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ITU-T

K.10

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(03/93)

PROTECTION AGAINST INTERFERENCE

UNBALANCE ABOUT EARTH OF TELECOMMUNICATION INSTALLATIONS

ITU-T Recommendation K.10

(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.10 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 Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.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.

CONTENTS

UNBALANCE ABOUT EARTH OF TELECOMMUNICATION INSTALLATIONS

(Revised at Helsinki, 1993)

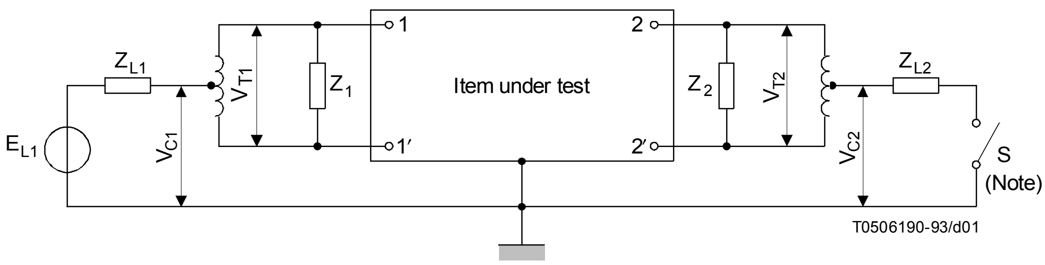
1 Unbalance about earth of telecommunication equipment

In the interests of maintaining an adequate balance of telecommunication installations, it is recommended that the minimum permissible value for the unbalance of analogue telecommunication equipment, 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 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 equipment, 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 3.2/O.121.)

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):

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

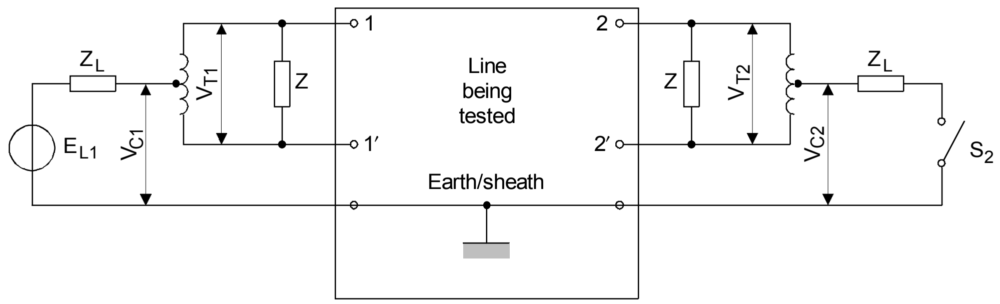
1) See, in particular, Recommendation Q.45 and also the outcome of further studies under Question 4/5 [1].

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

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 $20 \log_{10} \left\lvert \frac{E_{L1}}{V_{T1}^{o}} \right\rvert$	Longitudinal conversion transfer losses $20 \log_{10} \left\lvert \frac{E_{L1}}{V_{T2}^{o}} \right\rvert$	S_2 Open
	$20 \log_{10} \left\lvert \frac{E_{L1}}{V_{T1}^{c}} \right\rvert$	$20 \log_{10} \left\lvert \frac{E_{L1}}{V_{T2}^{c}} \right\rvert$	S_2 Closed
Open S_1	Longitudinal conversion transfer losses $20 \log_{10} \left\lvert \frac{E_{L2}}{V_{T1}^{o}} \right\rvert$	Longitudinal conversion losses $20 \log_{10} \left\lvert \frac{E_{L2}}{V_{T2}^{o}} \right\rvert$	E_{L2}
Closed S_1	$20 \log_{10} \left\lvert \frac{E_{L2}}{V_{T1}^{c}} \right\rvert$	$20 \log_{10} \left\lvert \frac{E_{L2}}{V_{T2}^{c}} \right\rvert$	

NOTES

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

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

T0506200-93/d02

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

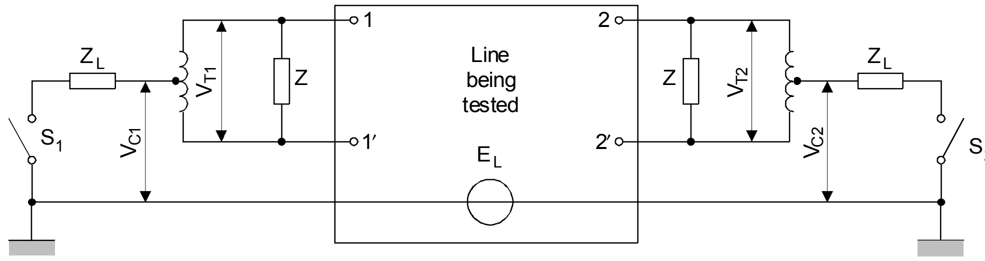
It is worth mentioning that the LCL values for telecommunication lines are normally significantly higher than those minimum values specified for telecommunication equipment in clause 1 (examples are shown in Table A.1).

