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Supplement 25

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SERIES K: PROTECTION AGAINST INTERFERENCE

ITU-T K.117 – Long reach single twisted-pair Ethernet resistibility testing

ITU-T K-series Recommendations – Supplement 25

Supplement 25 to ITU-T K-series Recommendations

ITU-T K.117 – Long reach single twisted-pair Ethernet resistibility testing

Summary

Short distance single-pair Ethernet (SPE) is well established in the automotive industry. The evolved 10 Mb/s SPE, with up to 1 km or more of link length, is aimed at industrial, building and security applications. This relatively new Ethernet variant is still being standardized and a full set of preferred implementation components are not widely available. The first part of this Supplement gives an overview of the SPE system before proposing possible SPE surge protective device (SPD) test circuits.

The long distance between the SPE terminal equipment means that coupled transients can be significantly larger than those tested for in Recommendation ITU-T K.117. The transient levels are higher due to local earth potential rise differences and Ethernet link cable length. The SPE configuration combines the Ethernet signal and any powering voltage on the two SPE link conductors, making the separate measurement of signal and powering protection performance more complicated.

Field data on 10 Mb/s, 1 km SPE resistibility was minimal in 2020 due to lack of deployment. In 2021 there should be wider availability of support hardware such as cable, connectors and Ethernet PHY transceivers. Supplement 25 to the K-series Recommendations is necessarily predictive on resistibility requirements. Once 10 Mb/s, 1 km SPE is widely deployed and field data is available, resistibility requirements can be based on such data and incorporated in the appropriate K-Recommendations.

Certain clauses are still under study.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K Suppl. 25	2021-05-20	5	11.1002/1000/14754

Keywords

10 Mb/s, 1 km, building control, industrial, protection levels, resistibility, security, single-pair Ethernet.

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Table of Contents

Supplement 25 to ITU-T K-series Recommendations

ITU-T K.117 – Long reach single twisted-pair Ethernet resistibility testing

1 Scope

Two-pair and four-pair Ethernet test circuits are defined for equipment in [ITU-T K.44] and for surge protective devices (SPDs) in [ITU-T K.117]. This Supplement proposes 10 Mb/s, 1 km single-pair Ethernet (SPE) test circuits and test levels for SPDs. As 10 Mb/s, 1 km SPE deployment is currently minimal, there is an absence of field data to support resistibility requirements. These proposals are made from extrapolation of existing communications link data and published papers on the subject. The following factors are considered:

- Overvoltage and overcurrent threats;
- Threat coupling;
- Threat levels;
- Threat modes and circuit occurrence; common mode or differential mode occurring on the cable conductors or any cable screening;
- Appropriate components or devices and techniques to mitigate threat levels down to a level that prevents equipment component or insulation failure;
- Ethernet circuit configurations and maximum electrical signal, insulation withstand and powering values to determine the best placement of mitigation measures;
- Ethernet SPE SPD testing.

2 References

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3 Definitions

3.1 Terms defined elsewhere

This Supplement uses the following terms defined elsewhere:

3.1.1 balanced cable [ITU-T L.76]: Cable consisting of one or more metallic symmetrical cable elements (twisted pairs or quads).

3.1.2 cable element [ISO/IEC 11801]: Smallest construction unit (for example pair, quad or single fibre) in a cable.

NOTE – A cable element may have a screen.

3.1.3 cabling [ITU-T L.76]: System of telecommunications cables, cords and connecting hardware that supports the connection of information technology equipment.

3.1.4 link [ISO/IEC 11801]: Transmission path between two cabling system interfaces, including the connections at each end.

3.1.5 network powered device (NPD) [ISO/IEC TR 29108]: Device that derives its power from the network.

3.1.6 power source equipment (PSE) [ISO/IEC TS 29125]: Equipment that provides power.

3.1.7 transceiver: [ISO/IEC 14776-121]: Device that both transmits and receives data.

3.1.8 twisted pair [ISO/IEC 11801]: Cable element consisting of two insulated conductors twisted together in a regular fashion to form a balanced transmission line.

3.2 Terms defined in this Supplement

This Supplement defines the following terms:

3.2.1 phantom powering: Transmission of electrical power from power source equipment (PSE) to a network powered device (NPD) using the two balanced data pairs; with the power being applied to the pair balance nodes at the PSE link end and extracted from the pair balance nodes at the NPD link end.

NOTE 1 – The data pair balance node is usually the centre tap of the data pair isolating transformer.

NOTE 2 – When all four pairs of an Ethernet link are used, double phantom powering occurs if the two power transmissions are kept separate. Single phantom powering is considered to occur when the NPD combines the two power transmissions into one.

3.2.2 power over ethernet (PoE): Link phantom powering of a network powered device (NPD) using two or four balanced data pairs connected to a power source equipment (PSE).

3.2.3 power over data line (PoDL): Single-pair Ethernet (SPE) powering of a network powered device (NPD) using the link data conductors connected to a power source equipment (PSE).

NOTE – May also be referred to as single-pair power over Ethernet (SPoE).

3.2.4 injector power source equipment (injector PSE): Entity, located in a link, that provides powering to the link section that connects to the network powered device (NPD).

NOTE – The injector can be a single item or consist of a coupling network with a separate power supply.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

EPR Earth Potential Rise

IC Integrated Circuit

ICT Information and Communication Technology

IP Ingress Protection

IR Insulation Resistance

NPD Network Powered Device

PE Protective Earth

PHY Physical layer

PoDL Power over Data Line

PoE Power over Ethernet

PSE Power Source Equipment

SPD Surge Protective Device

SPE Single-Pair Ethernet

SPoE Single-Pair Power over Ethernet

5 Conventions

None.

