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SERIES K: PROTECTION AGAINST INTERFERENCE

Primary protector parameters for the surge protection of equipment Ethernet ports

Recommendation ITU-T K.117

ITU-T

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Summary

Recommendation ITU-T K.117 specifies the common-mode, differential mode and common mode to differential mode conversion surge parameter and test circuit requirements of an Ethernet port primary protector. The preferred surge generator voltage levels are 2.5 kV, 6 kV and 12 kV, but the test circuits can be used for any surge voltage environmental. Power over Ethernet (PoE) feed requirements are also given. Ethernet signal performance parameters are not covered and standards such as [b-IEC 60603-7-7] may be used for this purpose.

This Recommendation should be used for the harmonization of existing or future specifications issued by Ethernet surge protective device (SPD) manufacturers, telecommunication equipment manufacturers, administrations or network operators.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K.117	2016-12-14	5	11.1002/1000/13133

Keywords

Ethernet, in-line SPD, insulation resistance, overvoltage protector, Power over Ethernet (PoE), primary protector, surge protective device (SPD).

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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Primary protector parameters for the surge protection of equipment Ethernet ports

1 Scope

This Recommendation applies to surge protective devices (SPDs) to be used for Ethernet primary protection in surge voltage environments with a peak value of 2.5 kV and above. It covers the following device parameters:

a) electrical surge

b) electrical d.c.

c) identification and marking.

This Recommendation does not deal with:

a) mountings for SPDs and their effect on characteristics;

b) mechanical dimensions;

c) quality assurance requirements;

d) units containing current limiters;

e) signal performance parameters, standards such as [b-IEC 60603-7-7] may be used for this purpose;

f) diagnostic properties such as indicators and status monitor outputs.

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.44] Recommendation ITU-T K.44 (2016), *Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation*.

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.

NOTE – This definition is based on the definition provided in [b-IEC 60050-161].

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 connector [b-IEC 14776-153]: Electro-mechanical components consisting of a receptacle and a plug that provide a separable interface between two transmission segments.

3.1.4 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.

3.1.5 hard-wired [b-IEC 60601-2-1]: Term used where the features of a system can be modified only by physically removing and re-routing wires.

3.1.6 insulation [b-IEC 60664-2-1]: That part of an electrotechnical product which separates the conducting parts at different electrical potentials.

3.1.7 isolating transformer [b-IEC 60065]: Transformer with protective separation between the input and output windings.

NOTE – Isolating transformers can be divided into three groups; mains, switched mode and signal (e.g., Ethernet data).

3.1.8 impulse limiting voltage, V_P [b-ITU-T K.28]: Highest value of voltage across the terminals of the SPD during the application of a specified impulse.

NOTE – Also called voltage protection level or measured limiting voltage.

3.1.9 in-line SPD [b-ITU-T K.28]: A two-port SPD connected in series with the service feed.

3.1.10 insulation resistance (effective) [b-ITU-T K.28]: Quotient of the voltage applied to a designated terminal pair, V_{IR}, by the current, I_{IR}, drawn from the applied voltage.

3.1.11 impulse generator charge voltage, V_C [b-ITU-T K.82]: Value of impulse generator charging voltage.

3.1.12 impulse withstand voltage [b-IEC 60664-2-1]: Highest peak value of impulse voltage of prescribed form and polarity applied to a circuit or equipment, which does not cause degradation or result in breakdown or flashover.

3.1.13 let-through current [b-ITU-T K.28]: In-line SPD peak short-circuit output current when a specified impulse is applied to the SPD input.

3.1.14 overvoltage [b-IEC 60664-2-1]: Any voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions.

3.1.15 parameter [b-IEC 61643-341]: Device descriptor that is measurable or quantifiable, such as a characteristic or rating.

3.1.16 port [b-IEC 60050-131]: Access to a device or network where electromagnetic energy or signals may be supplied or received or where the device or network variables may be observed or measured.

NOTE – An example of a port is a terminal pair.

3.1.17 primary protection [ITU-T K.44]: Means by which the majority of the surge stress is prevented from propagating beyond a designated location (preferably the building entrance point).

3.1.18 rated peak impulse current [b-ITU-T K.28]: Maximum value of peak impulse current of specified amplitude and waveshape that may be applied without causing degradation.

3.1.19 sparkover [b-IEC 60050-212]: Disruptive discharge in a gaseous or liquid insulating material.

3.1.20 surge [b-ITU-T K.96]: Temporary disturbance on the conductors of an electrical service caused by an electrical event not related to the service.

NOTE – For non-linear SPCs a surge event is defined as an overvoltage or overcurrent or both.

3.1.21 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.

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

3.1.23 two-port [b-IEC 60050-131]: Device or network with two separate ports.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

GDT Gas Discharge Tube

IR Insulation Resistance

PD Powered Device/equipment

PE Protective Earth

PoE Power over Ethernet

PSE Power Sourcing Equipment

RJ45 Registered Jack #45

SPC Surge Protective Component

SPD Surge Protective Device

5 Conventions

5.1 Connections

The connection designation used in this Recommendation corresponds to the normal Ethernet cable RJ45 contacts. Figure 1 shows the RJ45 contact numbers that are associated with signal connections and the PoE power feed modes. When an SPD does not use a RJ45 receptacle but uses, for example, a hard-wired cable connection, the terminal notations may be different. A hard-wire connector may be required when the RJ45 contact currents exceed 1 kA or voltages between adjacent contacts will exceed 4 kV. The SPD configuration is assumed as in-line (2 port) with the test being applied to one port and the let-through surge measured on the other terminated port.