3 Unbalance about earth of telecommunication installations

When the unbalance about earth of a complete telecommunication installation is considered, attention is drawn to the fact that the magnitude of LCL applicable to evaluating the induced voltages depends both on the distribution of the induced longitudinal e.m.f. and on the termination of the circuit for common mode (see Annex A). Therefore, when calculating the induced transverse voltages, the LCL relevant to the actual conditions should be considered. The practical experiences show that the actual existing values for LCL are in many cases higher in the frequency range of 300-3400 Hz than the minimum values specified for equipment at least in the order of 6 dB.

TABLE 2/K.10

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



Test No.	Termination (Port 1)	Longitudinal conversion losses (Port 1)	Longitudinal conversion losses (Port 2)	Termination (Port 2)
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

NOTES

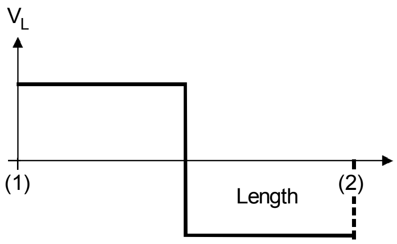
1 The superscripts of o and c indicate the open and closed state of the switches, respectively.

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

T0506210-93/d03

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 (Table 1)  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 (Table 2)  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 pratical 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
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.	

T0506220-93/d04

Annex A

Example for calculating transverse voltages of a telecommunications line

(This annex forms an integral part of this Recommendation)

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 this Recommendation.

The most important results are summarized in Table A.1. 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 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); and

– the termination of the longitudinal path (see column 3 of Table A.1).

On the basis of schemes indicated in column 2 of Table A.1, 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 and 2) 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 as one-sided, perfectly equalized and equalized with additional unbalance. The one-sided uniform ΔC = 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.

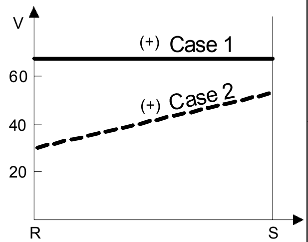
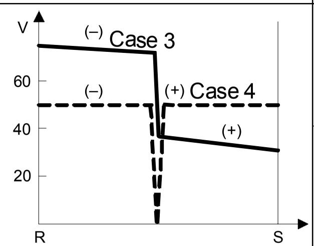
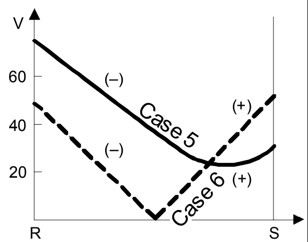
In the case of a well equalized line, the magnitude of the longitudinal conversion losses is high and is largely independent of both the location of the e.m.f. and the position of the switches at the terminals (see column 5 in Table A.1).

If the conversion losses decrease 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).

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). This is the case for this Recommendation where the testing method specified in clause 2 may produce significantly lower 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.

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)	S (2)	R (1)	S (2)	R (1)	S (2)	R (1)	S (2)
1	At terminal S (2)		Case 1 open S	150 Ω	49	49	101	101	77	84
			Case 2 closed 150 Ω S	150 Ω	53	53	112	102	83	90
2	At the middle		Case 3 open S_2	150 Ω S_1 closed	57	58	96	100	78	84
			Case 4 closed 150 Ω S_2	150 Ω S_1 closed	70	70	100	99	83	88
3	Uniform		Case 5 open S_2	150 Ω S_1 closed	57	58	95	102	78	84
			Case 6 closed 150 Ω S_2	150 Ω S_1 closed	74	74	99	101	83	88
	Column 1	Column 2	Column 3		Column 4		Column 5		Column 6	

T0506230-93/d05

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) 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 4/5 *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.