6 SPE configuration

SPE uses the link twisted-pair conductors to carry both the Ethernet data and any powering voltage to the network powered device (NPD). Figure 1 shows the basic system arrangement of power source equipment (PSE) and NPD connected by a single twisted-pair cable link.

The Ethernet data path shown uses the conventional isolating transformers, T1 and T2, and the link cable to connect the primary (PSE) and secondary (NPD) physical layer (PHY) transceivers. Common-mode chokes are used to attenuate any common-mode disturbances, and DC blocking capacitors, C1 and C2, are used to prevent a DC path through the transformers. Besides the link end connectors, the link may contain up to a further 10 connectors. It is assumed that the link connectors' contribution to total loop resistance shall not exceed 1 Ω.

The powering path uses the link cable to connect the PSE power source to NPD power conversion. Series differential-mode PSE and NPD chokes are used to mitigate shunt loading of the Ethernet data path. There can be some negotiation between the PSE and NPD before NPD powering occurs as described in [SPE update] and [IEEE 802.3].

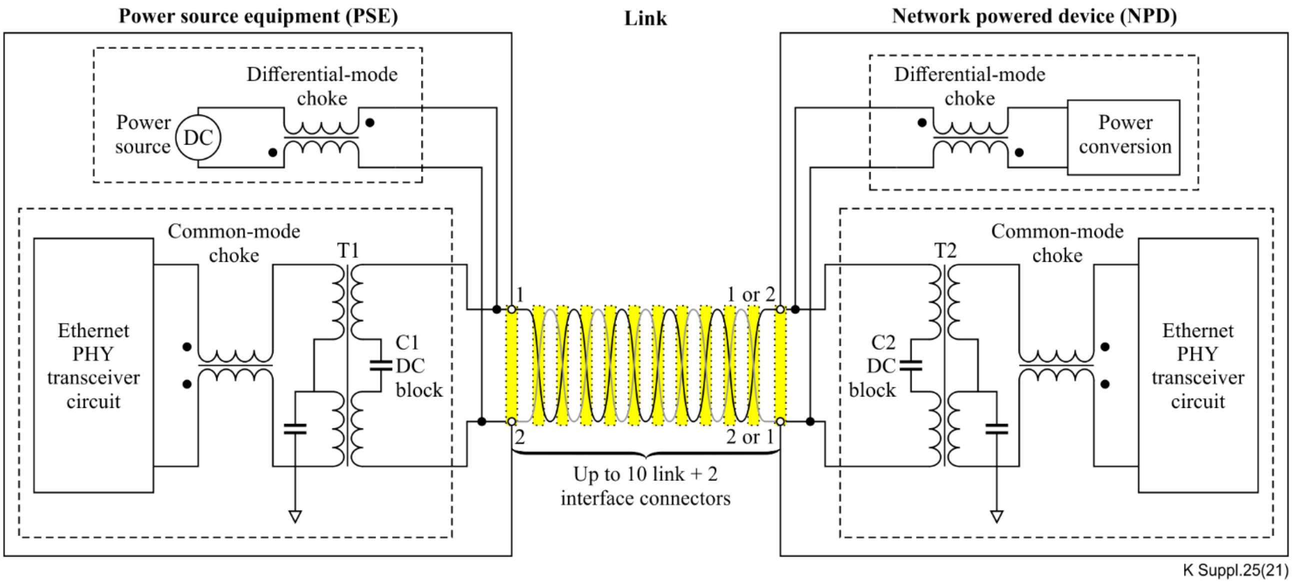

Figure 1 – Basic 10 Mb/s, 1 km SPE system arrangement providing both Ethernet data and powering

Some configurations show the isolating transformers replaced by coupling capacitors. For a webinar discussing these options, see [SPE magnetics]. Unlike power over Ethernet (PoE), with an isolated power source, the SPE system gives the option of earthing the power source. The original powering voltage polarity (PSE terminals 1 and 2) may not be maintained at the NPD connector end of the link, making some powering polarity correction, such as a diode bridge, necessary.

7 10 Mb/s, 1 km SPE overvoltage and overcurrent threats

7.1 General

Surges can couple to a system in four ways: directly (Earth potential rise (EPR), flashover, SPD operation); by magnetic induction; by electrical fields (capacitively); and electromagnetically. These mechanisms are described in [ITU-T K.147]. As the Ethernet link distance is now 1 km and not 100 m, the magnetically coupled disturbances will be larger, as will the PSE and NPD differential EPR. Without any individual flashover or protection common-mode to differential-mode conversion, the main threat will be common-mode voltage.

7.2 Link transmission lines

Although the SPE link is often visualized as a single transmission line, in fact, there are three parallel transmission lines. The obvious transmission line is the twisted-pair conductors, but each conductor forms a transmission line with its local surroundings, which could be the cable screen or, for unscreened cable, the local earth plane. Differential-mode surges travel down the twisted-pair conductors and common-mode surges travel down the conductor to screen or earth plane transmission lines. Figure 2 illustrates the three transmission lines and the surge types that propagate along the lines.

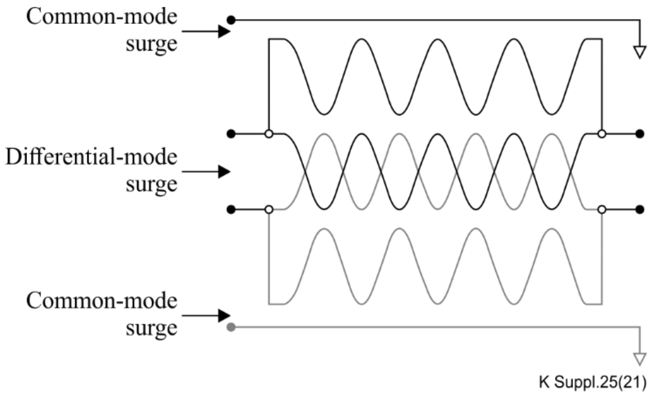

Figure 2 – SPE surge propagation

The differential-mode surge and common-mode surge transmission lines will have different impedances and delay times, particularly for common mode with screen and unscreened cable links. Figure 3 shows examples of a link terminating network [IEC 61156-1].

