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SERIES K: PROTECTION AGAINST INTERFERENCE

Multiservice surge protective device application guide

Recommendation ITU-T K.148

ITU-T

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Multiservice surge protective device application guide

Summary

A multiservice surge protective device (MSPD) protects two or more services e.g., mains and telecommunications, and has a common bonding point for the service surge protective devices (SPDs) contained in the MSPD. Recommendation ITU-T K.148 provides application guidance on MSPDs and explains their uses, required performance parameters and usage consequences.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Keywords

ICT service, multiservice surge protective device, MSPD, power service, surge reference equaliser.

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Multiservice surge protective device application guide

1 Scope

This Recommendation provides application guidance on multiservice surge protective devices (MSPDs) and explains how MSPDs provide local overvoltage protection for the services used by an equipment or equipment cluster. The requirements of the individual service surge protective devices (SPDs) are outlined, together with possible interactions on the MSPD protected side. This Recommendation also explains how the MSPD interacts with the surges on the services and the consequences of these surges when the local protective earthing (PE) connection is high impedance or is missing.

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.

None.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 common mode conversion [b-ITU-T K.96]: Process by which a differential mode electrical signal is produced in response to a common mode electrical signal.

3.1.2 common-mode surge [b-ITU-T K.96]: Surge appearing equally on all conductors of a group at a given location.

NOTE 1 – The reference point for common-mode surge voltage measurement can be a chassis terminal, or a local earth/ground point.

NOTE 2 – Also known as longitudinal surge or asymmetrical surge.

3.1.3 band-pass filter [b-ITU-T K.96]: Filter that allows passage of a desired range of frequencies and attenuates frequencies outside the desired range.

NOTE – This definition is based on the definition provided in [b-IEEE Std 802.7].

3.1.4 common-mode choke filter [b-ITU-T K.96]: Series in-line transformer used to mitigate common-mode current flow without affecting differential current flow.

3.1.5 common-mode rejection filter [b-ITU-T K.96]: Filter type, usually a balanced filter that attenuates the signal common to both input lines; that signal is called the common-mode signal.

NOTE – This definition is based on the definition provided in [b-IEEE Std 1549].

3.1.6 differential-mode surge [b-ITU-T K.96]: Surge occurring between any two conductors or two groups of conductors at a given location.

NOTE 1 – The surge source maybe be floating, without a reference point or connected to reference point, such as a chassis terminal, or a local earth/ground point.

NOTE 2 – Also known as metallic surge or transverse surge or symmetrical surge or normal surge.

3.1.7 filter [b-IEEE Std 802.7]: Circuit that selects or rejects one or more components of a signal related to frequency.

3.1.8 high-pass filter [b-ITU-T K.96]: Electrical network that passes higher frequencies, attenuates lower frequencies and blocks DC levels.

NOTE – This definition is based on the definition provided in [b-IEEE Std 1149.6].

3.1.9 low-pass filter [b-IEEE Std 1149.6]: Electrical network that passes lower frequencies, including DC levels, and attenuates higher frequencies.

3.1.10 modes of protection (of a voltage limiting surge protective device (SPD) or equipment port) [b-ITU-T K.99]: List of terminal-pairs where the diverted surge current is directly between that terminal-pair without flowing via other terminals.

3.1.11 multiservice surge protective device [b-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 surge protective component (SPC) [b-ITU-T K.96]: Component specifically included in a device or equipment for the mitigation of the onward propagation of overvoltages or overcurrents or both.

3.1.13 surge protective device (SPD) [b-ITU-T K.96]: Device that mitigates the onward propagation of overvoltages or overcurrents or both.

3.1.14 surge reference equalizer [b-IEC TR 62066]: Device used for connecting equipment to external systems whereby all conductors connected to the protected load are routed, physically and electrically, through a single enclosure with a shared reference point between the input and output ports of each system.

NOTE – 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.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 earth loop: Potentially detrimental loop formed when two or more points in an electrical system that are connected to their local earth potential are also interconnected by earth referenced conductors, which creates a loop that will carry current if the local earths are not at the same potential.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

GDT Gas Discharge Tube

IP Ingress Protection

ICT Information and Communication Technology

MOV Metal-oxide Varistor

MSPD Multiservice Surge Protective Device

PE Protective Earthing

SPC Surge Protective Component

SPD Surge Protective Device

5 Conventions

None.