Appendix I

Test methods related to unbalance of equipment connected to symmetric pair lines

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

I.1 Analogue transmission in the voice frequency range 300 Hz up to 3400 Hz

With conventional analogue voice frequency transmission the noise voltages generated in the equipment connected to a transmission line are proportional to the common mode noise voltage induced into the line and also to longitudinal conversion losses of the terminal equipment under consideration. However, the admissible noise voltage in the signal circuit is frequency dependent due to the varying frequency sensitivity of the human ear. The psophometric weighting coefficient for telephone circuits is given in Recommendation O.41. For an induced voltage with a fundamental frequency of 16 2/3 Hz the relative weight is –85 dB and for the fundamental frequency 50 Hz –63 dB. The frequency with the most unfavourable weighting coefficient of +1.0 dB is 1000 Hz. Considering the above-mentioned proportional relationship between induced voltages and transverse voltages in the signal circuit, it seems to be sufficient to recommend only minimum LCL values or statistical values for the terminal equipment under consideration. These LCL values, however, must be dependent on frequency. For fundamental frequencies it is not usual to specify minimum LCL values for normal applications, assuming that weighting coefficients suppress the effective noise sufficiently and with floating subscriber sets the effective longitudinal noise voltage at the terminal equipment is much lower with fundamental frequencies than the total induced voltage. Up to now LCL values were only specified in the frequency range between 300 Hz and 3000 Hz for conventional voice-frequency transmission. In the frequency range between 300 Hz and 600 Hz minimum LCL values may be relaxed due to favourable psophometric weighting coefficients.

Measurements of LCL values for terminal equipment can be performed in a simplified way, according to Figure 1. Test methods are described in Volume IX of the 1988 CCITT *Directives* and in the measuring handbook of the CCITT.

I.2 Analogue transmission in the voice frequency range with analogue digital conversion

With pure analogue voice frequency transmission the noise energy in the signal path is dependent mainly on the common mode noise voltage which is effective on the terminal equipment itself and on the magnitude of its longitudinal conversion loss (LCL).

However, in addition to this amount of noise energy an additional part of noise energy is generated by the analogue digital conversion procedure which is called quantizing distortion. The quantizing distortion is due to the fact that a digital encoder/decoder pair is not able to reproduce at its output signal which is exactly the same as the original one.

The output values at the decoder may be greater or smaller than would occur in a linear analogue system. The quantizing error is smaller when more quantizing steps are available. If there would be a truly logarithmic encoding characteristic the quantizing error would be independent of the signal input level. However, the real encoding law follows the logarithmic characteristic only approximately. The quantizing steps at low input signal levels are higher as they would be if they followed the true logarithmic characteristic. This means that the relative quantizing noise at low input levels is higher compared with higher input levels. Consequently, the noise due to quantizing effects is dependent on the signal input level. For voice frequency transmission with analogue/digital conversion the total generated noise therefore consists of two parts with different origins. The first part increases linearly with the stimulus which may be a noise voltage induced into the common mode circuit of the line connected to the terminal equipment which is transferred into the symmetric circuit according to the longitudinal conversion ratio. The second part, however, is also caused by the longitudinally induced noise voltage. However, the noise voltage due to the quantizing effect is not linear to the level of the common mode noise voltage effective at the encoder input. Moreover, there is also a change of the characteristic of the generated noise voltage at the output of the decoder. If, for example, the input voltage is a sinusodial frequency at the output a broadband noise is generated which has an energy content in the whole relevant transmission band. The frequency conversion, which transforms low frequency energy into noise energy of higher frequencies, may increase the weighted noise considerably due to very unfavourable weighting coefficients at higher frequencies. This means that due to non-linear effects at the input of a terminal equipment with analogue/digital conversion noise voltages in their original magnitude have to be simulated to be able to reproduce exactly the same noise which may be expected in practice. It can be summarized that the noise produced within systems based on analogue/digital conversion consist of two parts which have to be assessed differently. Noise voltages with frequencies below 200 Hz are of greater effect with systems based on analogue/digital conversion than with analogue ones. At frequencies higher than 200 Hz, however, there is no big difference between the two generation phenomena. At noise frequencies below 200 Hz the effective noise may be unfavourable with systems using analogue/digital convrsion due to the generation of broadband noise which is not strongly attenuated by psophometric weighting in the frequency range of the signal. The protection against noise caused by fundamental frequencies has therefore to be dealt with in some detail.

I.2.1 Protection against quantizing noise with systems using analogue/digital conversion

The systems have to be protected in such a way that permissible disturbance for voice transmission is not exceeded. According to CCITT *Directives* Volume VI, 6.2.1, the total psophometric weighted noise voltage (e.m.f) for a line between subscriber set and international exchange should not exceed 1 mV.

