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OF ITU

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PROTECTION AGAINST INTERFERENCE

RESISTIBILITY OF TELECOMMUNICATION SWITCHING EQUIPMENT TO OVERVOLTAGES AND OVERCURRENTS

ITU-T Recommendation K.20

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. 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, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation K.20 was revised by the ITU-T Study Group V (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

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

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RESISTIBILITY OF TELECOMMUNICATION SWITCHING EQUIPMENT TO OVERVOLTAGES AND OVERCURRENTS

(Malaga-Torremolinos, 1984; revised in 1990 and at Helsinki, 1993)

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 the CCITT Manual, *Protection of telecommunication lines and equipment against lightning discharges* and Recommendation K.11 which deals with the general economic and technical aspects of protection. The methods may be varied in the light of particular local circumstances and technical developments.

2 Scope

The 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.

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 Overvoltages 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);
- 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.

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 not covered by this Recommendation at this time and the subject is still being studied in CCITT (see Appendix I – Information about practical experiences in Norway). The aspects of rise of earth potential are not covered but are being studied in CCITT.

4 Levels of resistibility

4.1 Only two levels of resistibility are covered: a lower level suitable for unexposed environments where overvoltages and overcurrents are low, and a higher level for more exposed environments. Account is taken of the fact that in the more exposed environments, protection may be fitted on the main distribution frame (MDF) or elsewhere outside the equipment.

4.2 Extreme conditions are not covered. In very sheltered environments, it may be possible for equipment of lower resistibility than specified herein to operate satisfactorily. On the other hand, equipment with even higher resistibility than specified may be needed for exceptionally exposed environments. Equally, other combinations of equipment resistibility and external protection are possible. For example, certain equipment may require protection even in unexposed environments and other equipment may operate satisfactorily in exposed environments without external protection. Although only two categories of resistibility are described in this Recommendation, these cover a large proportion of present-day needs.

4.3 It is for Administrations to classify the environment of a particular switching centre, taking into account business policy, economic and technical considerations. Recommendation K.11 gives information to help in making this decision.

4.4 The test conditions and voltages of Table 1 reflect the conditions which are expected to occur on lines in unexposed environments.

TABLE 1/K.20

Test conditions and voltages for unexposed environments

No.	Test	Between	Test circuit	Maximum test voltage and duration	Number of tests	Acceptance criteria
1	Lightning surge simulation	A and E with B earthed	Figure 1a)	$U_{c\,(max)}$ = 1 kV (Note 1)	10	Clause 7, criterion A
		B and E with A earthed	Figure 1a)	$U_{c\,(max)}$ = 1 kV (Note 1)	10	
		A + B and E	Figure 1b)	$U_{c\,(max)}$ = 1 kV (Note 1)	10	
2	Power induction	A + B and E	Figure 2 $R_1 = R_2 = 600\ \Omega$ S_2 unoperated Tests made with and without S_1 operated	$U_{ac\,(max)}$ = 300 $V_{r.m.s.}$ 200 ms (Note 2)	5 for each position of S_1	Clause 7, criterion A
3	Power contact	A + B and E	Figure 3 Tests are made with switch S in each position (Note 3)	$U_{ac\,(max)}$ = 220 $V_{r.m.s.}$ 15 min (Note 2)	1 for each position of S	Clause 7, criterion B

NOTES

1 Administrations may specify a lower value of $U_{c\,(max)}$.

2 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 voltage).

3 Heat coils, fuses, fuse cables, etc., may be left in circuit during these tests.

4.5 The test conditions and voltages of Table 2 simulate the effects of an exposed environment on equipment protected by main distribution frame protectors and constitute 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 MDF protection operates, the effects on the equipment may not be more severe.

4.6 Equipment satisfying the requirements for an exposed environment may be used in either environment, but equipment satisfying only the requirements for an unexposed environment should be used only in an unexposed environment.

