INTERNATIONAL TELECOMMUNICATION UNION

CCITT

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

K.21

(11/1988)

SERIES K: PROTECTION AGAINST INTERFERENCE

RESISTIBILITY OF SUBSCRIBERS' TERMINALS TO OVERVOLTAGES AND OVERCURRENTS

Reedition of CCITT Recommendation K.21 published in the Blue Book, Volume IX (1988)

NOTES

1 CCITT Recommendation K.21 was published in Volume IX of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

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

Recommendation K.21

RESISTIBILITY OF SUBSCRIBERS' TERMINALS TO OVERVOLTAGES AND OVERCURRENTS

(Melbourne, 1988)

Introduction

This Recommendation has been produced by Study Group V to meet the urgent requirements of Administrations and manufacturers who are using or designing subscriber's equipment. The attention of the reader is drawn to the following subjects which CCITT is studying further:

– rise of earth potential;

– electrical fast transients;

– operational tests for barriers between mains ports and telecommunication ports;

– high frequency mains-voltage surges;

– short duration interruptions of mains voltages.

When these studies have been completed, this Recommendation may be expanded.

1 Purpose of the Recommendation

When modern telecommunications equipment is connected to local subscribers' lines, the equipment may be damaged as a result of overvoltages or overcurrents which occur on these lines under occasional conditions. The probability and magnitude of these conditions vary due to many factors, e.g. geography, climate, construction methods, shielding effects. Overvoltage or overcurrent surges arising from electrostatic discharges or transient surges which occur on mains-voltage power supplies may also damage equipment or cause its misoperation. This Recommendation seeks to establish fundamental testing methods which may be varied in detail to suit particular local circumstances and which help to predict the likelihood of survival when the equipment is exposed to these overvoltages or overcurrents.

In its present form, the Recommendation describes tests that should be applied to equipment which is metallically connected directly to balanced pairs. Further studies relating to equipment connected to coaxial and optical fibre cables are being made.

The Recommendation assumes that line protectors are fitted externally to the equipment in exposed areas. Administrations individually will decide their policies for protection. The guidance of Recommendation K.11 should be followed when making this judgement and should take account of the routing of lines to the equipment, in addition to its location.

2 Scope

This Recommendation deals principally with desk-borne equipment. Recommendation K.20 deals with switching equipment powered by central-battery. For the more complex subscriber equipment, Administrations should use either Recommendation K.20 or K.21 as appropriate.

The Recommendation relates to type tests only. Recognizing the difficulty in testing a complex item of subscribers' equipment, the Recommendation concentrates on a series of tests made principally at the telecommunication line and mains input terminals. The tests should be applied at any chosen stage during the normal use of the equipment.

As the equipment may be used in either an exposed or unexposed environment, tests are made with and without line protectors fitted.

The tests for lightning surges assume that an electrical connection between the power system earth terminal and the telecommunications equipment earth can be effected. A study of special test requirements for situations where this is not possible is being made.

The tests for power induction apply only to longitudinal effects and a further study is being made of test requirements for transverse surges.

Some aspects of rise of earth potential, such as may arise from a power line system fault, are not at present covered but are being studied.

Electrical fast transient requirements are not yet included and a study is being made of test requirements for both the telecommunication and mains power lines.

The Recommendation deals primarily with reliability of equipment and although it may provide some level of safety, it is not sufficient by itself to fully protect the user. National standards for electrical safety should be followed in each country where the equipment is used. Furthermore, this Recommendation is not intended to establish whether equipment could produce harmful effects to the network when connected. Interference from low frequency induced voltages or radio frequency interference to the operation of the equipment is not included.

3 Overvoltage and overcurrent conditions

Aspects of overvoltage or overcurrent covered by this Recommendation are:

- surges due to direct or indirect lightning strokes on or near the line plant;
- short-term induction of 50/60 Hz voltages from adjacent power lines or railway systems, usually when these lines or systems develop faults;
- direct contacts between telecommunications lines and power lines, usually of a low voltage nature;
- electrostatic discharges generated by users touching the equipment or adjacent plant;
- transient surges on mains-voltage power supplies to the equipment.