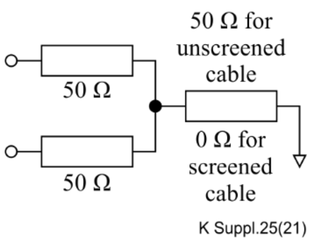

Figure 3 – Signal terminating network for an SPE link cable

Figure 4 shows, for an 2/80 magnetically coupled surge, the terminated 1 km link end voltages (blue and green lines) for screened and unscreened cable. As the unscreened cable common-mode transmission line has the lowest shunt capacitance it has a shorter propagation time (2 µs end to end) than the screened cable (4.5 µs end to end) (propagation time per unit length is approximately equal to the square root of the product of the inductance per unit length and capacitance per unit length).

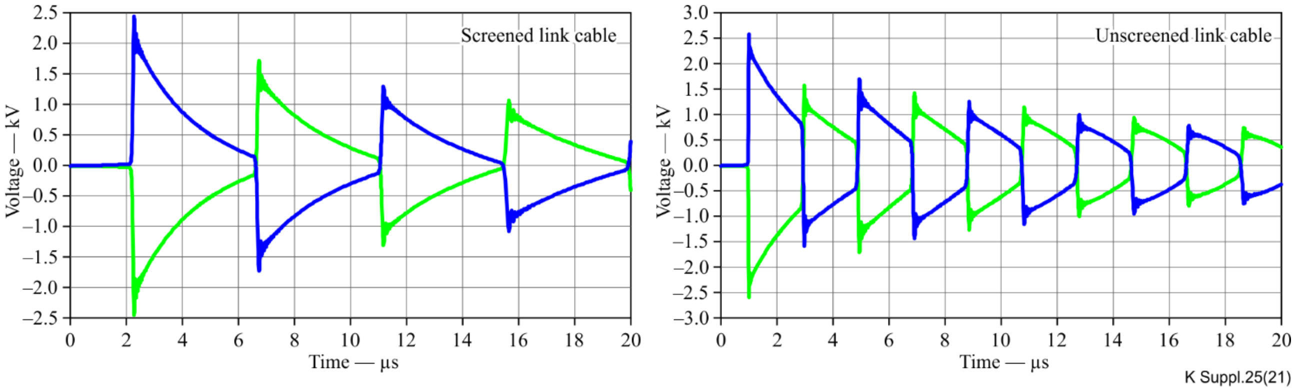

Figure 4 – Magnetically coupled surge voltages at link ends for screened and unscreened cable (terminated 1 km link end voltages — blue and green lines)

7.3 Earth potential rise surges

If the PSE has an earthed power source and there is a 5 kV, 2/80 earth potential rise (EPR, green line), then the unearthed NPD link end can have an even greater voltage (blue line) as shown in Figure 5. Link reflections increase the common-mode NPD voltage by some 60%.

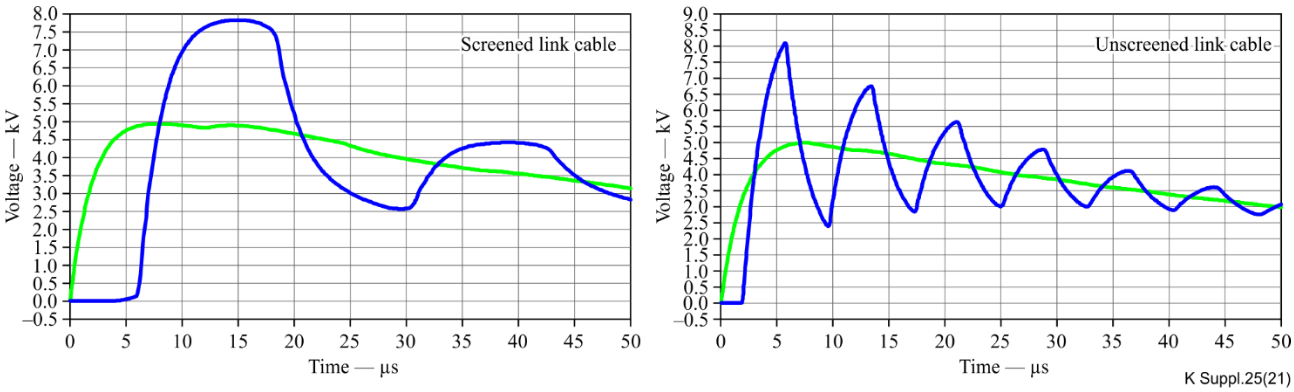

Figure 5 – 5 kV peak earth potential rise at one link end produces some 8 kV at the other link end (EPR – green line; NPD – blue line)

Figure 5 does not include the effect of the PSE differential-mode choke of Figure 1. This choke presents a high impedance to the EPR surge. Figure 6 shows that the 5 kV EPR (green line) is reduced to 2.5 kV at the PSE link connector (blue line) and results in 4 kV (red line) at the NPD link connector.

