Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation
Recommendation ITU-T K.44

Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents - Basic Recommendation

Summary
Recommendation ITU-T K.44 seeks to establish fundamental test methods and criteria for the resistibility of telecommunication equipment to overvoltages and overcurrents. Overvoltages or overcurrents covered by this Recommendation include surges due to lightning on or near the line plant, short-term induction of alternating voltages from adjacent electric power lines or electrified railway systems, earth potential rise due to power faults and direct contacts between telecommunication lines and power lines.

Major changes compared with the 2018 version of this Recommendation include:

– removed Appendices I and II and replaced them with ITU-T K.44 supplements;
– added new twisted-pair transverse/differential surge test circuit;
– added Ethernet insulation resistance test to avoid port power cross test;
– revised the test schematics to improve clarity.

History

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

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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Recommendation ITU-T K.44

Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation

1 Scope

This Recommendation describes resistibility tests for all telecommunication equipment against overvoltages and overcurrents for use by network operators and manufacturers.

This Recommendation applies to all telecommunication equipment connected to external or intra-building metallic conductors. It should be read in conjunction with [ITU-T K.11] and [ITU-T K.39], which deal with the general economic and technical aspects of protection.

This Recommendation does not specify either test levels or particular acceptance criteria for specific equipment.

The appropriate test levels and test points are contained in the specific product family or product Recommendation.

Therefore, this Recommendation has to be used together with the product family or product Recommendation dealing with the resistibility requirements relevant to the equipment to be tested.

If a product family or product Recommendation or clause of it differs from this basic Recommendation, the product family or product Recommendation applies. As product Recommendations are updated, they should be coordinated with and refer to this Recommendation.

This Recommendation assumes that the earthing and bonding configurations comply with the appropriate Recommendation related to the type of installation.

The tests are type tests and, although they are applicable to a complete system, it is recognized that they may be applied to individual items of equipment during development and design work. In performing the tests, it is necessary to take into account any conditions, either in the unit under test or elsewhere, which may affect the results.

Electrostatic discharge (ESD) testing is not covered by this Recommendation, and [IEC 61000-4-2] should be followed.

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.


3 Definitions, abbreviations and symbols

3.1 Definitions

To assist in understanding the various definitions used in this Recommendation, refer to Figure 3-1. This figure shows elements associated with protecting the equipment that may be in an installation. Not all of these elements are expected to be used in an installation.
This Recommendation uses the following terms defined here and elsewhere:

3.1.1 **1.2/50-8/20 combination wave generator (CWG):** Generator producing a 1.2/50 open-circuit voltage waveshape and an 8/20 short-circuit current waveshape.

3.1.2 **access network (AN):** That part of the overall telecommunication network that is located between a telecommunication centre and the customer premises building.

3.1.3 **agreed primary protection:** An agreed primary protector is the type of surge protective device (SPD) that will be used to protect the equipment. An agreed primary protector may be a specific SPD or a range of SPDs that comply with a particular Recommendation, standard or specification. The agreed primary protector is often specified by the network operator, but it may be the result of discussions between the network operator and the equipment manufacturer. The agreed primary protector can be 'nothing' if it has been agreed that no external protection elements need to be used for the equipment.

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

3.1.5 **coaxial cable [b-IEC 60194]:** Cable in the form of a central wire surrounded by a conductor tubing or sheathing that serves as a screen and return.

3.1.6 **coupling element:** A coupling element is a low impedance component, under surge conditions, used to connect the surge generator to the port being tested or to couple an untested port to earth.

3.1.7 **customer premises equipment (CPE):** Equipment intended to be directly connected to the termination of a public telecommunication network in a customer's premises.
3.1.8 **decoupling element**: A component with a suitable impedance to reduce the surge amplitude into auxiliary equipment or terminations.

3.1.9 **dedicated power feed (dpf)**: A power feed provided by a dedicated telecommunication cable that leaves the building and is used exclusively to provide the power feed. See also clause 3.1.29.

3.1.10 **embedded primary protection**: High current-carrying protection components, mounted inside the equipment, that form part of the equipment port inherent protection.

NOTE – As mounted high current-carrying protection components are used, field replacement is not usually possible.

3.1.11 **external cable termination point**: The point where the external cable terminates and connects to the building cabling.

NOTE – This is also the point where SPDs would be installed, if required.

3.1.12 **foldback protection device**: A clamping-type voltage limiter that utilizes transistor action to create a re-entrant or "foldback" characteristic.

3.1.13 **high current-carrying protection components**: Surge protective component (SPC) that is typically used in a primary protector surge protective device (SPD) and which can conduct the SPD rated surge current.

NOTE 1 – In most cases the high current-carrying protection component will be a voltage limiter that diverts the surge current, e.g. a gas discharge tube (GDT).

NOTE 2 – These components can be used in equipment ports providing inherent primary protection that removes the need for external primary protection.

3.1.14 **IEEE 802.3 power over Ethernet (PoE)**: Technology simultaneously using an Ethernet cable for normal twisted-pair signalling and a DC powering feed over two or four twisted pairs.

3.1.15 **inherent protection**: Protection that is provided within the equipment either by virtue of its intrinsic characteristics, by specific design, or by suitable protection components.

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

3.1.17 **insulation coordination** [IEC 60664-2-1]: Mutual correlation of insulation characteristics of electrical equipment taking into account the expected micro-environment and other influencing stresses.

3.1.18 **integrated primary protection**: Primary protection surge protective devices (SPDs), mounted inside the equipment, that form part of the equipment port inherent protection.

NOTE – By definition an SPD is a combination of a protection circuit and holder, which should allow field replacement.

3.1.19 **interface ports**:

3.1.19.1 **external port**: Any interface on the equipment that is connected to a cable that exits the building runs outdoor and which may be subjected to conducted a.c. surges and lightning surges.

NOTE – Clause A.2.1 provides guidance on classification of ports.

3.1.19.1.1 **coaxial cable port**: The port connects to a coaxial cable.

3.1.19.1.2 **dedicated power feed port**: The port connects to a dedicated power feed cable.

3.1.19.1.3 **mains power port**: The port connects to a cable that provides mains power.

3.1.19.1.4 **symmetric pair port**: The port connects to a cable with metallic symmetric pair conductors (see [b-ITU-T K.46]). The cable may be shielded or non-shielded. The port may connect to a single pair or multiple pairs.
3.1.19.2 internal port: An internal port is any interface on the equipment that is connected to a cable that does not exit the building and may be subjected to short duration induced transient surges.

NOTE – Clause A.2.1 provides guidance on classification of ports.

3.1.19.2.1 d.c. power interface ports: The port connects to a cable, e.g., a shielded cable that provides d.c. power, e.g., −48 V.

3.1.19.2.2 multiple port: Term that is used to describe equipment with more than one type of port, e.g., a mains port and an external symmetric pair port.

3.1.19.2.3 screened/shielded cable port: Port providing a connection for the screen/shield of a cable.

NOTE – In some cases, such as Ethernet ports, unscreened/unshielded cables may be connected to the port.

3.1.19.2.4 unscreened/unshielded cable port: Port that does not provide a connection for the screen/shield of a cable.

3.1.19.3 intra-building system port: A port used for interconnecting equipment modules of the same system within a telecommunication centre building. The interconnecting cabling is under the control of the equipment manufacturer.

3.1.20 isolating transformer [b-IEC 61558-1]: Transformer with protective separation between the input winding(s) and output winding(s).

3.1.21 IT power distribution system: An IT power system is isolated from earth, except that one point may be connected to earth through an impedance or a voltage limiter. The parts of the equipment to be earthed are connected to earth electrodes at the user premises.

3.1.22 multiservice surge protective device [IEC 61643-12]: A surge protective device providing protection for two or more services such as power, telecommunication and signalling in a single enclosure in which a reference bond is provided between services during surge conditions.

3.1.23 positive temperature coefficient thermistor (PTC): Thermistor in which the resistance increases with increasing temperature throughout the useful part of its characteristic. The PTC thermistors covered in this Recommendation typically exhibit a very sharp increase in resistance over a narrow temperature range.

3.1.24 primary protection: Means by which the majority of the surge stress is prevented from propagating beyond a designated location (preferably the building entrance point).

3.1.25 primary protector: An SPD used for the primary protection of an installation at the location (preferably the building entrance point) where it diverts most of the surge current and prevents the majority of the surge stress from propagating further into the installation. This SPD must be accessible, removable and have equipotential bonding.

3.1.26 protection coordination: The act of ensuring that all protection elements, internal and external to the equipment, react in such a way so as to limit the amount of energy, voltage or current to levels such that damage does not occur to protection elements or equipment.

3.1.27 rated impulse voltage (insulation) [IEC 60664-2-1]: Impulse withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against transient overvoltages.

3.1.28 rated insulation voltage [IEC 60664-2-1]: RMS withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified (long-term) withstand capability of its insulation.

3.1.29 remote power feed: A remote power feed is a power feed provided by symmetric signal pairs or inner conductors of coaxial circuits simultaneously used for signal transmission. Remote power feeds complying with the requirements for a TNV circuit are not classified as a remote power feed.
feed. The requirements for a TNV circuit are provided in [b-IEC 60950-1], and a dedicated power feed (dpf) is defined in clause 3.1.9.

3.1.30 resistibility: The ability of telecommunication equipment or installations to withstand, in general, without damage, the effects of overvoltages or overcurrents, up to a certain specified extent, and in accordance with a specified criterion.

NOTE – Resistibility is considered to cater for the needs of the whole of the telecommunication network, i.e., all types of networks, public and private, as well as any equipment installed in or connected to this network. The resistibility requirements are based on the following electromagnetic phenomena: lightning, power induction, earth potential rise and low-voltage power contact.

3.1.31 screen, shield, (US) [b-IEC 60065-151]: Device intended to reduce the penetration of an electric, magnetic or electromagnetic field into a given region.

3.1.32 screened cable, shielded cable (US): Group of one or more pairs of twisted wires balanced with respect to earth, assembled together and covered by a continuous metallic sheath.

3.1.33 shield [b-IEC 60065-151]: Barrier or enclosure provided for mechanical protection, which may also have the function of a screen.

3.1.34 special test protector: The special test protector is a component or circuit used to replace the agreed primary protector for the purposes of confirming coordination. The special test protector limiting characteristics ensure that the voltage and current levels at the input of the equipment will be higher during the test than in service and provides a level of guarantee that the equipment will be protected by the addition of primary protection.

3.1.35 surge protective component (SPC) [ITU-T K.11]: Constituent part of a surge protective device which cannot be physically divided into smaller parts without losing its protective function.

NOTE 1 – This is a modification to definition of item 151-11-21 (component) in the International Electrotechnical Vocabulary [b-IEC 60050-151].

NOTE 2 – The protective function is non-linear; amplitude restriction effectively begins when the amplitude attempts to exceed the predetermined threshold value of the component.

3.1.36 surge protective device (SPD): Device that restricts the voltage of a designated port or ports, caused by a surge, when it exceeds a predetermined level:

1) secondary functions may be incorporated, such as a current-limiting device to restrict a terminal current;

2) typically, the protective circuit has at least one non-linear voltage-limiting surge protective component;

3) an SPD is a combination of a protection circuit and holder.

3.1.37 telecommunication: Any transmission, emission or reception of signs, signals, writing, images and sounds or intelligence of any nature by wire, radio, optical or other electromagnetic systems [IEC 60050-701].

3.1.38 telecommunication centre: A telecommunication facility where the earthing and bonding is in accordance with [ITU-T K.27].

3.1.39 telecommunication network: A transmission medium intended for communication between equipment that may be located in separate buildings.

NOTE 1 – The term telecommunication network is defined in terms of its functionality, not its electrical characteristics.

