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PROTECTION AGAINST INTERFERENCE

PRINCIPLES OF PROTECTION AGAINST OVERVOLTAGES AND OVERCURRENTS

ITU-T Recommendation K.11

(Previously "CCITT Recommendation")

FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation K.11 was revised by the ITU-T Study Group 5 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 6th of october 1993.

NOTE

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

CONTENTS

INTRODUCTION

Current ITU-T documents recognize lightning and faults on nearby electrical installations as sources of dangerous disturbances in telecommunications lines, which may cause damage leading to interruptions in service and the need for repairs or even hazards to personnel.

The object of the present Recommendation is to set out principles which enable the frequency and seriousness of such disturbances to be limited to levels which take account of quality of service, operating costs and safety of personnel. These principles are applicable to all parts of a telecommunications system. More details on certain methods of protection and for certain parts of the system are given in the References and in the following Recommendations: K.5, K.6, K.9, K.12, K.15, K.16, K.17. Information about disturbing phenomena and protection techniques are given in [1] and [2] (see also Recommendation K.26).

This Recommendation deals principally with the local exchange, local loop plant and subscribers' equipment, but its contents may have wider application.

Annex A gives definitions of a number of terms used in connection with protection.

NOTE – The disturbing phenomena, when they appear, are relatively rare or of very brief duration (usually of the order of a fraction of a second) and in framing the present Recommendation, consideration has not been given to methods of avoiding interruption of the functioning of equipment during an actual disturbance. The ITU-T is pursuing the study of such methods.

Recommendation K.11

PRINCIPLES OF PROTECTION AGAINST OVERVOLTAGES AND OVERCURRENTS

(Geneva, 1972; modified at Malaga-Torremolinos, 1984; Melbourne, 1988 and Geneva, 1993)

1 General considerations

1.1 Origin of dangerous overvoltages and overcurrents

1.1.1 Direct lightning strikes

Such strikes may cause currents of some thousands of amperes to flow along wires or cables for some microseconds. Physical damage may occur and overvoltage surges of many kilovolts may apply stress to the dielectrics of line plant and terminal equipment.

1.1.2 Lightning strikes nearby

Lightning currents flowing from cloud to earth or cloud to cloud cause overvoltages in overhead or underground lines near to the strike. The area affected may be large in districts of high earth resistivity.

1.1.3 Induction from fault currents in power lines including electric traction systems

Earth faults in power systems cause large unbalanced currents to flow along the power line inducing overvoltages into adjacent telecommunications lines which follow a parallel course. The overvoltages may rise to several kilovolts and have durations of 200 to 1000 ms (occasionally even longer) according to the fault clearing system used on the power line.

1.1.4 Contacts with power lines

Contacts may occur between power and telecommunication lines when local disasters, e.g. storms, fires, cause damage to both types of plant or when the normal safeguards of separation and insulation are not followed. Overvoltages rarely exceed 240 V a.c., r.m.s. above earth in countries where this is the normal distribution voltage but may continue for an indefinite period until observed. Where higher distribution voltages, e.g. 2 kV, are used the power line protection arrangements usually ensure that the voltage is removed in a short time if a fault occurs. The overvoltage may cause excessive currents to flow along the line to the exchange earth causing damage to equipment and danger to staff.

1.1.5 Rise of earth potential

Earth faults in power systems cause currents in the soil which raise the potential in the neighbourhood of the fault and of the power supply earth electrode. (See also Recommendation K.9.) These earth potentials may affect telecommunication plant in two ways:

a) Telecommunication signalling systems may malfunction if the signalling earth electrode is in soil whose potential rises by as little as 5 V with respect to true earth. Such voltages may be caused by minor faults on the power system which may remain undetected for long periods.

b) Higher rises of earth potential can cause danger to staff working in the affected area or, in extreme cases, may be sufficient to break down the insulation of the telecommunications cable causing extensive damage.

1.2 Methods of protection

1.2.1 Some of the protective measures for lines which are described in clause 2 have the effect of reducing overvoltages and overcurrents at their source and so reduce the risk of damage to all parts of the system.

1.2.2 Other protective measures which may be applied to specific parts of the system as indicated in clauses 2, 3 and 4 fall broadly into 2 classes:

- the use of protective devices which prevent excessive energy from reaching vulnerable parts either by diverting it (for example, spark gaps) or by disconnecting the line (for example, fuses);
- the use of equipment with suitable dielectric strength, current carrying capacity and impedance so that it can withstand the conditions applied to it.

