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# Classification of interface for application of standards on resistibility and safety of telecommunication equipment

Recommendation ITU-T K.75

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## Classification of interface for application of standards on resistibility and safety of telecommunication equipment


### Summary

Recommendation ITU-T K.75 provides guidance to manufacturers, network operators and test houses on the classification of the type of interface, i.e., external (subjected to a.c. surges or conducted lightning surges) or internal (subjected to short fall-time transients induced into building cabling).

This Recommendation defines telecommunication overvoltage categories as a function of the inherent resistibility voltage of the equipment port or interface. For each category, the impulse withstand voltages between the telecommunication interface and the person or hazardous circuit have been defined (peak value and waveshape).

These peak values and waveshapes should be suitable for insulation coordination purposes.



### Source

Recommendation ITU-T K.75 was approved on 13 April 2008 by ITU-T Study Group 5 (2005-2008) under Recommendation ITU-T A.8 procedure.

### Keywords

Equipment interface, equipment port, external circuit, external port, impulse withstand voltage, injury to people, internal port, intra-building or indoor conductor, outdoor conductor, resistibility, safety, telecommunication overvoltage category.

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## Introduction

IEC TC 108 has traditionally used 1.5 kV as the maximum magnitude of transients occurring at equipment interfaces connected to network, or inter-building, cables, and 800 V as the maximum magnitude of transients occurring at the equipment interfaces connected to intra-building cables.

ITU-T Study Group 5 (SG 5) introduced "enhanced" requirements into Recommendations ITU-T K.20, K.21 and K.45 in the year 2000. There is now a range of resistibility levels for interfaces connected to inter- and intra-building cables. These enhanced requirements were introduced as a result of field failures and to enable an improvement in equipment reliability. SG 5 also recognizes that it is sometimes difficult, expensive or impossible to correctly install primary protection on telecommunication lines. This can be due to old buildings being difficult to retrofit primary protection or for regulatory reasons.

With the introduction of equipment installed in customer premises deriving copper services, it is necessary to have clear guidelines on when to classify an interface as either "external" (subjected to a.c. transients and conducted lightning surges) or "internal" (subjected to transients induced into intra-building cables).

The purpose of this Recommendation is to:

1) achieve coordination of the test voltages used for safety testing with the test voltages used for resistibility testing;
2) to provide clear guidelines on classifying interfaces as external or internal.

# Recommendation ITU-T K.75

## Classification of interface for application of standards on resistibility and safety of telecommunication equipment

### 1 Scope

The purpose of this Recommendation is to provide:

– guidance to manufacturers, network operators and test houses on the classification of the type of interface, i.e., external (subjected to a.c. surges or conducted lightning surges) or internal (subjected to short fall-time transients induced into building cabling);

– information on the waveform of transients appearing at equipment interfaces for insulation coordination purposes.

This Recommendation mainly applies to customer equipment due to safety being achieved in other ways for network equipment, e.g., earthing or powering from a safe supply, e.g., a supply voltage equal to or less than 60 V d.c. (Note, 60 V d.c. is an ES1 voltage.) However, the waveform of transients appearing at equipment interfaces is also provided for telecommunication centres and access network sites in case it is needed in the future.

This Recommendation assumes that the telecommunication equipment is either mains powered or powered from the telecommunication network, and is installed according to the earthing and bonding requirements relevant to each different environment (i.e., [ITU-T K.27], [ITU-T K.35] and [ITU-T K.66]).

This Recommendation does not provide safety or resistibility requirements such as test procedures and test criteria.

This Recommendation does not describe mitigation measures or the various approaches used to determine the need to provide additional protection external to the equipment (primary protection).

This Recommendation does not address overvoltages caused by power contact with low-voltage or medium-voltage power lines.

### 2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.


[ITU-T K.20] Recommendation ITU-T K.20 (2003), *Resistibility of telecommunication equipment installed in a telecommunications centre to overvoltages and overcurrents*.

[ITU-T K.21] Recommendation ITU-T K.21 (2003), *Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents*.

[ITU-T K.27] Recommendation ITU-T K.27 (1996), *Bonding configurations and earthing inside a telecommunication building*.

[ITU-T K.35] Recommendation ITU-T K.35 (1996), *Bonding configurations and earthing at remote electronic sites*.

[ITU-T K.45] Recommendation ITU-T K.45 (2003), *Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents*.

[ITU-T K.66] Recommendation ITU-T K.66 (2004), *Protection of customer premises from overvoltages*.