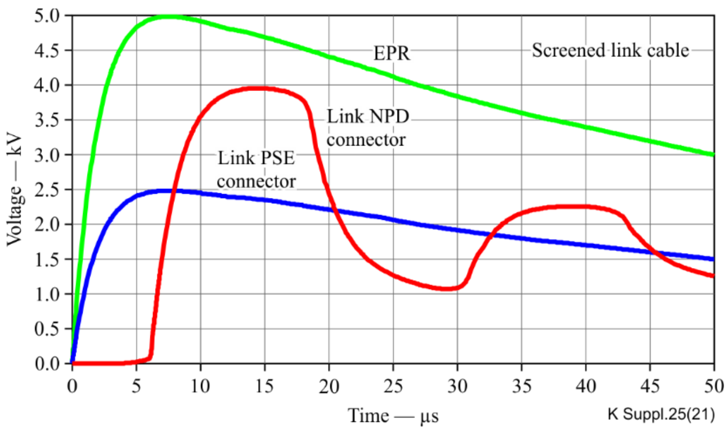

Figure 6 – PSE differential-mode choke EPR link voltage reduction (5 kV EPR — green line; reduced to 2.5 kV at the PSE link connector – blue line; results in 4 kV – red line)

To correctly function, the differential-mode choke must be able to withstand the voltage developed across it and not saturate at the conducted currents. Figure 5 uses a choke inductance of 150 µH. Where the power source is connected to local earthing with EPR, the power source filtering function can strongly control the level of EPR delivered to the link.

7.4 1 km SPE threat levels

Without actual SPE field data being available, material from the following paper, presentation and standard references is used to predict transient stresses caused by lightning events.

Examples of EPR and magnetically induced voltage levels are given in [Martin]. In [Pretorius-3] EPR values of 60 kV for high resistivity soil were reported. The [IEEE 1682] standard observes that when there is a transient EPR event, an SPD can conduct providing a connection to the communication path in the reverse direction from that in which the SPD was intended to operate. This action increases the possibility of equipment damage in communications and power installations. Common-mode protection chokes can increase the transient loop impedance and mitigate voltage and current stress levels. In [Sekioka], induced transient premise values of 6 kV and 4 kA were reported. Papers [Pretorius-1], [Pretorius-2], [Pretorius-3] and [Hanaffi] give further observations on coupled lightning transients.

Based on the above references it would seem that SPE values of 12 kV EPR and 6 kV magnetically induced transient voltages are possible for a 1 km link.

8 SPE component resistibility

8.1 General

Appropriate components or devices and techniques should be used to mitigate threat levels down to a level that prevents equipment component or insulation failure. The SPE circuit configurations and maximum electrical signal, insulation withstand and powering values will determine the best placement of mitigation measures.

8.2 Link cable

Although the cable continuous voltage ratings might be quite low, under transient voltage conditions the cable connectors will often be the factor that limits the maximum voltage. The most critical cable parameter is often the current capability under bundled cable conditions and lightning transient conditions. Results of bundled cable heating experiments are given in [PIA] and [IEC 61156-1-4]. ISO/IEC cabling standards are [IEC 11801-2] and [IEC 11801-3]. The screen of screened cable can carry substantial surge current during an EPR event. Often missing is the parameter for the screen transient current capability. Generally, cables using an outer foil screen will have less transient current capability than cables using an outer braided screen. The screen current level can be reduced by making multiple earthing connections along the link length. Specific 10 Mb/s, 1 km symmetrical single-pair cable standards using nominal conductor diameters between 0.56 mm and 1.7 mm are in development e.g., [IEC 61156-13] and [IEC 61156-14].

SPE can use various sizes of conductor diameter to enable the desired powering reach to be achieved. The general principle for maximum delivered power is for the link loss to be 31% of the total power supplied by the PSE. For a nominal 54 V PSE, the maximum link voltage is 15 V when the minimum NPD voltage is 35 V (50 V minimum PSE voltage). Table 1 shows the relationship between wire size and resistance per unit length.

Table 1 – Wire size and resistance

Wire diameter mm	Wire size AWG	Resistance at 70°C Ω/m
0.4	26	0.16
0.51	24	0.10
0.65	22	0.064
0.81	20	0.040
1.02	18	0.025
1.29	16	0.016
1.63	14	0.010
2.05	12	0.0063

For a nominal 54 V PSE, Figure 7 shows the maximum NPD power capability versus distance for various wire sizes. Preferred power levels are standardized at 7.7 W, 20 W and 52 W.

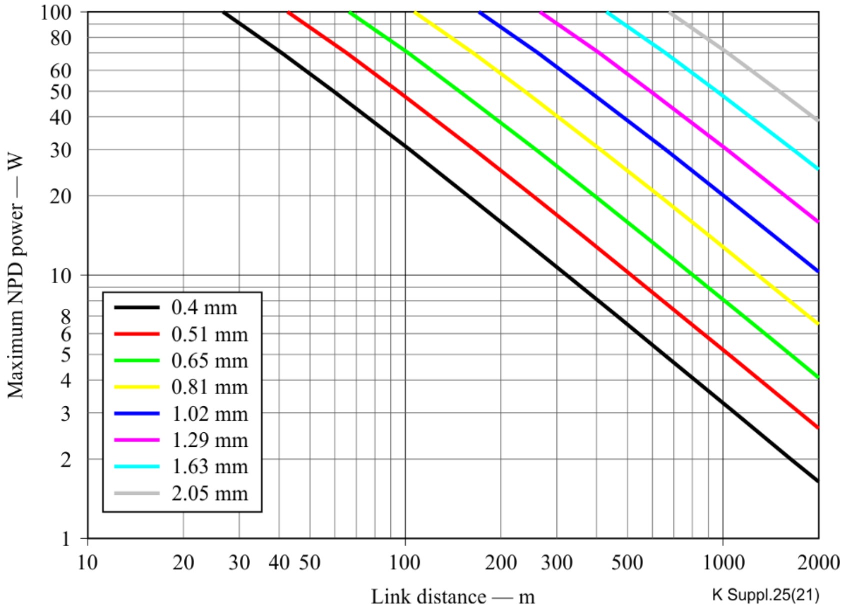

Figure 7 – Maximum NPD power versus distance for various wire diameters (based on a nominal 54 V PSE)

At higher powers the conductor current can be substantial. For example, at 1 km and 50 W, using a 1.63 mm diameter conductor, the conductor operating current will be in the region of 1.5 A.