4 Equipment boundary

Variations in equipment make it necessary for each unit to be seen as a “black box” having three or more terminals, A, B, etc. and E (earth). Some protective devices may have already been provided within the equipment, e.g. distributed on cards, or connected to internal terminals. For the purposes of these tests, manufacturers are expected to define the boundaries of the “black box” and any protective device which is thereby included must be considered as an immutable part of the equipment. Where any auxillary telecommunications lead 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, etc. and E (earth).

5 Test conditions

The following general conditions apply to all the tests specified in §§ 7, 8 and 9 except where otherwise stated.

1) All tests are type tests.
2) The input terminals at which tests on the equipment are to be applied should be identified by the manufacturer and labelled A, B, C, D, etc. and Earth.
3) For the tests specified in §§ 7 and 9 only, the equipment should be enclosed in a foil shroud over those parts likely to have a human contact during use, and the foil connected to the E terminal.
4) The equipment should be tested in each operating mode of significant duration.
5) The equipment should pass the tests listed in §§ 7 and 9 throughout the ranges of temperature and humidity of its intended use.
6) Some of the tests in Table 1/K.21 require the addition of agreed primary protection. It is current practice to protect exposed subscribers' lines with some surge protectors such as gas-discharge tubes. Recognizing that some such device is likely to be needed in most cases to handle high surge currents, and that the operation of these protectors exposes subscribers' equipment to other modified conditions, the characteristics of the external protectors to be used should be agreed between the equipment supplier and the Administration. Administrations applying the tests included in this Recommendation are free to select such protectors with any characteristics within the range acceptable for these nominated devices, when carrying out tests with external protection fitted.

   Protectors having characteristics within the agreed range should be used where specified in Table 1/K.21. A new set of protectors may be used after the completion of each test sequence. Alternatively, some Administrations may choose to omit the external protectors and to modify the applied voltages and durations, so that the conditions applied to the equipment are the same as could reasonably be expected to occur under the conditions of Table 1/K.21.
7) In all cases where a maximum voltage is specified, tests should also be made at lower voltages if this is necessary to confirm that the equipment will resist any voltage up to the maximum value specified.

8) Each test should be applied the number of times indicated in Table 1/K.21. The time interval between applications should be one minute and, in the case of pulse tests, the polarity should be reversed between consecutive pulses.

9) Power induction and power contact tests should be made at the frequency of the a.c. mains or electric railway used in the country of application.

6 Permitted malfunction or damage

Two levels of malfunction or damage are recognized:

– *Criterion A* – Equipment shall withstand the test without damage or other disturbance, e.g. corruption of software or misoperation of fault-protection facilities and shall operate properly within the specified limits after the test. It is not required to operate correctly while the test condition is present.

  If specifically permitted by the Administration, the test may cause the operation of fuses or other devices which have to be replaced or reset before normal operation is restored.

– *Criterion B* – A fire hazard should not arise in the equipment as a result of the tests. Any damage or permanent malfunction occuring should be confined to a small number of external line interface circuits.

The conditions likely to give rise to criterion B are considered to be so rare that complete protection against them is not economical.

7 Tests related to lightning surges, power induction and contacts

The test circuits used for the three overvoltage or overcurrent conditions are as follows:

– Figure 1/K.21: lightning surges;

– Figure 2/K.21: power induction;

– Figure 3/K.21: power contacts.

The equipment should be tested according to Table 1/K.21.

8 Tests related to electrostatic discharges

The requirements of IEC publication 801-2 [1] should be followed. The equipment should meet criterion A of this Recommendation when tested to both severity levels 2 and 4 of IEC 801-2. These two severity levels have been chosen because at severity level 2, the rise time is much faster than that at severity level 4. This fast rise time may cause coupling into sensitive circuits to take place and will require an assessment for misoperation due to software corruption, rather than just for energy dissipation.

However, when deemed appropriate by an Administration, alternative severity levels of testing may be used. In addition, an Administration may choose to relax the conditions of criterion A to a limited extent.

9 Tests related to mains-powered equipment

The following tests are made on mains-powered equipment to ensure that the equipment can adequately resist high voltage surges which may arise on power conductors from lightning or other causes, such as load switching.

The equipment under test should be tested with normal operating power applied and with the telecommunication line access at the equipment terminated in such a manner as to simulate the conditions in each state of operation of significant duration.

