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SERIES K: PROTECTION AGAINST INTERFERENCE

**Resistibility of telecommunication switching
equipment to overvoltages and overcurrents**

ITU-T Recommendation K.20

(Previously CCITT Recommendation)

ITU-T K-SERIES RECOMMENDATIONS
PROTECTION AGAINST INTERFERENCE

For further details, please refer to ITU-T List of Recommendations.

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.20 was revised by ITU-T Study Group 5 (1993-1996) and was approved by the WTSC (Geneva, 9-18 October 1996).

NOTES

1. In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.
2. The status of annexes and appendices attached to the Series K Recommendations should be interpreted as follows:
 - an *annex* to a Recommendation forms an integral part of the Recommendation;
 - an *appendix* to a Recommendation does not form part of the Recommendation and only provides some complementary explanation or information specific to that Recommendation.

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SUMMARY

This Recommendation seeks to establish fundamental testing methods and criteria for the resistibility of telecommunications switching equipment to overvoltages and overcurrents.

This Recommendation relates to telephone exchanges and similar telecommunication switching centres and is concerned mainly with the conditions to be applied to points intended for connections to subscriber lines.

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 power lines or railway systems, direct contacts between telecommunication lines and power lines and electrostatic discharges.

RESISTIBILITY OF TELECOMMUNICATION SWITCHING EQUIPMENT TO OVERVOLTAGES AND OVERCURRENTS

(Malaga-Torremolinos, 1984; revised in 1990, 1993, 1996)

1 General

This Recommendation seeks to establish fundamental testing methods and criteria for the resistibility of telecommunication switching equipment to overvoltages and overcurrents. It should be read in conjunction with Recommendations K.11 and K.39 which deal with the general economic and technical aspects of protection.

2 Scope

This Recommendation relates to telephone exchanges and similar telecommunication switching centres and is concerned mainly with test conditions to be applied to points intended for the connection of 2-wire subscriber lines. Ports carrying more complex circuits or more concentrated traffic (such as junctions or multi-channel circuits) may be tested either in accordance with this Recommendation or in accordance with other Recommendations such as K.15 and K.17, as considered appropriate.

This Recommendation assumes that the earthing and bonding configurations comply with Recommendation K.27 or K.35.

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

3 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; (equipment complying with this Recommendation may not necessarily resist severe direct lightning strokes; see Recommendation K.40);
- short-term induction of alternating voltages from adjacent power lines or railway systems, usually when these lines or systems develop faults;
- direct contacts between telecommunication lines and power lines, usually of a low voltage nature;
- electrostatic discharges from operators directly and via radiated fields from discharges to adjacent objects.

It is recognized that under some circumstances, problems may arise if overvoltages or overcurrents occur simultaneously on a number of lines and produce large currents in common wiring or components. Such conditions are covered by the test requirement Table 1, No. 1c). This test simulates the simultaneous lightning surge on a group of lines of the subscriber line card.

4 Levels of resistibility

4.1 Telecommunication lines are more or less influenced in the practical environment by lightning or power lines. The several degrees of influence and protection measures are described in Recommendation K.11. With reference to the resistibility of the switching equipment, it is distinguished between two levels in this Recommendation. The lower resistibility level suitable for less exposed environments is reached either by the inherent protection or the secondary

protection of the equipment. The higher resistibility level for more exposed environments is achieved by an added primary protection outside the equipment. The same equipment is usually supposed to operate satisfactorily in both environments. Therefore, the equipment is tested under all conditions according to Table 1.

4.2 It is for Administrations to classify the environment of a specific switching centre, taking into account business policy, economic and technical considerations, and to decide about the use of agreed primary protectors according to Recommendation K.39.

4.3 The test conditions with agreed primary protection simulate additional requirements to ensure compatibility with external protection and proper functioning in the more severe environment. Higher voltages may well occur on the lines, but because the primary protection operates, the effects on the equipment may not be more severe.

4.4 The best place for the insertion of the primary protection is the border of the building. However, presently the primary protectors are fitted in most cases at the Main Distribution Frame (MDF). Then the MDF should be located as close as possible to the entry point of the cables to the building.