TABLE 2/K.20

Test conditions and voltages for exposed environments

No.	Test	Between	Test circuit	Maximum test voltage and duration	Number of tests	Added protection (subclause 6.5)	Acceptance criteria
1	Lightning surge simulation	A and E with B earthed	Figure 1a)	$U_{c\,(max)}$ = 1 kV (Note 1)	10	None	Clause 7, criterion A
		B and E with A earthed	Figure 1a)	$U_{c\,(max)}$ = 1 kV (Note 1)	10	None	
		A + B and E	Figure 1b)	$U_{c\,(max)}$ = 1 kV (Note 1)	10	None	
2	Lightning surge simulation	A and E with B earthed	Figure 1a)	$U_{c\,(max)}$ = 4 kV (Note 2)	10	Agreed primary protection	Clause 7, criterion A
		B and E with A earthed	Figure 1a)	$U_{c\,(max)}$ = 4 kV (Note 2)	10	Agreed primary protection	
		A + B and E	Figure 1b)	$U_{c\,(max)}$ = 4 kV (Note 2)	10	Agreed primary protection	
3 (a)	Power induction	A + B and E	Figure 2 $R_1 = R_2 = 600\ \Omega$ S_2 operated	$U_{ac\,(max)}$ = between 600 and 650 $V_{r.m.s.}$, 1 s (Note 3)	5	Agreed primary protection	Clause 7, criterion A
3 (b)	Power induction	A + B and E	Figure 2 $R_1 = R_2 = 200\ \Omega$ S_2 operated	(Note 4)	1	Agreed primary protection	Clause 7, criterion B

NOTES

1 Where the maximum impulse spark-over voltage of the agreed primary protection is less than 1 kV, then Administrations may choose to reduce $U_{c\,(max)}$.

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

3 Administrations may lower values of U_{ac} and vary the period of application.

4 Voltages and durations should be in accordance with CCITT Directives or such other limits as Administrations may set.

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 three terminals, A, B 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 an immutable part of that exchange.

6 Test conditions

The following conditions apply to all the tests specified in clause 8.

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 and Earth.

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

6.4 The equipment should be able to pass the tests in clause 8 throughout the ranges of temperature and humidity of its intended use.

6.5 For tests in the "exposed" situation, it is current practice to protect subscribers' lines at the MDF with some surge protectors such as gas-discharge tubes. Recognizing that such a device is likely to be needed in most cases to handle high surge currents, and that the operation of these protectors exposes exchange switching equipment to other modified conditions, the characteristics of the external protectors to be used should be agreed between the equipment supplier and the Administration. Protectors having characteristics within the agreed range should be used where specified in Table 2. 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 but 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 2.

6.6 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.

6.7 Each test should be applied the number of times indicated in the relevant table. The time interval between applications should be 1 minute and, in the case of pulse tests, the polarity should be reversed between consecutive pulses.

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

7 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 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 occurring 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.

8 Tests

8.1 General

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

- Figure 1: lightning surges;

- Figure 2: power induction;

- Figure 3: power contacts.

NOTE – 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 impedance 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.

8.2 Unexposed environment

Equipment for use without external protection in unexposed environments should be tested according to Table 1.

8.3 Exposed environment

Equipment for use in exposed environments should pass the tests described in Table 1 and also those in Table 2.