For a nominal 25 V PSE, the maximum link voltage is 6 V when the minimum NPD voltage is 14 V (20 V minimum PSE voltage). The general principle for maximum delivered power is for the link loss to be 30% of the total power supplied by the PSE.

8.3 Connectors

The standard RJ45 Ethernet connector typically has a DC voltage rating of 1 kV contact to contact and 1.5 kV for all contacts connected together to screen (if applicable). Impulse voltage ratings should be slightly higher.

SPE connectors have many variants. The overall [IEC 63171] standard specifies a contact to contact voltage rating of DC 1 kV and for all contacts connected together to screen (if applicable) a rating of DC 2.25 kV. Level 1 connectors have a 60°C DC rating of 2 A with an absolute maximum of 3.5 A.

Level 2 connectors have a 60°C DC rating of 4 A with an absolute maximum of 7 A. Published subparts of [IEC 63171] define specific physical connector types, [IEC 63171-1], [IEC 63171-2] and [IEC 63171-6], and two further subparts are in development, [IEC 63171-4] and [IEC 63171-5]. Figure 8 shows [IEC 63171-2] and [IEC 63171-5] single SPE connectors with ingress protection (IP) classes of IP 20 and IP 67. Dual and quad SPE connectors are also available.

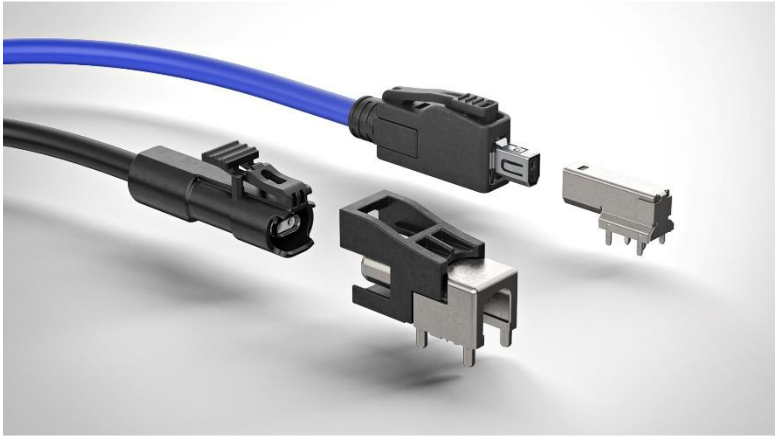

Figure 8 – Examples of single SPE connectors
Photograph courtesy of Rosenberger Hochfrequenztechnik

8.4 Magnetics

Choke and transformer magnetics are shown in Figure 1. The powering differential-mode choke requirements were covered in clause 7.3. The voltage withstand requirement of the common-mode choke depends on its circuit placement. When it is directly connected to the Ethernet PHY transceiver its voltage requirements are quite low. If the common-mode choke is connected between the link interface and the isolating transformer its voltage requirements will be higher.

8.5 Ethernet PHY transceiver integrated circuit (IC)

Available ICs are typically powered by voltages of 3.5 V or less and need a differential protection function that operates at this voltage level.

8.6 Power source and conversion ICs

Generally, the IC technology used for these functions will typically have a maximum IC voltage in the 70 V region for PSE use and the 100 V region for NPD use. For a safety classification of [IEC 62368-1] ES1 the operating powering supply voltage will be somewhat less than 60 V. The IC protection function applied should limit the surge peak voltages to the IC absolute maximum ratings, typically 70 V for PSE and 100 V for NPD.

8.7 SPD protective functions

As the SPE peak voltage will be less than 3.5 V, there are two favoured protection options: clamping diodes to the Ethernet PHY transceiver supply voltage rails inside the equipment; or to using a low capacitance bridged punch-through diode [ITU-T K.103].

To ensure that the DC powering voltage is not a safety hazard it needs to be no more than DC 60 V, as required by [IEC 62368-1]. Assuming avalanche diodes, which have a temperature coefficient of 0.1%/°C [ITU-T K.103], are used for differential-mode protection, the diode 25°C minimum threshold voltage should be 62.7 V based on a minimum ambient temperature of −20°C (lowest recorded lightning temperature is −18°C). If the powering voltage is 5% or 10% lower than 60 V, the 25°C minimum threshold voltages become 59.6 V and 56.4 V. As discussed in clause 8.5, the protection should typically limit the surge peak voltage to 70 V for PSE interface and 100 V for NPD power conversion IC.

Common-mode protection should limit the surge voltage to be below the magnetics, connector, link cable and equipment insulation voltage withstands. Generally, this means that the surge limiting voltage range should be within 1 kV to 2.5 kV, depending on the components being protected. Where there is a possibility of power cross occurring the common-mode minimum threshold protection voltage should be above 500 V. Further, if the power source has a connection to the local earthing, the SPD may need to incorporate overcurrent protection for the power cross condition.

9 Ethernet SPE SPD testing

9.1 General

This part of the Supplement covers the same device parameters as [ITU-T K.117]:

a) Surge tests

b) DC tests

c) Identification and marking.

9.2 Surge tests

9.2.1 General

The objective of an SPE SPD is to mitigate the cable surge voltage 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.

Four [IEC TR 60664-2-1] preferred values of generator charging voltage are used: 2.5 kV, 6 kV, 12 kV and 15 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 and 15 kV are intended for severe installation environments (such as 1 km link length) to protect equipment ports that only have the basic (2.5 kV) or enhanced (6 kV) withstand voltages.

9.2.2 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 9. To test this, set the generator charge voltage to the required level from Table 2, then 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. A minimum of three surges in each polarity must be applied and the recorded value is the highest measured value. Finally, measure the DC insulation resistance of the SPD cable port terminals, as described in clause 9.3.1.