5 Exchange equipment boundary

The variations of different types of equipment make it necessary for each exchange to be seen as a “black-box” having several terminals, A, B, etc. and Earth. It is likely that some protective devices have already been provided in the equipment, either distributed on its line cards, etc., or connected to its terminals. 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 that exchange.

6 Test conditions

The following conditions apply to all the tests specified in clause 9, except those for ESD (9.5).

6.1 All tests are type tests.

6.2 The input terminals at which tests on the equipment are to be applied should be identified by the manufacturer and labelled A, B, etc. and Earth.

6.3 The equipment should be tested in any operating state of significant duration.

6.4 The equipment should be capable of passing the tests in clause 9 within the ranges of temperature, relative humidity and air pressure of its intended use.

6.5 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.

6.6 Each test should be applied the number of times indicated in the table. The time interval between consecutive tests should be 1 minute. The polarity of surge tests should be reversed between consecutive surges.

6.7 Power induction tests should be made at the frequencies of the a.c. mains and electric railways used in the country of application.

7 Coordination with primary protection

7.1 General

For equipment installed in a more exposed environment, it is current practice to protect subscribers' lines at the MDF with Surge Protective Devices (SPDs) such as gas discharge tubes or solid-state arrestors (see also 4.1). The characteristics of these primary SPDs shall comply with the requirements of Recommendations K.12 and K.28 respectively and should be agreed between the equipment supplier and the operator. In this Recommendation, it is called “agreed” primary protection. The agreed type should be used for the operation and for the test of the equipment.

A new set of protectors may be used after the completion of each test sequence.

7.2 Lightning surge simulation

The operation of the primary protection has two effects:

- It limits the maximum voltage applied to the equipment and hence, depending on the internal impedance of the equipment, the maximum current which the equipment must withstand.
- It produces a very rapid change of voltage and current, which by inductive or capacitive effects can reach sensitive parts of the exchange switching equipment not apparently exposed to line voltages.

The coordination is achieved when the primary SPD is activated carrying out tests with U_c below 4 kV and the equipment complies with criterion A of this Recommendation when tested following the test procedure in 6.5.

If the primary protection is not activated, attention should be paid to the value of the currents that can flow in the internal cabling network. Large currents in the internal cabling network may disturb other equipment. Recommendation K.27 describes earthing and bonding inside a telecommunication building and treats coordination with electrical protection devices.

7.3 Power induction and power contact

The input impedance to ground of both A and B inputs of present exchange equipment may be low when the secondary overvoltage protection is activated. In this case the voltage across the impedance to ground caused by the current that flows during the power induction test may be too low to activate the primary protection and therefore coordination is not achieved.

8 Permitted malfunction or damage

Two levels of malfunction or damage are recognized:

Criterion A – Equipment shall withstand the test without damage or other disturbance (such as 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 during the test.

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

9 Tests

The tests shall be carried out according to Table 1.

9.1 Lightning surge tests on a single line port:

- Figure 1 shows the surge generator used for lightning surge tests. Its open-circuit voltage has a 10/700 μ s waveform.
- Figure 2 shows the test circuits for the single port test.