NOTE 2 – A telecommunication network may be:

– publicly or privately owned;

– subject to transient overvoltages due to atmospheric discharges and faults in power distribution systems;
subject to permanent port to earth (common mode) voltages induced from nearby power lines or electric traction lines.

NOTE 3 – Examples of telecommunication networks are:

- public switched telephone network (PSTN);
- next generation network (NGN);
- public data network;
- a private network with electrical interface characteristics similar to the above.

3.1.40 **termination component**: A component used to simulate the connection of auxiliary equipment to a tested or untested port.

3.1.41 **thermistor**: Thermally sensitive semiconducting resistor whose primary function is to exhibit an important change in electrical resistance with a change in body temperature.

3.1.42 **transverse (differential) mode voltage**: The voltage at a given location between two conductors, or pairs of conductors, of a group.

3.1.43 **trunk network (TNW)**: That part of the telecommunication network that is located between two telecommunication centres and that provides the communication between the centres.

3.1.44 **TT power distribution system**: A TT power distribution system has one point directly earthed, the parts of the equipment required to be earthed being connected at the user premises to earth electrodes that are electrically independent of the earth electrodes of the power distribution system.

3.2 **Abbreviations and acronyms**

This Recommendation uses the following abbreviations and acronyms:

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<th>Description</th>
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<tr>
<td>a.c.</td>
<td>Alternating Current</td>
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<td>AE</td>
<td>Auxiliary Equipment</td>
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<td>AN</td>
<td>Access Network</td>
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<tr>
<td>ANE</td>
<td>Access Network Equipment</td>
</tr>
<tr>
<td>AUX</td>
<td>Auxiliary</td>
</tr>
<tr>
<td>BN</td>
<td>Bonding Network</td>
</tr>
<tr>
<td>CBN</td>
<td>Common Bonding Network</td>
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<tr>
<td>CPE</td>
<td>Customer Premises Equipment</td>
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<tr>
<td>d.c.</td>
<td>Direct Current</td>
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<td>DMT</td>
<td>Discrete Multitone</td>
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<td>dpf</td>
<td>dedicated power feed</td>
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<tr>
<td>ECL</td>
<td>Electronic Current Limiter</td>
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<td>ECTP</td>
<td>External Cable Termination Point</td>
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<td>EPR</td>
<td>Earth Potential Rise</td>
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<td>ESD</td>
<td>Electrostatic Discharge</td>
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<td>EUT</td>
<td>Equipment Under Test</td>
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<td>GDT</td>
<td>Gas Discharge Tube</td>
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<td>HV</td>
<td>High Voltage (power line of a.c. voltage &gt; 36 kV and &lt; 200 kV)</td>
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<td>IBN</td>
<td>Isolated Bonding Network</td>
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<td>ISDN</td>
<td>Integrated Services Digital Network</td>
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<td>LE</td>
<td>Local Exchange</td>
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<td>LI</td>
<td>Line Interface</td>
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<tr>
<td>LT</td>
<td>Line Termination</td>
</tr>
<tr>
<td>LV</td>
<td>Low Voltage (power line of a.c. voltage &lt; 1 kV)</td>
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<tr>
<td>MDF</td>
<td>Main Distribution Frame</td>
</tr>
<tr>
<td>MET</td>
<td>Main Earthing Terminal</td>
</tr>
<tr>
<td>MOV</td>
<td>Metal Oxide Varistor</td>
</tr>
<tr>
<td>MSPD</td>
<td>Multiservice Surge Protective Device</td>
</tr>
<tr>
<td>MV</td>
<td>Medium Voltage (power line of a.c. voltage &gt; 1 kV and &lt; 35 kV)</td>
</tr>
<tr>
<td>n/a</td>
<td>not applicable</td>
</tr>
<tr>
<td>NGN</td>
<td>Next Generation Network</td>
</tr>
<tr>
<td>NT</td>
<td>Network Termination</td>
</tr>
<tr>
<td>PD</td>
<td>Powered Device</td>
</tr>
<tr>
<td>PoE</td>
<td>Power over Ethernet</td>
</tr>
<tr>
<td>POTS</td>
<td>Plain Old Telephone System</td>
</tr>
<tr>
<td>PS</td>
<td>Power Supply</td>
</tr>
<tr>
<td>PSE</td>
<td>Power Sourcing Equipment</td>
</tr>
<tr>
<td>PSTN</td>
<td>Public Switched Telephone Network</td>
</tr>
<tr>
<td>PTC</td>
<td>Positive Temperature Coefficient thermistor</td>
</tr>
<tr>
<td>RMS</td>
<td>Root Mean Square</td>
</tr>
<tr>
<td>ROEP</td>
<td>Rise of Earth Potential</td>
</tr>
<tr>
<td>RSE</td>
<td>Remote Switching Equipment</td>
</tr>
<tr>
<td>SHDSL</td>
<td>Single-pair High-speed Digital Subscriber Line</td>
</tr>
<tr>
<td>SOHO</td>
<td>Small Office, Home Office</td>
</tr>
<tr>
<td>SPC</td>
<td>Surge Protective Component</td>
</tr>
<tr>
<td>SPD</td>
<td>Surge Protective Device</td>
</tr>
<tr>
<td>SLIC</td>
<td>Subscriber Line Integrated Circuit</td>
</tr>
<tr>
<td>SSA</td>
<td>Solid State Arrester</td>
</tr>
<tr>
<td>SSOP</td>
<td>Solid State Overcurrent Protector</td>
</tr>
<tr>
<td>STP</td>
<td>Special Test Protector</td>
</tr>
<tr>
<td>STPE</td>
<td>Shielded Twisted Pair Ethernet</td>
</tr>
<tr>
<td>SW</td>
<td>Switch</td>
</tr>
<tr>
<td>TCE</td>
<td>Telecommunication Centre Equipment</td>
</tr>
<tr>
<td>TDD</td>
<td>Time Division Duplex</td>
</tr>
<tr>
<td>TN-C</td>
<td>Type of power distribution system</td>
</tr>
</tbody>
</table>
This Recommendation uses the following symbols:

- $U_c$: d.c. charge voltage of the surge generator
- $U_{c\text{ (max)}}$: Maximum d.c. charge voltage of the surge generator
- $U_{\text{a.c. (max)}}$: Maximum a.c. (open) voltage for the a.c. voltage tests

### 4 Overvoltage and overcurrent conditions

Aspects of overvoltage or overcurrent covered by this Recommendation are:

- surges due to lightning strokes on or near to the line plant;
- large currents in common wiring or components when overvoltages or overcurrents occur simultaneously on a number of lines;
- large currents flowing into the equipment when high current-carrying protection components, which eliminate the need for primary protection, are integral to the equipment;
- short-term induction of alternating voltages from adjacent electric power lines or electrified railway systems, usually when these lines or systems develop faults;
- earth potential rise (EPR) due to power faults;
- direct contacts between telecommunication lines and mains power lines;
- transient surges on mains-voltage lines;
- the potential difference which can occur between a TT power distribution system or IT power distribution system and the telecommunication system.

### 5 Resistibility requirements

Telecommunication lines, remote (dedicated) power feeding lines and mains power lines are influenced in the practical environment by lightning or power lines. The several degrees of influence and protection measures are described in [ITU-T K.11](https://www.itu.int). With reference to the resistibility of telecommunication equipment connected to metallic conductors, there may be different resistibility requirements in different environments. An example is the different power systems described in [b-ITU-T K.66](https://www.itu.int). In particular, the TT and IT power systems, which have no connection to the building main earthing terminal (MET), result in higher surges with respect to the MET. It is for administrations or network operators to select the appropriate resistibility requirement from the product family or product Recommendations. In the interest of reducing the number of equipment designs, only the basic and enhanced requirements are specified in the product Recommendations at this point in time.

While the product Recommendations do not provide special resistibility requirements, it is acknowledged that special conditions can exist where even the enhanced resistibility requirements are not sufficient.
Some countries may have different power systems in some areas or it is not possible to install primary protection. [b-ITU-T K.98] shows that multiservice surge protective devices (MSPDs) are an effective way to protect equipment particularly collocated equipment. To protect equipment connected to long internal cables it may be desirable to use MSPDs for the protection of internal ports. MSPDs are readily available for this purpose. This information should be kept in mind when selecting the requirements. It is better to use the higher requirements for all equipment.

5.1 Basic resistibility requirement

This applies to equipment intended for use in:

– environments with a low exposure. The equipment protection is achieved by the inherent protection;
– environments with a high exposure, equipment protection is achieved by the inherent protection and adding the agreed primary protection;
– ports that rely on insulation coordination can add an agreed isolating transformer device of higher rated voltage withstand instead of the agreed primary protection.

5.2 Intermediate resistibility requirement

This resistibility requirement may be applied to the cases that the basic resistibility is not sufficient considering the aspects of environmental condition, and/or customer's requirement on reliability of service, nevertheless, the enhanced resistibility cannot be applied due to the cost. It has better resistibility than the basic requirement, and also it is achieved by relatively small cost addition and has a good price-performance ratio.

5.3 Enhanced resistibility requirement

Where the basic resistibility requirements are not sufficient due to harsh environmental conditions, national regulations, economic and technical considerations, installation standards or reliability of service requirements, network operators may request the enhanced resistibility requirement.

Examples of when "enhanced" resistibility levels may be required include when:

– the \( I^2t \) of power induction and EPR surges exceed 1 A2s;
– primary protector SPDs are not normally installed;
– equipotential bonding at customer premises is difficult to achieve, e.g., the bond wire is greater than 1.5 m long;
– customer equipment has more than one type of port, e.g., mains port plus external telecommunication port or mains port plus internal ports.

5.4 Special resistibility requirement

There are circumstances where even the enhanced resistibility requirements are not sufficient for customer premises due to environmental conditions, national regulations, economic and technical considerations, installation standards or reliability of service requirements. Network operators may then request the special resistibility requirement.

The special resistibility requirement applies when all of the following conditions coexist:

– IT or TT power system;
– earthing and bonding is not installed in compliance with [b-ITU-T K.66];
– primary protection is not installed in compliance with [b-ITU-T K.66] when required by a risk assessment;
– there is difficulty in installing MSPDs.
In this case, the network operator may need to request special resistibility requirements. Some guidance and possible test levels are provided in Annex A of [b-ITU-T K.21] and [b-ITU-T K.45]. Annex A of [b-ITU-T K.21] and [b-ITU-T K.45] contain both test descriptions and requirements for special resistibility requirements. It is proposed that the test requirements, described in clause 7, be amended as indicated.

6 Equipment boundary

The variations of different types of equipment make it necessary for the equipment to be seen as a "black-box" having several ports, a, b, c, d, e and f, etc., and E (earth). It is possible that some protective devices have already been provided in the equipment, either on the printed circuit board, etc., or connected to its ports. For the purpose of these tests, manufacturers are expected to define the boundaries of the "black-box" and any protective device which is included must be considered as an immutable part of the equipment (e.g., small exchange in street cabinet, multiplexer, customer premises equipment (CPE)). Where high current-carrying protection components are used within the equipment, see clause 10.1.1. Where any auxiliary telecommunication wire is provided, e.g., to an extension or as a signalling earth, these wires should be seen to extend the number of terminals to be tested, e.g., a, b, c, d, e and f and E for earth.

7 Test conditions

7.1 Interface ports

7.1.1 Port classification

There are three different ports: external, internal and intra-system.

1) External ports are:
   – symmetric pair;
   – coaxial cable;
   – dedicated power feed (dpf);
   – a.c. mains power.
2) Internal ports are:
   – unshielded symmetric pair cables;
   – shielded cable including symmetric and asymmetric pair shielded cables and coaxial cables;
   – floating DC powering;
   – earth bonded DC powering.