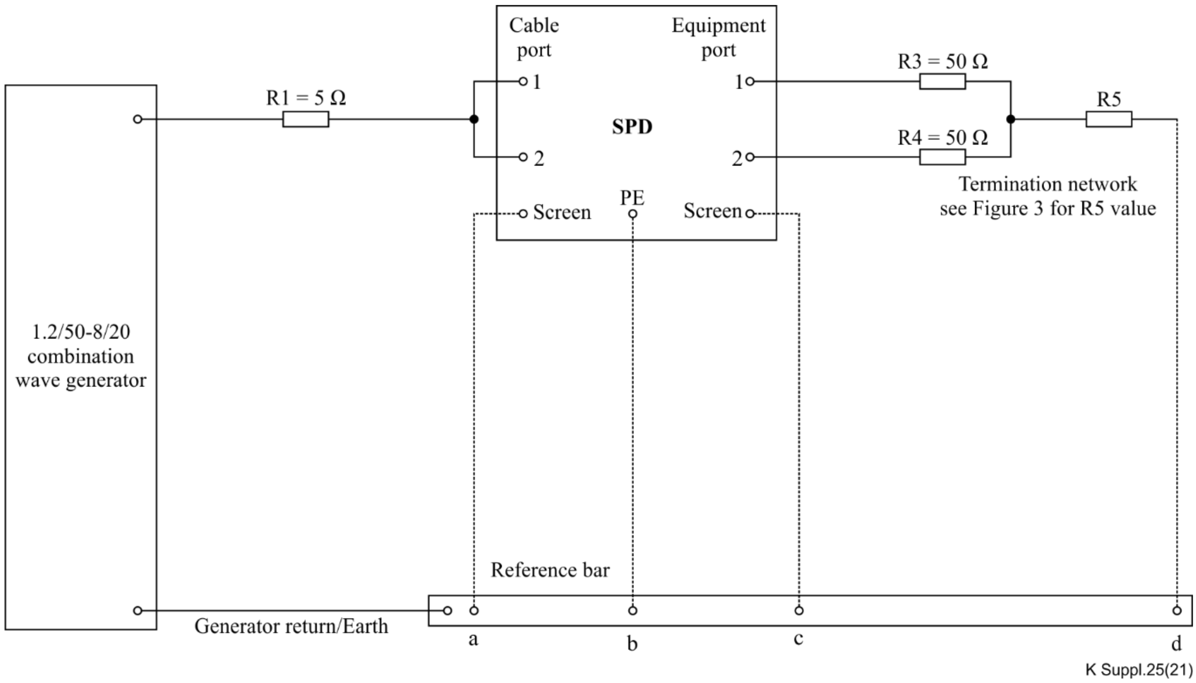

Figure 9 – Impulse limiting voltage under common-mode surge conditions

Table 2 – Preferred values of common-mode impulse limiting voltage

Generator charge voltage kV	Maximum impulse limiting voltage of any SPD equipment port terminal (excluding the screen connection) kV
2.5	1.0
6	1.5
12	2.0
15	2.5
Manufacturer defined	Manufacturer defined

The recorded peak voltages shall not exceed the impulse limiting voltage corresponding to the selected generator charge voltage.

9.2.3 Differential-mode surge

The most critical factor for the Ethernet data path is the surge current waveform as the port termination under surge conditions can be a low value resistance, often 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 IC, which is usually rated in the range of 70 V to 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.

9.2.3.1 Ethernet link

The purpose of this test is to measure the termination differential-mode surge levels of the single twisted pair. The test circuit is shown in Figure 10. Figure 10 shows the test configuration for port terminal pair 1-2 with the generator output connected to terminal 1 via the resistive network of R1 and R2.

To test this, set the generator charge voltage to the required level from Table 3 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. A minimum of three surges in each polarity must be applied and the recorded value is the highest measured value. Finally, measure the DC insulation resistance of the SPD cable port terminals, as described in clause 9.3.1.