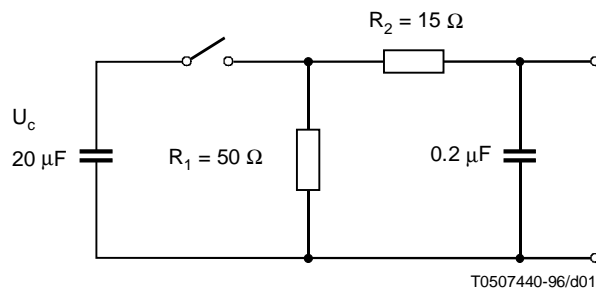
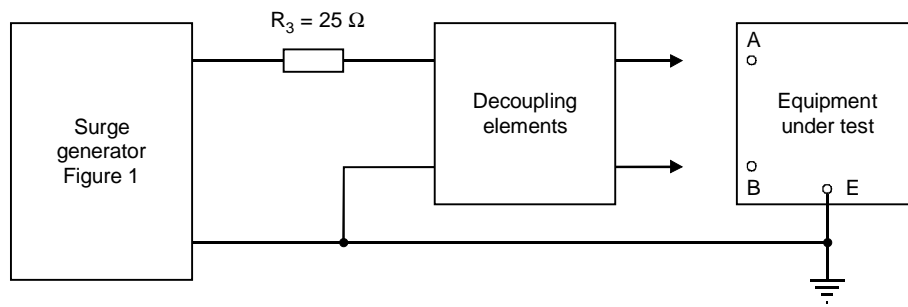
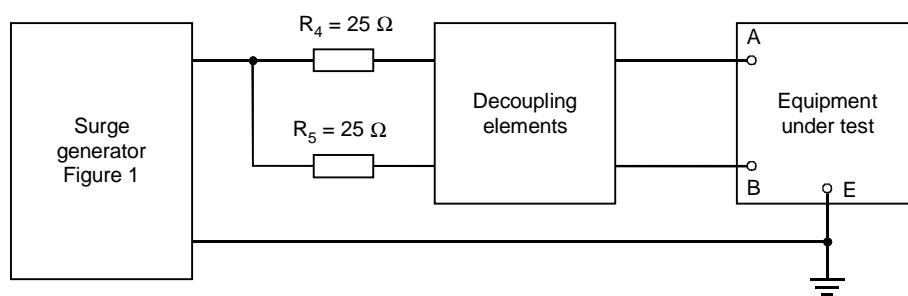


Figure 1/K.20



a) Transversal test



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b) Longitudinal test

Figure 2/K.20

Decoupling elements (e.g. diodes) are necessary between the surge generator and equipment under test to prevent a short-circuit of the input terminals of the equipment.

NOTE – The decoupling elements used in the tests shall be selected in such a way as to have a minimum influence on the waveform from the generator regarding the waveshape, voltage and current profiles.

Certain considerations which justify the test proposals are stated in Annex A. The response of equipment to lightning surges may be modified by the input impedance of the equipment. To explain this effect, Annex A includes an example in which, for clarity, values are assigned to the input impedances so that instantaneous levels of voltage at different points in the circuit may be compared. These values are included for illustration only and do not form any part of this Recommendation.

9.2 Simultaneous surge test on a group of line ports

For the simultaneous lightning surge test, it is supposed that an average of 50% of the subscriber line card ports are connected simultaneously to exposed cables. Therefore, it is recommended to test simultaneously 50% of the ports evenly distributed over the subscriber line care, e.g. $n = 4$ pairs for a line card with 8 ports. The untested input-ports are unconnected during the test.

Figure 3 shows the test circuit for the simultaneous surge test.

9.3 Power induction test

Figure 4 shows the test circuit for the power induction test.