[ITU-T K.67] Recommendation ITU-T K.67 (2006), *Expected surges on telecommunications and signalling networks due to lightning*.

[IEC 60664-1] IEC 60664-1 (2007), *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*.
<http://webstore.iec.ch/webstore/webstore.nsf/artnum/037956>

[IEC 60950-1] IEC 60950-1 (2005), *Information technology equipment – Safety – Part 1: General requirements*.
<http://webstore.iec.ch/webstore/webstore.nsf/artnum/035320>

[IEC 62305-2] IEC 62305-2 (2006), *Protection against lightning – Part 2: Risk management*.
<http://webstore.iec.ch/webstore/webstore.nsf/artnum/035440>

# 3 Definitions

## 3.1 Terms defined elsewhere

This Recommendation uses the following terms defined by IEC or currently under study in IEC.

**3.1.1 basic insulation**: Insulation to provide basic safeguard against electric shock.

**3.1.2 double insulation**: Insulation comprising both basic insulation and supplementary insulation.

**3.1.3 equipotential bonding**: Electrical connection putting various exposed conductive parts and extraneous conductive parts at a substantially equal potential.

**3.1.4 external circuit**: Circuit that is, in whole or in part, external to the equipment and is neither a mains nor a d.c. power distribution system.

NOTE – This definition is different to the ITU-T SG 5 definition for external interfaces.

**3.1.5 reinforced insulation**: Single insulation system that provides a degree of protection against electric shock equivalent to double insulation.

**3.1.6 supplementary insulation**: Independent insulation applied in addition to basic insulation to provide supplementary safeguard for fault protection against electric shock.

## 3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

**3.2.1 circuit isolation voltage**: Highest value of a specified overvoltage that does not cause breakdown of insulation or other safeguards between a telecommunication line and another circuit within the equipment.

**3.2.2 external interface**: Any port on the equipment which may be subjected to a.c. surges and conducted lightning surges.

**3.2.3 internal interface**: Any port on the equipment which is only ever exposed to short duration induced transients.

**3.2.4 person isolation voltage**: Highest value of a specified overvoltage that does not cause breakdown of insulation between a telecommunication line and a person in contact with the equipment.

**3.2.5 telecommunication overvoltage category**: A designation defining a transient overvoltage condition.

## 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ES Energy Source

GDT Gas Discharge Tube

EPR Earth Potential Rise

EUT Equipment Under Test

LPS Lightning Protection System

MET Main Earth terminal

PE Protective Earth

SELV Safety Extra Low Voltage

SPD Surge Protective Device

TNV Telecommunication Network Voltage

## 5 Conventions

None.

## 6 Classification of interfaces

Two things are needed to classify an interface. Firstly, an interface has to be classified as either "internal" or "external". Secondly, it is necessary to define the interface in terms of the magnitude of the likely transient.

### 6.1 Type of interface

This is done by determining the types of overvoltages that the interface is exposed to.

If the interface is exposed to a.c. surges or to lightning surges conducted by an outdoor or external cable, it is an external interface.

If it is only exposed to short transients, due to induction into building wiring, it can be classified as an internal interface.

Figure 1 shows a reference configuration for the telecommunication lines with metallic symmetric conductors where the reference nodes ([IEC 62305-2] uses the term "transition points") and the cable sections between them can be seen. Table 1 defines the various nodes in Figure 1.

Figure 1 can be used for identifying parts of the telecommunication network to be classified as either "internal" or "external":

a) External conductors

External or outdoor conductors, subject to power induction and lightning-caused overvoltages, are conductors between nodes E-S, E-R, R-S, S-S shown in Figure 1 (see also Appendix I).

b) Internal conductors

Internal or intra-building or indoor conductors, not subject to the electromagnetic interference due to power systems, are conductors between nodes I-I and M-M shown in Figure 1 (see also Appendix I).

A detailed method for classifying interfaces is given in Annex A.