6 Individual service SPDs

6.1 Surge mitigation functions

SPDs are normally fitted to cabling when failures have occurred due to overvoltages or there are concerns about the service overvoltage levels. Common-mode surge overvoltages occur on all conductors within the cable. Figure 1 shows several mitigation options for a common-mode surge:

a) voltage limit the surge voltage from an earth reference potential by using non-linear voltage limiting components,

b) block the voltage surge with an isolating transformer,

c) filter out the surge frequencies if the service and lightning spectrums do not overlap,

d) use a common-mode choke, which has a high impedance to common-mode surge and a low impedance to the differential signal,

e) use a series electronic current limiter as these are fast enough to operate under surge conditions.

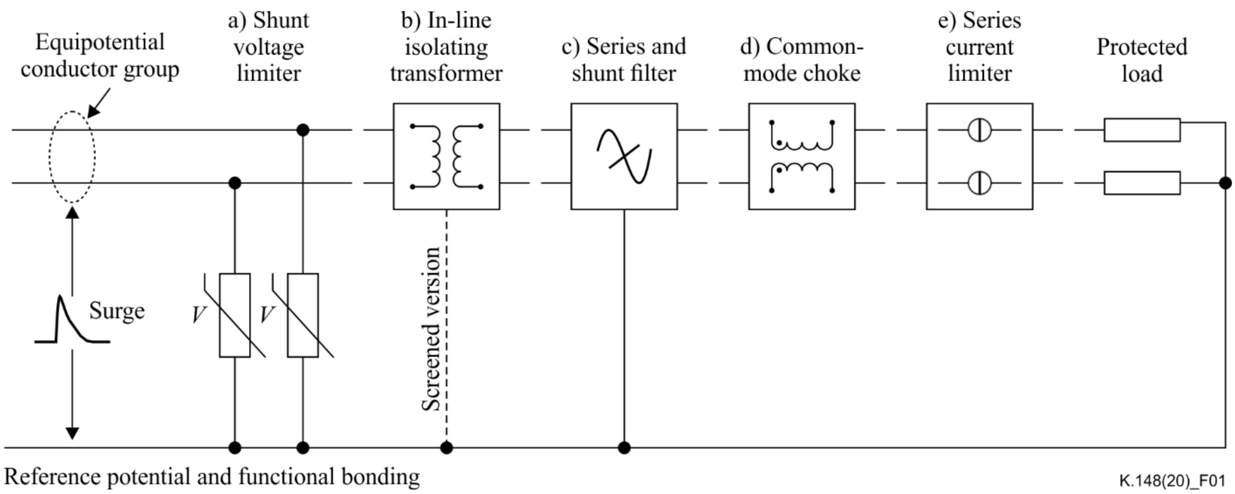

Figure 1 – Common-mode surge mitigation options

The Figure 1 a) shunt voltage limiter could be realised by many technologies such as metal-oxide varistor (MOV), gas discharge tube (GDT), PN junction diode, foldback diode and punch-through diode. The description and operation of these protection technologies is covered in [b-ITU-T K.96].

Differential mode surge overvoltages occur between conductors or sets of cable conductors. Figure 2 shows several mitigation options for a differential-mode surge:

a) voltage limit the surge voltage between the conductors by using non-linear voltage limiting components,

b) if the signal transformer core saturates, stopping transformer action, surge truncation will occur, see [b-ITU-T K.126],

c) filter out the surge frequencies if the service and lightning spectrums do not overlap,

d) use a series electronic current limiter as these are fast enough to operate under surge conditions.