NOTE – Overview of floating and earth bonded DC powering:

DC power: floating and earth-bonded can be single polarity or dual voltage polarity. The plus or minus polarity of single polarity DC powering may be connected to the local equipotential earthing system making the supply earth bonded. Alternatively, the single polarity DC powering can be made floating by not making a direct connection to the local equipotential earthing system.

Dual polarity DC powering can have two configurations. The first configuration consists of two series connected single polarity supplies arranged to give the three voltage polarities of plus, 0 V and minus. Typically, at the DC power source the 0 V is earth bonded. The second configuration consists of a single polarity supply, which has two equal value resistors in series connected across the DC power feed. The connection between the two resistors is earth bonded making the supply effectively float with equal plus and minus voltages with respect to earth, e.g. a single 400 V d.c. supply would have feed voltages of +200 V d.c. and –200 V d.c. The reason for this configuration is to limit the current of any feed conductor to earth by the use of high value resistors and so meet safety standard touch-
current requirements. For more information on bonding configurations and earthing inside a telecommunication building see [ITU-T K.27].

3) Intra-system ports within a telecommunication centre switching system are expected to be interconnected by short cables or shielded cables (e.g., cable screen or cable trays) under the control of the manufacturer. As these types of ports are not normally exposed to damaging overvoltages, requirements have not been specified.

7.1.2 Interface ports

Ports may connect to different cable types and different service types. This is explained in clause A.2.

7.2 Test types

The following types of test need to be performed on equipment, depending on the port type and equipment earthing. These tests are:

– transverse/differential (conductor to conductor and pair to pair for power over Ethernet (PoE));
– external port to earth;
– external port to external port;
– external port to internal port;

NOTE 1 – This test is performed as part of the external port to earth test.
– internal port to earth;
– internal port to internal port.

NOTE 2 – This test is performed as part of the internal port to earth test.

7.2.1 Transverse/differential

A transverse or differential test should be performed on all external port types of the equipment. The test is performed with some untested ports of each port type terminated.

7.2.2 External port to earth

External port to earth tests should be performed on all equipment with external ports. This test is performed with all untested ports (both internal and external) terminated and then repeated with each type of internal port, earthed via a coupling element, in turn.

7.2.3 External port to external port

External port to external port tests should be performed on equipment with more than one external port. When the equipment is designed to be used with a connection to earth, the product Recommendation specifies when the test is to be performed. This test is performed with all untested ports (both internal and external) terminated, with each type of external port, including a port of the same type, earthed via a coupling element, in turn.

It is necessary in external port to external port testing to consider the following as the second port:

1) other lines/pairs of the port type being tested (e.g., pair 1 to pair 2 of port type 1);
2) lines/pairs of other port types (e.g., pair 1 of port type 1 to pair 1 of port type 2).

An example of a test sequence is provided in Figure 7-1. Clause A.2 contains some examples of the different ports and test sequences.
Example test sequence

\( a_1 - b_1 \) (transverse/differential test)

\( a/b_1 - E \) (external port to earth test)

\( a/b_1 - E \) with \( e/f_1 \) coupled to \( E \) (external port to earth test with one internal port coupled to ground)

\( a/b_1 - c/d_1 \) with \( E \) disconnected (external port to external port test with one external port coupled to ground)

\( e/f_1 - E \) (internal port to earth test)

\( e/f_1 - E \) (internal port to earth test with one internal port coupled to ground)

\( i_1/i_2/i_3/i_4/i_5/i_6/i_7/i_8 - E \) (PoE port to earth test)

\( i_1/i_2 - i_3/i_6 \) or \( i_4/i_5 - i_7/i_8 \) (PoE transverse/differential powering pair to powering pair test)

Figure 7-1 – Example of a test sequence

7.2.4 Internal port to earth

Internal port to earth tests are performed on all internal port types classified as an internal port (see clause A.2.1), unless excluded by the product Recommendation. This test is performed with some untested ports of each port type terminated and then with each type of internal port coupled to earth, in turn.

7.3 Test conditions

The following conditions apply to all the tests specified in clause 10.

1) All tests are type tests and are tested under standard operating conditions unless otherwise specified in the product family or product Recommendation.

2) The ports at which tests on the equipment are to be applied should be identified by the manufacturer:

- \( a \) and \( b, c \) and \( d, e \) and \( f \), etc., for different single symmetric pair ports;
- \( a_1 \) to \( a_n \) and \( b_1 \) to \( b_n \), \( c_1 \) to \( c_m \) and \( d_1 \) to \( d_m \), \( e_1 \) to \( e_p \) and \( f_1 \) to \( f_p \), etc., for different multiple symmetric pair ports;
- inner and outer for coaxial cable ports;
- \( dpf_1 \) and \( dpf_2 \), etc., for dedicated power feed ports;
- \( L_1, L_2, L_3 \) and \( N \) for mains power ports; and
- \( E \) is used to designate that point on the equipment nominally connected to the safety earth. In some test configurations this point will not be connected to the safety earth.

Parts labelled on the test schematics are:

- generator return/Earth is used to designate a common reference point connected to safety earth. This connection to safety earth may in some cases be via the test generator;
- equipment under test (EUT) reference bar is used to designate a bonding bar for the EUT.
3) Tests shall be performed with the equipment operating; the only exception to this is during the power contact test. If the power contact test is performed without the equipment being powered, it must not affect the test result. The equipment shall be tested in any operating state of significant duration, see clause A.2.4. To prove compliance, the equipment may need to be tested with both the tested and untested ports terminated and with untested ports coupled to earth, see clauses A.5 and clause 6.5.1 of [b-ITU-T K-Sup.17]. For Ethernet port testing, the equipment is surge tested in a powered condition, but not connected to a LAN. After surge and any insulation resistance testing, the tested equipment performance is verified with a LAN connected.

4) Terminations for the tested and untested ports include auxiliary equipment (AE), e.g., LI, LT, network termination (NT), CPE, a power supply (PS), a simulator or a passive termination. If it is not necessary to have the auxiliary equipment connected in order to verify that the EUT will resist the test voltage, the test may be performed without the auxiliary equipment connected. Where different terminations may occur, e.g., with or without primary protection, these terminations need to be considered, refer to clause 6.5.1 of [b-ITU-T K-Sup.17]. Decoupling elements are used to prevent the surge damaging the auxiliary equipment or termination.

5) Ports may need to be tested with a finite number of untested ports of the same and different types earthed in order to confirm that the equipment fulfils the specified acceptance criteria. Coupling elements are used to earth the appropriate port as required in conditions 7 and 8 below.

6) Transverse/differential tests shall be performed with at least one port of each type of port terminated, except for internal ports.

7) External port to earth tests shall be performed without coupling to earth on the untested ports and also with each type of internal port coupled to earth in turn.

8) External port to external port tests shall be performed with each type of external port, including a port of the same type, coupled to earth in turn.

9) Each test shall be applied the number of times indicated in the product family or product Recommendation. The polarity of lightning surge tests should be reversed between consecutive surges. The time interval between consecutive tests on the same port should be approximately one minute. The tests shall also be applied at longer time intervals, if necessary, to confirm that the equipment fulfils the specified acceptance criteria for surges which occur at intervals exceeding one minute. An example of this is to confirm that the equipment passes when all surges are applied to positive temperature coefficient thermistors (PTCs) at normal operating temperature.

10) When the transverse/differential test is applied between two terminals, one of the terminals shall be connected to the surge generator and the other terminal shall be connected to earth. The test shall then be repeated with the terminals transposed.

11) Power induction tests should be made at the frequencies of the electric power system or the electrified railway systems used in the country of application.

12) In all cases where a maximum voltage, current or \( I^2t \) is specified, tests shall also be made at lower values to confirm that the equipment fulfils the specified acceptance criteria for any voltage, current or \( I^2t \) up to the maximum value specified. Confirming that the equipment complies with the requirements at voltages less than \( U_{c(max)} \) can be performed using either of the two methods described below:

- using knowledge of the protection elements. Clause 6 of [b-ITU-T K-Sup.17] gives an example of how to perform lightning and power induction tests at specific test points to ensure that the equipment complies with the requirements of the product Recommendation. Where the tests are only performed at maximum values, the reason...
shall be given in the test report, e.g., the equipment does not contain switching type secondary protectors;

• using set test levels as described in [b-IEC 61643-21]. If this method is used, tests shall be performed at 20%, 30%, 45%, 60%, 75%, 90% and 100% of $U_{c(\text{max})}$;

• where product Recommendations allow reduced testing, e.g., power contact tests, as many tests as necessary shall be performed in order to confirm that the equipment fulfills the specified acceptance criteria.

NOTE – Particular components which need to be considered during testing include the primary protector, switching or foldback type inherent protectors, PTCs and fuses. Where fuse resistors are used, tests shall be applied at a range of test levels to ensure that the worst case is tested.

13) A new primary protection component (special test protector (STP) or agreed primary protector) may be used if degradation of the protector is thought to, or known to, have occurred.

14) Where components may have significant variations in characteristics which can affect the resistibility level of the equipment, e.g., PTCs where their cold resistance could vary from, for example, 2-7 $\Omega$, tests should be performed on equipment using the worst-case component or by using any other method which achieves the aim. A worst-case component is one which causes the equipment to have the lowest resistibility level.

15) Cards shall be tested in one or more slots as is necessary to confirm that the equipment fulfills the specified acceptance criteria.

16) If a card has two or more identical ports, only one of these needs to be tested in single port tests.

7.4 Test schematics

Refer to Annex A.

8 Protection coordination

8.1 General

For equipment installed in a more exposed environment, it is current practice to protect ports, connected to external metallic conductors, with primary protectors such as gas discharge tubes (GDTs), solid state arresters (SSAs) or metal oxide varistors (MOVs). The best place for the insertion of the primary protection is the border of the building, shelter or equipment housing. This is not always possible but every attempt should be made to place the primary protection as close as possible to the entry point of the cables into the building, shelter or equipment housing. The characteristics of these primary surge protective devices (SPDs) shall comply with the requirements of [ITU-T K.12], [ITU-T K.28] or [IEC 61643-12].

Primary protection coordination is required to ensure compatibility of the equipment with the primary protection. Coordination testing should be done with an agreed primary protector. Ethernet primary protection relying on an isolating transformer to block longitudinal/common mode voltage surges does not divert current to earth like SPDs. This type of Ethernet protector is best placed close to the port it is protecting.

8.2 Lightning

To achieve coordination for protection against lightning surges, the following must occur:
the inherent protection within the equipment must provide protection up to the voltage at which the agreed primary protection operates for generator voltages less than the $U_{c(max)}$ specified in the product family or product Recommendation;

between this voltage and a generator voltage of $U_{c(max)}$, the primary protection must operate and protect the equipment;

the equipment must comply with the specified criterion of the product family or product Recommendation;

the lightning-surge coordination tests use a special test protector (see clause 8.4), instead of the primary protector, to allow the use of a safety factor during the tests. This safety factor includes: the maximum primary protector voltage, tolerances on equipment components, the number of test samples and the effect of multiple impulses. At a generator voltage setting equal to the $U_{c(max)}$ of the product family or product Recommendation, the special test protector must operate. The special test protector may of course also operate at values less than $U_{c(max)}$;

Ethernet primary protection reliant on an isolating transformer to block longitudinal/common mode voltage surges should have a rated impulse voltage greater than the highest expected surge voltage. Such a protection arrangement does not necessarily have an impulse voltage withstand equal to the summation of the port and protector withstands as explained in clause 6.7.5 of [b-ITU-T K-Sup.18].

8.2.1 Primary SPDs with a switching characteristic

Coordination is achieved with a switching type SPD when the special test protector (see clause 8.4.1) is activated with a $U_c$ below the maximum level specified in the relevant product family or product Recommendation, for testing with agreed primary protection, and the equipment complies with the specified criterion of that Recommendation.