1.3 Types of protective devices

1.3.1 Air-gap protectors with carbon or metallic electrodes

Usually connected between each wire of a line and earth, they limit the voltage which can appear between their electrodes. They are inexpensive but their insulation resistance can fall appreciably after repeated operation and they may require frequent replacement.

1.3.2 Gas discharge tubes

Usually connected between each wire of a line and earth or as 3-electrode units between a pair and earth. Their performance may be specified to precise limits to meet system requirements. The protectors are compact and will operate frequently without attention.

Detailed requirements for gas discharge tubes appear in Recommendation K.12.

1.3.3 Semi-conductor protective devices

Developments in the technology of these devices have produced some units which may be used as primary protectors and others which should be used as secondary protectors only.

Primary and secondary protection should always be coordinated correctly.

a) *Primary protection devices*

A widespread trial of these devices is taking place in which the units are being used to replace carbon electrode protectors and gas discharge tubes. The outcome of the trials may depend on both technical and commercial factors.

Typically, the benefits which may be provided over carbon electrodes may be the elimination of circuit noise and lower operating levels, while the disadvantages may be higher costs and self-capacitance with lower current handling capability.

In the case of gas discharge tubes, benefits may arise from the elimination of spark discharges while the higher self-capacitance and the lower current handling capability may be considered to be disadvantageous.

The trials are continuing and further developments of this technology may arise.

b) *Secondary protection devices*

Depending on their location in a circuit, they may be designed to have overvoltage operation levels as low as 1 V. They are precise and fast-acting, but may be damaged by excessive currents unless coordinated correctly.

1.3.4 Fuses

These are connected in series with each wire of a line to disconnect when excessive current flows. Simple fuses have a uniform wire which melts. Slow-acting fuses have a uniform wire which melts quickly when a large current flows, and a spring-loaded fusible element which melts gradually and disconnects when lower currents flow for a prolonged time. High level currents of 2 A and prolonged currents of 250 mA are typical operating levels. Fuses should not sustain an arc after operation. Fuses do not give protection against lightning surges and in districts where such surges are common, fuses of a high rating (up to 20 A) may be necessary to avoid trouble from fuse failures. Such fuses may not give adequate protection against power line contacts. Fuses can also be a source of noise and disconnection faults.

1.3.5 Heat coils

Fitted in series with each wire of a line, heat coils either disconnect the line, earth it, or do both, with the earth extended to line. Heat coils have some fusible component and operate when currents of, typically, 500 mA flow for some 200 s.

1.3.6 Self-restoring current-limiting devices

These are placed in series with each wire of a line and operate to limit excessive a.c. currents as an open circuit. Fuses and heatcoils permanently interrupt a circuit when operated and it is necessary to replace them manually. Certain variable impedance deviced are available which, when heated by overload currrents. increase their electrical resistance to a very high value. When the overload is removed the devices will return to their normal condition and permit operation of the line. Detailed requirements for such devices appear in Recommendation K.30.

1.3.7 Fusible links

Fuseless over-voltage protector assemblies installed on telecommunication lines can be protected against the risk of overheating in the event of a prolonged contact between the telecommunication line and a power distribution line by means of a fusible link.

A fusible link usually consists of insulated conductors in series with the telecommunication line and located between the exposure to the power line and the protector assembly. The conductors are usually at least two wire gauges smaller than the conductors terminated on the protector assembly and are of a suitable length to avoid a sustained arc if the power system does not de-energize promptly and the conductors fuse. If the fusible link or part of it is installed in a building or other location where a fire hazard might occur, it is enclosed within a cable sheath, splice enclosure, or other suitable enclosure to contain any arcing that may result if the conductors fuse.

1.4 Residual effects

The essential purpose of protective measures is to ensure that the major part of the electrical energy arising from a disturbance is not dissipated in a vulnerable part of the installation and does not reach personnel. However, no device exists which has characteristics for suppressing ideally all voltages or currents connected with disturbances, for the following reasons:

1.4.1 Residual overvoltages

Account should be taken of

a) voltages which are unaffected by the protective device because they are below its operating level;

b) transients which pass before the device operates;

c) residuals which are sustained after the device operates;

d) transients produced by the operation of the device.