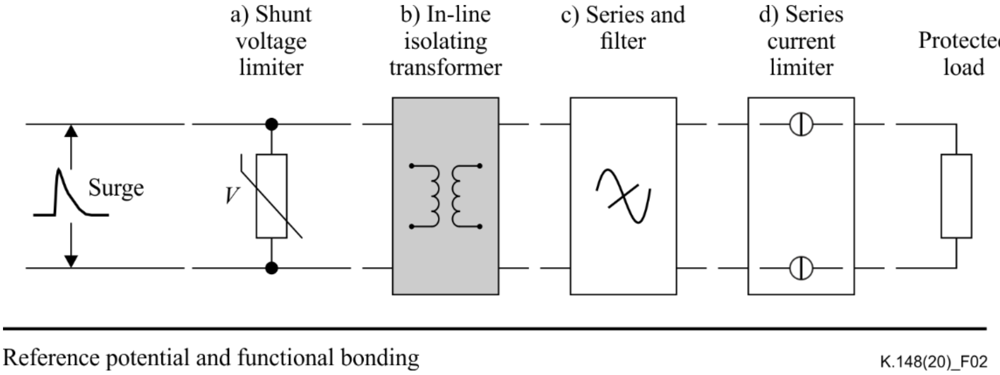

Figure 2 – Differential-mode surge mitigation options

The description and operation of these protection technologies is covered in [b-ITU-T K.96].

6.2 Power service protection

The main requirement for power service protection is to limit the common mode surge overvoltage and generally the approach of Figure 1a) is used. Figure 3 shows different ways MOVs can be connected to protect a two-wire power source. Circuit a) has one MOV (MOV1) to directly protect the power source and a second MOV (MOV2) to protect the power source insulation to earth. Circuit b) has one MOV (MOV1) protecting the power feed conductor to earth and a second MOV (MOV2) to protect the power return conductor to earth. Circuit c) has one MOV (MOV1) protecting the power feed conductor to earth, a second MOV (MOV2) protecting the power return conductor to earth and a third MOV (MOV3) directly protecting the power source. Circuit d) has two series connected MOVs (MOV1 and MOV3) directly protecting the power source and one MOV (MOV2), connected to the junction of MOV1 and MOV3, protecting the power source insulation to earth.

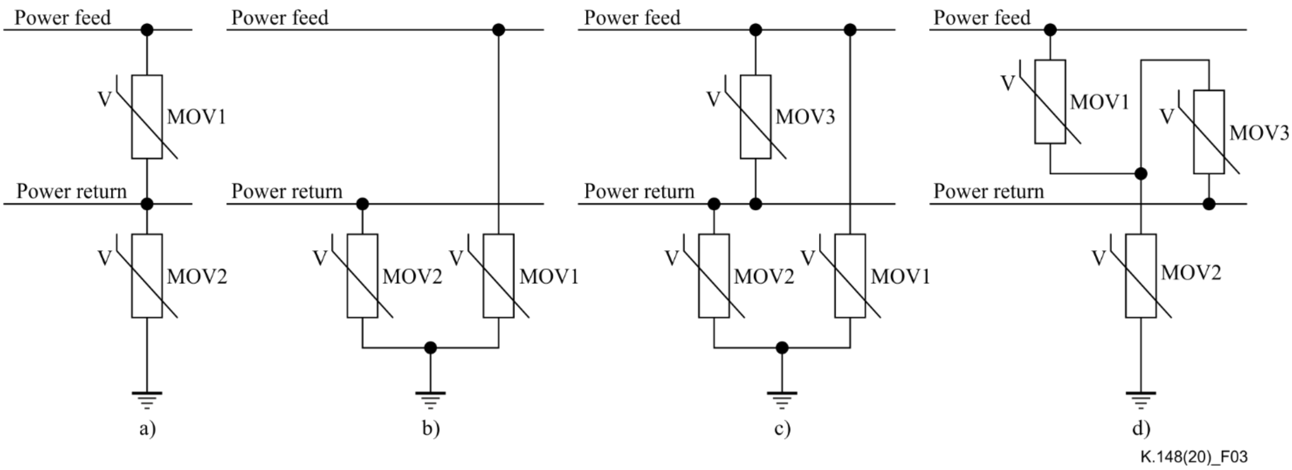

Figure 3 – Circuit examples of powering feed protection

Circuits a) and b) are the least cost using only two MOVs. Circuits c) and d) are more expensive using 3 MOVs. For DC supplies, if the voltage polarity of the powering conductors is known, diode steering, D1 and D2, can be added to the Figure 3 c) circuit to ensure that common-mode impulses of any polarity only charge and do not discharge the power source, see Figure 4. For any impulse polarity, the powering source voltage increase during an impulse is limited by MOV3.