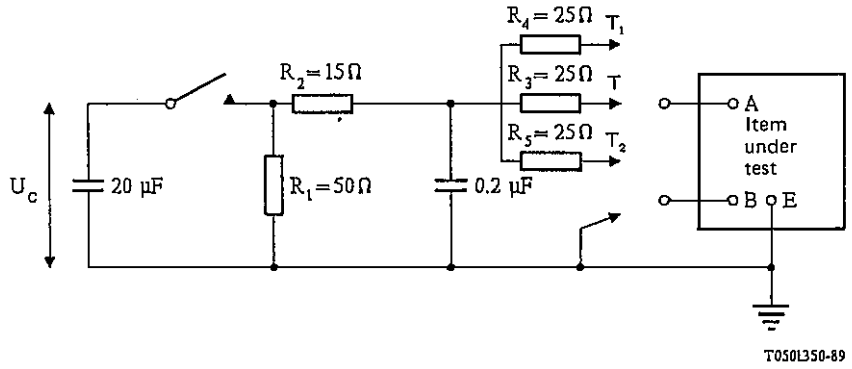

FIGURE 1/K.21

Test circuit for lightning surges

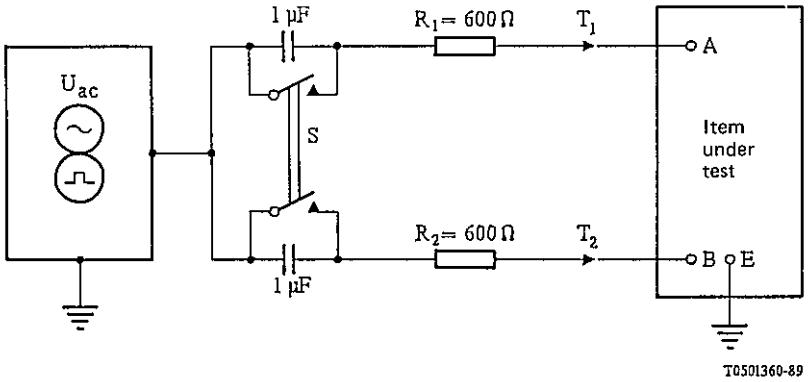

FIGURE 2/K.21

Test circuit for power induction

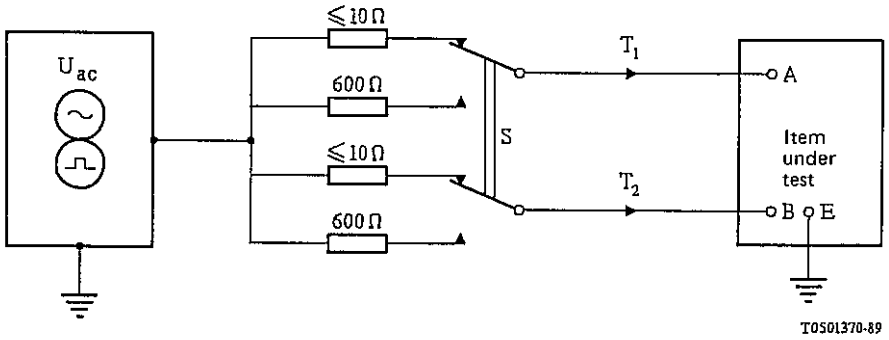

FIGURE 3/K.21

Test circuit for power contacts

TABLE 1/K.21

No.	Test	Terminal connections	Test circuit	Maximum test voltage and duration	Number of tests	Added protection [see 6) of § 5]	Acceptance criteria (see § 6)
1	Lightning surge simulation	T and A, B, etc. in turn with all other equipment terminals earthed (Note 1)	Figure 1/K.21	U_c = 1.0 kV (Note 2)	10	None	Criterion A
				U_c = 4 kV (Note 3)	10	Agreed primary protection	Criterion A
		T_1 and A T_2 and B	Figure 1/K.21	U_c = 1.5 kV (Note 2)	10	None	Criterion A
				U_c = 4 kV (Note 3)	10	Agreed primary protection	Criterion A
2	Power induction	T_1 and A T_2 and B	Figure 2/K.21 S unoperated	$U_{ac\,(max)}$ = 300 V_{rms} for 200 ms (Note 4)	5	None	Criterion A
			Figure 2/K.21 S operated	(Note 5)	1	Agreed primary protection	Criterion B
3	Power contact	T_1 and A T_2 and B	Figure 3/K.21 Tests made with S in each position (Note 6)	$U_{ac\,(max)}$ = 230 V_{rms} for 15 min (See Note 4)	1 For each position of S	None	Criterion B