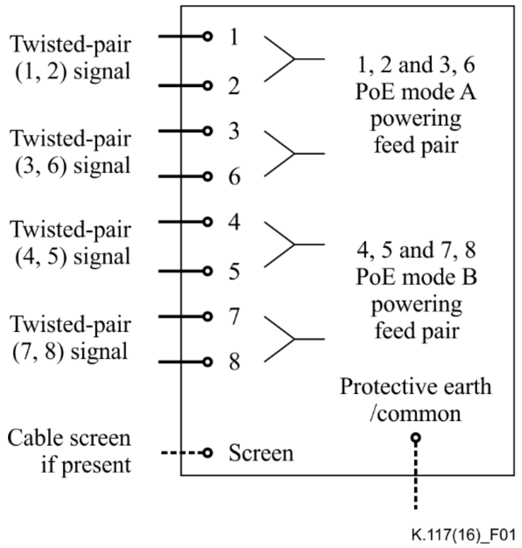


Figure 1 – Ethernet RJ45 contact connections

5.2 Protective function

This Recommendation tries to be technology neutral on the surge protective components (SPCs) used in the SPD. SPDs using voltage limiting components or isolating components, or both are tested with the SPD terminated. Figures 2 and 3 show examples of a voltage limiting gas discharge tube (GDT) and isolating transformer in a common-mode surge test with the termination connected.

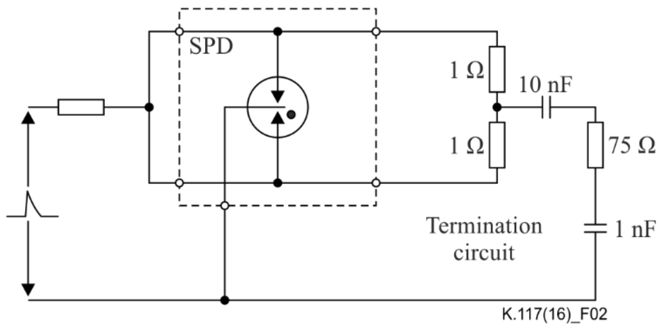


Figure 2 – GDT common-mode voltage limiting (partial circuit for only one twisted pair)

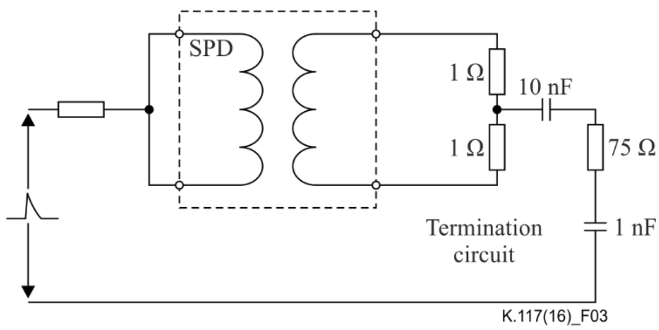


Figure 3 – Isolating transformer common-mode voltage blocking (partial circuit for only one twisted pair)

6 Electrical parameters

The objective of an Ethernet SPD is to mitigate the cable surge levels down to levels that the equipment port can withstand. Cable surges can be common mode or differential mode. In addition the SPD must not generate an excessive differential surge in common-mode surge operation; see Tables 2 and 3 for preferred maximum differential surge values.

Three [b-IEC 60664-2-1] preferred values of generator charging voltage are used: 2.5 kV, 6 kV and 12 kV. Manufacturers may also define levels to suit specific applications. SPDs rated for 2.5 kV are intended to protect equipment ports that do not meet a basic port withstand voltage of 2.5 kV. SPDs rated for 6 kV are intended to protect equipment ports that have a basic port withstand voltage of 2.5 kV but the equipment has been installed in an environment that requires an enhanced 6 kV capability. SPDs rated for 12 kV are intended for severe installation environments to protect equipment ports that only have the basic (2.5 kV) or enhanced (6 kV) withstand voltages.

The testing assumes all 8 Ethernet conductors are protected. Where the SPD is designed to protect a lesser number of conductors and surge mode requirements (e.g. non-PoE) only the appropriate SPD equipment terminals are tested and measured.

6.1 Common-mode surge

The purpose of this test is to measure the impulse limiting voltage at the SPD port connecting to the equipment Ethernet port. The test circuit is shown in Figure 4. To test this, set the generator charge voltage to the required level from Table 1 and surge the SPD while recording an SPD equipment port terminal voltage. Record the terminal peak voltage measured. Repeat this test with the generator voltage polarity reversed. Repeat this procedure until all the port terminals have been measured for positive and negative surges and their peak voltage values have been recorded. For each configuration a minimum of three surges must be applied and the recorded value is the highest measured value. Finally, measure the d.c. insulation resistance for terminals 1 to 8 of the SPD cable port, as described in clause 7.1.