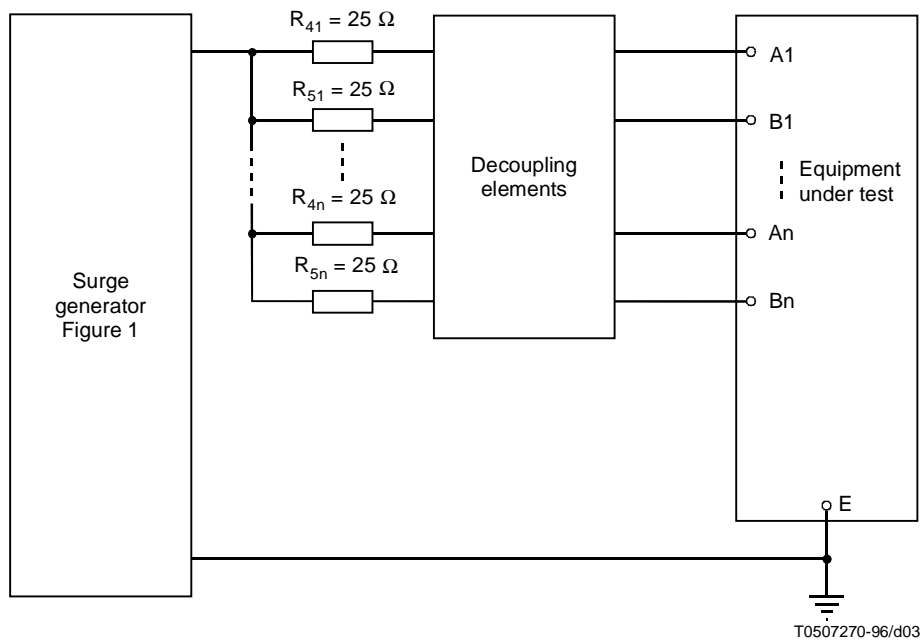


Figure 3/K.20

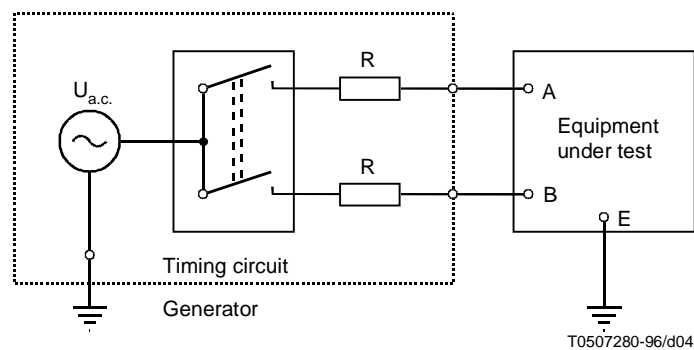


Figure 4/K.20

The rationale for the test circuit and the test voltage and duration values is given in A.2.

The power induction test shall be carried out without and with primary protection.

The following test conditions are to be applied in the tests without primary protection (according to Figure 4 and Table 1, No. 2a):

$$U_{a.c.(max)r.m.s.} = 600 \text{ V}, t = 200 \text{ ms}, R = 600 \Omega$$

The test conditions with primary protection cover in normal cases (according to Figure 4 and Table 1, No. 2b) the following values:

$$U_{a.c.(max)r.m.s.} = 600 \text{ V}, t = 1000 \text{ ms}, R = 600 \Omega$$

The normal test conditions with primary protection may be adapted to the local conditions by variation of the test parameters within the following limits, so that I^2t equal to $1 \text{ A}^2\text{s}$ is fulfilled:

$$U \quad 300 \text{ V} \leq U_{\text{a.c.}(\text{max})\text{r.m.s.}} \leq 600 \text{ V}$$

$$t \quad \leq 1000 \text{ ms}$$

R is to be adjusted after calculation of I^2t (for the purpose of this calculation the input resistance of the equipment under test is taken as 0)

I is the current flowing through each output terminal of the generator.

9.4 Power contact test

Figure 5 shows the test circuit for the power contact test.

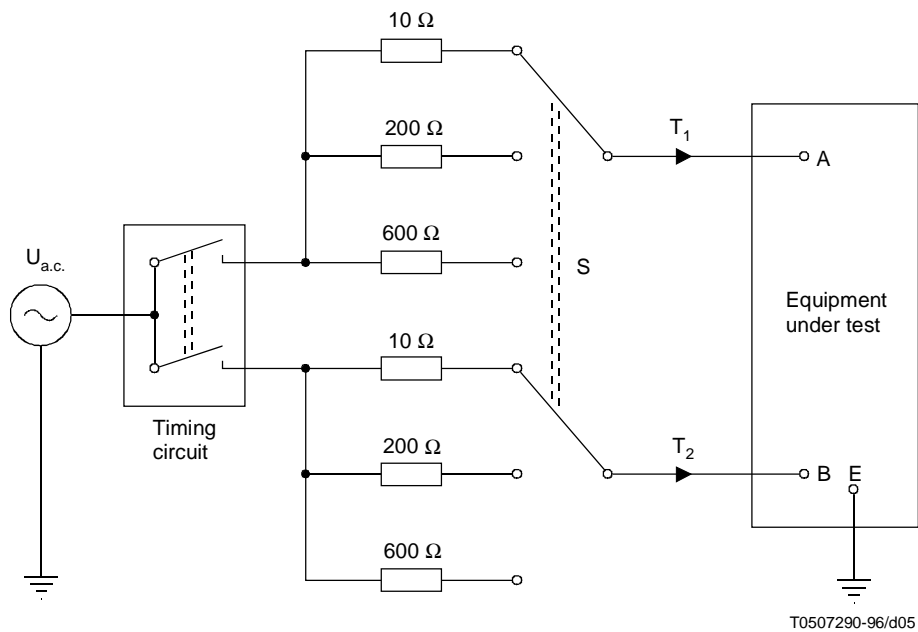


Figure 5/K.20

Current-limiting devices (e.g. fuses, heat coils, fuse cables) may be left in the circuit during this test.