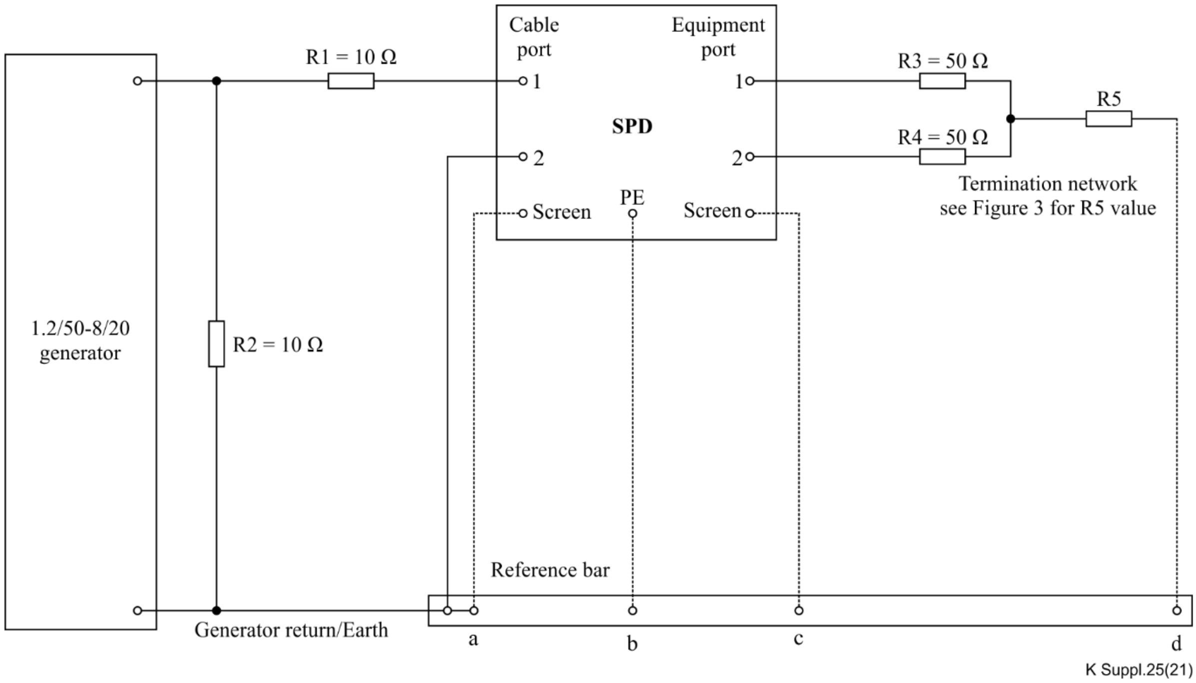

Figure 10 – Single twisted-pair differential-mode surge test circuit

Table 3 – Preferred values of termination peak voltage and current

Generator charge voltage **kV**	**Measured values termination peak voltage** **V**
2.5	100
6	200
12	300
15	350
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 as described in clause 9.3.1.

9.3.2.2 NPD power feed and Ethernet signal limiting

While it is possible to design an SPD with different limiting voltages for signal and powering [PEG], such SPDs are not commercially available at the time of writing. Until such SPD types are available this topic is regarded as being under study (Table 4).

Under study by ITU-T

Figure 11 – Signal and power feed differential mode surge test circuit

Table 4 – Preferred peak voltage

Generator charge voltage kV	Peak signal voltage V	Peak powering voltage V
2.5	Under study	Under study
6	Under study	Under study
12	Under study	Under study
15	Under study	Under study
Manufacturer defined	Manufacturer defined	Manufacturer defined

The recorded peak voltages shall not exceed the peak 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 as described in clause 9.3.1.

9.2.4 Common-mode to differential-mode surge conversion

The purpose of this test is to measure the SPE SPD common-mode to differential-mode surge conversion.

In Figure 12 the generator output connects to the twisted-pair conductors via a 10 Ω feed resistor. The SPD twisted-pair output is terminated with a 100 Ω resistance.

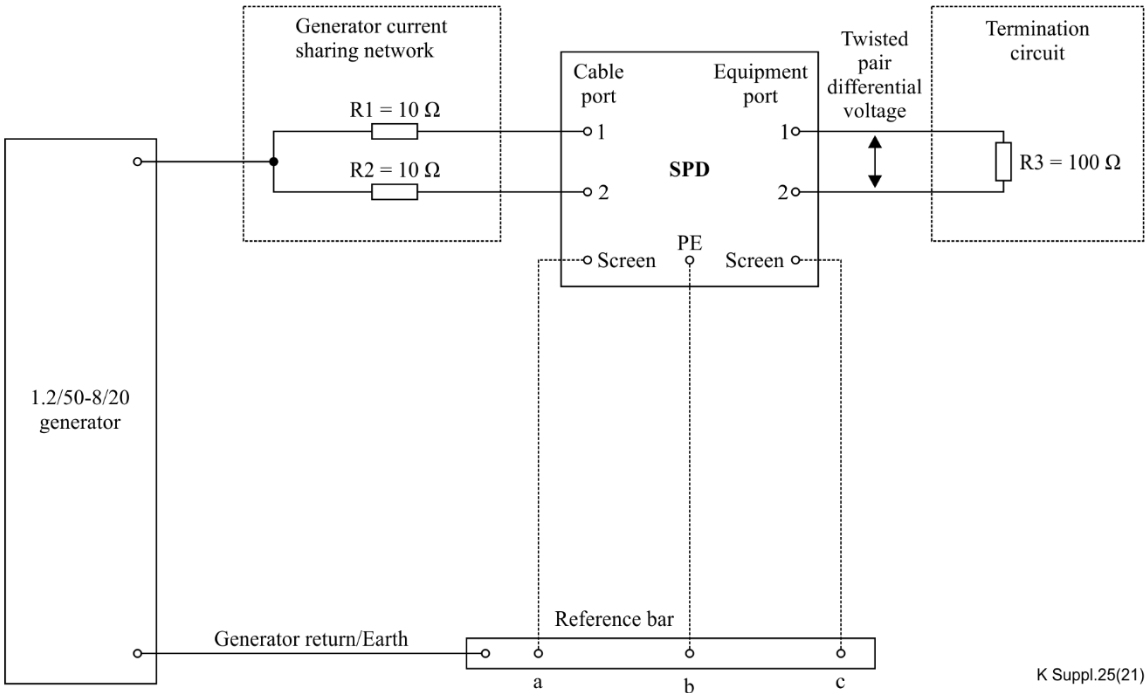

Figure 12 – Twisted-pair common-mode to differential mode voltage surge conversion test circuit

For Figure 12, set the generator charge voltage to the selected level of Table 5 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. A minimum of three surges in each polarity must be applied and the recorded value is the highest measured value.

Table 5 – Preferred maximum values common-mode to differential mode surge voltage

Generator charge voltage kV	Peak differential termination voltage V
2.5	90
6	95
12	100
15	110
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 as described in clause 9.3.1.

9.2.5 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 13, these test configurations are switch SW positions 1, 2 and 3. SPDs using isolating transformers may not have a PE terminal. SPDs employing chokes in the screen or PE connections will develop large voltages and are outside the intent of this test, see clause 7.3.

To test bonding, set the generator charge voltage to the required level from Table 6, 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. A minimum of three surges in each polarity must be applied and the recorded value is the highest measured value. Finally, measure the d.c. insulation resistance of the SPD cable port, as described in clause 9.3.1.