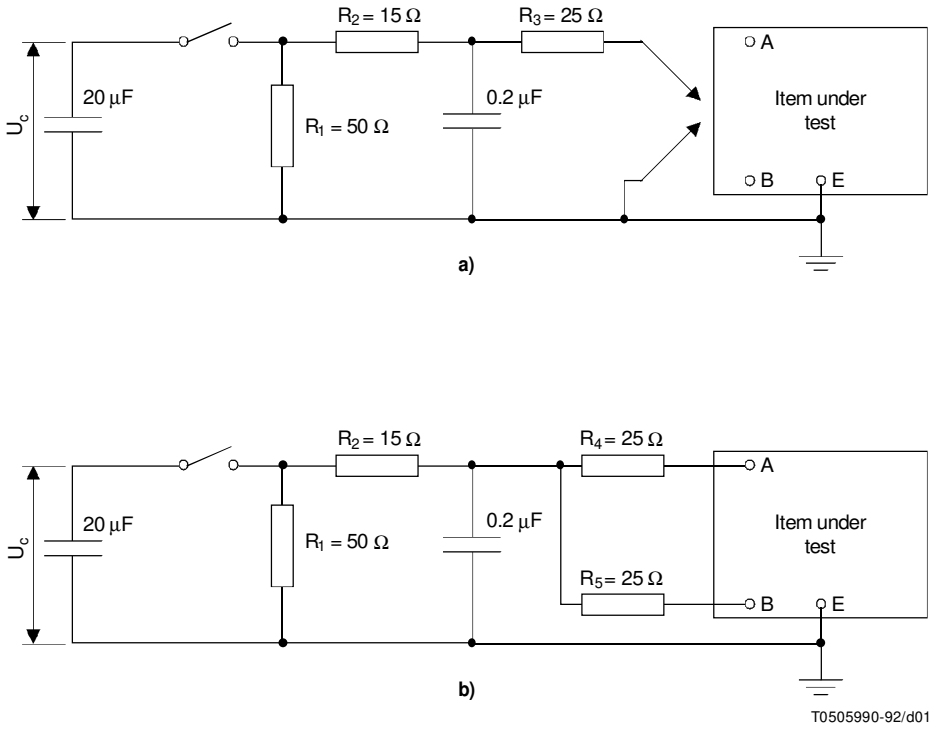


FIGURE 1/K.20

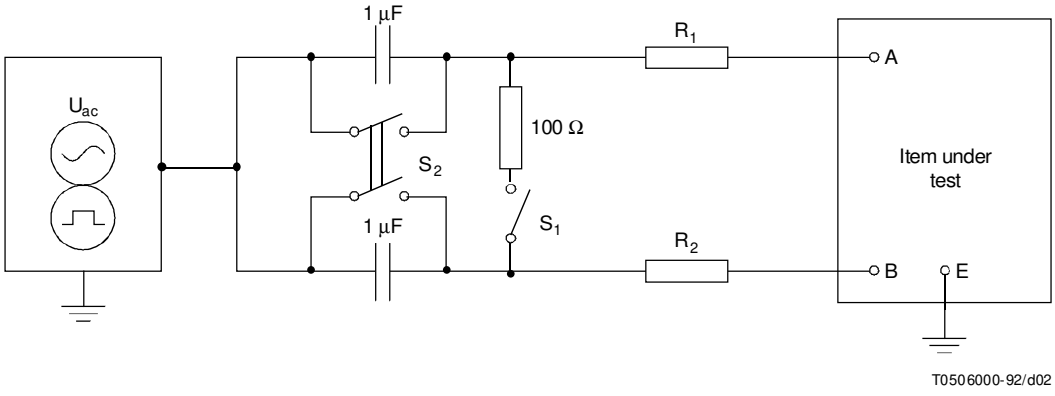


FIGURE 2/K.20

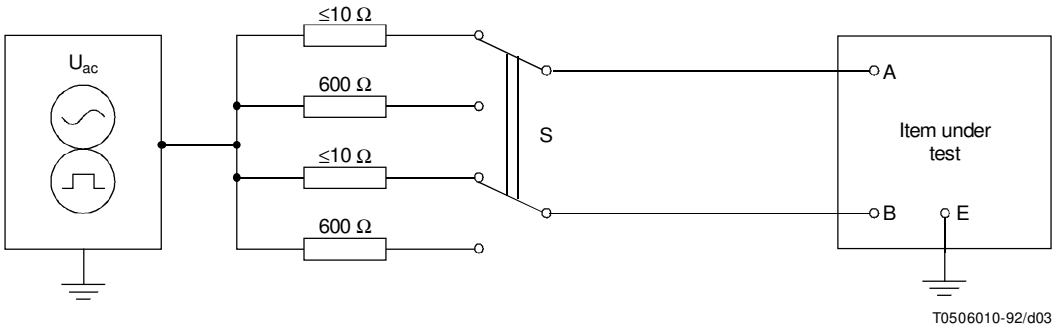


FIGURE 3/K.20

Annex A

Explanations which illustrate test conditions

(This annex forms an integral part of this Recommmendation)

A.1 Lightning surges

A.1.1 Operation of simulation circuit

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 purely for explanatory purposes and are not put forward as some recommended practice.