If the switch S is in the position “ 10Ω ” the current may be limited to lower values according to national regulations.

The user may vary the value of $U_{\text{a.c.}(\text{max})}$ according to the local mains voltage.

9.5 Test related to electrostatic discharges

The resistibility of the switching equipment is tested against electrostatic discharge according to IEC Publication 1000-4-2 and Recommendation K.32.

The equipment should meet criterion A of this Recommendation when tested to severity level 3 of IEC 1000-4-2.

Table 1/K.20 – Test conditions

No.	Test	Between	Test circuit	Maximum test voltage and duration	Number of tests	Agreed primary protection	Acceptance criterion
1a)	Lightning surge simulation	A and E with B earthed	Figure 2 a)	$U_{c(max)} = 1 \text{ kV}$	10	None	A
		B and E with A earthed	Figure 2 a)	$U_{c(max)} = 1 \text{ kV}$	10	None	
		A + B and E	Figure 2 b)	$U_{c(max)} = 1 \text{ kV}$	10	None	
1b)	Lightning surge simulation	A and E with B earthed	Figure 2 a)	$U_{c(max)} = 4 \text{ kV}$	10	Yes	A
		B and E with A earthed	Figure 2 a)	$U_{c(max)} = 4 \text{ kV}$	10	Yes	
		A + B and E	Figure 2 b)	$U_{c(max)} = 4 \text{ kV}$	10	Yes	
1c)	Simultaneous surge simulation on a group of n line ports	$n \times (A + B)$ and E	Figure 3	$U_{c(max)} = 1 \text{ kV}$	10	None	A
2a)	Power induction	A + B and E	Figure 4	$U_{a.c.(max)r.m.s.} = 600 \text{ V}$ 0.2 s	5	None	A
2b)	Power induction	A + B and E	Figure 4	$U_{a.c.(max)r.m.s.} = 600 \text{ V}$ 1 s (Note)	5	Yes	A
3)	Power contact	A + B and E	Figure 5 Tests are made with S in each position	$U_{a.c.(max)r.m.s.} = 230 \text{ V}$ 15 min	1 for each position of S	None	B
NOTE – See the possible variation of the test conditions in 9.3.							

Annex A

Explanations which illustrate test conditions

A.1 Lightning surges

Figure A.1 shows the test generator of Figure 1 connected to an example of an exchange circuit with primary protection provided at the MDF and secondary protection in the exchange equipment itself. Apart from the test generator of Figure 1, all the circuit layout and component values have been chosen only for explanatory purposes and are not put forward as some recommended practice.

When the charging voltage U_c is progressively raised, the different components are subjected to different voltages, currents and energies. The choice of the components of the circuit is determined by:

- The maximum voltage across the component.
- The maximum current through the component.
- The maximum energy that will be absorbed by the component (the integral voltage current for the duration of the pulse).

For $U_c = 0-300\text{ V}$, the current flows only through the $100\ \Omega$ resistor in the equipment.

At $U_c = 300\text{ V}$, the secondary protection operates. This will limit the voltage across the $100\ \Omega$ resistor and therefore also the current through the resistor. The maximum voltage and current will increase until the charging voltage is just below the activation level of the primary protection.

When the primary protection is activated, the voltage U_P drops to a low value (typically about 25 V). The current I_E flowing into the equipment falls to a very low value and becomes practically independent of U_c .

