INTERNATIONAL TELECOMMUNICATION UNION

CCITT

K.10

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THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

SERIES K: PROTECTION AGAINST INTERFERENCE

UNBALANCE ABOUT EARTH OF TELECOMMUNICATION INSTALLATIONS

Reedition of CCITT Recommendation K.10 published in the Blue Book, Volume IX (1988)

NOTES

1 CCITT Recommendation K.10 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.10

UNBALANCE ABOUT EARTH OF TELECOMMUNICATION INSTALLATIONS

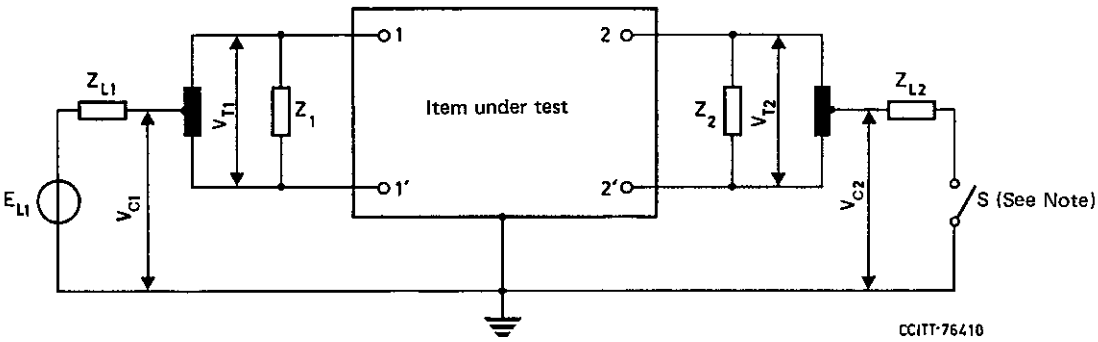
(Mar del Plata, 1968; modified at Malaga-Torremolinos, 1984)

1 Unbalance about earth of telecommunication equipments

In the interests of maintaining an adequate balance of telecommunication equipments and of the lines connected to them, it is recommended that the minimum permissible value for the unbalance of telecommunication installations longitudinal conversion loss (LCL) should be 40 dB (from 300 to 600 Hz) and 46 dB (from 600 to 3400 Hz). This is a general minimum value and does not exclude the possibility of higher minimum values being quoted for particular requirements in other Recommendations of the CCITT[1].

The test arrangement in Figure 1/K.10 should be used to measure the unbalance of telecommunications equipment.

Nomenclature, definition and measurement of unbalance are based on Recommendations G.117 and O.121.



Note – Measurements are normally made, and limits specified, with switch S closed. However, for certain equipments, e.g. those described, in Recommendation Q.45, it may be necessary to specify limits for longitudinal conversion transfer loss (LCTL) with switch S closed and with switch S open.

FIGURE 1/K.10

Test arrangement

The specification $Z_{L1} = Z_1/4$, $Z_{L2} = Z_2/4$ should apply in the audiofrequency range. (See Recommendation Q.45 and Recommendation O.121, § 3.2.)

The following terms are specified:

– longitudinal conversion loss (LCL) (applicable for one- and two-port networks):

$$20 \log_{10} \left| \frac{E_{L1}}{V_{T1}} \right| \text{dB}$$

– longitudinal conversion transfer loss (LCTL) (applicable for two-port networks only):

$$20 \log_{10} \left| \frac{E_{L1}}{V_{T2}} \right| \text{dB}$$

2 Unbalance about earth of telecommunication lines

If a long line is tested, essentially the same test circuit and nomenclature should be used as given in Figure 1/K.10. However, both the longitudinal induction and unbalances are distributed along the line. Consequently, the longitudinal conversion losses and longitudinal conversion transfer losses are not only determined by the inherent parameters but also by the distribution of the wire to earth/sheath voltages. To obtain the effect of unbalance in practical cases, it is recommended that measurements be made both with the wire to sheath voltage of constant polarity (i.e.