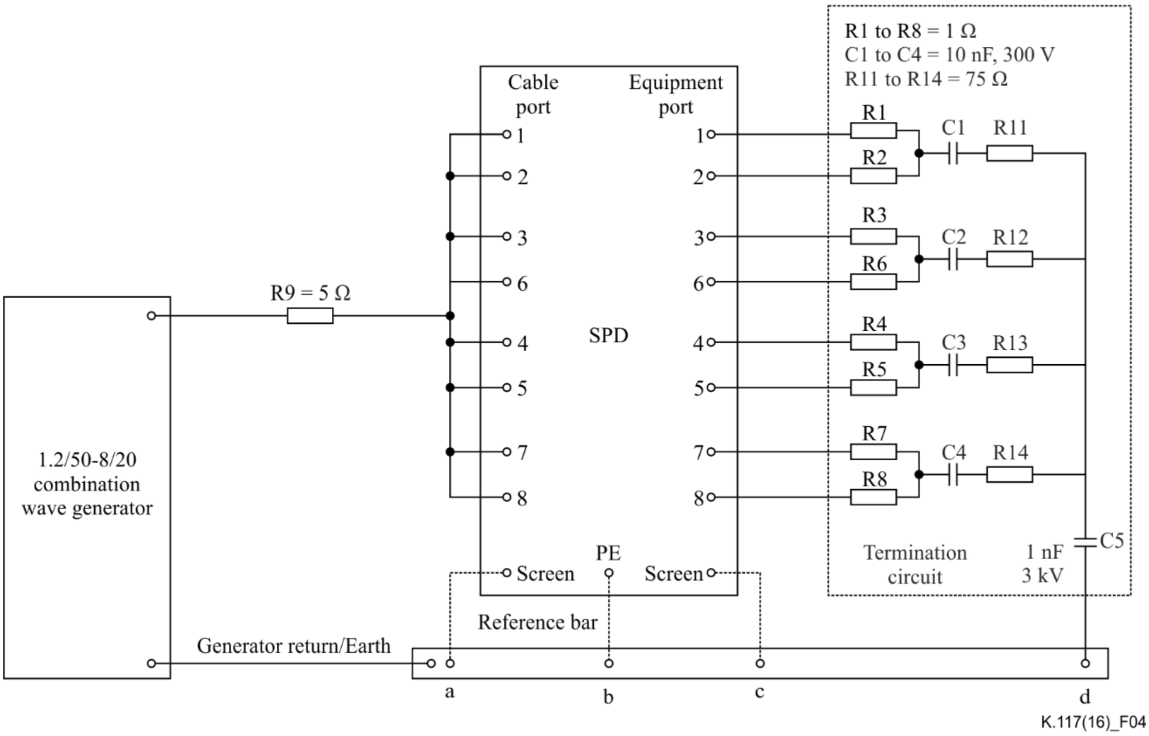


Figure 4 – Impulse limiting voltage under common-mode surge conditions

Table 1 – Preferred values of common-mode impulse limiting voltage

Generator charge voltage kV	Maximum impulse limiting voltage on any SPD equipment port terminal (excluding the screen connection) kV
2.5	1.0
6	1.5
12	2.0
Manufacturer defined	Manufacturer defined

The recorded peak voltages shall not exceed the impulse limiting voltage corresponding to the selected generator charge voltage. After the surge testing, the 500 V insulation resistance values shall not be less than 2 MΩ.

6.2 Differential-mode surge

The most critical factor for a twisted pair differential surge is the current waveform as the port termination is a low value resistance, usually below 5 Ω. Conversely, the most critical factor for a PoE power feed pair is peak voltage as the need is to protect some form of integrated circuit, which usually is rated at about 100 V. Common-mode surge operation of an SPD can generate differential-mode surges and these self-generated differential-mode surges at the SPD cable connection should not exceed the specified differential-mode surge voltage levels for a single twisted pair and power feed pairs.

6.2.1 Single twisted pair

The purpose of this test is to measure the termination differential-mode surge levels of a single twisted pair. The test circuit is shown in Figure 5. In Figure 5 all four switches, SW(1-2) to SW(7-8), are single-pole change-over break before make ones. The switch contact arm is shown in red to clearly indicate the arm position. Figure 5 shows the test configuration for port terminal pair 1-2 with the generator output connected to terminal 1 via switch SW(1-2). The test configuration for a given terminal pair is with that terminal pair switch connecting the switched terminal to the generator series resistor R9, while all the other three terminal pair switches connect their terminals to the reference bar.

To test this, set the generator charge voltage to the required level from Table 2 and surge the SPD while recording the selected SPD equipment port termination peak voltage and current. Record the termination peak voltage and current. Repeat this test with the generator voltage polarity reversed. Repeat this procedure until all the appropriate port terminals have been measured and their peak voltage and current values recorded. Finally, measure the d.c. insulation resistance for terminals 1 to 8 of the SPD cable port, as described in clause 7.1.