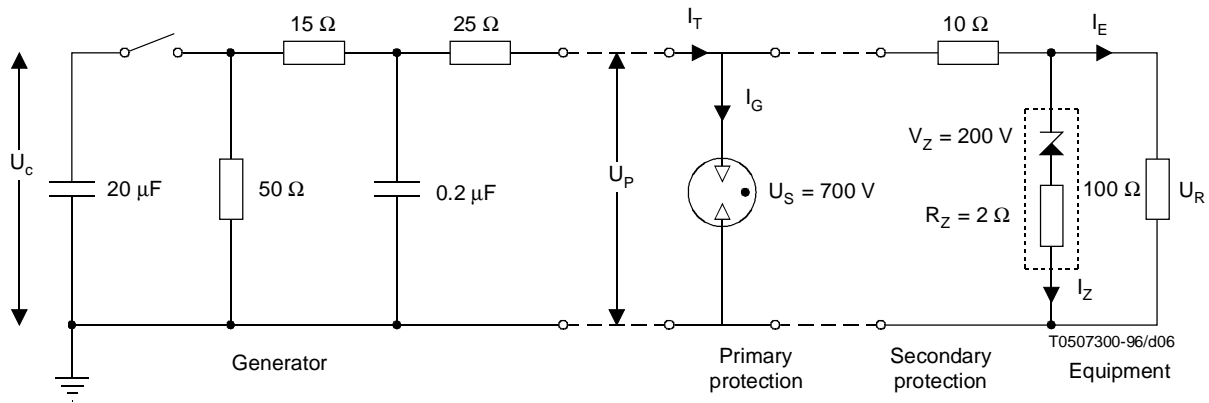


Figure A.1/K.20

For the coordination with the primary protection, attention must be paid to the operating principles of the Gas Discharge Tube (GDT). A GDT has a specified d.c. breakdown voltage. For fast-rising voltages the breakdown voltage of the GDT is higher as mentioned in Recommendation K.12. The test generator of Figure 1 produces a pulse with a fast-rise time ($10\ \mu\text{s}$) and a long decay time ($700\ \mu\text{s}$). If the primary protection is not activated during the rising edge, it can still be activated during the decay period as the voltage remains initially almost constant during the decay period. When the GDT is activated during the decay period, the breakdown voltage is lower and approaches the d.c. breakdown voltage.

Figure A.2 shows the measured voltage U_P across the primary protection and the voltage U_R across the $100\ \Omega$ resistor for a charging voltage U_c of 1 kV and a GDT with a d.c. breakdown of $350\text{V} \pm 20\%$. The different currents can be calculated from the voltages. The primary protection is activated after $18\ \mu\text{s}$ and the maximum voltage across the GDT is 416 V .

Figure A.3 shows U_R for a charging voltage U_c of 4 kV . The primary protection is activated after $2.4\ \mu\text{s}$ and the maximum voltage across the GDT is 612 V . Although the voltage is higher, the amount of energy that is passed to the equipment is lower.

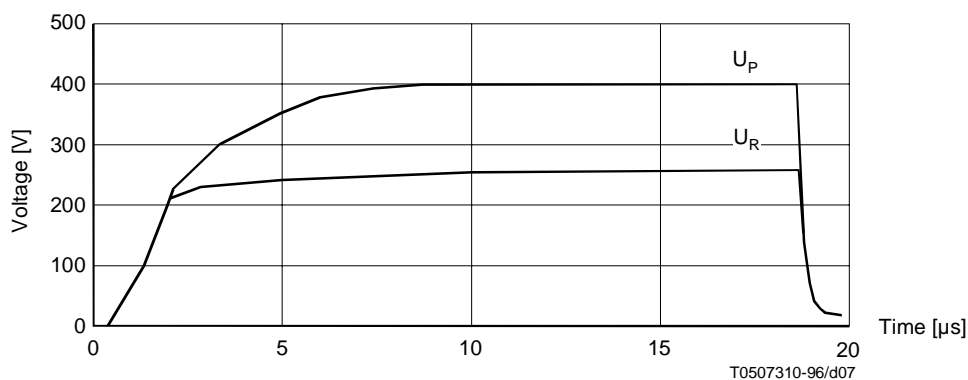


Figure A.2/K.20 – Voltage U_P across the primary protection and U_R across the $100\ \Omega$ resistor for a charging voltage U_c of 1 kV . Test circuit of Figure A.1

This example with two different charging voltages shows the importance of the knowledge of the characteristics of the primary protection in order to assure a proper coordination between primary and secondary protection.