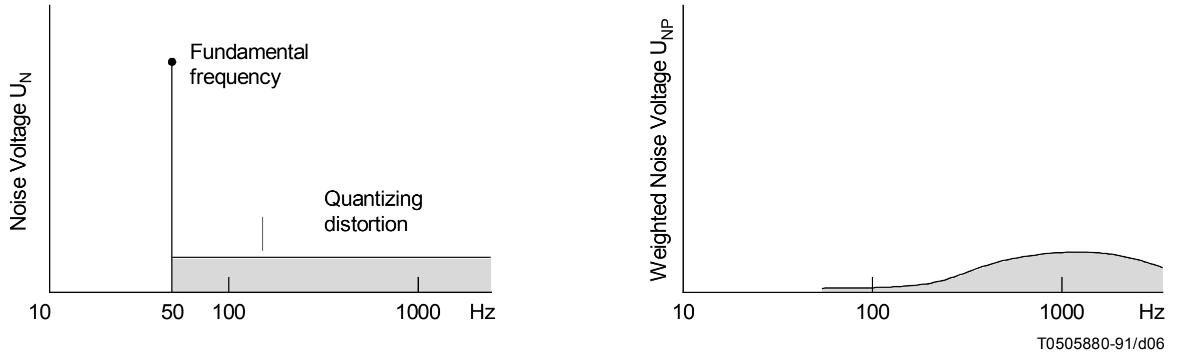
Subclause 4.1/G.712 stipulates for equipment under consideration a total noise value for the idle channel not higher than –65 dBm0p if there is some additional induced noise. In this case noise caused by fundamental frequencies (50 Hz) in the transverse circuit should be below –30 dBm0. For admissible longitudinal voltages in the range of one volt, however, LCL values for fundamental frequencies 50 Hz higher than 30 dB are necessary.

For fundamental frequencies high unbalance values are difficult to achieve. Therefore it may be advisable to reduce the effective noise voltage in addition to the LCL values also by additional high pass filters. High pass filters have to be designed in such a way that useful signals are not attenuated unduly.

Figure I.1 demonstrates, in principle, the distribution of quantizing distortion caused by fundamental frequency along the transmission band.

In Figure I.1 a) the noise voltage is plotted without psophometric weighting. In this case the fundamental frequency mainly determines the total noise voltage. Figure I.1 b) shows effective noise voltage with phosphometric weighting. In this case mainly the quantizing distortion caused by the induced fundamental frequency is left, demonstrating the necessity of suppressing also fundamental frequencies in the signal paths to avoid disturbance in the transmission band. Figure I.2 demonstrates protection measures against induced noise and quantizing distortion. Conventional noise, caused by induction into the connected line is reduced by adequate LCL values at the equipment input. To avoid the generation of undue quantizing distortion by outband fundamental frequencies a high pass filter may be inserted before the analogue/digital converter. After reconverting the digital signal into an analogue one the noise is measured and weighted by a suitable noisemeter. Noise caused by induced voltages with frequencies in the transmission band is mainly controlled by the LCL values of the equipment under test which are clearly specified in the transmission band by Recommendations. Quantizing noise performance is also controlled by requirements specified in Recommendations O.132 and O.131.

In addition to the noise caused by the unbalance of the equipment and by the quantizing effect noise may be increased by saturation effects of the electronic circuits or intermodulation between signal and noise voltages.



a) Quantizing distortion caused by induced fundamental frequencies without psophometric weighting

b) Quantizing distortion caused by induced fundamental frequencies with psophometric weighting

FIGURE I.1/K.10

Effect of psophometric weighting on quantizing distortion (Principle)

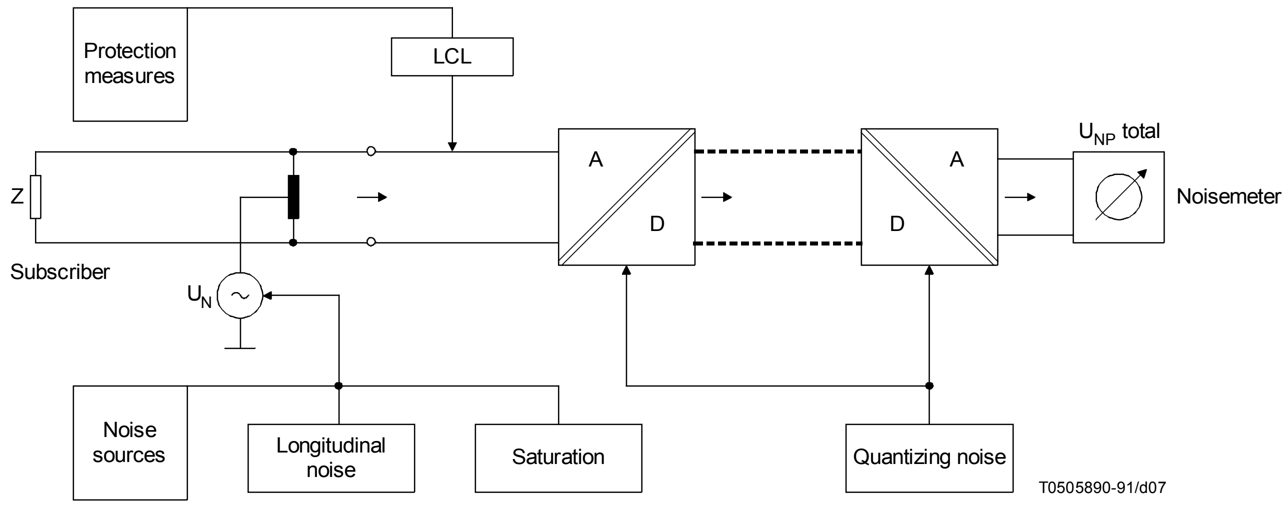


FIGURE I.2/K.10

Noise generation and suppression in systems with analogue digital conversion at fundamental frequencies

I.2.2 Testing noise rejection of equipment with analogue to digital conversion

It is advisable to test noise rejection performance separately for quantizing distortion due to fundamental frequencies and for adequate LCL values in the transmission band.