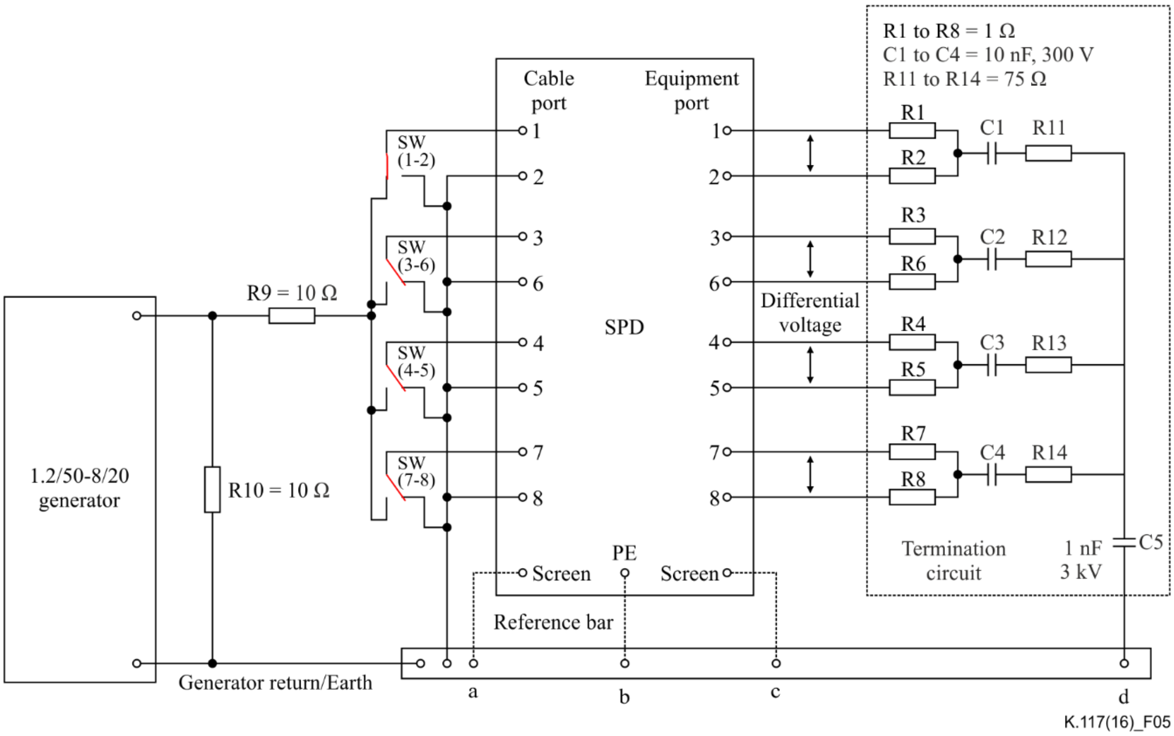


Figure 5 – Single twisted-pair differential-mode surge test circuit

Table 2 – Preferred values of termination peak voltage and current

Generator charge voltage kV	Measured values for 1-2, 3-6, 4-5 and 7-8	
	Termination peak voltage V	**Termination peak current A**
2.5	100	50
6	200	100
12	300	150
Manufacturer defined	Manufacturer defined	Manufacturer defined

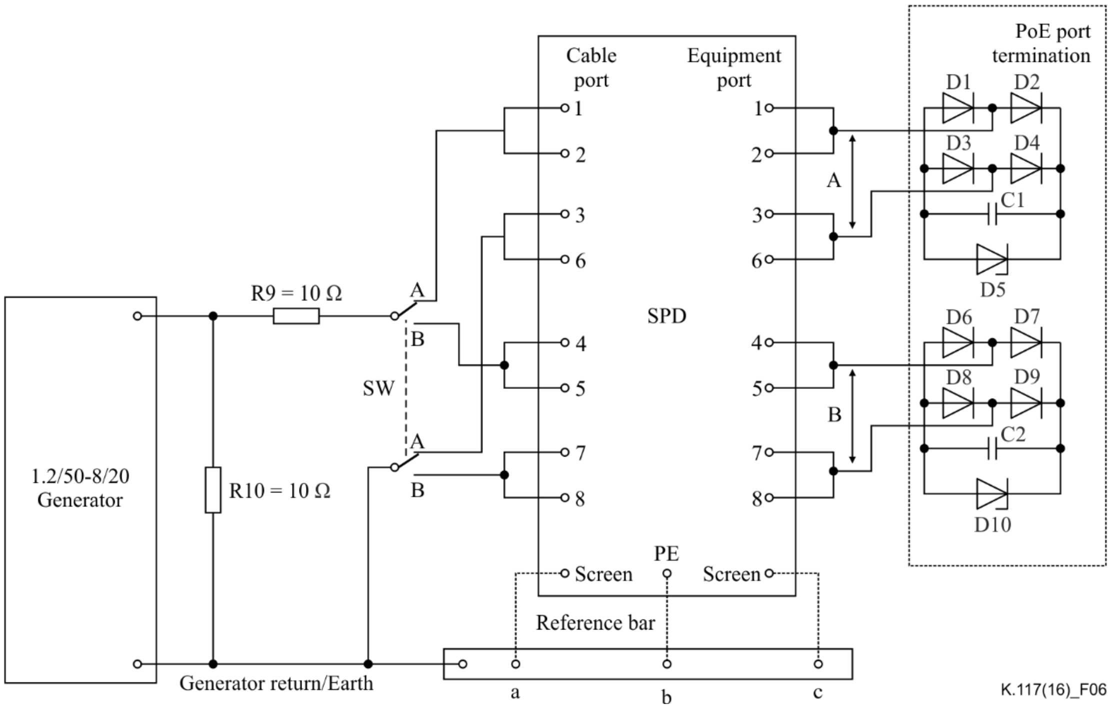
The recorded peak levels shall not exceed the termination peak values corresponding to the selected generator charge voltage. After the surge testing, the 500 V insulation resistance values shall not be less than 2 MΩ.