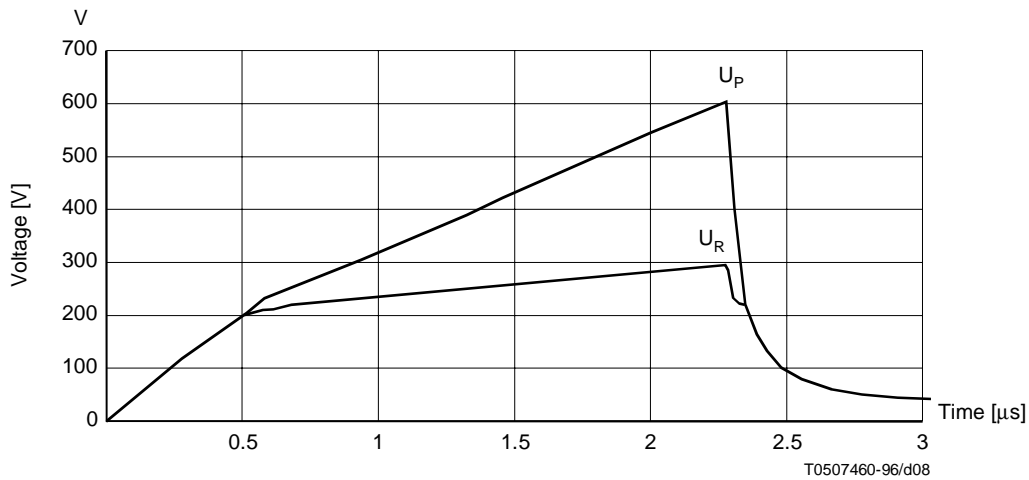


Figure A.3/K.20 – Voltage U_P across the primary protection and U_R across the 100 Ω resistor for a charging voltage U_c of 4 kV. Test circuit of Figure A.1

A.2 Power induction

Induced voltages are more likely to occur on long lines, and in the common case where subscribers' lines do not provide a low resistance to earth, induced voltages E may be considered to have a high source impedance consisting of a 600 Ω wire resistance in series with a 0.33 μF line to earth capacitance as shown in Figure A.4. The telephone is represented by a 100 Ω resistance and the hook-switch. The GDT shown in Figure A.4 are needed only on high exposed lines. However, because of the liberalization of subscriber equipment, such protectors may also be present on less-exposed lines. These GDT fire at the subscriber line end in the short-term power induction case and short-circuit the telephone and the line capacitances. Therefore, the test circuit given in Figure 4 consists only of the induced voltage $E = U_{a.c.}$ and the wire resistances R .