Figure 3, subclause 3.3 and clause 4/G.712 are reproduced.

In this subclause, minimum values for the longitudinal conversion loss of the equipment under consideration are specified for the transmission band between 300 Hz and 3400 Hz. The measurement arrangements for longitudinal balance parameters should be in line with those given in Recommendation O.121. The noise caused by quantizing distortion due to induced longitudinal voltages is evaluated preferably by using “coupling networks”. Coupling networks are intended to simulate the performance of the induced line connected to equipment under test and the inducing source as closely as possible according to the real situation met in practice. The coupling network can be a simplified one in comparison to the real inducing line, if only the noise for fundamental frequencies and their harmonics would be simulated. For simplified versions it is acceptable to simulate only the longitudinal circuit which may be realized by series combinations resistors and parallel capacitors.

Typical circuits for coupling networks are dealt with in the “handbook for interference measurements”. Test circuits must provide for the possibility for powerfeeding, injection of longitudinal voltages and measuring noise voltages.

I.2.3 **Longitudinal balance** (from 3.3/G.712)

The measurement arrangements for longitudinal balance parameters referred to below are defined in Recommendation O.9 which also gives some information about the requirements of test circuits (see Note 1). The value of *Z* in the driving test circuit should be 600 ohm ± 20% and the termination at the other port should be the nominal characteristic impedance.

a) The longitudinal conversion loss (see 2.1/O.9) as measured at the *input port* should not be less than the limits shown in Figure 3/G.712.

b) The longitudinal conversion loss (see 2.1/O.9) as measured at the *output port* should not be less than the limits shown in Figure 3/G.712.

c) The difference between the longitudinal conversion transfer loss (see 2.3/O.9) at the specified frequencies and the insertion loss at the same frequencies should not be less than the limits shown in Figure 3/G.712. The requirement is only applicable to the configuration where the driving test circuit is applied to the input port and a measurement made at the output port. The measurement should be made with the switch *S*, shown in Figure 3/O.9, closed.

NOTES

1 Attention is drawn to 3/O.9 which shows the equivalence between a number of different test driving circuits and also includes information concerning the inherent balance requirements of the test bridge.

2 Attention is drawn to the fact that these values represent minimum requirements. The magnitude of potential longitudinal signal voltages depends, for example, on system use, the system environment, the location of hybrid transformers and attenuators, and may therefore vary for different Administrations. Some Administrations have found it necessary to specify higher values for longitudinal conversion loss and longitudinal conversion transfer loss to ensure that transverse voltages caused by possible longitudinal signal voltages are sufficiently small.

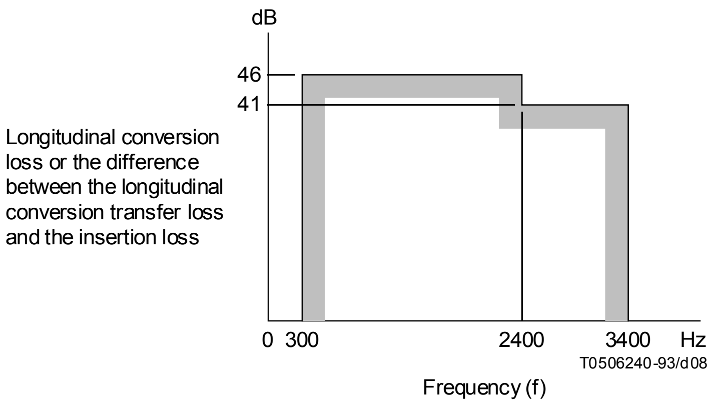


FIGURE I.3/K.10

Requirements for LCL values according to Recommendation G.712 for terminal equipment with analogue digital conversion
(from Figure 3/G.712)

I.2.4 **Idle channel noise** (from 4/G.712)

I.2.4.1 **Weighted noise** (from 4.1/G.712)

With the input and output ports of the channel terminated in the nominal impedance, the idle channel noise should not exceed –65 dBm0p.