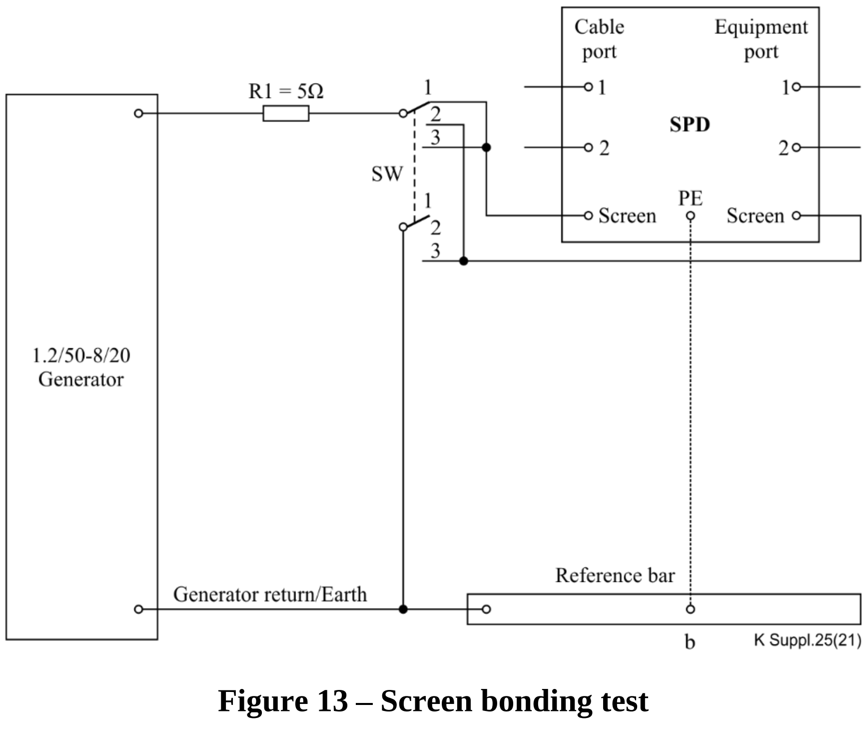

Figure 13 – Screen bonding test

Table 6 – Preferred maximum values of screen surge voltage based on [IEC 60603-7-7] screen contact resistance limits

Generator charge voltage kV	Maximum screen to PE voltage, Figure 13 SW positions 1 and 2 V	Maximum screen to screen voltage, Figure 13 SW position 3 V
2.5	40	80
6	90	180
12	180	360
15	230	450
Manufacturer defined	Manufacturer defined	Manufacturer defined

9.3 DC tests

9.3.1 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 14 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 the twisted-pair cable port contacts and the PE/screen terminals, then repeated for the equipment contacts. For the reason given in clause 8.7 the insulation resistance is measured at 500 V d.c. and shall be at least 2 MΩ.

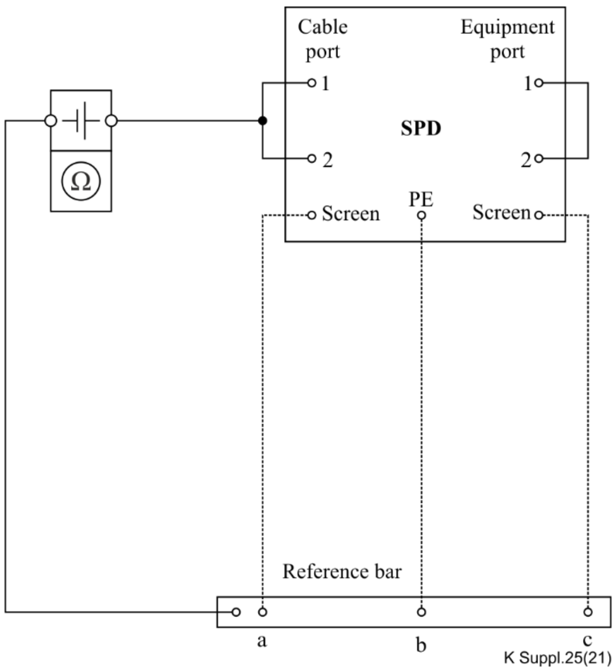

Figure 14 – Test circuit to measure the insulation resistance of an SPD with a PE terminal or screen terminals, or both

For SPDs using isolating transformers, the circuit of Figure 14 can be used without a PE connection. In this case, the insulation resistance is measured between the cable port and the equipment port.

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, by removing any internal components.

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

9.3.2 DC voltage drop

It is important that the SPE SPD does not cause a significant power loss and the d.c. voltage drop test verifies the likely SPE SPD power loss in service.

The test circuit of Figure 15 passes 0.5 A through all the SPD input/output contacts. The loop terminal pair measured voltage shall not exceed 0.1 V. This will guarantee that the total SPD loop resistance will not exceed 0.2 Ω.

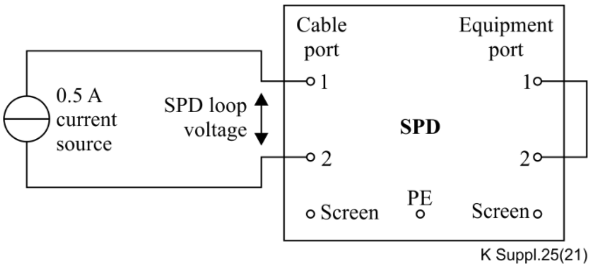

Figure 15 – Test circuit to measure the PoE SPD d.c. input/output voltage drop

9.4 Identification and marking

9.4.1 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.

9.4.2 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 described in this Supplement

b) component mounting requirements and processes.

9.4.3 Ordering information

The following information should be supplied by the user:

a) a drawing giving all dimensions, finishes and termination details

b) type or model

c) quantity

d) quality assurance requirements.

10 Summary

The material in this Supplement represents a topic that is not totally standardized, and its deployment practices are not established. For these reasons, long reach SPE as described in this Supplement should be regarded as being still under study.

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