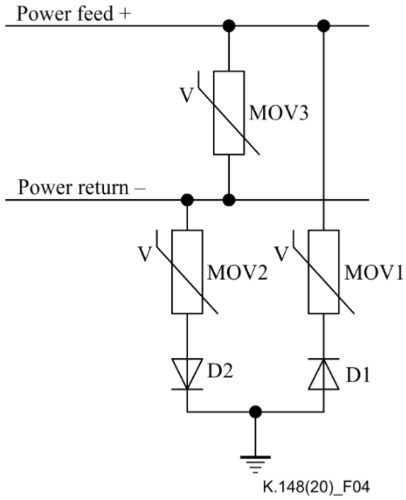

Figure 4 – Diode steering variant of circuit c)

Important power service SPD performance parameters are the maximum continuous operation voltage, limiting voltage and surge resistibility. For all the SPD parameters consult the appropriate international, regional or national standards and manufacturers data sheets. Examples of power SPD standards are [b-IEC 61643-11] and [b-UL 1449]. Generally, power SPD standards do not cover the inclusion of filters simultaneous surge on all the powering lines. Outside use SPDs are likely to have an ingress protection (IP) rating indicating the enclosure sealing effectiveness against intrusion of foreign bodies and moisture.

[b-IEC 60664-1] lists the following preferred overvoltage categories of 60 V, 330 V, 500 V, 800 V, 1.5 kV, 2.5 kV, 4 kV, 6 kV, 8 kV, 10 kV and 15 kV.

6.3 Signal service protection

Generally, ports for signal services have less surge resistance than power services, particularly for differential mode surge. Differential mode surges are often created by non-synchronous operation of common mode protection elements.

Services supplied using co-axial cable only need voltage mitigation between the centre conductor and cable screen. In high frequency signal cases a passive quarter-wave shorting stub protector can be used to filter out the lightning frequency components.

Services supplied with twisted pair cabling need voltage mitigation between the conductors. Multi-twisted pair cables supplying power may also need inter-pair voltage mitigation between the pairs of differing potentials.

Important signal service SPD performance parameters are the maximum continuous operation voltage, limiting voltage and surge resistibility both for common mode and differential mode surges. For all the SPD parameters consult the appropriate international, regional or national standards and manufacturers data sheets. Outside use SPDs are likely to have an ingress protection IP rating indicating the enclosure sealing effectiveness against intrusion of foreign bodies and moisture.

6.4 Individual SPD earthing problems

When SPDs are individually applied to services, as shown in Figure 5, the common mode surge current from the SPD "C" terminal to the local earth reference via the earthing cable can create a potential difference from the true earth potential. Further the local earth references themselves may be at different potentials. For example, a 1 m connecting cable has an inductance of about

1.5 µH/m. A diverted surge current of 50 A/µs would create an inductive voltage of 75 V/m. This inductive voltage adds to the SPD limiting voltage.