8.2.2 Primary SPDs with a clamping characteristic

Coordination with a clamping type SPD is achieved when the equipment complies with specified criterion of the product Recommendation when tested with the special test protector (see clause 8.4.2), when tested at the maximum test voltage and current of the coordination test, i.e., when the primary SPD is conducting maximum current.

8.3 Power induction, earth potential rise and power contact

Protection against power induction and EPR, as a result of a power fault to earth, is achieved by the inherent protection or a combination of the inherent protection and the agreed primary protection.

Protection against power contact must be achieved by the inherent protection unless the equipment is designed to always be used with primary protection. In this case protection is provided by a combination of the inherent protection and the agreed primary protection.

The input impedance to earth of both the a and b inputs of some equipment may be low when the inherent overvoltage protection is activated. In this case, the voltage across the impedance to earth, caused by the current that flows during power induction or EPR, may be too low to activate the primary protection. If the primary protection is not activated, internal heating may damage the equipment.

Testing should be done at a.c. levels that result in overvoltage protector voltages being just below their limiting voltage threshold. These conditions on primary and on any secondary protectors should maximize the equipment power dissipation and temperature rise.

8.4 Special test protector

The special test protector shall have similar behaviour to that of the agreed primary protector.
8.4.1 Switching type protector

The d.c. operating voltage of the special test protector shall be equal to 1.15 times the specified maximum d.c. operating voltage, after life test value, of the agreed primary protector. The tolerance of this firing voltage is ±5%. It should also have a similar impulse to d.c. operating ratio as the agreed primary protector. The manufacturer may use a special test protector with a higher operating voltage.

8.4.2 Clamping type protector

The clamping voltage of the special test protector shall be equal to 1.15 times the specified maximum clamping voltage of the agreed primary protector. The tolerance of this clamping voltage is ±5%. The manufacturer may use a special test protector with a higher operating voltage.

8.4.3 Multistage modules

When the primary protection is a multistage module, replace the primary protection with a special test module which uses components according to clauses 8.4.1 and 8.4.2.

8.5 Selection of the agreed primary protector

A test house or laboratory needs to be given the characteristics of the "agreed" primary protector for the equipment under test so that they can select the special test protector. Information on how to select the "agreed" primary protector for GDTs is contained in [ITU-T K.12].

9 Acceptance criteria

Two acceptance criteria are recognized:

1) Criterion A – The equipment shall withstand the test without damage and shall operate within the manufacturer's specified performance limits after the test without an operator or user having to repower the equipment, perform a software or hardware reset or remove printed circuit cards. The test shall not affect the continuous operation of other hardware and software parts of the equipment, but a temporary degradation of performance is allowed. However, users may need to reinitiate a service, e.g., remake a call or restart a download. It should be ensured that all components of the equipment (e.g., ports, processor unit, display, wireless local area network (WLAN)) will continue to operate without any constraints after the surge. The operation of overcurrent protection may temporarily disable the operation of some ports. The service may not become immediately available straight after the protection resets, for example, retraining may need to occur. It is expected that all ports should recover to normal functionality within a reasonable amount of time, from the cessation of the test, and documented by the equipment manufacturer.

If the power contact test is performed without the equipment being powered, it must not affect the test result. After the test, the system shall operate within the specified performance limits.

2) Criterion B – The equipment may be damaged, but tests must not result in a safety hazard; in particular:

− if a flame occurs, it shall not propagate beyond the equipment; and
− the equipment shall not emit hot materials, e.g., molten metals.

A cheesecloth indicator may be used. In this case, the test shall not damage the structural integrity of the cheesecloth by ignition, charring, forceful ejection of fragments or melted materials into it.

10 Tests

The test generators, test circuits, coupling and decoupling elements and port terminations are provided in Annex A.
Certain considerations which justify the test proposals are stated in [b-ITU-T K-Sup.17]. The response of equipment to surges may be modified by the input impedance of the equipment. To explain this effect, [b-ITU-T K-Sup.17] includes an example circuit and instantaneous levels of voltage at different points in the circuit to show the effect of input impedance. These values are included for illustration only and do not form any part of this Recommendation.

The port types shown in Table 1 are considered. Remote feed telecommunication circuits share the same port as the signal port.

Depending on the equipment, the PoE port either sources power or receives power. 10/100/1000 Base T may use the spare pairs or the signal pairs.

Specific ITU-T K Recommendations may exempt internal port surge testing where the interconnecting cable is not longer than a defined maximum value, e.g., 10 m.

No surge tests are applied to internal ports with cables that are not permanently connected according to the manufacturer's specifications, e.g., maintenance ports.

### Table 1 – Port types

<table>
<thead>
<tr>
<th>Port type</th>
<th>Test type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td>Symmetric pair</td>
<td>Lightning</td>
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<tr>
<td></td>
<td></td>
<td>Power induction and earth potential rise</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mains power contact</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Analogue customer interface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Integrated services digital network (ISDN) basic-rate interface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remote power feeding circuits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>xDSL interface</td>
</tr>
<tr>
<td>Coaxial cable</td>
<td>Lightning</td>
<td>ISDN primary-rate interface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remote power feeding circuits</td>
</tr>
<tr>
<td>Dedicated power feed</td>
<td>Lightning</td>
<td>Optical network unit/termination power feed interface</td>
</tr>
<tr>
<td>(a.c., d.c.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power induction and earth potential rise</td>
</tr>
<tr>
<td>a.c. mains power</td>
<td>Lightning</td>
<td>a.c. mains power</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Earth potential rise and neutral potential rise</td>
</tr>
<tr>
<td>Internal</td>
<td>Unshielded cable</td>
<td>Lightning</td>
</tr>
<tr>
<td>Shielded cable (including coaxial cable)</td>
<td>Lightning</td>
<td></td>
</tr>
<tr>
<td>d.c. power interface</td>
<td>Lightning</td>
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</tbody>
</table>

Ethernet port pairs have common components in the "Smith" termination network and adaptive functionality depending on the LAN data rate. Ethernet ports are tested with the surge being applied simultaneously to all pairs. PoE ports are a special case and have a unique transverse/differential test where the surge is applied to the feed and return powering pairs.

A summary of the applicable tests is given in Table 2. The numbers given in the "port type" columns, e.g., 10.1.2, refer to the appropriate clause number in this Recommendation which discusses this test. The letters "n/a" mean the test is not applicable. The words "under study" mean that ITU-T is still studying this test.
The terms "transverse/differential", "port to earth" or "port to external port" refer to whether the surge is applied transversely/differentially (i.e., line to line, line to shield, or in differential mode), port to earth (line to earth or in common mode) or port to external port (port to port with the earth reference floating).

The terms "single" and "multiple" refer to the number of pairs tested. For a test on an external or internal port with a single pair (single pair port), the surge test is applied on that pair (refer to Figure A.2-6).

If there are different external ports of the same type, the surge test (lightning only) is then repeated on the specified number of pairs of that port type simultaneously, refer to Figure A.2-6.

For a test on an external port with multiple pairs (a multiple-pairs port), the surge test is applied on each pair as for a test on a single pair port, refer to Figure A.2-7.

Then the surge test (lightning only) is repeated on the specified number of pairs of that port simultaneously, refer to Figure A.2-7.

For a test on a product with external ports that consist of different interface types, each connected to a single pair or multiple pairs, the surge test is applied on each pair as for a test on a single pair port, refer to Figure A.2-8.

Then the surge test (lightning only) is repeated on the specified number of pairs simultaneously, refer to Figure A.2-8.

For surge tests on an internal port with a single pair or multiple pairs, the surge test (lightning only) is applied to all pairs of that port simultaneously, refer to Figure A.2-9.

More information and examples are given in clause A.2.
<table>
<thead>
<tr>
<th>Test type</th>
<th>Number of pairs simultaneously tested</th>
<th>Test mode</th>
<th>Primary protection</th>
<th>Port type</th>
<th>Symmetric port</th>
<th>Coaxial port</th>
<th>Dedicated power feed port</th>
<th>Mains power port</th>
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</thead>
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<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
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<td>Lightning voltage</td>
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<td>Transverse/ differential</td>
<td>No</td>
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<td>10.2.1</td>
<td>10.3.1</td>
<td>10.4.1</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Port to earth</td>
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<td></td>
<td>Port to external port</td>
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<td>10.3.1</td>
<td>10.4.1</td>
<td></td>
</tr>
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<td></td>
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<td>10.3.1</td>
<td>10.4.1</td>
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<td></td>
<td>Port to earth</td>
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<td>10.1.1.1</td>
<td>n/a</td>
<td>10.3.1</td>
<td>10.4.1</td>
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<tr>
<td></td>
<td></td>
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<td>10.3.1</td>
<td>10.4.1</td>
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<td>n/a</td>
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<td>10.2.3</td>
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<td>Test type</td>
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<td>Test mode</td>
<td>Primary protection</td>
<td>Port type</td>
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<td>Symmetric port</td>
<td>Coaxial port</td>
<td>Dedicated power feed port</td>
<td>Mains power port</td>
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<tr>
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<td>10.2.3</td>
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<tr>
<td></td>
<td>Multiple</td>
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<td>Multiple</td>
<td>Port to external port</td>
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<td>10.1.2</td>
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<tr>
<td>Power induction and/or earth potential rise</td>
<td>Single</td>
<td>Transverse/differential</td>
<td>No</td>
<td>10.1.3</td>
<td>10.2.4</td>
<td>10.3.3</td>
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Table 2b – Applicable tests for internal ports (Specific K Recommendations may exempt port testing based on interconnecting cable length)

<table>
<thead>
<tr>
<th>Test type</th>
<th>Primary protection</th>
<th>Unshielded cable</th>
<th>Shielded cable</th>
<th>Floating DC power interface</th>
<th>Earthed bonded DC power interface</th>
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<tr>
<td>Lightning voltage</td>
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<td>10.5.3</td>
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</tbody>
</table>
10.1 External symmetric pair port

10.1.1 Lightning voltage

For equipment with high current-carrying protection components, which eliminates the need for primary protection, the following applies:

– if this component is removable, an exception to clause 6 applies and it shall be removed and replaced by the special test protector for the coordination tests, see clause 8.4;

– if this component is not removable, all tests are performed with the protection provided and the manufacturer must provide a test report to show that the coordination tests were performed with the special test protector during the design tests.

10.1.1.1 Single pair

The single port lightning test checks that each port of the equipment has the required level of overvoltage resistibility. Transverse/differential, port to earth, and port to external port tests shall be performed. PoE ports, which combine signal and power, have the transverse/differential test applied to the feed and return powering pairs.

10.1.1.2 Multiple pairs/ports

The multiple pairs/ports lightning surge test checks that the equipment has the required level of resistibility when an overvoltage surge occurs on n pairs or ports simultaneously, which can result in a high current flowing into a common component or part of the equipment.

The number or percentage of pairs or ports to be tested simultaneously is specified in the product family or product Recommendation.

Both port to earth and port to external port tests shall be performed.

Care should be taken in the case where the equipment does not have SPDs to earth. The voltage at the equipment input should not be allowed to exceed the single port test $U_{c(max)}$.

10.1.2 Lightning current

The overcurrent test checks that the equipment has the required level of inherent resistibility when high current-carrying protection components are installed within the equipment to eliminate the need for primary protection. This test checks the coordination of high current protectors, integral to the equipment, with connectors and printed circuits tracks, etc. The overcurrent test is specified in the product family or product Recommendation.

When applying the test to multiple wires, care should be taken to ensure that the current is divided equally between the wires. Particular care should be taken to ensure that the operation of one or more protectors does not prevent the operation of the other protectors.

Both port to earth and port to external port tests shall be performed.

