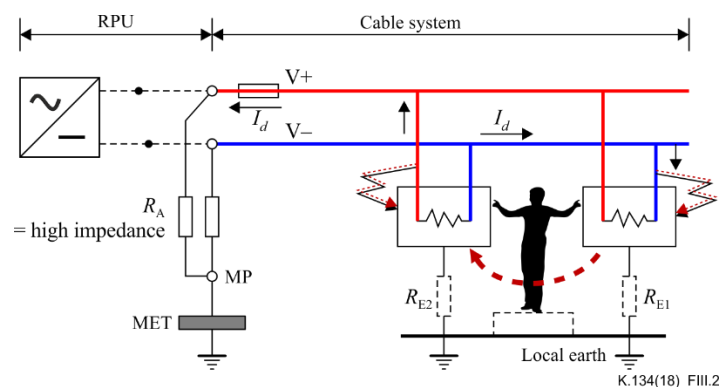


Figure III.2 – Example of possible hazards of electric shock in several class I equipment powered by a d.c. IT system

The available solutions for these hazards include:

- for equipment within a metallic enclosure, enclosure live voltage detection, as described in Annex A; or
- class II equipment as described in clause 7.1.2.1; or
- an insulation case as described in clause 7.1.2.2.

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