I.3 Unbalance requirements for ISDN transmission

ISDN transmission is based on digital signals which need a broad frequency band between 10 kHz and 1 MHz. The signals are transmitted via symmetric pair lines. Therefore, adequate balance within this frequency range is necessary for the connected equipment as well as for the connected lines. The balance of the line should not be deteriorated by the equipment. In Figure I.4 measured values for the longitudinal conversion losses in paired cables are plotted. The values of conversion losses for ISDN equipment therefore should be at least in the same magnitude of order. In Recommendation I.430 "Longitudinal conversion losses (LCL)" are specified for the signal receiver. The longitudinal voltages of receivers and transmitters are measured across a longitudinal termination of 150 Ω shown in Figure I.7.

Longitudinal conversion loss

Longitudinal conversion loss (LCL), which is measured in accordance with 4.1.3/G.117(see Figure 15/I.430), shall meet the following requirements:

a) 10 kHz < $f \leq$ 300 kHz: $\geq$ 54 dB;

b) 300 kHz < $f \leq$ 1 MHz: minimum value decreasing from 54 dB at 20 dB/decade.

The minimum unbalance values specified by Recommendation I.430 are illustrated in a diagram in Figure I.5. Compared with unbalance values for subscriber lines shown in Figure I.4, the specified unbalance values for connected terminal equipment are of nearly the same magnitude. For measuring unbalance values of ISDN terminal equipment special measuring set-ups are proposed by Recommendation I.430. Recommendation I.430 also proposes a method for powerfeeding the equipment under test. In Figure I.6 the measurement of the receiver input or transmitter output unbalance about earth is explained. A voltage of 1 V is injected into the longitudinal path of the terminal equipment. In Figure I.7 the measurement of the transmitter output unbalance about earth is dealt with. In this case the longitudinal voltage generated by the send signal in the transverse circuit is measured.

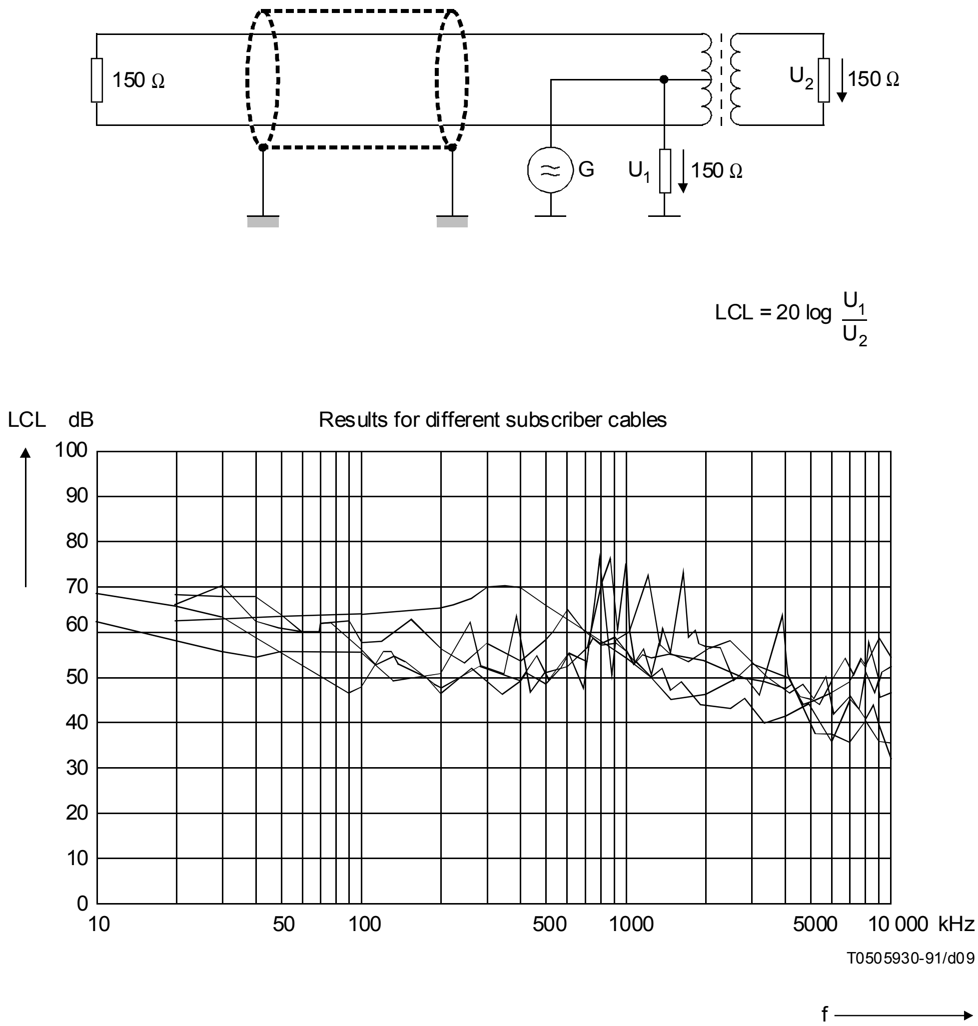


FIGURE I.4/K.10

Longitudinal conversion losses for pairs in cables with excitation as indicated in the sketch