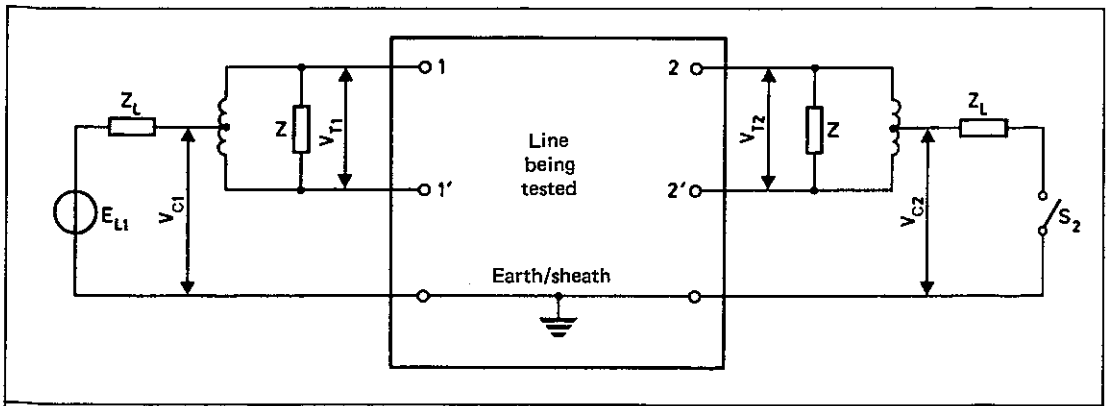
[1] See, in particular, Recommendation Q.45, and also the outcome of further studies under Question 13/V [1].

supply at end, see Table 1/K.10) and with the wire to sheath voltage changing in polarity at the midpoint (i.e. supply at the middle, see Table 2/K.10).

In Table 3/K.10, conclusions derived from those measurements are listed.

TABLE 1/K.10

Unbalance test results for a line when the longitudinal path is energized at one of the terminations



Port 1		Port 2	
Termination	Terms used	Terms used	Termination
E_{L1}	Longitudinal conversion losses $20 \log_{10} \left\| \frac{E_{L1}}{V^o_{T1}} \right\|$	Longitudinal conversion transfer losses $20 \log_{10} \left\| \frac{E_{L1}}{V^o_{T2}} \right\|$	S_2 Open
	$20 \log_{10} \left\| \frac{E_{L1}}{V^c_{T1}} \right\|$	$20 \log_{10} \left\| \frac{E_{L1}}{V^c_{T2}} \right\|$	S_2 Closed
Open S_1	Longitudinal conversion transfer losses $20 \log_{10} \left\| \frac{E_{L2}}{V^o_{T1}} \right\|$	Longitudinal conversion losses $20 \log_{10} \left\| \frac{E_{L2}}{V^o_{T2}} \right\|$	E_{L2}
Closed S_1	$20 \log_{10} \left\| \frac{E_{L2}}{V^c_{T1}} \right\|$	$20 \log_{10} \left\| \frac{E_{L2}}{V^c_{T2}} \right\|$	