When the charging voltage, U_c, is progressively raised, the voltages and currents which occur at various points in the circuit of Figure A.1 are shown on the graph in Figure A.2.

For U_c = 0-300 V, the current flows only through the 100 Ω resistor in the equipment.

At U_c = 300 V, the secondary protection operates and the current I_T rises more rapidly.

At U_c = 2385 V, the voltage U across the primary protection reaches U_s = 700 V in the case illustrated, and I_E reaches its maximum value of 3 A.

The primary protection operates when U_c = 2385 V and the total current thereafter rises still more rapidly, reaching 100 A when U_c = 4 kV. The voltage U however drops to a low value and the current I_E flowing into the equipment falls to a very low value and becomes practically independent of U_c.

A.1.2 Effect of protective devices

Operation of the primary protection when $U = U_s$ therefore 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 in U and I which, by inductive or capacitive effects can reach sensitive parts of the exchange switching equipment not apparently exposed to line voltages.

For these reasons it is important that the Administration and equipment suppliers should agree on the primary protection which should be used and for the equipment user to provide or simulate this protection when tests are made. The tolerances allowed for such protection components should be taken into account when tests are made.

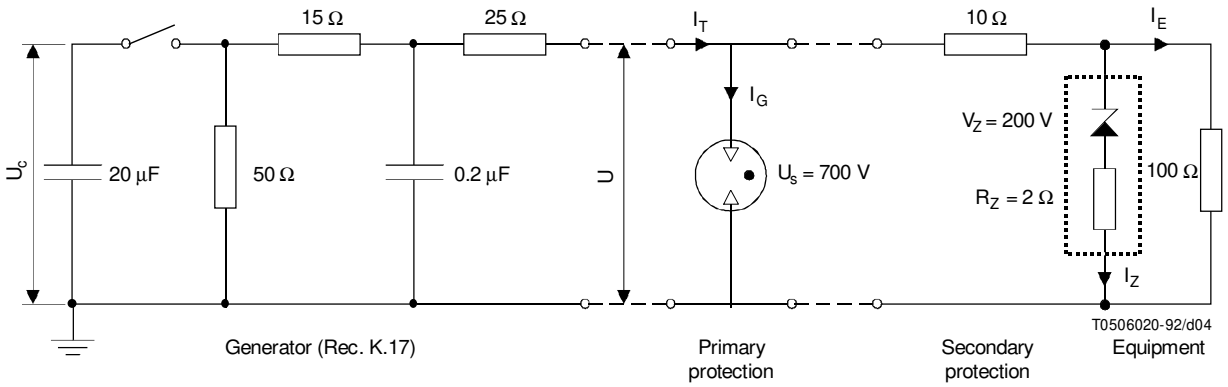
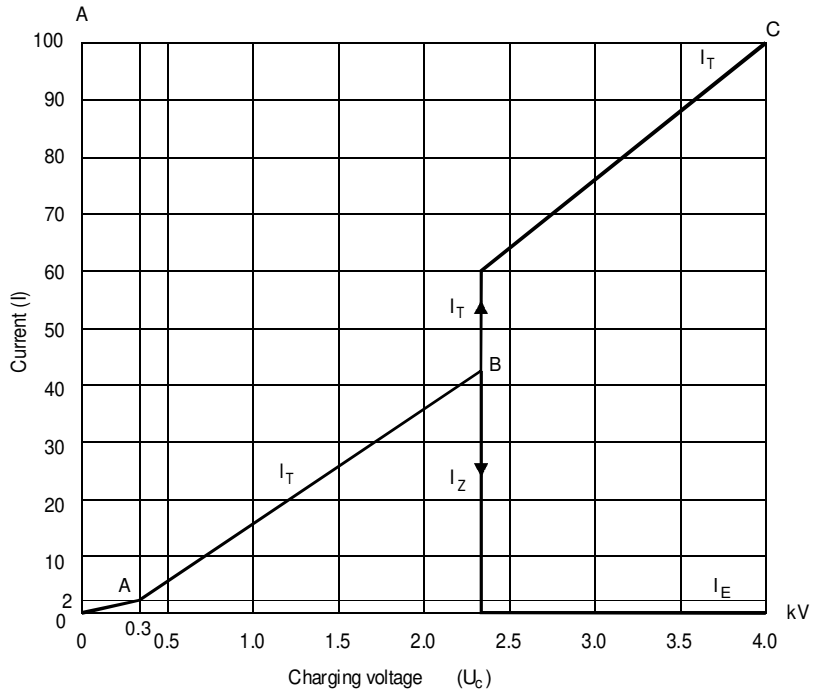