10.1.3 Power induction and earth potential rise

Transverse/differential, port to earth, and port to external port tests shall be performed.

If the equipment port has inherent primary protection, which eliminates the need for primary protection, the following applies:

– if the inherent primary protection is integrated primary protection, an exception to clause 6 applies and the primary protection SPD shall be removed and replaced by the special test protector for both the inherent and coordination tests, see clause 8.4;

– if the inherent primary protection is embedded primary protection, all tests are performed with the protection provided. In addition, the manufacturer must provide a test report to show
that inherent and coordination type testing was performed with high current-carrying protection components having the minimum specified power frequency limiting voltage.

**10.1.4 Mains power contact tests**

Transverse/differential, port to earth, and port to external port tests shall be performed. If the equipment port has inherent primary protection, which eliminates the need for primary protection, the following applies:

- perform the test with the protection as supplied by the manufacturer. Ensure that the protection operates during the test. This may require selecting a line with a protector which has a low limiting voltage. It is not necessary to confirm protector operation if one or more of the following apply:
  - the equipment manufacturer, during the equipment design, has chosen the protector firing voltage so that the protector will not operate for power contact;
  - the equipment input impedance prevents the power contact voltage, at the input of the equipment, from exceeding the specified minimum limiting voltage of the protector type.
- if the inherent primary protection is integrated primary protection, an exception to clause 6 applies and the primary protection SPD shall be removed and replaced by the special test protector for both the inherent and coordination tests, see clause 8.4;
- if the inherent primary protection is embedded primary protection, all tests are performed with the protection provided. In addition, the manufacturer must provide a test report to show that inherent and coordination type testing was performed with high current-carrying protection components having the minimum specified power frequency limiting voltage.

**10.2 External coaxial port**

**10.2.1 Lightning voltage**

The lightning voltage test is applied in differential mode.

For equipment with high current-carrying protection components, which eliminates the need for primary protection, the following applies:

- if this component is removable, an exception to clause 6 applies and it shall be removed and replaced by the special test protector for both the inherent and coordination tests, see clause 8.4;
- if this component is not removable, all tests are performed with the protection provided and the manufacturer must provide a test report to show that the inherent and coordination tests were performed with the special test protector during the design tests.

The lightning test checks that the port of the equipment has the required level of overvoltage resistibility. The tests are applied to the inner conductor. The equipment is tested as installed in the field, e.g., if any components are normally connected between the port and the surge protector, these components should be in place during the surge testing.

**10.2.2 Lightning current differential**

The lightning current test is applied in differential mode.

The overcurrent test checks that the equipment has the required level of inherent resistibility when high current-carrying protection components are installed within the equipment to eliminate the need for primary protection. This test checks the coordination of high current protectors, integral to the equipment, with connectors and printed circuits tracks, etc. The overcurrent test is specified in the product family or product Recommendation.
10.2.3 Lightning current shield test

The lightning current test is applied to the shield.

The overcurrent test checks that the connection of the shield to the frame/earth of the equipment is adequate to conduct the high levels of surge current which may occur in the field. The overcurrent test is specified in the product family or product Recommendation.

Both port to earth and port to external port tests shall be performed.

10.2.4 Earth potential rise

The earth potential rise test is applied in differential mode.

If the equipment has high current-carrying protection components, which eliminates the need for primary protection, the following applies:

– if this component is removable, an exception to clause 6 applies and it shall be removed and replaced by the special test protector for both the inherent and coordination tests, see clause 8.4;

– if this component is not removable, all tests are performed with the protection provided and the manufacturer must provide a test report to show that the inherent and coordination tests were performed with the special test protector during the design tests.

10.3 External d.c. and a.c. dedicated power feeding ports

10.3.1 Lightning voltage

The lightning test is used to check that each port of the equipment has the required level of overvoltage resistibility. Transverse/differential, port to earth, and port to external port tests shall be performed.

For equipment with high current-carrying protection components, which eliminates the need for primary protection, the following applies:

– if this component is removable, an exception to clause 6 applies and it shall be removed and replaced by the special test protector for both the inherent and coordination tests, see clause 8.4;

– if this component is not removable, all tests are performed with the protection provided and the manufacturer must provide a test report to show that the inherent and coordination tests were performed with the special test protector during the design tests.

10.3.2 Lightning current

The overcurrent test checks that the equipment has the required level of inherent resistibility when high current-carrying protection components are installed within the equipment to eliminate the need for primary protection. This test checks the coordination of high current protectors integral to the equipment, with connectors and printed circuits tracks, etc. The overcurrent test is specified in the product family or product Recommendation. Both port to earth and port to external ports tests shall be performed.

10.3.3 Power induction and earth potential rise

Transverse/differential, port to earth, and port to external port tests shall be performed.

If the equipment has high current-carrying protection components, which eliminates the need for primary protection, the following applies:

– if this component is removable, an exception to clause 6 applies and it shall be removed and replaced by the special test protector for both the inherent and coordination tests, see clause 8.4;
if this component is not removable, all tests are performed with the protection provided and the manufacturer must provide a test report to show that the inherent and coordination tests were performed with the special test protector during the design tests.

10.3.4 **Mains power contact**

Transverse/differential, port to earth, and port to external port tests shall be performed. If the equipment has high current-carrying protection components, which eliminates the need for primary protection, the following applies:

- perform the test with the protection as supplied by the manufacturer. Ensure that the protection operates during the test. This may require selecting a line with a protector which has a low firing voltage. It is not necessary to confirm protector operation if one or more of the following apply:
  - the equipment manufacturer, during the equipment design, has chosen the protector firing voltage so that the protector will not operate for power contact;
  - the equipment input impedance prevents the power contact voltage, at the input of the equipment, from exceeding the specified minimum firing voltage of the protector type.

- if this component is removable, an exception to clause 6 (equipment boundary) applies and it shall be removed and replaced by the special test protector (see clause 8.4) and the tests repeated.

If this component is not removable, the manufacturer must provide a test report to show that the tests were repeated with a protector with a firing voltage equal to the specified minimum d.c. firing voltage during the design tests.

10.4 **External a.c. mains power port**

10.4.1 **Lightning voltage**

Transverse/differential, port to earth, and port to external port tests shall be performed.

Three types of primary protector SPDs are known to exist for use on the electricity supply mains, and these are:

1) clamping (MOV) type;
2) switching (spark gap);
3) a combination of both.

Because of the different characteristics of these SPDs, a manufacturer may need to check that this equipment coordinates with all three types.

10.4.2 **Earth potential rise**

ITU-T is studying the need for a test to check resistibility of the equipment from the earth potential rise, which can occur when a high voltage (HV) earth fault occurs on the substation providing mains power to the equipment.

10.4.3 **Neutral potential rise**

This test applies only on the request of the network operator, and when the neutral is not connected to the protective earth (i.e., a TT or IT mains system). An example of such a configuration is described in clause 6.5 of [b-ITU-T K-Sup.18].
10.5 Internal ports

10.5.1 Unshielded cable
The lightning voltage test is to check that the equipment port has the required level of overvoltage resistibility. Only a port to earth test is performed.

10.5.2 Shielded cable
The lightning voltage test is to check that the equipment port has the required level of overvoltage resistibility. Only a port to earth test is performed.

10.5.3 Floating DC power interface
The lightning voltage test is to check that the equipment port has the required level of overvoltage resistibility. Only a port to earth test is performed.

10.5.4 Earthed bonded DC power interface
The lightning voltage test is to check that the equipment port has the required level of overvoltage resistibility. Only a transverse/differential-mode surge test is performed.

10.6 Intra-system ports
Intra-system ports within a telecommunication centre equipment (TCE) are expected to be interconnected by short cables or shielded cables under the control of the manufacturer. Hence, there is a low possibility that overvoltage is induced directly on that cables. However, intra-system ports are exposed to the overvoltage that gets in from other external or internal ports.

From this, by deeming equipment interconnected via intra-system ports as a "combined equipment" and performing the resistibility tests specified for its other external and internal ports, which apply overvoltage to them, the resistibility of its intra-system ports can be considered as compliant, as shown in Figure 10-1.

Therefore, in the case that a manufacturer specifies the dedicated and combined use of multiple equipment as a combined equipment and specifies the cables for this interconnection, which cables shall be short or shielded (cable screen or cable trays, etc.), the ports for this interconnection may be regarded as "intra-system ports". Requirements for intra-system ports have not been specified.

The description above cannot apply to the equipment which may be used as in connection configurations other than that the manufacturer specifies. The ports of a combined equipment connected to other equipment need to perform the specified tests.
Figure 10-1 – Intra-system ports are not tested directly, but by surging the available system internal and external ports
Annex A

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

A.1 Introduction

Equipment needs to be tested in all likely states and conditions. This means that the test specified in each line of the test table may need to be performed many times.

To ensure repeatability of testing by test houses and manufacturers, it is necessary to ensure that the tests are performed in the same way. Below are the generator circuits, coupling, decoupling and powering circuits, the termination of untested ports, and the connection to the EUT.

A.2 Equipment

A.2.1 Equipment ports

Multiple port is the term used to describe equipment with more than one type of port, e.g., a mains port and an external symmetric pair port. Figure A.2-1 shows the possible ports of a piece of equipment with multiple ports.

NOTE 1 – Not all ports need to be tested but they may need to be terminated.

NOTE 2 – “External ports” means ports connected to cables which exit the building and “Internal ports” means ports connected to cables which remain within the building.

Figure A.2-1 – Multiple port equipment

Figure A.2-2 shows the classification of ports of equipment.
Table A.2-1 provides a description of the nodes.

**Table A.2-1 – Description of nodes**

<table>
<thead>
<tr>
<th>Node</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Transition between equipment interface inside the exchange building and the external cabling.</td>
</tr>
<tr>
<td>E</td>
<td>Entrance of the exchange building, e.g., main distribution frame (MDF).</td>
</tr>
<tr>
<td>R</td>
<td>Transition between line and equipment inside a remote site.</td>
</tr>
<tr>
<td>S</td>
<td>External cable termination point (ECTP).</td>
</tr>
<tr>
<td>A</td>
<td>Transition between equipment interface inside the customer's building and the external cabling.</td>
</tr>
<tr>
<td>M</td>
<td>Transition between equipment interface inside the exchange's building and the internal cabling.</td>
</tr>
<tr>
<td>I</td>
<td>Transition between equipment interface inside the customer's building and the internal cabling.</td>
</tr>
</tbody>
</table>

It is necessary to consider the differences between external ports, internal ports and intra-system ports. An equipment port can only be classified as an intra-system port if both of the following apply:

– the port is cabled to an intra equipment port of the same system; and
– the cabling is installed according to the equipment manufacturer's directions.

An equipment port can only be classified as an internal port if all of the following apply:

– it is only connected to intra-building cables;
– the cable is connected to an internal port of the associated equipment;
the equipment and the associated equipment have the same earth reference or the equipment is floating;
- the port will not be connected to an external port of the associated equipment;
- the port is designated by the equipment manufacture to be only suitable for intra-building cable connection;
- the port will not have a conductive connection to a cable which leaves the building via other equipment (e.g., via a splitter).

Any port not complying with the requirements for an intra-building system port or an internal port is an external port.

Figure A.2-3 is an example of port classifications.

Antenna ports on equipment need to be classified according to the location of the antenna and the intended use of the equipment. Where the equipment will only be connected to antennas installed in an inherently protected location, i.e., the shaded area in Figure A.2-4, the antenna port could be classified as an internal port. The complete antenna and all antenna cables have to fit and to be installed into the protected area. If the port could be connected to antennas installed in exposed locations, e.g., antenna positions 1 and 2, the antenna port should be classified as an external port. If it is unclear where the antenna may be installed, it is best to be conservative and classify the antenna port as an external port.