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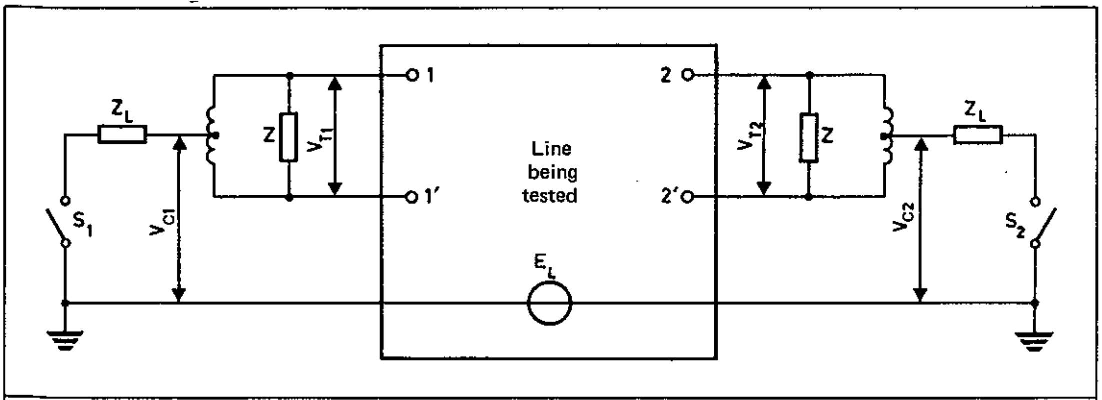
Note 1 – The superscripts of o and c indicate the open and closed state of switch S, respectively.

Note 2 – The values of V_{C1} and V_{C2} give some indication to the distribution of wire to earth/sheath voltage.

TABLE 2/K.10

Unbalance test results for a line
when the longitudinal path is energized at an intermediate section



Test No.	Port 1 Termination	Port 1 Longitudinal conversion losses	Port 2 Longitudinal conversion losses	Port 2 Termination
1	Open S_1	$20 \log_{10} \left\lvert \frac{E_L}{V_{T1}^{oo}} \right\rvert$	$20 \log_{10} \left\lvert \frac{E_L}{V_{T2}^{oo}} \right\rvert$	S_2 Open
2	Closed S_1	$20 \log_{10} \left\lvert \frac{E_L}{V_{T1}^{cc}} \right\rvert$	$20 \log_{10} \left\lvert \frac{E_L}{V_{T2}^{cc}} \right\rvert$	S_2 Closed
3	Open S_1	$20 \log_{10} \left\lvert \frac{E_L}{V_{T1}^{oc}} \right\rvert$	$20 \log_{10} \left\lvert \frac{E_L}{V_{T2}^{oc}} \right\rvert$	S_2 Closed
4	Closed S_1	$20 \log_{10} \left\lvert \frac{E_L}{V_{T1}^{co}} \right\rvert$	$20 \log_{10} \left\lvert \frac{E_L}{V_{T2}^{co}} \right\rvert$	S_2 Open

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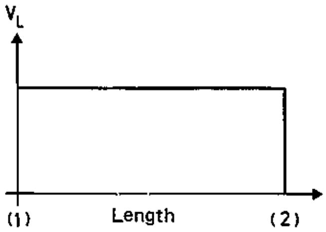
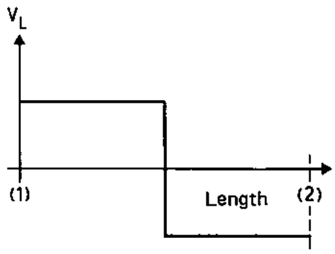
Note 1 – The superscripts of o and c indicate the open and closed state of the switches, respectively.

Note 2 – The values of V_{C1} and V_{C2} give some indication to the distribution of wire to earth/sheath voltage.

TABLE 3/K.10

Measurement procedures for the determination of unbalance about earth for lines

Measurement situation	Characteristics under examination
E.m.f. applied to terminals (see Table 1/K.10)  Wire to sheath voltage of some polarity	Degree of unbalance inherent to a line itself : – highest transverse voltage normally measured on a line – distribution of unbalance along a line (by interchanging transmitter and receiver) – determination of line sections with abnormal high unbalance
E.m.f. applied at the midpoint of line (see Table 2/K.10)  Wire to sheath voltage changes polarity at the midpoint	Influence of distribution of line to sheath voltage along a line : – transverse voltages more in accordance with practical situations – compensation effects due to changing polarity of line to sheath voltage – indications for polarity of unbalance by comparison with results of other line to sheath voltage distributions

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Note – If the longitudinal path is closed by switches, the effect of a terminal equipment connected to line with low impedance with respect to earth is simulated.