FIGURE A.1/K.20



The voltage and current values along the graph are as follows:

Point on graph	U_c	U	I_T	I_G	I_Z	I_E
	(V)		(A)			
A: Secondary protection operates	300	200	2	0	0	2
B: Before GDT strikes	2385	700	42	0	39	3
B: After GDT strikes	2385	30	59	59	0	0.3
C: Maximum U_c	4000	30	100	100	0	0.3

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FIGURE A.2/K.20

A.2 Power induction

Induced voltages are likely to occur more on long lines, and in the general case where subscribers' lines do not provide a low resistance earth, induced voltages may be considered to have a high source impedance consisting of a 600 Ω wire resistance in series with 1 μF line to earth capacitance as shown in Figure A.3. Tests 3(a) and 3(b) of Table 2 represent typical requirements for long and short lines respectively but they do not necessarily provide for limiting conditions. The gas discharge tube shown in Figure A.3 only exists on exposed lines. Such tubes are represented by S_2 in Figure 2 and the telephone is represented by S_1.

CCITT *Directives* admit induced voltages up to 430 V from normal power lines and 650 V from high-security lines, but most Administrations expect voltages to be below 300 V except on the lines in exposed environments.

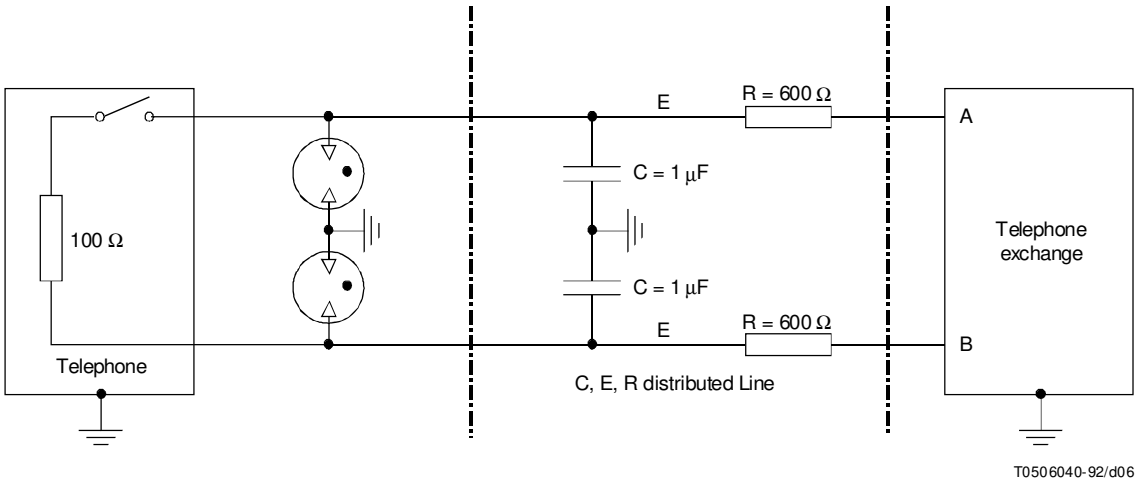

FIGURE A.3/K.20

A.3 Power contacts

Direct contact with electrical mains power can occur through network line 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 a 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.