6.2.2 PoE power feed pairs

PoE power can be delivered in either mode A or mode B, or both modes (A + B). In powered equipment (PD) the power feed is extracted from the twisted pairs, sent to a multiphase diode bridge, decoupled and overvoltage protected before being applied to a d.c./d.c. converter. Power sourcing equipment (PSE) usually has some form of power regulator with overvoltage protection which feeds the power to the twisted pairs. The Figure 6 test circuit uses a powered equipment type termination as it works for both surge polarities and is often the equipment with the lowest surge resistibility. The components and their values correspond to the established components used in [b-IEEE 802.3] designs. Diodes D1 to D4 and D6 to D9 form polarity correction bridges that feed the avalanche breakdown diodes D5 and D10 and capacitors C1 and C2. Typical emulation components used are Schottky rectifier bridge diodes type B1100/B, avalanche breakdown diode type SMAJ58A and decoupling capacitor 100 nF, 100 V.

In Figure 6, switch SW selects test mode A or test mode B. The peak surge voltage in these modes is measured at the SPD equipment port termination.

To test this, set the generator charge voltage to the required level from Table 3, set switch SW for a mode and surge the SPD while measuring the SPD equipment port termination peak voltage for that mode. Record the termination peak voltage. Repeat this test with the generator voltage polarity reversed. Repeat this procedure for the other mode. Finally, measure the d.c. insulation resistance for terminals 1 to 8 of the SPD cable port, as described in clause 7.1.



Key			
SW =	Double pole, two position selector switch	D5, D10 =	SMAJ58A or equivalent 400 W avalanche breakdown diodes
R9, R10 =	10 Ω	D1 to D4, D6 to D9 =	B1100/B Schottky rectifier diodes or equivalent 1 A, 100 V diodes
C1, C2 =	100 nF, 100 V		

Figure 6 – Power feed differential mode surge test circuit

Table 3 – Preferred mode A or mode B peak voltage

Generator charge voltage **kV**	**Peak mode A or mode B termination voltage** **V**
2.5	90
6	95
12	100
Manufacturer defined	Manufacturer defined

The recorded peak voltages shall not exceed the peak mode A and peak mode B voltages corresponding to the selected generator charge voltage. After the surge testing, the 500 V insulation resistance values shall not be less than 2 MΩ.

6.3 Common-mode to differential-mode surge conversion

The purpose of this test is to measure the SPD common-mode to differential-mode surge conversion for the twisted-pair and power-feed situations of clause 6.2.

In both Figure 7 and Figure 8 the generator output connects to each cable contact via a high value 40 Ω feed resistor to reduce the interactions. In Figure 7, the twisted pair is terminated in a high value resistance of 150 Ω to maximise the measured twisted-pair differential voltage. In Figure 8 the twisted pair termination is low in value (1 Ω+1 Ω) as the measurement is being made pair to pair.

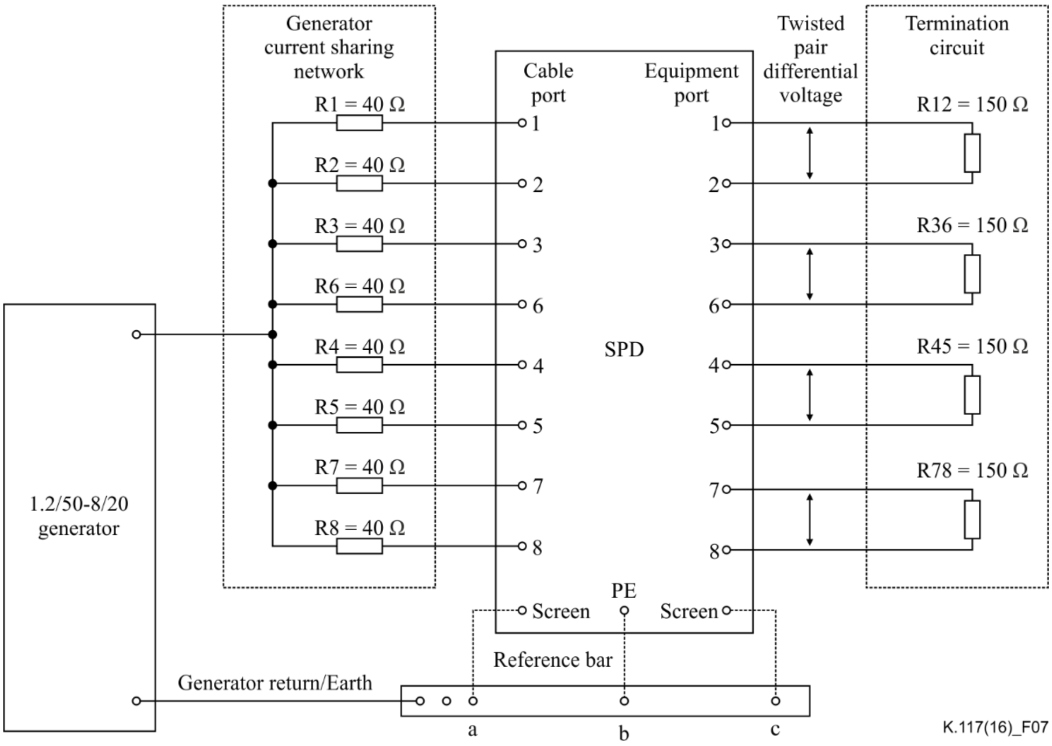


Figure 7 – Twisted-pair common-mode to differential mode voltage surge conversion test circuit