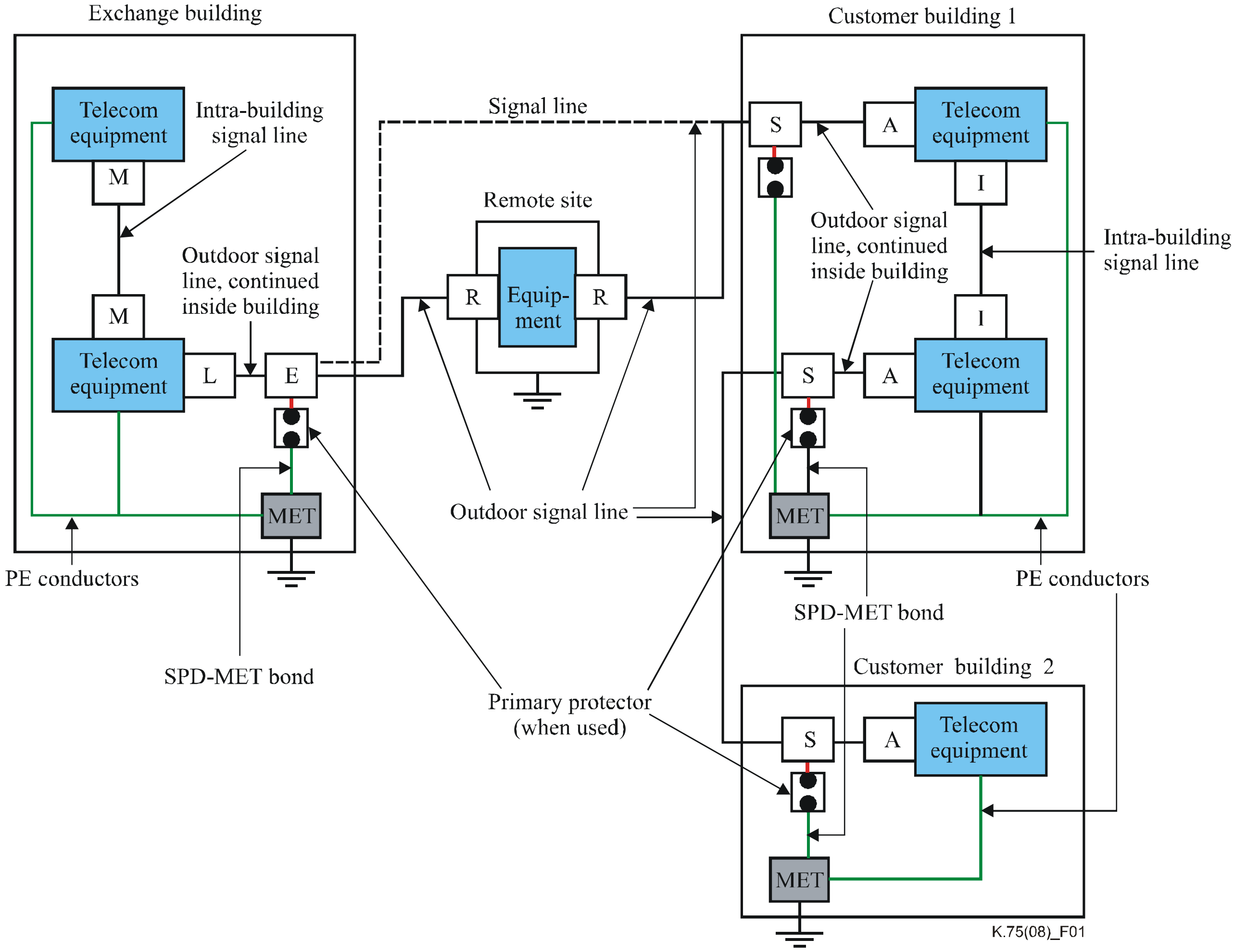


**Figure 1 – Reference configuration of telecommunication and signal lines**

**Table 1 – Description of nodes**

| Node | Description |
|---|---|
| L | Transition between equipment interface inside the exchange building and the external cabling. |
| E | Entrance of the exchange building, e.g., MDF. |
| R | Transition between line and equipment inside a remote site. |
| S | Entrance of the customer's building. |
| A | Transition between equipment interface inside the customer's building and the external cabling. |
| M | Transition between equipment interface inside the exchange's building and the internal cabling. |
| I | Transition between equipment interface inside the customer's building and the internal cabling. |

## 6.2 Defining the transient

This Recommendation adopts an approach suggested by [IEC 60664-1] by defining "telecommunications overvoltage categories".

Table 2 shows the overvoltage categories and overvoltage transient on mains according to [IEC 60664-1].