1.4.2 Transverse voltages

Protective devices on the two wires of a pair may not operate simultaneously and so a transverse pulse may be produced. Under certain conditions, particularly if the equipment to be protected has a low impedance, operation of one protective device may prevent the operation of the other one and a transverse voltage may remain as long as the longitudinal voltages are on the line.

1.4.3 Effect on normal circuit operation – Coordinated design

Sufficient separation should be allowed between the operating voltage of the protective devices and the highest voltage occurring on the line during normal operation.

Likewise the normal characteristics (internal impedances) of the protective elements must be compatible with the normal functioning of the installations, which must take account of their possible presence.

1.4.4 Modifying effects

A protective device may safeguard one part of a line at the expense of another, e.g. if a main distribution frame (MDF) fuse operates due to a power line contact, the voltage on the line may rise to full power line voltage when the fuse disconnects the telecommunication's earth.

Likewise the operation of a protector may greatly reduce the equivalent internal impedance of a circuit relative to equipment connected to it, thus permitting the circulation of currents which may cause damage.

1.4.5 Coordination of primary and secondary protection

For the protection of sensitive equipment it is sometimes necessary to use more than one protective device, e.g. a fast-operating, low-current device such as a semiconductor and a slower-operating, high-current device such as a gas-discharge tube. In such cases steps must be taken to ensure that in the event of a sustained overvoltage, the low-current device does not prevent the operation of the high-current device since, if this happens, the smaller device may be damaged, or the interconnecting wiring may conduct excessive current.

1.4.6 Temperature rise

Protective components should be designed and positioned in such a way that the rise in temperature which occurs when they operate is unlikely to cause damage to property or danger to people.

1.4.7 Circuit availability

The circuit being protected may be temporarily or permanently put out of service when a protective device operates.

1.4.8 Fault liability

The use of protective devices may cause maintenance problems due to unreliability. They may also prevent some line and equipment testing procedures.

1.5 Assessment of risk

1.5.1 The performance of a telecommunications system with respect to overvoltages depends on

- the environment, i.e. the magnitude and probability of overvoltages occurring in the line network associated with the system;
- the construction methods used in the line network, see clause 2;
- the resistibility of equipment in the system to overvoltages;
- the provision of protective devices;
- the quality of the earth system provided for operation of the protective devices.

1.5.2 The environment

In assessing the environment, consideration should be given to the factors mentioned in 1.1.

The severity of overvoltages due to lightning varies widely in different localities. A high keraunic level and a high soil resistivity increase the risk of direct and nearby lightning strokes and, since lightning is the cause of a large proportion of power system faults, induction and rise of earth potential effects are also increased. On the other hand buried metal plant such as water pipes, armoured cables, etc., screens telephone cables and greatly reduces overvoltages due to lightning or induction.

- In city centres and in regions of low keraunic activity experience shows that overvoltages rarely exceed the residual voltages of protective devices and such environments may be classified as "unexposed". Recommendations K.20 and K.21 specify the tests to be applied to equipment for use in unexposed environments without protection and these tests give an indication of the most severe environment which can be regarded as unexposed.

– All other environments are classified as “exposed” but this, of course, covers a wide range of conditions including exceptionally exposed situations where a satisfactory service can only be achieved by the use of all available protective measures.

In the case of induced voltages and rise of earth potential the overvoltages can be calculated as indicated in [2] which also recommends the maximum values which may be permitted under various conditions.

1.5.3 Fault records

The risk of overvoltages and overcurrents can only be properly assessed in the light of experience. It is recommended that fault statistics be kept in a form which is convenient for that purpose. Faults due to overvoltages or overcurrents and faults due to failures of protective components should be separated from each other and from other component faults.

1.6 Decision on protection

1.6.1 In considering the degree to which a telecommunications network should withstand overvoltages, two classes of failure may be recognized:

- Minor failures affecting only small parts of the system. These may be allowed to occur at a level acceptable to the Administration.

- Major breakdowns, fires, exchange failures, etc., which must, so far as possible, be avoided completely.

Examples of conditions which may be permitted to cause minor failures but not major breakdowns are given in Recommendation K.20. It is desirable also that failure of a single protective device should not cause a major breakdown.