Two 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 by the test in Figure A.4 by applying 220 V through an impedance of 10 Ω.

– 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 the test in Figure A.4 by applying 220 V through an impedance of 600 Ω.

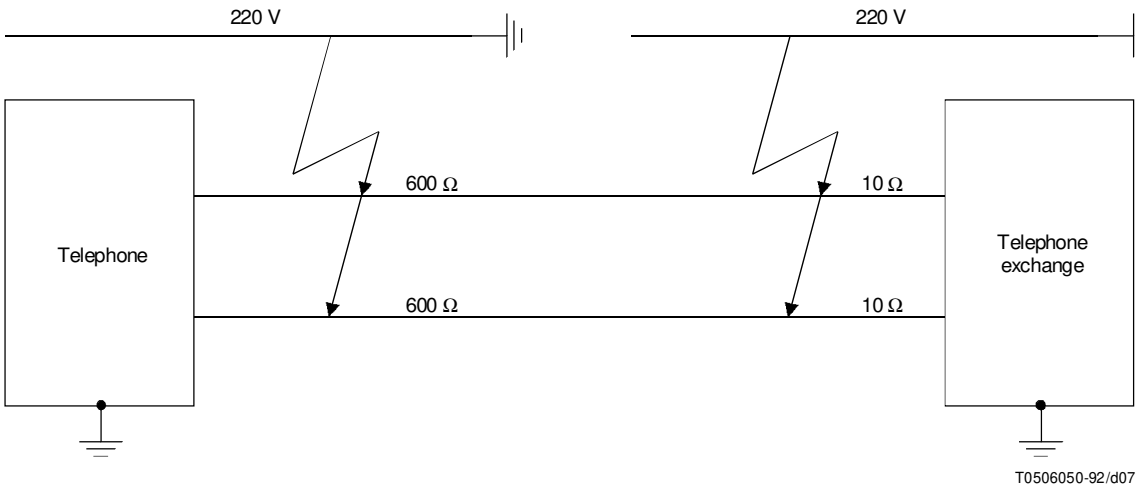

FIGURE A.4/K.20

Appendix I

Overvoltages occurring simultaneously on a number of telephone lines

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

(Information about practical experience in Norway)

I.1 Type test

The overvoltage resistibility of a new digital exchange system introduced in Norway was tested according to the requirements specified in this Recommendation.

The acceptance test was performed on a 2-wire basis on a complete installation with the prescribed 1 kV and 4 kV pulse voltages. The equipment under test complied with the specified test requirements.

I.2 Effects of lightning

Practical experience with this particular exchange system showed that a large number of line cards in the exchanges were damaged by lightning. The damage mainly appeared in rural areas defined as exposed environments. In such areas in Norway, all telephone lines entering electronic exchanges are protected with gas discharge tubes at the MDF.

I.3 Lightning simulation

A complete overvoltage test according to this Recommendation was performed on site on one of the installations where line cards had earlier been damaged by lightning. Again the system complied with the test requirements, and no weakness was revealed in the system.

Overvoltages were then imposed simultaneously on a number of lines as shown in Figure I.1.

The circuit shown was used to impose negative pulses. To apply positive pulses the diodes were connected in the opposite direction.