**Table 2 – Mains overvoltage categories and overvoltage transient on mains interfaces, according to [IEC 60664-1]**

| Mains overvoltage categories | Lightning impulse transient (1.2/50 μs) |
|---|---|
| IV | 6000 V |
| III | 2500 V |
| II | 2500 V |
| I | 1500 V |

Each overvoltage category relates to a set of network design and protection practices that correspond to a particular resistibility level of the equipment in terms of transient overvoltages. The relevant values of the impulse overvoltage at the equipment input, taking into account the different installation environments, are in the following ITU-T Recommendations:

– [ITU-T K.20] for the exchange environment;

– [ITU-T K.45] for the access network environment; and

– [ITU-T K.21] for the customer's environment.

The inherent equipment impulse resistibility requirements, based on the data in these Recommendations, are used in Tables 3 and 4 to define the telecommunication overvoltage categories for telecommunication circuits.

## 7 Application of overvoltage categories

Three types of insulation are generally used in equipment, in particular in telecommunications equipment designed for use in customer premises. Each type of insulation has a different test requirement. These three types of insulation and their test requirements are as follows:

– **Basic insulation** – Basic insulation is nominally tested at the relevant voltage and waveshape listed in Tables 2-4.

– **Reinforced insulation** – Reinforced insulation is tested at one step higher according to [IEC 60664-1]. The test is determined by selecting the relevant transient from Tables 2-4. Using Table 5, taken from [IEC 60664-1], select the next highest voltage in the table. The insulation is then nominally tested at this voltage using the relevant waveshape from Tables 2-4. If the impulse withstand voltage required for basic insulation is other than a value taken from the preferred series, reinforced insulation shall be dimensioned to withstand 160% of the value required for basic insulation (e.g., 1.6 kV for 1 kV value specified for basic insulation).

– **Double insulation** – Double insulation consists of basic insulation and a supplementary insulation. Both insulations are independently tested as for basic insulation above.

**Table 3 – Telecommunication overvoltage categories and overvoltage transients on interfaces declared as "internal interfaces"**

| Telecommunication Overvoltage category | Additional qualifying conditions | Inherent impulse resistibility | Impulse withstand voltage of double or reinforced insulation |
|---|---|---|---|
| $I_1$ | Equipment with "enhanced" resistibility installed in a customer building. | 1500 V<br>1.2/50 µs | 2500 V<br>1.2/50 µs |

**Table 3 – Telecommunication overvoltage categories and overvoltage transients on interfaces declared as "internal interfaces"**

| Telecommunication Overvoltage category | Additional qualifying conditions | Inherent impulse resistibility | Impulse withstand voltage of double or reinforced insulation |
|---|---|---|---|
| $I_{2a}$ | Equipment with "basic" resistibility installed in a customer building. | 1000 V<br>1.2/50 μs | 1500 V<br>1.2/50 μs |
| $I_{2b}$ | Equipment with "enhanced" resistibility installed in a telecommunication centre. | 1000 V<br>1.2/50 μs | 1500 V<br>1.2/50 μs |
| $I_3$ | Equipment with "basic" resistibility installed in a telecommunication centre. | 500 V<br>1.2/50 μs | 800 V<br>1.2/50 μs |

**Table 4 – Telecommunication overvoltage categories and overvoltage transients on interfaces declared as "external interfaces"**

<table>
<tr><th>Telecommunication overvoltage category</th><th>Additional qualifying conditions</th><th>Inherent impulse resistibility</th><th>Impulse withstand voltage of double or reinforced insulation</th></tr>
<tr><td>$O_1$</td><td>Equipment with "enhanced" resistibility installed in a customer building.</td><td>6000 V<br>10/700 μs</td><td>8000 V<br>10/700 μs</td></tr>
<tr><td>$O_{2a}$</td><td>Equipment with "basic" resistibility installed in a customer's building.</td><td>1500 V<br>10/700 μs</td><td rowspan="2">2500 V<br>10/700 μs</td></tr>
<tr><td>$O_{2b}$</td><td>Equipment with "basic" or "enhanced" resistibility installed in a remote site.</td><td>1500 V<br>10/700 μs</td></tr>
<tr><td>$O_{2c}$</td><td>Equipment with "enhanced" resistibility installed in a telecommunications centre or large commercial building.</td><td>1500 V<br>10/700 μs</td><td>2500 V<br>10/700 μs</td></tr>
<tr><td>$O_3$</td><td>Equipment with "basic" resistibility installed in a telecommunications centre or large commercial building.</td><td>1000 V<br>10/700 μs</td><td>1500 V<br>10/700 μs</td></tr>
</table>

**Table 5 – IEC 60664-1 – preferred series values of rated impulse voltage (V) for insulation coordination**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 330 | 500 | 800 | 1500 | 2500 | 4000 | 6000 | 8000 | 12000 |

In order to protect people, it is necessary to insulate non-hazardous circuits (which may be touched by persons) from hazardous circuits, e.g., mains.