1.6.2 Particular attention should be given to overvoltage and overcurrent protection for new types of exchange or subscribers' equipment to ensure that the benefits of its improved facilities are not lost due to unacceptable failures arising from exposure to overvoltages or overcurrents. Such equipment may be inherently sensitive to these conditions and damage or malfunction may affect large parts of a system.

1.6.3 It should be noted that over-protection, by the provision of unnecessary protective devices, is not only uneconomic but may actually worsen system performance since the devices themselves may have some liability to cause failures.

To avoid disturbances in telecommunication circuits caused by activated protective devices, the striking voltage values and the numbers of arrestors should be considered.

1.6.4 In the light of the above considerations and the assessment of risks in accordance with 1.5, a decision should be made on the protection to be provided in all parts of the system. Account should be taken of commercial considerations such as the cost of protective measures, the cost of repairs, relations with customers and the probable frequency of faults due to overvoltage and overcurrent relative to the fault rate due to other causes.

The responsibility for making this decision and for ensuring the provision of any protective devices needed to coordinate lines and equipment should be clearly laid down.

It is necessary for manufacturers of equipment to know from the operating Administration the conditions the equipment will need to resist and for line engineers to know the resistibility of the equipment which will be connected to the lines. The line engineer should also define the constraints which equipment connected to the line will encounter, depending on the standards of line protection provided. Where parts of the network, such as subscribers' apparatus, lines and switching centres may be under different ownership, this coordination may require formal procedures such as the production of local standards. Recommendations K.20 and K.21 give guidance for the preparation of these standards.

2 Protection of lines

2.1 Protective measures external to the conductors themselves

2.1.1 Telecommunication lines may be shielded from lightning to some extent by adjacent earthed metal structures, e.g. power lines or electric railway systems. Efficient metallic screens either in the form of cable sheaths, cable ducts or lightning guard wires, reduce the effects of lightning surges and power line induction. In areas with a high risk of lightning strikes special cables with multiple screens and high strength insulation are often used. Bonding all metal work gives useful protection.

2.1.2 Induction from power lines may be minimized by coordinating the construction practices for the power and telecommunication lines. The level of induction may be reduced at its source by the installation of earth wires and current limiters in the power system.

2.1.3 The likelihood of contacts occurring between power and telecommunications lines is reduced if agreed standards of construction, separation and insulation are followed. Economic considerations arise but it is often possible to benefit from jointly using trenches, poles and ducts, providing suitable safe practices are adopted. (See Recommendations K.5 and K.6.) It is particularly important to avoid contacts with high voltage power lines by a high standard of construction since, if such contacts occur, it may be very difficult to avoid serious consequences.

2.2 Special cables

Special cables of high dielectric strength may be used where high overvoltages are likely to occur.

Standard plastic insulated and sheathed cables have a higher dielectric strength than paper insulated, lead-sheathed cables and are suitable for most situations where cables with extra thick insulation were formerly used. The use of cables with strengthened insulation may be justified in situations where there is exceptional proximity or length of parallelism to power lines, high rise of earth potential in the immediate neighbourhood of power stations or extreme exposure to lightning due to high keraunic level and low soil conductivity.

Other examples of the use of special cables are

– cables with metal sheaths which provide a good reduction factor to screen circuits within the cable;

– cables which carry circuits to exposed radio towers and which must be able to carry lightning discharge currents without damage;

– all-dielectric (i.e. non-metallic) optical fibre cables to effect isolation between conductive lengths of cable.

2.3 Use of protective devices

The use of protective devices may be desirable in the following circumstances:

2.3.1 They may be more economical than the special construction described in 2.1 and 2.2. In this connection the cost of maintenance should not be overlooked since protective devices inevitably incur some maintenance expenditure whereas special cables, screening, etc., though initially expensive, usually incur no continuing costs.

2.3.2 Cables with extra thick insulation may themselves be undamaged by overvoltages or overcurrents but they can nevertheless conduct such conditions to other more vulnerable parts of the network. Extra protection is then required for the more vulnerable cables and is particularly important if these are large underground cables which are expensive to repair and affect service to many customers.

2.3.3 Induced overvoltages from power or traction line faults may still exceed levels permitted by the *Directives* even after all practicable avoidance measures have been followed.