ANNEX A

(to Recommendation K.10)

Example for calculating transverse voltages of a telecommunications line

A.1 *General*

The Contribution mentioned in reference [2] contains many calculated values regarding the relationship between the longitudinal voltage and its conversion into the transverse one. This annex is an extract of that Contribution. It gives background information about the application of measurement proposals for lines which are contained in Recommendation K.10.

The most important results are summarized in Table A-1/K.10. They relate to a symmetric pair composed of paper-insulated copper wires of 0.9 mm in diameter and stranded in star quads with an equivalent mutual capacitance of 34 nF/km. In the course of the calculation, only the capacitance unbalance has been simulated.

A.2 *Wire to sheath voltages*

The distribution of the wire to sheath (earth) voltages are basically determined by (see column 2 of Table A-1/K.10 where, for the sake of simplicity, it is assumed that the total voltage source in the longitudinal path is 100 V):

– the location of the longitudinal source (see column 1 in Table A-1/K.10), and

– the termination of the longitudinal path (see column 3 of Table A-1/K.10).

On the basis of schemes indicated in column 2 of Table A-1/K.10, the following tendencies are worth mentioning:

a) When the e.m.f. is applied at one of the terminals of the longitudinal path, the wire to sheath voltages tend to be uniform with the same polarity along the line. When switch S is closed, the voltages decrease (compare the solid line with broken ones in the 1st row and 2nd column).

b) When the e.m.f. is applied at an intermediate section of the line, e.g. concentrated in the middle or distributed uniformly, then the wire to earth voltages have the same magnitudes but opposite polarity on each half of the line (see the curves of broken line in the 2nd and 3rd rows). The symmetry of the distribution is disturbed if only one switch at the terminals is closed (see the solid lines in the 2nd and 3rd rows). The differences between voltage distributions arising from terminations of open/closed and closed/closed switch positions tend to decrease with the increase of both the length of line and frequency.

A.3 *Longitudinal conversion losses*

The longitudinal conversion losses and the longitudinal transfer losses (defined in Tables 1/K.10 and 2/K.10) are basically determined by:

– the distribution of wire to sheath voltages, see § A.2, and

– the magnitude and distribution of capacitance unbalance.

Regarding the second aspect, three cases have been studied. These are indicated in Table A-1/K.10 as one-sided, perfectly equalized and equalized with additional unbalance. The one-sided uniform C = 600 pF/km tends to simulate the worst case which in practice does not exist. The perfectly equalized line (with crossing at each 0.5 km) can also never be reached.

The magnitudes of longitudinal conversion losses can be explained by a consideration of the fact that high transverse voltages are generated as a result of capacitance unbalance if the location of an unbalance coincides with high wire to earth voltages. The unbalance of a subsequent section tends to amplify the transverse voltage if both the direction of the unbalance and polarity of the wire to earth voltage are the same as those of the previous section. However, if one of them is reversed, the resultant transverse voltages become lower.