A general philosophy is that if a failure of basic insulation could result in serious injury or death, two methods of protection (two safeguards) should be used. These two methods could be any of the following:

– double insulation (basic + supplementary);
– reinforced insulation (an insulation system equivalent to double insulation); or
– basic insulation in conjunction with:
  • an earthed screen between the insulation and the non-hazardous circuit; or
  • earthing of the non hazardous circuit.

Where failure of the safeguards results only in damage to the equipment, a single safeguard is satisfactory. Examples of a single safeguard are:

– basic insulation only (single safeguard);
– earthing only (single safeguard).

To protect people touching unearthed parts from non-hazardous circuits, e.g., telecommunication or signal circuits, it is necessary to have adequate insulation tested with 2.5 kV (10/700 μs) according to [IEC 60950-1].

These safety requirements are summarized in Figure 2.

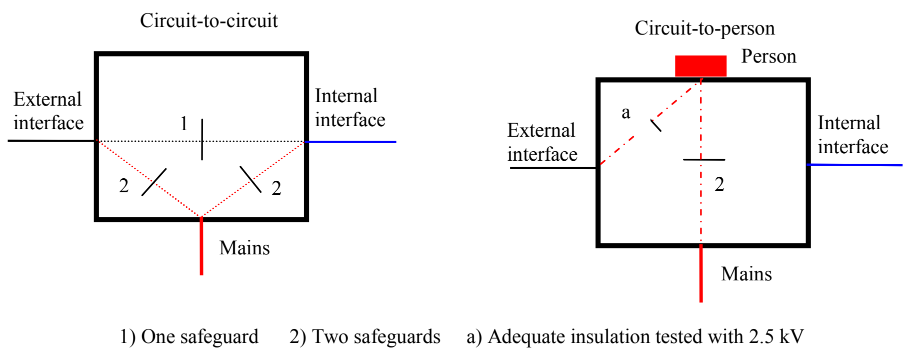


**Figure 2 – Scheme of circuit-to-circuit and circuit-to-person safeguards**

The withstand level of a basic safeguard (basic insulation) is equal to the inherent resistibility level of the equipment.

The withstand voltages for double or reinforced insulation, linked to the overvoltage categories, are reported in Tables 3 and 4.

# Annex A

## Classifying external and internal interfaces

(This annex forms an integral part of this Recommendation)

This annex provides a method for classifying external and internal interfaces. Note that these interfaces have different meanings compared with the IEC internal and external circuits.

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

– it is only connected to intra-building cables;
– the cable is connected to an internal interface or 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 interface or port of the associated equipment;
– the port does not provide a service which the customer may extend to an outbuilding (e.g., a POTS, Ethernet or video port);
– the port will not have a conductive connection to a cable which leaves the building via other equipment (e.g., via a splitter).

Any interface or port not complying with the requirements for an internal interface or port is an external port.

Figure A.1 is an example of interface (or port) classifications.