2.4 Installation of protective devices

2.4.1 To protect conductor insulation it is beneficial to bond all metal sheaths, screens, etc., together, and to connect overvoltage protectors between the conductors and this bonded metal which should be connected to earth. This technique is particularly useful in districts of high soil resistivity as it avoids the need for expensive electrode systems for the protector earth connection.

2.4.2 Where protectors are used to reduce high voltages appearing in telecommunication lines due to induction from power line fault currents, they should be fitted to all wires at suitable intervals and at both ends of the affected length of line, or as near to this as practicable.

2.4.3 To protect underground cables against lightning surges protective devices may be placed at the points of connection to overhead lines. The protective devices fitted at the MDF and at subscribers' terminals reduce the risk of damage to lines but their main function is to protect components having lower dielectric strength than the cables. See Recommendations K.20 and K.21.

2.4.4 Connections for lines and earth to overvoltage protectors used against lightning should be as short as possible to minimize surge voltage levels between lines and the equipotential bond point.

2.5 Planning of works

The general considerations of 1.5 and 1.6 apply to the protection of lines. To the greatest extent possible it is recommended that the protective measures applied to the line should be decided at the outset of a project and should depend on the environment. It may be difficult and expensive to achieve a satisfactory standard of reliability from a line provided initially with insufficient protection.

2.6 Recommended policy

Where lines in a telecommunications network are exposed to frequent or severe disturbances from power line faults or lightning, the voltage of these lines relative to local earth potential should be limited either by connecting protective devices between the line conductors and earth or by using appropriate construction methods for the line.

3 Protection of exchange and transmission equipment

3.1 Need for protection external to the equipment

Operating organizations should take account of the possible need to fit protection external to the equipment, bearing in mind the following considerations:

3.1.1 A telecommunication line will give some protection to equipment under certain conditions, e.g.:

- a conductor may melt and disconnect an excessive current;
- conductor insulation may break down and reduce an overvoltage;
- air-gaps in connection devices may break down and reduce overvoltages.

3.1.2 The increased robustness of plastic insulated cables has the effect of increasing the levels of overvoltages and overcurrents which can circulate in the lines and be applied to equipment. By contrast the use of miniature electronic components in exchange and transmission equipment tends to increase its vulnerability to electrical disturbances.

For these reasons, in districts exposed to frequent and serious disturbances (lightning, power lines, soil of low conductivity), it is usually necessary to interpose protective devices of the types described in 1.3 between the cable conductors and the equipment to which they are connected, preferably on the MDF. This will prevent cables from the MDF to equipment from having to carry heavy overcurrents.

The protective devices are fitted to the line side of the MDF to avoid the need to carry discharge currents in the MDF jumper field and to expose as little of the MDF wiring and terminal strips as possible to mains voltage in the event that a mains voltage line contact causes a series protective device to disconnect the line.

3.1.3 In less exposed locations it may be that disturbances (voltages and currents) have statistical characteristics of level and frequency so low that in practice the risks do not exceed those resulting from the residual effects indicated in 1.4 for exposed regions. Protective devices then serve no purpose and are an unnecessary expense.

3.2 Need for equipment to have a minimum level of electrical robustness

In locations where lines are exposed and protective devices are provided, the residual effects considered in clause 1 can cause overvoltages and overcurrents to appear in the equipment. In less exposed environments the disturbances described in 3.1.3 can cause similar effects. It is necessary for equipment to be designed to withstand these conditions and detailed recommendations on the resistibility which equipment should possess are given in Recommendation K.20.

3.3 Effect of switching conditions

Since the configuration and interconnection of equipment connected to a given line is required to vary during the successive stages of connecting a call, it is important not to limit the study of protection solely to individual line equipments. Much equipment is common to all lines and can be exposed to disturbances when connected to a particular line.

The effectiveness of the protection provided can be influenced by the reduction in the probability of exposure if the effective duration of the connection to lines is short. On the other hand common equipment should be better protected since its failure risks more serious degradation in the performance of the exchange or the district.

4 Protection of subscribers’ terminal equipment

The protection methods already set out for exchange equipment can often be usefully applied to subscribers’ equipment. Detailed tests to determine the resistibility of subscriber equipment are given in Recommendation K.21. It is also appropriate to consider the specific aspects described below.

4.1 Degree of exposure

Lines to installations near exchanges in urban or industrial zones are usually little exposed to surges on account of the screening effect of numerous nearby metallic structures as described in 2.1.