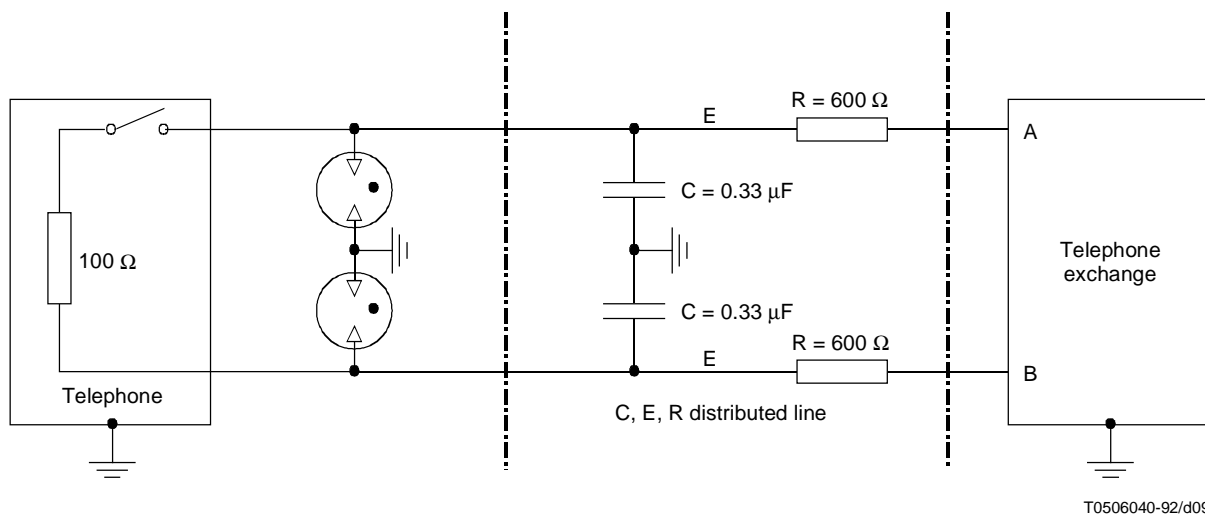


Figure A.4/K.20

Rationale for the test voltage and duration values indicated in Table 1, No. 2b):

Field experience showed that a large number of line cards in some exchanges were damaged by power induction during thunderstorm days. The damages appeared only in exposed rural areas. The currents induced on such lines and causing the line card damages were measured in a few cases and showed values between 4 and 6 A and duration between 200 and 500 ms.

These overcurrents with high specific energy values were estimated as rare events; therefore it was agreed that the induction test should simulate an overcurrent with a specific energy of about 1 A²s.

Considering that most test laboratories had available the test circuit indicated in Figure 4, it was decided to define, for the induction test, this maximum voltage value $U_{a.c.(max)} = 600 \text{ V}$ and to increase the test duration up to 1 s.

A.3 Power contact

Direct contact with electrical mains power can occur through network lines or cable faults, faulty or unapproved subscriber equipment or other causes. The contact may not cause the operation of a power system circuit breaker. a.c. currents resulting from direct contact may make effective protection both difficult and expensive. As such events are rare, equipment is not required to withstand overvoltages or overcurrents arising from direct contacts but may fail in an acceptable manner.

The following particular dangers to equipment may arise:

- A contact near to an exchange where the combined impedance of the cable circuit and exchange termination is low and a high current flow occurs. This condition is simulated in the test in Figure A.5 by an impedance of 10 Ω. The test current may be limited to lower values according to national regulations.
- A contact at the maximum distance from an exchange where the combined impedance of the cable circuit and exchange termination is high and a small but harmful current flows continuously. This condition is simulated by an impedance of 600 Ω.
- Experience shows that, in reality with values between 10 and 600 Ω, exchanges are most susceptible to damage and fire hazard from current overheating. An impedance of 200 Ω simulates this condition.

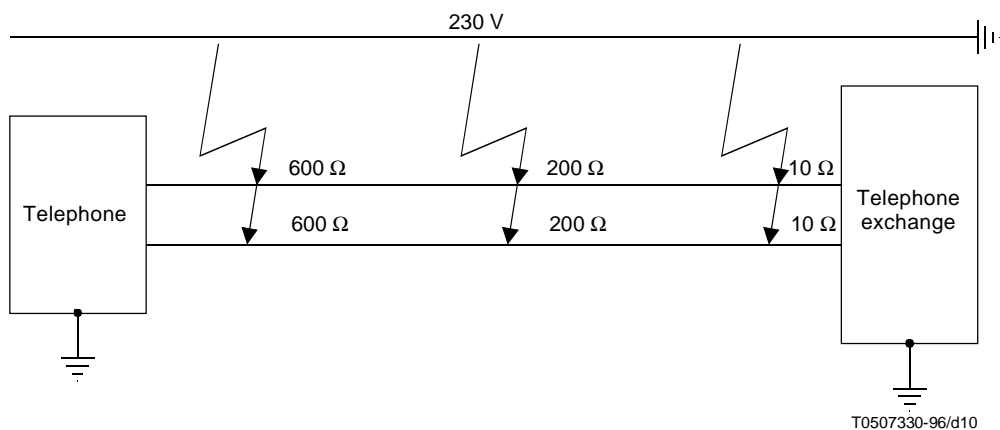


Figure A.5/K.20

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