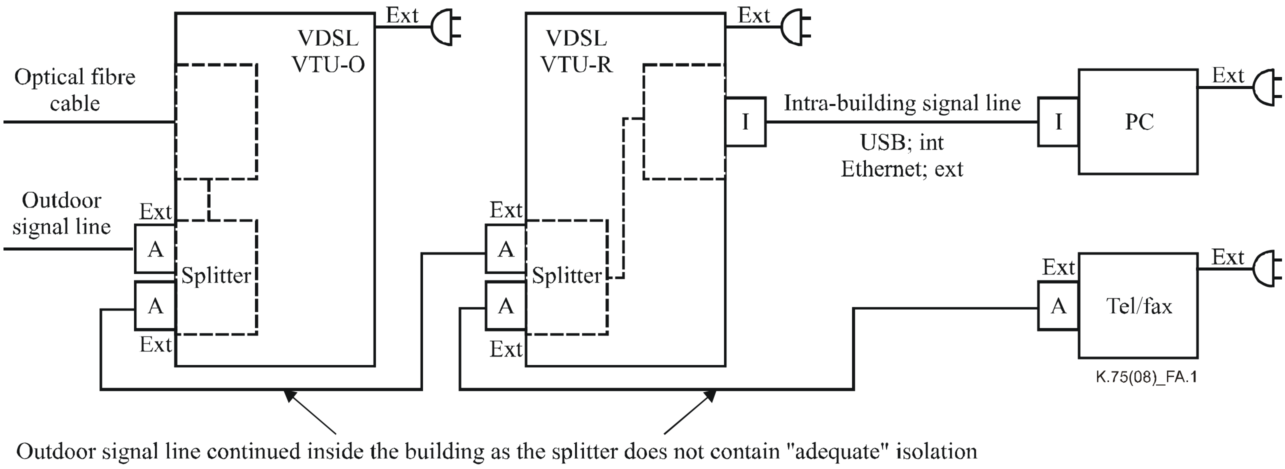


**Figure A.1 – Example of port classifications**

# Appendix I

## Overvoltages on telecommunication network

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

### I.1 General

A number of phenomena can affect metallic conductors in such a way that an overvoltage can be transmitted to the interface port of the equipment. The relevant phenomena are:

– Induction due to lightning.

– Direct lightning stroke.

– Induction by electric traction systems.

– Power cross/direct contact.

– Induction and earth potential rise (EPR) from power systems.

All of these phenomena lead to the appearance of overvoltages on the affected system. The overvoltages may be transient (surges) or, in the case of long-term induction, can occur almost continuously.

This Recommendation is concerned with categorizing transients on metallic conductors arising from effects of lightning (atmospheric discharges). Proper categorization of transients is needed to achieve insulation coordination between equipment and the external circuit.

The majority of data on transients is available in the context of the telecommunication networks. It is expected that these results are valid for other networks that use similar cable constructions, installation techniques and protection methods.

The fundamental international standards that document the characteristics of overvoltages on telecommunication conductors are [b-ITU-T Handbook] and [ITU-T K.67]. These documents allow determination of the characteristics of overvoltages, including the likelihood of occurrence, from first principles.

### I.2 Protection and risk assessment

The occurrence of overvoltages on telecommunication networks is a statistical phenomenon. The inherent equipment resistibility values in ITU-T K-series Recommendations have been chosen to help reduce the risk of damage or upset of equipment assuming certain installation conditions for various environments. However, overvoltages greater than the inherent resistibility level (e.g., 1500 $V_{peak}$ for customer premises equipment) can occur. To reduce the probability of such overvoltages, mitigation measures such as primary protection, adequate routing or shielding are used.

The requirements for determination of the need and the type of mitigation measures, which may be contained in national regulations for customer locations or are usually reported in the network operator practices for network equipment, can range from simple heuristic rules to complex risk assessment procedures. For example, [IEC 62305-2] allows the risk assessment against lightning to the structure together with the services entering the structure.

This Recommendation does not describe mitigation measures or the various approaches used to determine the need to provide primary protection. Risk assessment techniques to determine the need to install protection and other mitigation measures are evolving and becoming more sophisticated. Nevertheless, the goal of any of the methods used to determine the need for protection is to reduce the probability of the overvoltage exceeding the equipment resistibility value and the relevant safety value to a suitably low value. Therefore, it is possible to categorize the electrical environment on the basis of the resistibility value of the equipment.

## I.3 Telecommunication overvoltage categories

The occurrence of surges is a complex statistical phenomenon that is difficult to capture with a single "expected voltage" number. Therefore, this Recommendation adopts an approach suggested by [IEC 60664-1] by defining "telecommunications overvoltage categories". Each overvoltage category relates to a set of network design and protection practices that correspond to a particular resistibility level of the equipment in terms of transient overvoltages.

Although an overvoltage category is associated with a resistibility level, this does not mean that an overvoltage greater than this level cannot occur. Overvoltages are a statistical phenomenon, and for each resistibility level, larger overvoltages can occur with a reduced probability.

The transient overvoltages on communication conductors are defined in terms of open-circuit voltages and waveshape that appear at the interface of the telecommunication equipment with the external circuit. For the purpose of determining the transient, the input impedance of the equipment is considered infinite. Components in the equipment can reduce the voltage that can appear inside the equipment.

This Recommendation does not provide transient classification in terms of short-circuit currents. Although the short-circuit current is an important characteristic of a transient, it has limited relevance to insulation coordination. However, where SPDs are used to reduce the voltage appearing in the equipment, their capability to handle the short-circuit current for the interface needs to be considered.