Note 1 – An earthed connection may prevent the establishment of normal operation conditions when the test is made. In these cases, alternative testing procedures should be followed to meet the requirements of this test (e.g. a low voltage spark-gap or other variation in the earth connection should be used).

Note 2 – Administrations may choose other values of $U_{c\,(max)}$ to suit local circumstances, e.g. to avoid the use of protectors or to align with the impulse spark-over voltage of protectors that are normally used.

Note 3 – Administrations may vary $U_{c\,(max)}$ to meet their local requirements.

Note 4 – Administrations may specify lower values of $U_{ac\,(max)}$ and may vary the duration of the test to meet their local requirements (e.g. local mains voltages).

Note 5 – Voltages and durations should be in accordance with CCITT directives or such other limits as Administrations.

Note 6 – Fuses, fuse cables, etc., may be left in circuit during these tests. The current conducted by wiring shall not constitute a fire hazard within the premises where the equipment is located.

Equipment not complying with a) below should meet criterion A of this Recommendation when tested with surge tests applied between phase, neutral and protective earth terminals of the equipment in accordance with b) below.

a) *Insulation coordination*

IEC publication 664 [2] describes overvoltage categories for mains-powered equipment, including telecommunication equipment, in respect of overvoltages arising in the supply network. Most subscribers' equipment is expected to be installed in overvoltage category 11 in which the maximum surge voltage arriving at its mains terminals is 2.5 kV peak. Given this and certain other assumptions about atmospheric pollution (e.g. dust) and the quality of insulation, IEC 664 gives guidance to IEC standards committees on coordinated creepage distances and clearances that can be expected to give adequate performance during the lifetime of the equipment.

The guidance in IEC 664 has been adopted in IEC publication 950 [3]. Subject to cases mentioned in c) below, telecommunication equipment that employs insulation spacings that are dimensioned and tested in accordance with IEC 950 need not to be subjected to further tests under this Recommendation.

b) *No insulation coordination*

Where reliance is not placed on insulation coordination, the equipment shall be subjected to tests along the lines indicated in references [3] to [5].

c) *Exceptional overvoltages*

In cases where electrical disturbances may be of exceptional amplitude or simply greater than the values adopted for the tests, it is recommended that additional protective measures external to the terminal equipment be used, e.g.:

- power transformers with high dielectric strength (or the order of 10 kV) in relation to the mains leads;
- overvoltage limiting devices such as lightning arrestors, air gaps, non-linear resistances, etc.;
- combinations of the above.

Note 1 – For situation a), the experience of one country has shown that a Rec. K.17 generator may be substituted, i.e. with a waveshape 10/700 µs and an internal impedance of 40 ohms. A test voltage of $V_{C\,(max)}$ = 2.5 kV assured a satisfactory performance of equipment operated at a load level interface of low-voltage distribution systems with a nominal voltage of 230/400 V.

Note 2 – Attention is drawn to matters of safety which relate to electrical barriers between the mains power and telecommunication line terminals. These are normally subject to national regulations which have to be followed in each country.

References

[1] IEC publication 801-2, *Electromagnetic compatibility for industrial-process measurement and control equipment, Part 2: Electrostatic discharge requirements*, Geneva, 1984.

[2] IEC publication 664 *Insulation co-ordination within low-voltage systems including clearances and creepage distances for equipment*, Geneva, 1980.

[3] IEC publication 950 *Safety of information technology equipment including electrical business equipment*, Geneva, 1986.

[4] ANSI/IEEE Standard C 62.41, *IEEE guide for surge voltages in low-voltage AC power circuits*, New York, 1980.

[5] CENELEC ENV 41003 *Particular requirements for information technology equipment when connected to a telecommunication network*, Brussels, 1988.

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Printed in Switzerland

Geneva, 2010