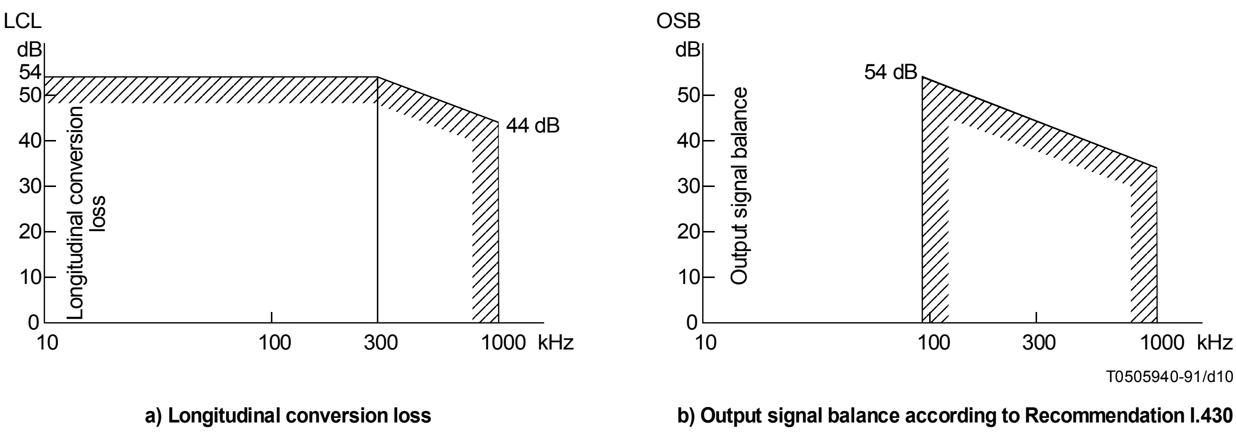
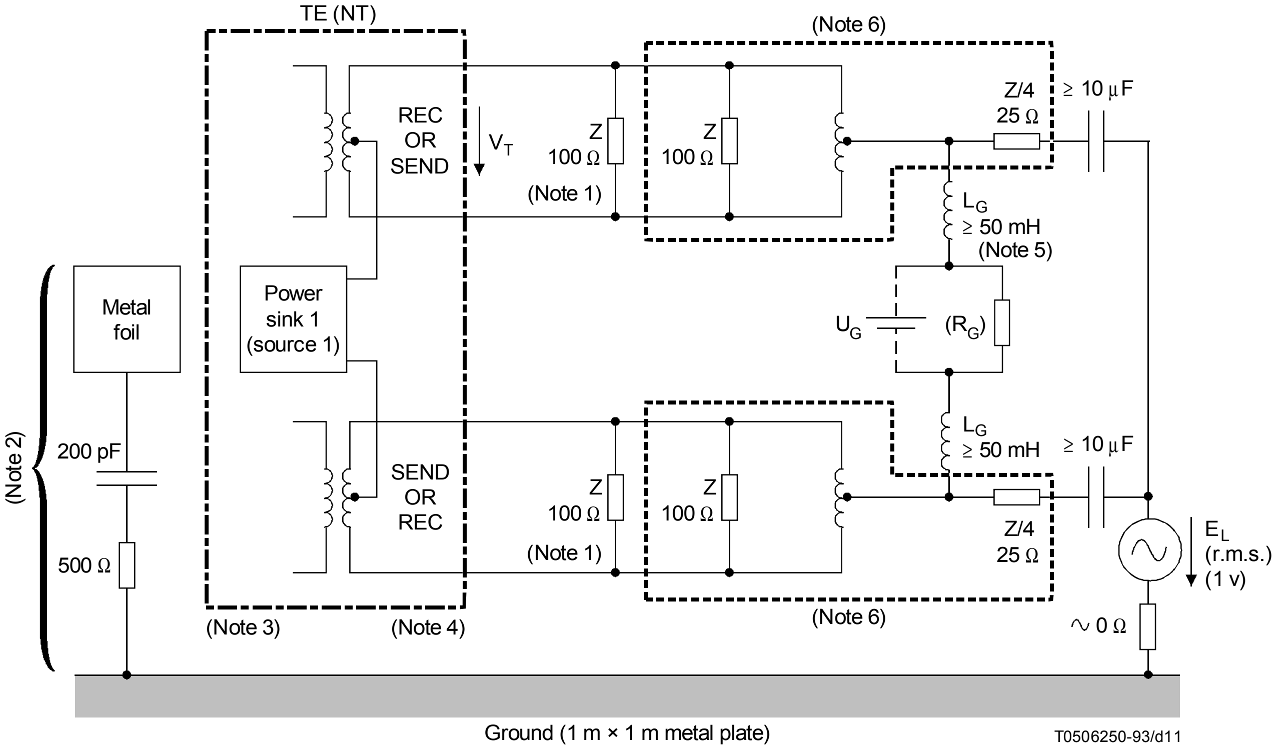