**Figure A.2-3 – Example of port classifications**
Symmetric pair ports may have a single pair or multiple pairs. Equipment may have multiple ports of the same or a different type.

Ports may connect to paired cables, unscreened cables or screened cables including coaxial cables and may connect to different service types including an a.c. port, ADSL port, single-pair high-speed digital subscriber line (SHDSL) port and Ethernet port, etc.

Examples of the different ports are shown in Figures A.2-5 to A.2-9.

The port types above also have a structure and these are:

- **port type**: A port that is connected to an interface with a specific function. The connection can consist of a single pair, multiple pairs, one or more coaxial or shielded cables, etc., e.g., a.c. port, ADSL port, SHDSL port, Ethernet port;
- **single pair port**: A port of a specific type connected to one single symmetric pair, e.g., ADSL port;
- **multiple pairs port**: A port of a specific type where that port is connected to multiple pairs, e.g., SHDSL with one TX pair and one RX pair, Gbit Ethernet port with 4 TX/RX pairs;
- **multiple pair ports**: Ports of different port types where each port is connected to one single pair or multiple pairs, e.g., a number of ADSL ports, a number of SHDSL ports.
Definitions

- ADSL1 port
- ADSL2 port
- SHDSL port
- AC port
- USB port
- Ethernet1 port
- Ethernet2 port

Example of different "Port types": ADSL, AC, USB, SHDSL, Ethernet

Example of a "Single pair port": ADSL1

Example of another "single pair port": ADSL2 (of the same port type)

Example of a "Multiple pairs port": SHDSL

Example of another "Multiple pairs port": Ethernet1 (of a different port type)

Example of another "Multiple pairs port": Ethernet2 (of the same port type (as Eth1))

Figure A.2-5 – Examples of equipment ports
For a test on an external or internal port with single pair (single pair port),
the surge test is applied on that pair (Test 1).
If there are different ports of the same type, the surge test (lightning only) is
then repeated on the specified number of pairs of that port type simultaneously (Test 2).

NOTE 1 – The tests are specified in clause 10.
NOTE 2 – The tests on this Figure mainly apply to line cards with a large number
of ADSL ports.

**Figure A.2-6 – Examples of equipment ports**
For a test on an EXTERNAL port with multiple pairs (multiple pairs port), the surge test is applied on each pair as for a test on a single pair port (Tests 1 and 2). The surge test (lightning only) is then repeated on the specified number of pairs of that port simultaneously (Test 3).

**Figure A.2-7 – Examples of equipment ports**

NOTE – The tests are specified in clause 10.
For a test on a product with external ports that consist of different port types, each connected to a single pair or multiple pairs, the surge test is applied on each pair as for a test on a single pair (Tests 1, 2 and 3). The surge test (lightning only) is then repeated on the specified number of pairs simultaneously (Test 4).

![Diagram](image)

**NOTE** – The tests are specified in clause 10.

**Figure A.2-8 – Examples of equipment ports**

For surge tests on internal ports with a single pair or multiple pairs, the surge test (lightning only) is applied to all pairs of that port simultaneously (Test 1).

![Diagram](image)

**NOTE** – The tests are specified in clause 10.

**Figure A.2-9 – Examples of equipment ports**

### A.2.2 Equipment type

Equipment may be of two general types: earthed and floating. Generally, TCE will be of the earthed type. Access network (AN) equipment and customer equipment may be either type.

### A.2.3 Protection type

Protecting equipment from high current surges is achieved by either installing primary protection or using equipment with integral high current protection. Generally, TCE will be protected by primary
protection installed on the MDF. Access network equipment (ANE) may be protected using either method. Customer equipment would normally be protected by installing primary protection.

A.2.4 Equipment conditions and states
As the components in the equipment, which are connected to the equipment port under test, may vary depending on which state the equipment is in, the equipment must be tested in all operating states of significant duration. Examples of equipment states that may need to be considered include:

- handset "on hook" and "off hook";
- power feed "on" and "off";
- during ring;
- during line test cycle, etc.

A.3 Test generators
Examples of circuits of test generators, which can be used to generate the waveforms specified in clause A.4, are contained in Figures A.3-1 to A.3-6. While the components shown should give the correct waveform, they may require adjustment.

Alternative test generators may be used providing that they give the same result.

NOTE 1 – The 10/700 open-circuit voltage waveshape shall have a front time of 10 µs ±3 µs and a time to half value from virtual zero of 700 µs ±144 µs.

NOTE 2 – The 5/320 short-circuit current waveshape in a single output of R = 25 Ω connected to the generator return shall have a front time of 5 µs ±1.0 µs and a time to half value from virtual zero of 320 µs ±64 µs.

NOTE 3 – All resistors shall have a ±5 % tolerance and all capacitors a ±10 % tolerance.

Figure A.3-1 – 10/700 µs voltage surge generator

NOTE 1 – The 1.2/50 open-circuit voltage waveshape shall have a front time of 1.2 µs ±0.36 µs and a time to half value from virtual zero of 50 µs ±10 µs as defined in IEC 60060-1:2010.

NOTE 2 – All resistors shall have a ±5 % tolerance and all capacitors a ±10 % tolerance.

Figure A.3-2 – 1.2/50 µs voltage surge generator
The test generator may be a 1.2/50-8/20 combination wave generator as detailed in Figure A.3-5 or an equivalent 1.2/50 voltage surge generator.

NOTE 1 – Any unused output shall be connected to the generator Return terminal to maintain the correct output current waveshape.

NOTE 2 – The 2 kV charge voltage is for 1 kA on each output. The 10 kV charge voltage is for 5 kA on each output.

NOTE 3 – The 8/20 short-circuit current waveshape shall be according to [IEC 62475] having a front time of 8 µs ± 20% and a time to half value from virtual zero of 20 µs ± 20%. The opposite polarity current undershoot shall not exceed 30% of the peak current.

NOTE 4 – The capacitor C tolerance is ±10 % and ±5 % for the resistors and inductors. For safety, a bleed resistor should be connected across the charging capacitor to ensure that it is completely discharged in the longer term.

**Figure A.3-3 – 2/10 µs voltage surge generator**

**Figure A.3-4 – Six output 8/20 current generator**

Equivalent test generator arrangements may be made by adding current sharing resistors to the output of standard generators. After the addition of current sharing resistors the short circuit output current must be an [IEC 62475] compliant 8/20 waveshape of the required amplitude. Sufficient voltage must be available to cause conduction of all the equipment primary protection components under test. Such test generators may be:

- any 8/20 surge current generator capable of producing the required current waveform and sufficient voltage;
- if suitable, a combination wave generator, as detailed in Figure A.3-5, capable of producing the required current waveform and sufficient voltage.
NOTE 1 – The 1.2/50 open-circuit voltage waveshape shall be according to [IEC 60060-1] having a front time of 1.2 µs ± 30% and a time to half value from virtual zero of 50 µs ± 20%.

NOTE 2 – The 8/20 short-circuit current waveshape shall be according to [IEC 62475] having a front time of 8 µs ± 20% and a time to half value from virtual zero of 20 µs ± 20%. The opposite polarity current undershoot shall not exceed 30% of the peak current.

NOTE 3 – The ratio of peak open-circuit voltage to short-circuit current \( R_i \) shall be 2 Ω ± 10%.

**Figure A.3-5 – Combination wave generator**

For the value of \( R \), refer to the appropriate test table in the appropriate product Recommendation.  
NOTE – If national regulations require it, the maximum current may be limited.

**Figure A.3-6 – Power induction, power contact and rise of neutral potential generator**

### A.4 Waveform generation

Where circuit values are provided, use this circuit. Where generator circuits are not given, refer to the quoted IEC standard, or [IEC 60060-1]/[IEC 62475] for guidance on verifying the waveform.

The following tolerances should be observed for both the power induction and power contact tests:

- **Voltage**  
  -0% to +5%

- **Current**  
  -0% to +5%

- **Time**  
  -0% to +10%

The procedure for verifying the tolerances of the above parameters for Figure A.3-6 is given below.

*Step 1*  
With both of the output terminals \( g_1 \) and \( g_2 \) in an open-circuit condition, check that the voltage is within the allowed tolerance.

*Step 2*  
With both of the output terminals \( g_1 \) and \( g_2 \) in short-circuit condition, check that the current is within the allowed tolerance.

*Step 3*  
With the output terminal \( g_1 \) in an open-circuit condition and with \( g_2 \) in a short-circuit condition, check that the voltage on terminal \( g_1 \) and the current in circuit \( g_2 \) are within the allowed tolerance.
Step 4  With the output terminal $g_2$ in an open-circuit condition and with $g_1$ in a short-circuit condition, check that the voltage on terminal $g_2$ and the current in circuit $g_1$ are within the allowed tolerance.

Step 5  With both of the output terminals $g_1$ and $g_2$ in an open-circuit condition, check that the length of the surge is within the allowed tolerance.

A.5  Powering, coupling, decoupling and terminations

A.5.1  General

The surge generator, powering, coupling and decoupling elements, the EUT and terminations are connected as shown in Figure A.5-1.
EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.

**Figure A.5-1 – Block diagram of a typical test set-up**
Coupling elements are used to connect the surge generator to the EUT and to connect other ports/lines to earth during port-to-port testing. The coupling element, if required, can be a MOV, a GDT, a capacitor or any other element with an operating voltage in excess of the maximum EUT working voltage. The coupling element should be considered as an integral part of the test generator and should not significantly affect the open-circuit voltage nor the short-circuit current. It may be necessary to increase the test voltage to compensate for voltage drop in coupling elements. There are a number of ways of connecting coupling elements to earth and some examples are shown in Figure A.5-2b.

Decoupling elements are used to reduce the level of surge, which would otherwise enter the powering equipment, auxiliary equipment or terminations. The decoupling elements, if necessary, have an impedance that reduces the level of surge entering the line simulator (e.g., a resistance of 200 Ω or greater, for symmetric pair circuits, an inductor or a choke) but still allowing power and signalling to take place to the EUT. It has to be proven (e.g., by calibration) that the decoupling network does not influence the pulse shape and the test level; otherwise, the test levels have to be adjusted to achieve the correct level. The equipment is powered via the mains or dpf port, etc., through an appropriate decoupling network, e.g., isolation transformer or chokes, etc.

An example of terminations of untested ports is given in Figure A.5-2a. All ports, including the test port, would normally be terminated in some way. Decoupling elements are used to prevent damage to the auxiliary equipment or termination. When required for the test, the appropriate untested port is coupled to earth by using a coupling element.

NOTE – For high speed data circuits it has been found that a more accurate result can be achieved by connecting up to 100 metres of cable between the EUT and the associated data circuit equipment. Using a simple termination may not detect data problems which can later be experienced in the field.

\[ \text{Figure A.5-2a} \quad \text{Example of termination and coupling to earth of untested port} \]

\[ \text{Z}_L, \text{Z}_p \text{ and } \text{Z}_s \text{ are the nominal terminations for a working system or associated equipment.} \]

The SPDs are used to couple the required untested port to ground in turn.

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Rec. ITU-T K.44 (10/2019)
Recommended component values for coupling and decoupling elements are provided in Table A.5-1. Record the method used in the test report. Many of the circuits referenced in Table A.5-1 are under study as they were designed circa 2000 and have not necessarily kept up with the needs of modern communications technology.