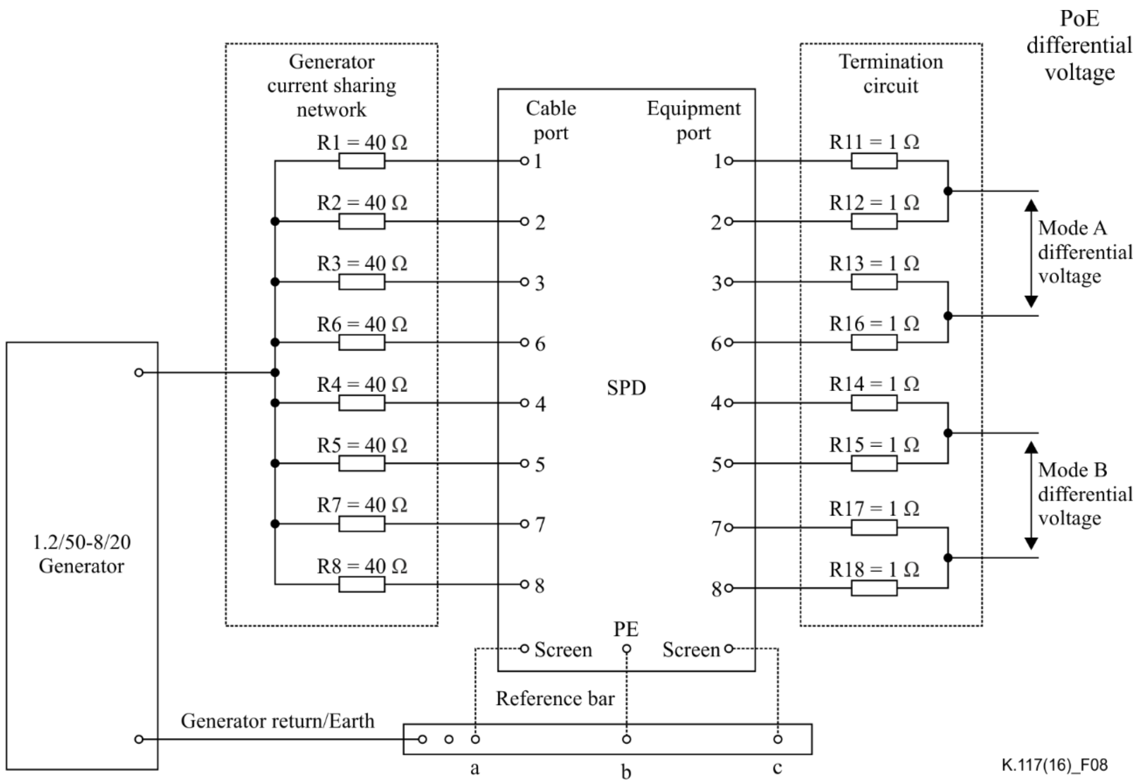


Figure 8 – Power feed pair common-mode to differential mode surge conversion test circuit

For Figure 7, set the generator charge voltage to the level used in clause 6.2.1 and surge the SPD while measuring the SPD equipment port pair 1-2 termination peak voltage. Record the termination peak voltage. Repeat this test with the generator voltage polarity reversed. Repeat this procedure for the port pairs of 3-6, 4-5 and 7-8. Finally, measure the d.c. insulation resistance for terminals 1 to 8 of the SPD cable port, as described in clauses 7.1 and 6.2.2 from Table 3.

For Figure 8, set the generator charge voltage to the level used in clause 6.2.2 and surge the SPD while measuring the SPD equipment port mode A peak voltage. Record the termination peak voltage. Repeat this test with the generator voltage polarity reversed. Repeat this procedure for the port mode B peak voltage. Finally, measure the d.c. insulation resistance for terminals 1 to 8 of the SPD cable port, as described in clause 7.1.

Table 4 – Preferred maximum values common-mode to differential mode surge voltage

Generator charge voltage **kV**	**Peak twisted-pair differential termination voltage** **V**	**Peak mode A or mode B differential termination voltage** **V**
2.5	100	90
6	200	95
12	300	100
Manufacturer defined	Manufacturer defined	Manufacturer defined

The recorded peak voltages shall not exceed the peak differential voltage values corresponding to the selected generator charge voltage. After the surge testing, the 500 V insulation resistance values shall not be less than 2 MΩ.

6.4 Surge durability (optional)

This test verifies the surge durability of the SPD.

For each of the selected test levels and configurations of clauses 6.1, 6.2.1 and 6.2.2 apply 50 surges in one polarity followed by 50 surges in the opposite polarity. Finally, measure the d.c. insulation resistance for terminals 1 to 8 as appropriate of the SPD cable port, as described in clause 7.1.