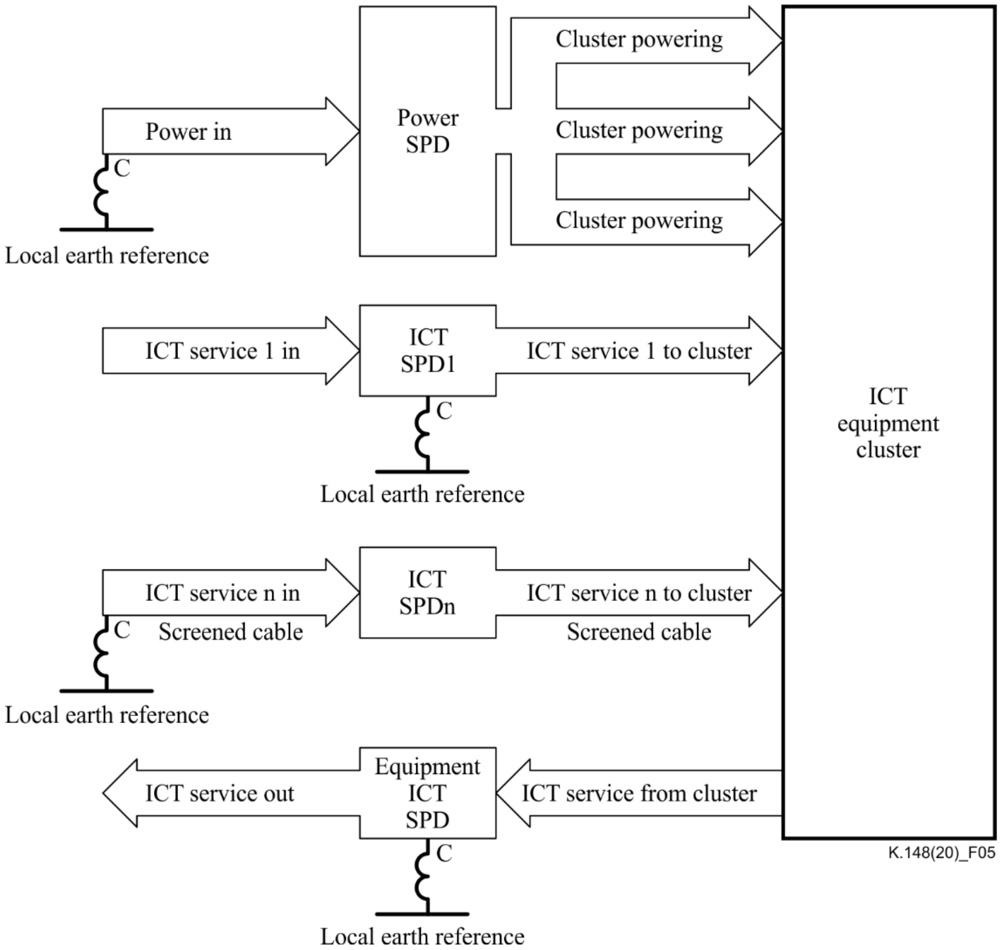

Figure 5 – Individual SPD earthing

The power SPD will be connected to the mains plug/socket local earth reference. The incoming service SPD1 and outgoing service equipment SPD will be connected to whatever local earth reference is provided. For the screened cable SPDn the earth reference could be applied to the cable originating end.

7 Surge reference equaliser (MSPD concept)

A surge reference equaliser does two things; it brings together all the service SPDs by locating them in a single enclosure and provides a local earth reference for all the SPD "C" terminals to directly connect to. Figure 6 shows the configuration.