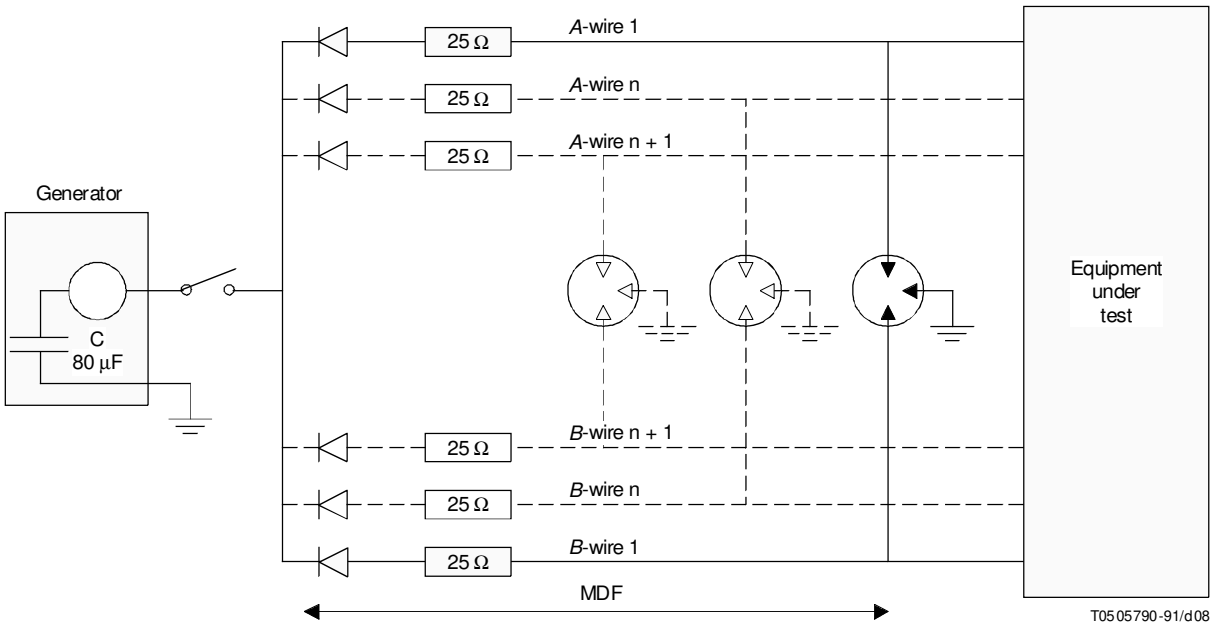

FIGURE I.1/K.20

The experiment revealed that the exchange responded differently to positive and negative surges. No damage appeared from the positive surges, but when negative surges were imposed on more than 20 line inputs simultaneously, the line cards showed the same type of damage as discovered after lightning storms.

Abstracts taken from the test report show (see Table I.1):

TABLE I.1/K.20

Generator		Current in one *a*–wire	Number of pairs in test	GDT operates	Damaged line card
(V)	(A)	(A)			
–400	–380	–5	5	No	No
–1400	–1400	–14	5	Yes	No
–400	–400	–10	20	No	Yes
–800	–860	–20	20	Yes	Yes
–400	–540	–5	40	No	Yes
–600	–890	–6	40	Yes	Yes

I.4 Modified secondary protection

Originally the secondary protection on the line cards drained positive current pulses to the chassis, and negative pulses to the –48 V d.c. power supply. The secondary protection was modified by the manufacturer so that both positive and negative pulses were later drained to the chassis.

After having all the line cards in a small exchange modified, the complete installation was tested on site with positive and negative surges imposed simultaneously on 1 to 40 line inputs with the circuit shown in Figure I.1. No failures in the exchange were detected during this test.

The modified exchange serves customers connected via exposed lines. After the modification, the exchange has given satisfactory service during thunderstorms.

Based on the on-site test experiment and the results from the field trial, it was decided to have new line cards for this particular exchange system produced with the mentioned modification.

I.5 Conclusion

When testing the resistibility of switching equipment to overvoltages and overcurrents, the user should be aware of the possibility that the exchange may respond differently to positive and negative surges. Furthermore, the EUT may respond differently to surges imposed on a single pair (as shown in Figure 1) and surges imposed on a group of lines.