On the other hand, lines to installations remote from built-up areas can be very exposed on account of their length, the absence of a protective environment, overhead construction at the subscriber's end and the high resistivity of the soil. The mechanical robustness of the overhead cables at the subscriber's end makes the effect of surges all the more serious since the line itself can carry higher voltages and currents.

4.2 Dielectric strength

It is desirable to have a high dielectric strength for the insulation between the conducting parts connected to the lines and all parts accessible to the user.

4.3 Use of protectors

4.3.1 Use of voltage limiting devices

Where telephone lines are exposed to frequent and severe disturbances from power line faults or lightning, the voltage of the lines relative to local earth potential should be limited by connecting protective devices of the types described in 1.3 between the line conductors and the earth terminal.

The terminal equipment dielectric strength should be chosen taking account of the breakdown voltage of the protective device and the impedance of the protector-line to earth connection.

4.3.2 Use of high voltage isolation devices

Where telecommunication lines, protected as in 4.3.1 above,

1) exhibit excessive trouble reports due to lightning activity; or

2) cannot have protection to 4.3.1 installed for whatever reason; or

3) when access to the subscriber premise by plant maintenance personnel is difficult;

then high voltage (to 50 kV) isolation, together with other suitable measures such as protection to 4.3.1 applied at the drop point from the telecommunications cable, may well be considered.

The isolation elements should be installed as close as possible to the subscriber premise on the outside. They must not be mounted inside buildings.

Isolation techniques may also be helpful at the telecommunications input to high-voltage plant (for example by means of isolation transformers), and in other situations where communications are vital and high plant-voltages probable.

4.4 Common bonding

At installations of subscriber terminal equipment a low resistance earth for overvoltage protectors may be unavailable, or the costs of procuring a suitable low-resistance earth may be excessive compared to other installation costs. Furthermore, the terminal equipment may be located adjacent to earthed systems, such as water pipes, or may receive power from an electricity system.

To minimize both equipment damage and exposure of the subscriber to high voltages, even if the earth resistance is not sufficiently low, all earthed systems, signalling earths and the power neutral should be bonded together either directly or by means of a spark gap. Although this bonding may be expensive it allows the difficulty of providing a low resistance earth to be resolved and is a technique widely used. In some countries connection to the electricity system neutral is governed by national regulations, so that agreement with the electrical Authority should be obtained.

4.5 High isolation technique

When telephone lines are located in areas with a very high level of exposure to lightning (frequent breakdowns on lines and also high probability on the terminal installations) and when lightning protectors cannot be installed on the subscriber plant owing to earthing and maintenance difficulties and costs, it is recommended to employ a high isolation technique (of a level of at least 50 kV) at the telephone line access.

This method should be widely introduced at the input to high-voltage plant and is strongly recommended for use with open-air terminal installations in rural areas, such as “telepoints” and card-operated telephones.

4.6 National regulations

Many countries have national standards covering the protection of users of telecommunications equipment not only from the risks associated with connection to the electricity mains but also from conditions which may appear on the telephone line.

4.7 High cost of maintenance of subscribers’ installations

The cost of repairs at exposed terminal installations may be high by reason of the distance from the maintenance centre, transport delays and, possibly, the seriousness of the damage. Moreover, insufficient protection is the cause of repeated interruptions of service which are particularly damaging to the quality of service and the satisfaction of the customer. This justifies the granting of special attention to protection measures.

References

[1] CCITT *Manual The protection of telecommunication lines and equipment against lightning discharges*, ITU, Geneva 1974, 1978.

[2] CCITT *Directives concerning the protection of telecommunications lines against harmful effects from electric power and electrified railway lines*, ITU, Geneva, 1988.

Annex A

Definition of terms associated with protection

(This annex forms an integral part of this Recommendation)

1.1 **primary protection**: Primary protection is applied at the location where it may prevent most of the stressful energy from propagating beyond the designated interface.

1.2 **secondary protection**: Secondary protection is applied subsequent to the primary protection. It may be provided by inherent protection.

1.3 **multistage protection**: Multistage protection is the application of sequential protection stages to achieve the intended overall protection level. The location and level of each stage must be coordinated.

1.4 **inherent protection**: Inherent protection is that protection which is provided at an equipment interface either by virtue of its intrinsic characteristics or by specific design.