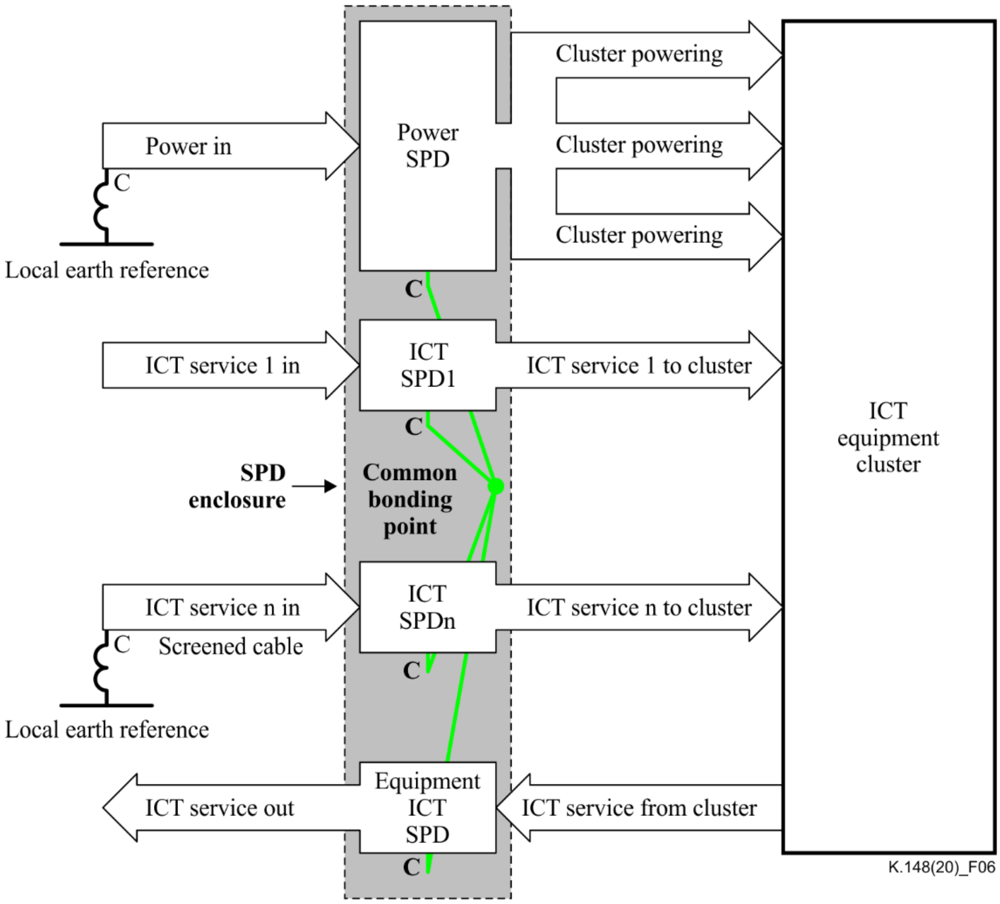

Figure 6 – SPDs in a surge reference equaliser configuration

In Figure 6, the common bonding point, or "star" connection has two external earth reference points; one from the power SPD mains plug/socket local earth reference and the other from the screened cable remote earth reference. This means that the diverted surge current can split between the power and screened cable earth references.

To avoid earth loops in normal operation, one SPDn option is to make the screened cable "C" connection to the common bonding point via an SPD with a switching function, which maintains isolation during normal conditions but provides a bond during the occurrence of a surge.

The surge reference equaliser is now called an MSPD, although there may not be any SPDs in it, only SPCs giving the equivalent surge functionality of the replaced SPDs. Figure 7 shows a typical MSPD for protecting power, antenna, telephone and Ethernet services with warning lights for protection failure and missing earth connection.

In terms of surge parameters for a particular service, [b-ITU-T K.44] and [b-ITU-T K.21] provide guidance on test circuits and values. Assuming the cluster equipment ports meet [b-ITU-T K.21] requirements, the MSPD should be regarded as [b-ITU-T K.21] primary protection that is coordinated with the equipment cluster port protection.

Figure 7 – MSPD for protecting power, antenna, phone and Ethernet services

8 MSPD implications

8.1 Protected-side earth loop currents

If there is a cluster of equipment, they are likely to be connected to the power service and possibly interconnected. This means there will be the possibility of earth loop currents if the MPSD earth referenced leads are ineffectively directly connected to the common bonding point. [b-IEEE C62.50] describes a surge test procedure that measures surge currents that flow in the protected side ground loops. Generally, such a test is not necessary provided all the earthed referenced conductors are correctly returned to the common bonding point.

8.2 SPD cross-coupling

Localized electric, magnetic and electromagnetic fields within the MSPD can be caused by the operation of a power SPD. These fields can couple into the SPDs and wiring on other services causing signal disruption. [b-IEEE C62.50] has a test procedure that measures the coupled levels of surge open-circuit voltage and surge short-circuit current on to unsurged services. The loads that are normally connected to communications service ports are simulated by resistive terminations connected to both the service port protected and unprotected sides.

8.3 High impedance or missing local earth connection

When SPD operation diverts surge current into the common bonding point, the voltage developed on the earthing system can appear as an earth potential rise on other service SPDs. If the potential rise is sufficiently large it can cause these other services SPDs into conduction, which will divert portions of the surge current on to these other services. If an earthing reference is not provided the surge will propagate to all services, see [b-ITU-T K.134]. Generally, the use of MSPD technology will not cause any additional hazards compared to individual SPDs applied to services.

9 Summary

Use of an MSPD creates a zone of protection for the equipment cluster on the protected side of the MSPD. Individual SPDs located at various positions cannot do this. The MSPD protection types and their performance depends on the type of services required by the equipment cluster protection and the expected transient voltage environment.

It should be remembered that equipment connected to the MSPD unprotected side may suffer surges diverted from other MSPD services and appropriate steps should be taken to protect such equipment from these diverted surges.

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