The transient overvoltages for an interface are defined with respect to the terminals where the voltage is defined. For the majority of cases, the relevant voltages are common ($U_c$) and differential ($U_d$) mode voltages at the interface. For unearthed conductive parts and non-conductive parts of the equipment expected to be held or otherwise maintained in continuous contact with the body during normal use (for example, a telephone handset or head set or the palm rest surface of a laptop or notebook computer), the voltage with respect to local earth ($U_{ce}$) may be relevant. Figure I.1 shows the definition of the various voltages for a paired-conductor interface.

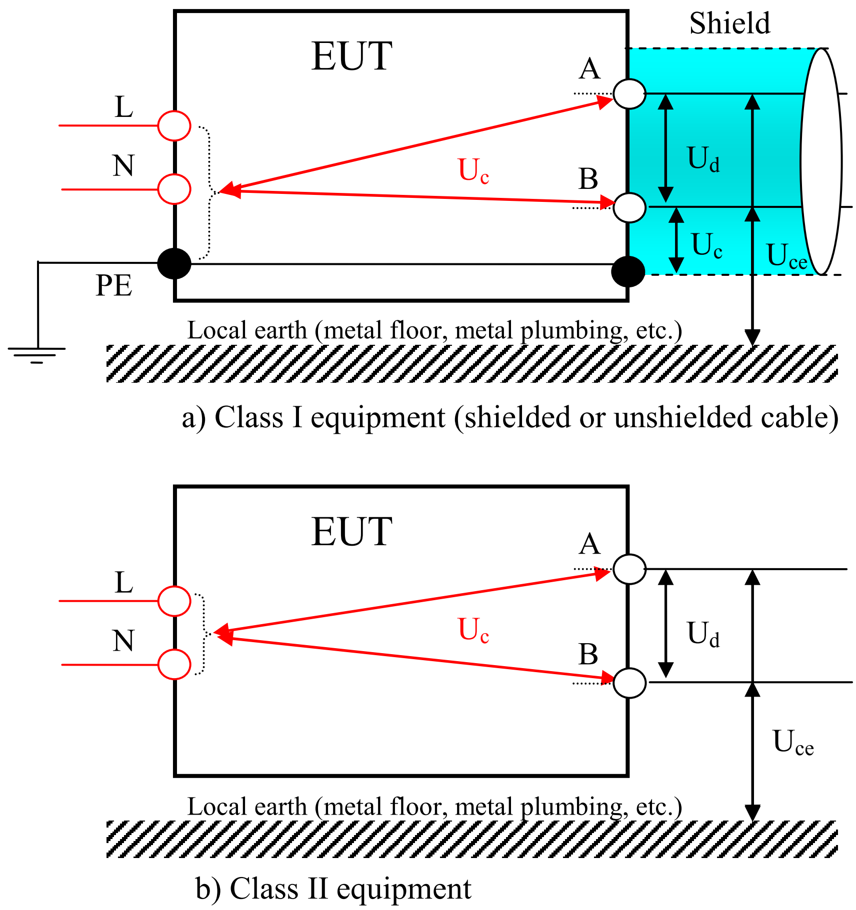


**Figure I.1 – Illustration of transient voltages on paired-conductor external circuits**

## I.4 Causes of overvoltage

This clause provides a high-level description of the sources of overvoltage on communication conductors. Figure 1 shows a reference configuration for the telecommunication lines with metallic symmetric conductors where the reference transition points and the cable sections between them can be seen.

### I.4.1 Outdoor conductors

Coupling mechanisms include: inductive coupling, resistive coupling, direct lightning flashes to the structure or telecommunication lines. For lightning-caused overvoltages, the typical overvoltage waveshape is 10/700 µs at the interfaces E, R and S.

The overvoltage at interfaces L and A comprises the overvoltage coming from the outdoor cabling and the overvoltage induced onto the indoor portions (E-L and S-A) as described in the following clause. The overvoltages at the interfaces L and A coming from the outdoor cabling can be reduced by the installation of primary protection at transition points E and S respectively.

NOTE – Even when protection has been installed, peak voltages as high as 1000 volts 10/700 µs and about 800 $V_{peak}$ 50/60 Hz can still occur at the L and A interfaces (under the firing voltage of the primary protector). These numbers correspond to the maximum (780 V) d.c. firing voltage of a 600 $V_{GDT}$, which is used by some operators at customer premises to prevent operation at 240 Vrms.