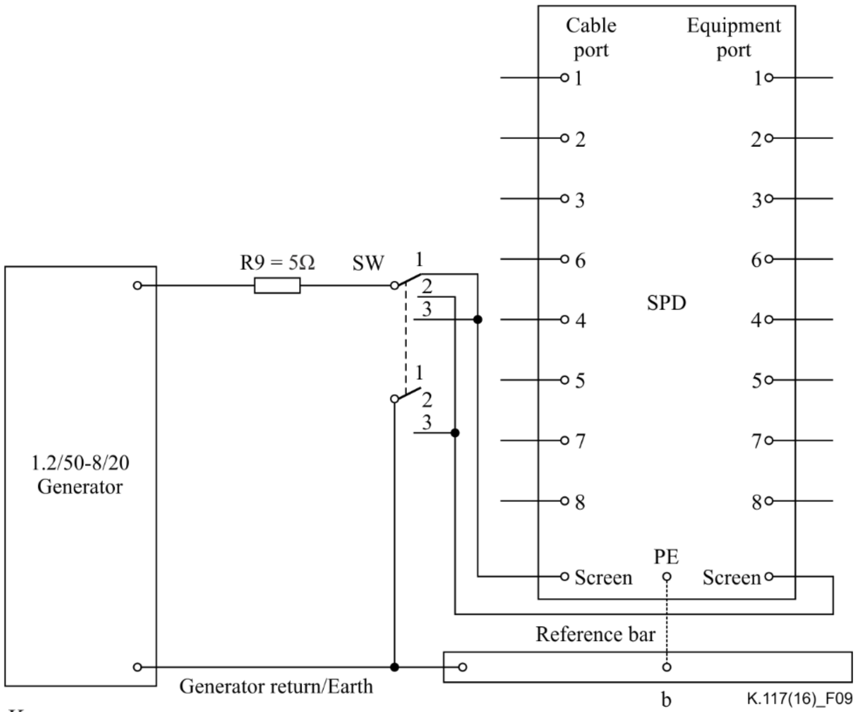
NOTE – Applying the surges first in one polarity, then in the opposite polarity maximises the electrode erosion of Figure 2 type technologies; see [b-ITU-T K.99].

After the surge durability testing, the SPD shall be tested as described in clauses 6.1, 6.2.1 and 6.2.2 at the selected surge levels. The SPD shall still comply with the requirements of these three tests.

6.5 Cable screen terminal

This test verifies the bonding of the cable port screen terminal to protective earth (PE) terminal, the equipment port screen terminal to PE terminal and the cable port screen terminal to the equipment port screen terminal. In the test circuit Figure 9, these test configurations are switch SW positions 1, 2 and 3. SPDs using the Figure 3 type protection may not have a PE terminal.

To test this, set the generator charge voltage to the required level from Table 5, set switch SW for the appropriate test configuration and surge the SPD while measuring the SPD screen voltage of that configuration. Record the measured peak voltage. Repeat this test with the generator voltage polarity reversed. Repeat this procedure for the other appropriate configurations. Finally, measure the d.c. insulation resistance for terminals 1 to 8 of the SPD cable port, as described in clause 7.1.



Key
SW = Double pole, three position selector switch R9 = 5Ω

Figure 9 – Screen bonding test

Table 5 – Preferred maximum values of screen surge voltage based on [b-IEC 60603-7-7] screen contact resistance limits

Generator charge voltage kV	Maximum screen to PE voltage, Figure 9 SW positions 1 and 2 V	Maximum screen to screen voltage, Figure 9 SW position 3 V
2.5	40	80
6	90	180
12	180	360
Manufacturer defined	Manufacturer defined	Manufacturer defined

7 DC tests

7.1 Insulation resistance

Insulation resistance (IR) meters can produce voltages of up to 1 kV d.c. or more. To avoid possible electric shock or personal injury, the safety guidelines issued by the IR meter manufacturer should be followed.

Figure 10 shows the test circuit to measure the insulation resistance of an SPD with a PE terminal or screen terminals, or both connections (protection function corresponding to Figure 2). The insulation resistance is measured between each twisted pair cable port contacts and the PE/screen terminals. [b-IEEE 802.3] requires that "the isolation resistance measured at 500 V d.c. shall be at least 2 MΩ".

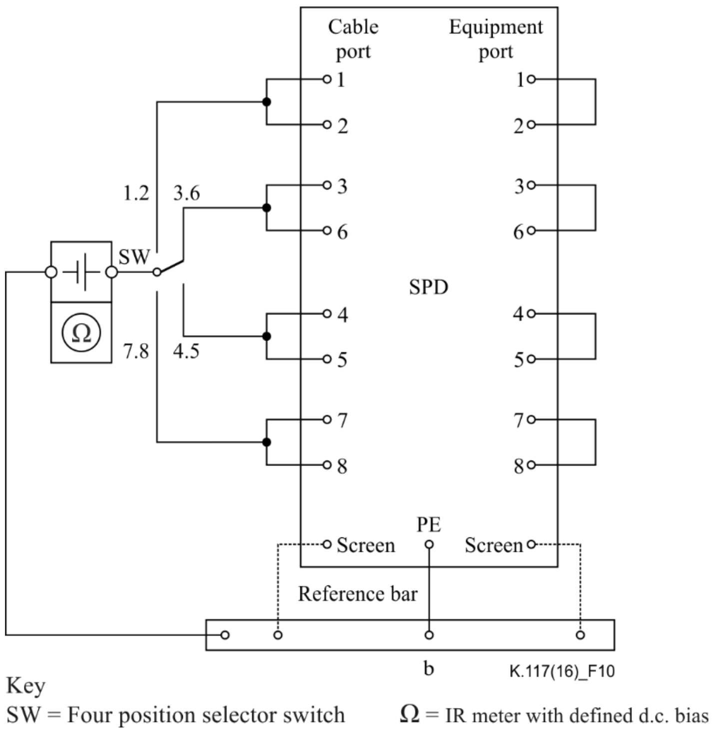


Figure 10 – Test circuit to measure the insulation resistance of an SPD with a PE terminal or screen terminals, or both

Figure 11 shows the test circuit to measure the insulation resistance of an SPD without a PE terminal (protection function corresponding to Figure 3). The insulation resistance is measured between each twisted pair cable port contacts and the equipment port twisted pair contacts.