**Table A.5-1 – Recommended coupling and decoupling elements**

<table>
<thead>
<tr>
<th>Port type</th>
<th>Test ports</th>
<th>Untested ports</th>
<th>Protection for untested port on EUT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Generator coupling elements</td>
<td>Decoupling element (Note 2)</td>
<td>Decoupling element (Note 2)</td>
</tr>
<tr>
<td>External symmetric pair ports</td>
<td>GDTs or MOVs (Note 1)</td>
<td>See Figure A.5-3</td>
<td>See Figure A.5-10</td>
</tr>
<tr>
<td>External coaxial cable</td>
<td>GDT</td>
<td>See Figure A.5-4</td>
<td>See Figure A.5-11</td>
</tr>
<tr>
<td>External dpf cable ports</td>
<td>MOVs</td>
<td>See Figure A.5-5</td>
<td>See Figure A.5-12</td>
</tr>
<tr>
<td>Mains power ports</td>
<td>MOVs</td>
<td>See Figure A.5-6</td>
<td>See Figure A.5-13</td>
</tr>
<tr>
<td>Internal unshielded cable ports</td>
<td>GDTs or MOVs</td>
<td>See Figure A.5-7</td>
<td>See Figure A.5-14</td>
</tr>
<tr>
<td>Internal shielded cable ports</td>
<td>None required; see Figure A.6.5-2</td>
<td>None required</td>
<td>See Figure A.5-15</td>
</tr>
<tr>
<td>Internal d.c. power ports</td>
<td>MOVs</td>
<td>See Figure A.5-9</td>
<td>See Figure A.5-16</td>
</tr>
<tr>
<td>Ethernet ports</td>
<td>10 Ω resistors</td>
<td>See Figure A.6.7-1</td>
<td>See Figure A.6.7-1</td>
</tr>
</tbody>
</table>

**NOTE 1** – It is allowed (see clause 7.3.3) for the power contact test to be performed without the equipment powered providing it does not affect the test result. The power line contact test generator, Figure A.3-6 incorporates switch (SW) which acts as the coupling element when closed. For power contact testing, the Figure A.6.1-3 generator coupling elements are omitted.

**NOTE 2** – The value of the decoupling resistor may sometimes need to be reduced to enable the system to function. The value of this decoupling resistor should be recorded in the test report.
A.5.2 Tested ports

A.5.2.1 External symmetric pair

When an external symmetric port is the tested port, it is suggested that 200 Ω be inserted in series with each line leg between the AE and the generator. A 33 kΩ in parallel with a 125 V clamping device may be connected between each line leg and earth at the AE to further decouple the AE, see Figure A.5-3. This will limit the current conducted into the AE to a few amps but still allow xDSL, plain old telephone system (POTS) or ISDN transmission even when remote power feeding up to 120 V DC is used. Other values or methods, e.g., an artificial cable, are allowed.

NOTE – The 200 Ω resistors must be capable to dissipate the power resulting from the applied test voltage

Figure A.5-3 – Decoupling network for AE connected to the tested external symmetric pair port

A.5.2.2 External coaxial cable port

When an external coaxial port is the tested port, it is suggested that a capacitor be inserted in series with the centre conductor between the AE and the generator. A coaxial 230 V GDT may be connected at the AE to further decouple the AE, see Figure A.5-4. This will limit the energy entering the AE but still allow transmission. A higher firing voltage GDT may be used if it is necessary for the application.

A high value inductance may be connected in parallel with the capacitor to allow remote power feeding, e.g., 120 V DC. Other values or methods, e.g., an artificial cable, are allowed.
A.5.2.3 External dedicated power feed port

When an external dedicated power feed port is the tested port, it is suggested that 3 mH be inserted in series with each line leg between the AE and the generator. A 125 V clamping device may be connected between each line leg and earth at the AE to further decouple the AE, see Figure A.5-5. This will limit the current conducted into the AE to a few amps for power feeding up to 120 V DC. Other values or methods, e.g., an artificial cable, are allowed.

Figure A.5-5 – Decoupling network for AE connected to the tested external dpf pair port

A.5.2.4 Mains ports

When the mains port is the tested port, it is necessary to decouple the mains source during testing for transverse/differential, port to earth and port to external port surges to protect the power source. Proposed decoupling elements are shown in Figure A.5-6.
If the recommended decoupling element cannot be used for the test, this fact should be noted in the test report. The value of the modified decoupling element should be reported along with the potential impact on the test result.

### A.5.2.5 Internal unshielded cable port

When an internal unshielded cable port is the tested port, it is suggested that 200 Ω be inserted in series with each line leg between the AE and the generator. A 33 kΩ in parallel with an 18 V clamping device may be connected between each line leg and earth at the AE to further decouple the AE. This will limit the current conducted into the AE to a few amps. Other values or methods are allowed.

**NOTE** – Normally, 18 V clamping diodes are used to protect the internal interface. If these diodes prevent normal operation, a diode with a higher clamping voltage may be used. If the 200 Ω decoupling resistor prevents normal operation, a resistor with a lower value may be used.

**Figure A.5-7 – Decoupling network for AE connected to the tested internal unshielded cable port**
A.5.2.6 Internal shielded cable port

Figure A.5-8 has been deleted.

NOTE – A decoupling network is not required for auxiliary equipment connected to the tested internal shielded cable port. See Figure A.6.5-2.

A.5.2.7 Internal DC power interface

The cable connecting the power source equipment and the powered equipment can have sufficient inductance to decouple the two pieces of equipment. To emulate this, it is suggested that 3 mH inductor be inserted in series with each powering conductor, see Figure A.5-9. Other values or methods, e.g., an artificial cable, are allowed.

![Figure A.5-9 – Internal DC power interface – decoupling network between the power source equipment and powered equipment](image)

The generator coupling elements consist of a 10 Ω resistor and a 9 µF capacitor connected in series.

A.5.3 Untested ports

A.5.3.1 External symmetric pair

When an external symmetric pair port is the untested port, it is suggested that 200 Ω be inserted in series with each line leg between the AE and the generator. A 33 kΩ in parallel with a 125 V clamping device may be connected between each line leg and earth at the AE to further decouple the AE. This will limit the current conducted into the AE to a few amps but still allow xDSL, POTS or ISDN transmission even when remote power feeding up to 120 V DC is used.

The methods of termination and coupling to earth for untested external symmetric pair ports are shown in Figure A.5-10.
NOTE – For Ethernet ports, refer to clause A.6.7 and Figure A.6.7-1 a) and b) for the coupling to earth and the decoupling and termination methods.

**Figure A.5-10 – Termination and coupling to earth of untested external symmetric pair ports**

### A.5.3.2 External coaxial cable port

When an external coaxial cable port is the untested port, it is suggested that the methods of termination and coupling to earth shown in Figure A.5-11 are used. Float the AE, and its power source, to "decouple" the AE. Ground the AE and its power supply to "couple" the EUT port to earth, see Figure A.5-18.
A.5.3.3 External dedicated power feed port

When an external dedicated power feed port is the untested port, it is suggested that 3 mH be inserted in series with each line leg between the AE and the generator. A 125 V clamping device may be connected between each line leg and earth at the AE to further decouple the AE, see Figure A.5-12. This will limit the current conducted into the AE to a few amps for power feeding up to 120 V DC. Other values or methods, e.g., an artificial cable, are allowed.
A.5.3.4 Mains ports

When the mains port is an untested port, three states for the mains network have to be considered, and these are:

- the mains distribution network appears as a high impedance network. This applies for a non-earthed neutral installation, e.g., a TT power distribution system. In this case, use 1.5 mH inductors in the L1 and N conductors;
- the neutral is earthed at the customer premises, e.g., a type of power distribution system (TN-C) power distribution system. In this case, connect the neutral conductor to the generator return;
- both L1 and neutral are earthed under surge conditions, i.e., SPDs have been installed. In this case, connect the neutral to earth and install an SPD L1 to N/E.

To test all possible scenarios and to allow testing under the conditions where the port is floating and coupled to earth, use the termination and coupling to earth methods shown in Figure A.5-13.
A.5.3.5 Internal unshielded cable port

When an internal unshielded cable port is the untested port, it is suggested that 200 \( \Omega \) be inserted in series with each line leg between the AE and the generator. A 33 k\( \Omega \) in parallel with an 18 V clamping device may be connected between each line leg and earth at the AE to further decouple the AE, see Figure A.5-14. This will limit the current conducted into the AE to a few amps. Other values or methods, e.g., an artificial cable, are allowed.

**Figure A.5-13 – Terminating and coupling to earth of untested mains ports**

![Diagram of decoupling network for untested mains ports](image-url)
NOTE 1 – Normally, 18 V clamping diodes are used to protect the internal interface. If these diodes prevent normal operation, a diode with a higher clamping voltage may be used. If the 200-Ω decoupling resistor prevents normal operation, a resistor with a lower value may be used.

NOTE 2 – For Ethernet ports, refer to clause A.6.7 and Figure A.6.7-1 a) for the decoupling and termination method.

**Figure A.5-14a – Termination of untested internal symmetric pair ports**
NOTE 1 – Normally, 18 V clamping diodes are used to protect the internal interface. If these diodes prevent normal operation, a diode with a higher clamping voltage may be used. If the 200-Ω decoupling resistor prevents normal operation, a resistor with a lower value may be used.

NOTE 2 – For Ethernet ports, refer to clause A.6.7 and Figure A.6.7-1 b) for the coupling to earth and the decoupling and termination method.

**Figure A.5-14b – Coupling to earth and termination of untested internal symmetric pair ports**

**A.5.3.6 Internal shielded cable port**

When an internal shielded cable port is the untested port, it is suggested that the methods of termination and coupling to earth shown in Figure A.5-15 are used:

- to "decouple" the AE from earth: float the AE and its power supply;
- to "couple" the AE to earth: connect the AE and its power supply to the generator return.

**Figure A.5-15 – Terminating and coupling to earth of untested internal shielded cable ports**
A.5.3.7 Internal d.c. power interface

When an internal d.c. power port is the untested port, it is suggested that 3 mH be inserted in series with each line leg between the AE and the generator. A 115 V clamping device may be connected between each line leg and earth at the AE to further decouple the AE, see Figure A.5-16. This will limit the current conducted into the AE to a few amps for power feeding up to 100 V DC. Other values or methods, e.g., an artificial cable, are allowed.

![Decoupling network](image)

a) Termination of an untested internal d.c. power port

![Decoupling network](image)

b) Coupling to earth and termination of an untested internal d.c. power port

**Figure A.5-16 – Terminating and coupling to earth of untested internal d.c. power interfaces ports**

A.5.4 Protection elements

When performing the coordination test for a tested port to an untested external or internal port, it is necessary to install protection for the EUT on the external or internal port which is coupled to earth.
A.5.4.1 External symmetric pair

Figure A.5-17 – Connection of protection for the untested external symmetric pair port coupled to earth

A.5.4.2 External coaxial cable port

Figure A.5-18 – Connection of protection for the untested external coaxial cable port coupled to earth

A.5.4.3 Dedicated power feed port

Figure A.5-19 – Connection of protection for the untested external dedicated power feed port coupled to earth

A.5.4.4 Mains power port

Figure A.5-20 – Connection of protection for the untested external mains power port coupled to earth
A.6  Test schematics for different types of ports

A.6.1  Symmetric pair ports
Figures A.6.1-1a and A.6.1-1b give the schematic for applying transverse/differential surges. Figure A.6.1-2 gives the schematic for applying surges from port to earth. Figure A.6.1-3 gives the schematic for applying surges from an external port to an external port. Figure A.6.1-4 gives the schematic for applying surges to multiple external ports to earth. Figure A.6.1-5 gives the schematic for applying surges to multiple external ports to an external port.

A.6.2  Coaxial ports

A.6.3  a.c. or d.c. dedicated power feed ports
Figures A.6.3-1a and A.6.3-1b give the schematic for applying transverse/differential surges. Figure A.6.3-2 gives the schematic for applying surges from port to earth. Figure A.6.3-3 gives the schematic for applying surges from an external port to an external port.

A.6.4  Mains power ports
Figure A.6.4-1 gives the schematic for applying transverse/differential surges. Figure A.6.4-2 gives the schematic for applying surges from port to earth. Figure A.6.4-3 gives the schematic for applying surges from an external port to an external port.