### I.4.2 Intra-building or indoor conductors

Because intra-building or indoor conductors (conductors between transition points I-I and M-M of Figure 1) are not subject to the electromagnetic interference due to power systems, [ITU-T K.20] and [ITU-T K.21] do not provide equipment resistibility requirements against induced voltages due to power lines. From the lightning protection point of view, the lightning flashes directly to or near the structure are relevant as a source of overvoltage by inductive coupling. Figure I.2 shows an illustrative configuration.

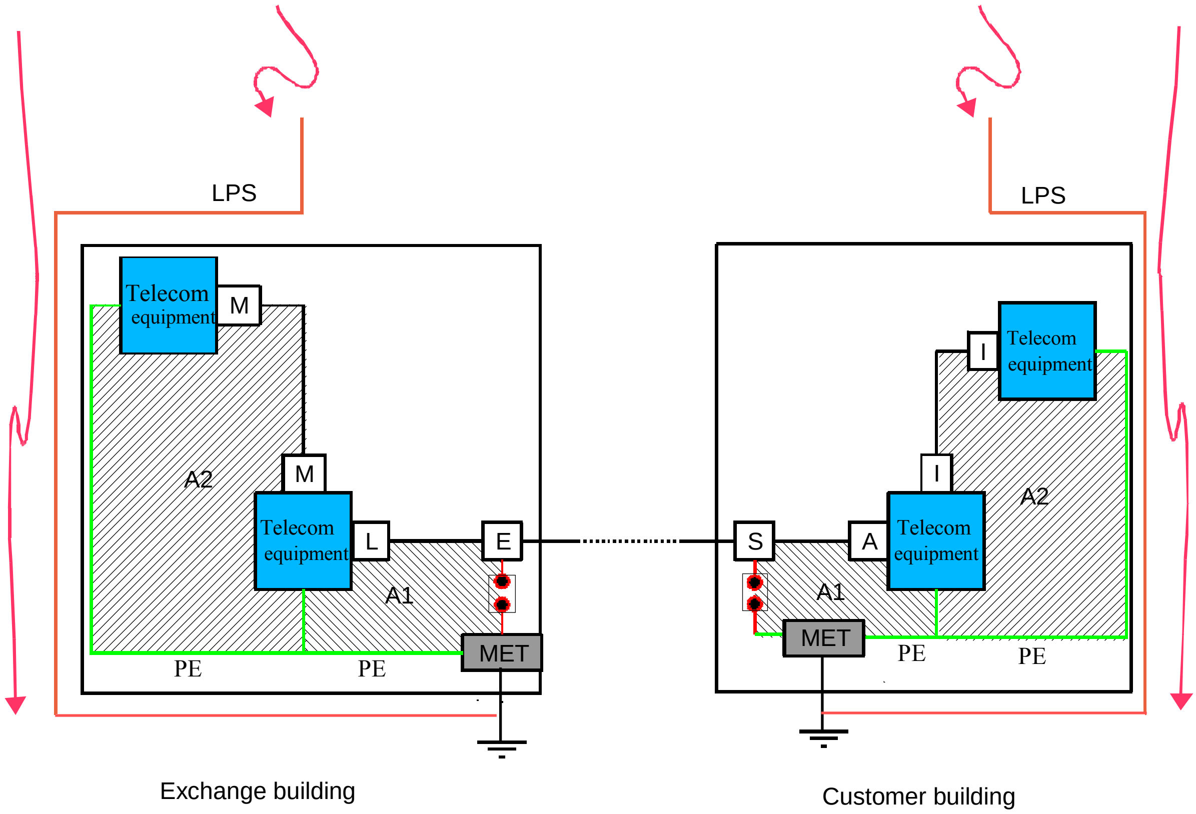


**Figure I.2 – Illustration of induction into loop areas (A1 and A2) due to lightning strike directly to or near the structure**

The waveform of the induced open circuit voltages should have a very short duration (in the order of a few µs, e.g., 2 µs to 10 µs) and a front time similar to that of the subsequent stroke (i.e., 0.25 µs).

NOTE – This has been confirmed by measurements of induced voltages into a loop carried out with triggered lightning reported in Appendix I of [ITU-T K.67].

For ease of testing, the test values for ports connecting to intra-building conductors are usually given using the 1.2/50 µs open-circuit voltage waveform (the combination wave). This Recommendation also specifies reference levels in terms of the 1.2/50 µs waveform to facilitate insulation testing.

# Bibliography

[b-ITU-T Handbook] ITU-T Handbook (1995), *The Protection of Telecommunication Lines and Equipment against Lightning Discharges – Chapters 9 and 10*.

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