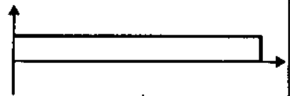
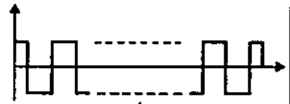
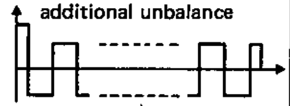
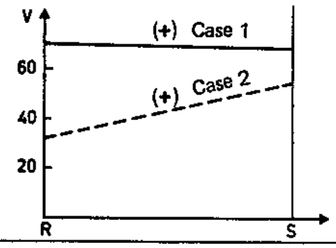
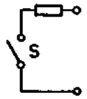
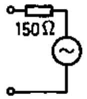
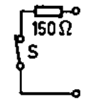
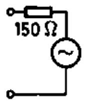
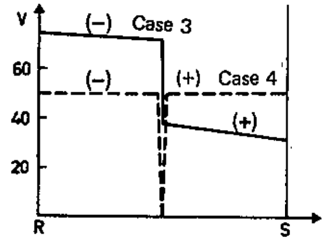
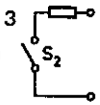
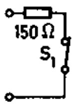
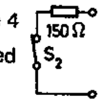
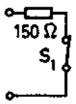
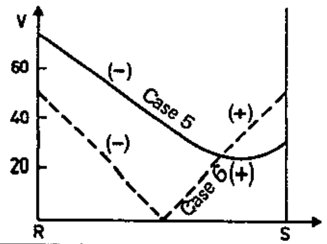
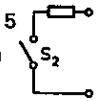
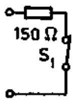
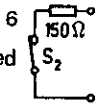
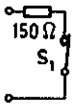
In the case of a well equalized line, the magnitude of the longitudinal conversion losses is high and is largely independent of both the location of the e.m.f. and the position of the switches at the terminals (see column 5 in Table A-1/K.10).

If the conversion losses increase significantly in magnitude with the opening of switch S and depend on the direction of supply, then the presence of local unbalance may be expected (see column 6 of Table A-1/K.10).

The low values of longitudinal conversion losses (i.e. less than 60 dB) might be caused by a one-sided nature of the capacitance unbalance (see column 4 of Table A-1/K.10). This is the case for Recommendation K.10 where the testing method specified in § 2 may produce significantly higher values for longitudinal conversion losses than the actual values in real conditions of power induction. In this case, more realistic values can be obtained by the method given in Table 2/K.10.

TABLE A-1/K.10

Demonstration of wire to earth voltages and longitudinal conversion losses
(length of cable: 10 km; frequency: 800 Hz; capacitance unbalance: ΔC = 600 pF/km)

	Location of e.m.f.	Distribution of wire to earth voltage	Termination of longitudinal path (switch position) at terminal		Longitudinal conversion losses dB					
					Character of ΔC distribution					
					One-sided 		Perfectly equalized 		Equalized with additional unbalance 	
			R (1)	R (2)	R (1)	S (2)	R (1)	S (2)	R (1)	S (2)
1	At terminal S (1)		Case 1 open 		49	49	101	101	77	84
			Case 2 closed 		53	53	112	102	83	90
2	At the middle		Case 3 open 	 closed	57	58	96	100	78	84
			Case 4 closed 	 closed	70	70	100	99	83	88
3	Uniform		Case 5 open 	 closed	57	58	95	102	78	84
			Case 6 closed 	 closed	74	74	99	101	83	88
	Col. 1	Col. 2	Col. 3		Col. 4		Col. 5		Col. 6	

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The main unbalance on lines is the capacitance unbalance. However, occasionally, the resistive unbalance (series resistance, R) is important as well. As has been pointed out before, when switch S_2 is open, the effect of shunt unbalance (in case of line *C*) is emphasized. If the switch S_2 (or S_1 and S_2 indicated in Table 2/K.10) is opened and the conversion loss remains unchanged (or even decreases), it indicates that series unbalance may not be the primary cause of the line unbalance. On the other hand, if there is an increase, the series unbalances are dominant. It should be noted, that while the reason for having Z_L and S_2 is to allow the tester to distinguish between series and shunt unbalances of the line, the effectiveness of this feature depends on the shunt impedance of the line provided by the resultant earth capacitance of the line (e.g. length of line [3]).

References

[1] CCITT Question 13/V *Unbalance of telephone installations*.

[2] CCITT Contribution COM V-38, *Study of relation between unbalance and induced transverse voltages*, 1981-1984 (Hungarian Administration).

[3] IEEE Std 455 – 1976 *IEEE Standard test procedure for measuring longitudinal balance of telephone equipment operating in the voice band*. Published by IEEE, Inc., September 30, 1976.

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