A.6.5  Internal cable ports
See Figures A.6.5-1 and A.6.5-2.

A.6.6  DC power ports
Figure A.6.6-1a gives a test circuit for applying a surge to the DC powered equipment port. Figure A.6.6-1b gives a test circuit for applying a surge to the DC power source equipment port. The increasing use of electronic control in power source ports necessitates surge resistibility testing.

In Figures A.6.6-1a and A.6.6-1b, if the power supply system is floating a common-mode/port to earth surge results. When one polarity of the power supply system in bonded to earth the applied common-mode/port to earth surge automatically becomes a differential-mode/transverse surge due to the polarity bonding. Figure A.6.6-1a can also be used for internal port to internal port testing.

A.6.7  Ethernet ports
Figure A.6.7-1 gives the termination and coupling network to earth for untested Ethernet ports. In Figure A.6.7-1 a), the series 10 Ω resistors are only an example. They could be replaced by an Ethernet cable of convenient length. Also, if the Ethernet ports on the AE have a low impedance to earth, it will be necessary to remove the earth connection from the AE and to use a floating PS to power the AE. This is to decouple the AE to prevent it conducting a surge current to earth.

Figure A.6.7-2 gives the schematic for applying a transverse/differential impulse to test the impulse current withstand of the Mode A and Mode B PoE powering feeds.

Figure A.6.7-3 gives the schematic for determining the d.c. insulation resistance and Figure A.6.7-3a provides the schematic for determining the Ethernet port rated impulse voltage.

Figure A.6.7-4 provides additional information for Ethernet longitudinal/common mode surge testing.

All tests on the Ethernet port except for the insulation resistance test are done in the powered condition but not operational. Ethernet port testing may be done in an unpowered condition when the EUT is a PoE powered device (PD), and the PoE power sourcing equipment (PSE), cannot sense the connected PD EUT. The coupling/decoupling network connected between the PSE and PD maximizes the surge...
level applied to the PD but may stop the correct operation of PSE load sensing, causing the PD to be unpowered. When the untested Ethernet port is coupled to earth, the Ethernet circuit will also be non-operational. The insulation resistance test is performed with the equipment unpowered. Subsequently the equipment must be tested in an operational state to verify it still meets its specification.
EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.

Figure A.6.1-1a – Example of a test circuit for a transverse/differential overvoltage or overcurrent on a single external symmetric pair port (a terminal to earth)
Figure A.6.1-1b – Example of a test circuit for a transverse/differential overvoltage or overcurrent on a single external symmetric pair port (b terminal to earth)

EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.
EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.

Figure A.6.1-2 – Example of a test circuit for an overvoltage or overcurrent on a single external symmetric pair port to earth
EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.

Figure A.6.1-3 – Example of a test circuit for an overvoltage or overcurrent on a single external symmetric pair port to another external port
EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.

**Figure A.6.1-4 – Example of a test circuit for an overvoltage or overcurrent on an external multiple symmetric pairs port, external multiple symmetric pair ports or a combination of both, to earth**
EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.

**Figure A.6.1-5** – Example of test circuit for an overvoltage or overcurrent on an external multiple symmetric pairs port, external multiple symmetric pair ports or a combination of both, to another external port
EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.

Figure A.6.2-1 – Example of a test circuit for a differential overvoltage or overcurrent on an external coaxial cable port
NOTE 1 – Output connections to be used for equipment designed to be connected to antennas/equipment exposed to direct lightning currents, e.g., connected to antennas/equipment mounted on a tower.

NOTE 2 – Output connections to be used for applicable equipment not covered by Note 1.

**Figure A.6.2-2** – Example of a test circuit for a lightning shield current test on an external coaxial cable port to earth
NOTE 1 – Output connections to be used for equipment designed to be connected to antennas/equipment exposed to direct lightning currents, e.g., connected to antennas/equipment mounted on a tower.

NOTE 2 – Output connections to be used for applicable equipment not covered by Note 1.

Figure A.6.2-3 – Example of a test circuit for a lightning shield current test on an external coaxial cable port to an external port

EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.
EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.

Figure A.6.3-1a – Example of test circuit for a transverse/differential overvoltage or overcurrent on a single external dpf port (dpf₂ earthed)
Figure A.6.3-1b – Example of test circuit for a transverse/differential overvoltage or overcurrent on a single external dpf port (dpf₁ earthed)

EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.
EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.

Figure A.6.3-2 – Example of test circuit for an overvoltage or overcurrent on a single external dpf port to earth
EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.

**Figure A.6.3-3** – Example of test circuit for an overvoltage or overcurrent on a single external dpf port to external port
Figure A.6.4-1 – Example of test circuit for a transverse/differential overvoltage or overcurrent on an external mains port

NOTE – Total lead length, per SPD, to connect the primary protection shall be one metre

EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.
NOTE 1 – Total lead length, per SPD, to connect the primary protection shall be one metre

EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.

**Figure A.6.4-2 – Example of test circuit for an overvoltage, overcurrent and rise of neutral potential on an external mains port to earth**
NOTE – Total lead length, per SPD, to connect the primary protection shall be one metre

EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.

Figure A.6.4-3 – Example of test circuit for an overvoltage, overcurrent and rise of neutral potential on an external mains port to external port
Figure A.6.5-1 – Example of test circuit for an overvoltage or overcurrent on an internal port connected to an unshielded cable with single or multiple symmetric pairs to earth
For repeatability of measurement, it is recommended that the test be performed on an earth reference plane, with the cable laid on the ground plane in a snake pattern. All conductors are connected together and with the shield. (Reason: in worst case, inserted protective elements in the auxiliary equipment – not included in this test set-up – can cause short circuit termination.)

EUT earthing is as follows:
1) If the equipment has an earthing point, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing point, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing point nor a conductive case, let the equipment float.

Figure A.6.5-2 – Example of a test circuit for an overvoltage or overcurrent on an internal port connected to a shielded cable to earth
DC powered equipment and DC power source equipment earth bonding is as follows:

1) If the equipment has an earthing connection, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing connection, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing connection nor a conductive case, let the item float.
4) If the equipment is intended to bond one of the DC supply polarities to the local earthing system that connection must be made.
5) A common-mode surge is applied to the DC supply, but if one polarity is bonded to earth the applied surge automatically becomes a differential-mode/transverse surge.

External electricity feed
Some DC power source equipment requires an external electricity supply for power.

Coupling network
C1a = C1b = 9 µF, 2 kV
R1a = R1b = 10 Ω

Cable inductance
L1=L2= 3 mH maximum or specifically 2.5xlm µH, where lm is the maximum cable length in m, or a commercial surge generator power decoupling network may be used.

Figure A.6.6-1a – DC power interface – Example of a surge test circuit for the DC powered equipment port
DC powered equipment and DC power source equipment earth bonding is as follows:

1) If the equipment has an earthing connection, connect this point to the EUT reference bar;
2) If the equipment has a conductive case, but does not have an earthing connection, connect the case to the EUT reference bar;
3) If the equipment has neither an earthing connection nor a conductive case, let the item float.
4) If the equipment is intended to bond one of the DC supply polarities to the local earthing system that connection must be made.
5) A common-mode surge is applied to the DC supply, but if one polarity is bonded to earth the applied surge automatically becomes a differential-mode/transverse surge.

**External electricity feed**
Some DC power source equipment requires an external electricity supply for power.

**Coupling network**
C1a = C1b = 9 µF, 2 kV
R1a = R1b = 10 Ω

**Cable inductance**
L1=L2= 3 mH maximum or specifically 2.5xlm µH, where lm is the maximum cable length in m, or a commercial surge generator power decoupling network may be used.

**Figure A.6.6-1b – DC power interface – Example of a surge test circuit for the DC power source equipment port**
Figure A.6.7-1 – Termination and coupling to earth of untested Ethernet ports
SW in position A: Test PoE Mode A powering terminals 1/2-3/6
SW in position B: Test PoE Mode B powering terminals 4/5-7/8
a = RJ45 screen cable connection
b = EUT protective or functional earth connection
c to d = Terminals of all other signal ports
1, 2, 3, 4, 5, 6, 7 and 8 are Ethernet RJ45 pin numbers
R = series current limiting resistor
R1 = optional shunt resistor
NOTE – For PSE, midspan power insertion equipment and PD ports, test in switch (SW) positions A and B. If the power sourcing equipment specifies the powering pairs, then the testing is only done on those pairs.

Figure A.6.7-2 – PoE port powering pair transverse/differential surge test circuit

U_{DC} = DC test voltage (limited to 100 mA)
SW = Switch closed for current measurement
A = A meter used to measure leakage current, I_L
Insulation resistance = U_{DC}/I_L

Secondary circuit reference node connections if available:
a = RJ45 screen cable connection
b = EUT protective or functional earth connection
c to d = terminals of all other signal ports
e = Power port terminals

Figure A.6.7-3 – Ethernet port, including PoE variants, d.c. insulation resistance test circuit
NOTE – This circuit shorts out an injector device or power sourcing equipment power supply. IEEE 802.3 compliant power supplies will not be damaged by this condition.

Figure A.6.7-3a – Ethernet port, including PoE variants, longitudinal/common mode withstand test circuit

1, 2, 3, 4, 5, 6, 7 and 8 are Ethernet RJ45 pin numbers
a = RJ45 screen cable connection for STP1 connections
b = EUT protective or functional earth connection
c to d = Terminals of all other signal ports

NOTE – This circuit shorts out an injector device or power sourcing equipment power supply. IEEE 802.3 compliant power supplies will not be damaged by this condition.
Figure A.6.7-4 – Ethernet port, including PoE variants, longitudinal/common mode to transverse/differential mode conversion surge test circuit

1, 2, 3, 4, 5, 6, 7 and 8 are Ethernet RJ45 pin numbers
a = RJ45 screen cable connection for STP\textsubscript{x} connections
b = EUT protective or functional earth connection
c to d = Terminals of all other signal ports
Twisted pair terminal pairs are 1a + 1b, 2a + 2b through to na + nb served by switches SW1, SW2 through to SWn, respectively.

For each terminal pair, when the switch is up one terminal is connected to the coupling network. When the switch is down that terminal is connected to functional earth.

a = RJ45 screen cable connection for STP connections
b = EUT protective or functional earth connection
c to d = Terminals of all other signal ports
R1 = R2 = 10 Ω
C1 = 0.5 μF, ±10 %, 5 kV, equivalent series resistance (ESR) < 0.5 Ω, inductance < 1 μH, different parasitic values are acceptable provided Note 3 conditions are met.

NOTE 1 – This test is conducted on each terminal pair selected by having that pair switch up and the remaining switches down. Surging is done with alternating polarities.

NOTE 2 – This circuit shorts out an injector device or power sourcing equipment power supply. IEEE 802.3 compliant power supplies will not be damaged by this condition.

NOTE 3 – The initial rate of rise of the short circuit current, di/dt, at 2.5 kV generator charging voltage shall be 60 A/μs ±10 A/μs in the first 0.5 μs.

Figure A.6.7-5 – Twisted pair transverse/differential surge test circuit for ports having one or more twisted pair connections such as Ethernet ports, including PoE variants
Figure A.6.7-6 – Screen/shield connection high current test for an Ethernet screened/shielded cable port

NOTE 1 – This circuit shorts out an injector device or power sourcing equipment power supply. IEEE 802.3 compliant power supplies will not be damaged by this condition.

NOTE 2 – This test is also applied to any Ethernet port that fails the insulation resistance test in any polarity.

NOTE 3 – This test is not applied to any Ethernet port that passes the insulation resistance test in both voltage polarities.

Figure A.6.7-7 – External Ethernet port, including PoE variants, power cross test circuit
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