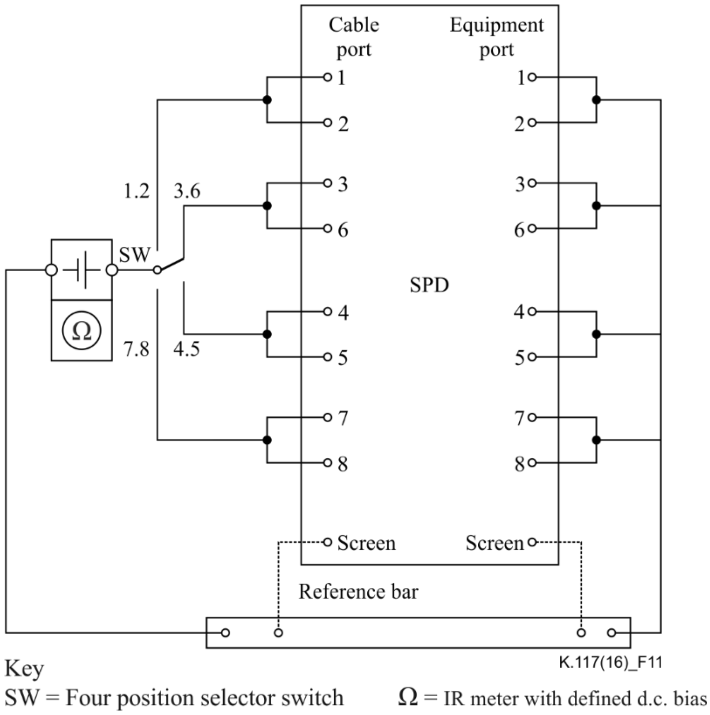


Figure 11 – Test circuit to measure the insulation resistance of an isolating transformer SPD without a PE terminal

This test measures the resistance of the insulation at a defined d.c. voltage. The insulation resistance meter shall be set for a d.c. test voltage of 500 V. The test voltage shall be applied for at least 60 s before the insulation resistance value is taken. The tested SPD must not be modified in any way for this test, for example removing any internal components.

To test this, set switch SW, to select terminals 1, 2. Measure and record the 500 V insulation resistance value. Repeat this procedure with terminals 3, 6 selected, then for terminals 4, 5 selected and finally for terminals 7, 8 selected.

The measured insulation resistance values shall be 2 MΩ or more, measured at 500 V d.c.

7.2 DC voltage drop

An Ethernet SPD intended for PoE will be able to transfer d.c. power in mode A, mode B or both (see clause 6.2.1). It is important that the SPD does not cause a significant power loss and the d.c. voltage drop test verifies the SPD power loss is less than the typical equipment Ethernet PoE transformer.

The test circuit of Figure 12 passes 0.5 A through all the input/output contacts. The individual measured voltages V12, V36, V45 and V78 shall not exceed 0.5 V. This will guarantee the total d.c power feed mode A or B series resistance of the SPD will not exceed 0.5 Ω.

NOTE – This test approach cannot be used for SPDs that isolate the cable side PoE feed from the equipment side PoE feed by means of a d.c./d.c. converter.

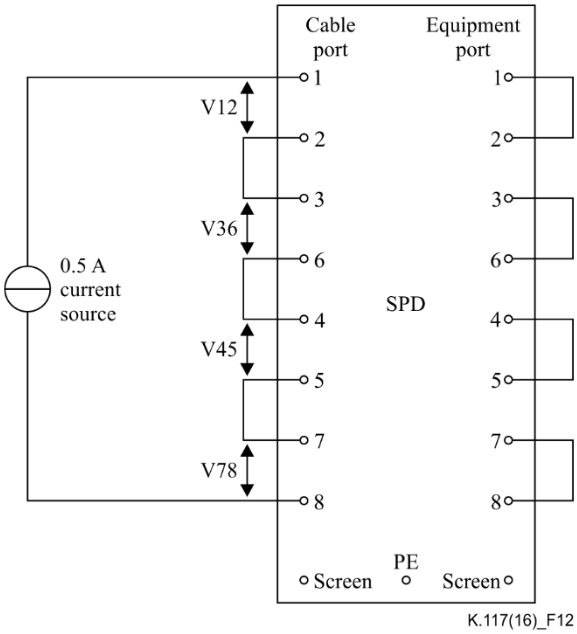


Figure 12 – Test circuit to measure the PoE SPD d.c. input/output voltage drop

8 Identification

8.1 Marking

Legible and permanent marking shall be applied to the SPD, as necessary, to ensure that the user can determine the following information by inspection:

a) manufacturer

b) year of manufacture

c) device number or code

d) port designation (cable or equipment) if the SPD requires specific installation.

If requested and agreed, the customer's identification should be marked on each device.

8.2 Documentation

Documents shall be provided to the user so that from the information in clause 8.1 the user can determine the following additional information:

a) appropriate device parameters as set out in this Recommendation

b) component mounting requirements and processes.

9 Ordering information

The following information should be supplied by the user:

a) drawing giving all dimensions, finishes and termination details

b) type or model

c) quantity

d) quality assurance requirements.

Bibliography

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[b-ITU-T K.82] Recommendation ITU-T K.82 (2010), *Characteristics and ratings of solid-state, self-restoring overcurrent protectors for the protection of telecommunications installations.*

[b-ITU-T K.96] Recommendation ITU-T K.96 (2014), *Surge protective components: Overview of surge mitigation functions and technologies*.

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