FIGURE I.5/K.10

Minimum unbalance values for ISDN equipment



The longitudinal conversion loss: $\text{LCL} = 20 \log_{10} \left| \frac{E_L}{V_T} \right| \text{ dB}$

The voltages V_T and E_L should be measured within the frequency range from 10 kHz up to 1 MHz using selective test measuring equipment.
The measurement should be carried out in the states:
– deactivated (receive, send),
– power off (receive, send),
– activated (receive).
The interconnecting cord shall lie on the metal plate.

NOTES

1 This resistor must be omitted if the termination is already built into the TE (NT).

2 Hand imitation is a thin metal foil with approximately the size of a hand.

3 TE (NT) with a metallic housing shall have a galvanic connection to the metal plate. Other TE (NT) with non-metallic housing shall be placed on the metal plate.

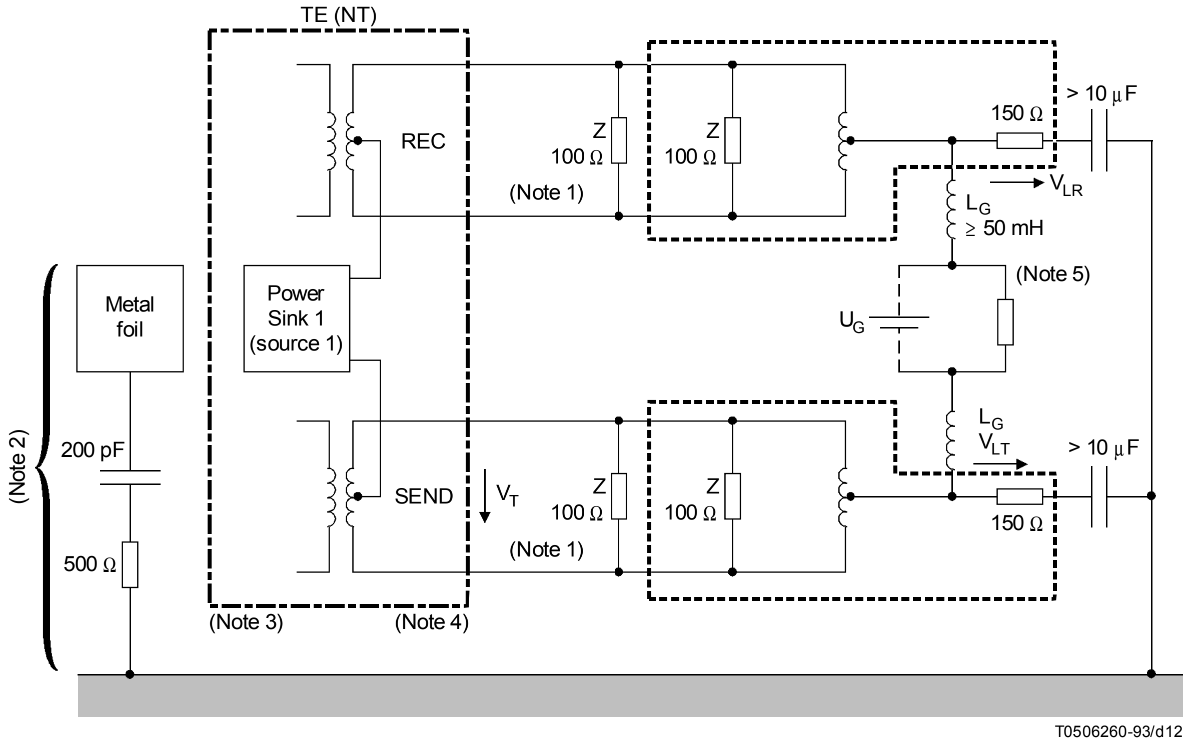
4 The power cord for mains-powered TE(NT) shall lie on the metal plate and the earth protective wire of the mains shall be connected to the metal plate.

5 If there is no power source 1 in the NT, R_G and L_G are not required.

6 This circuit provides a transverse termination of 100 ohms and a balanced longitudinal termination of 25 ohms. Any equivalent circuit is acceptable. However, for equivalent circuits given in Recommendations G.117 and O.121, powering cannot be provided.

FIGURE I.6/K.10

Receiver input or transmitter output unbalance about earth



V_{LT} and $V_{LR} \leq -24$ dBV peak
V_{LT} and V_{LR} shall be measured when NT sends INFO 2 and TE sends INFO 1.
The measured bandwidth shall be 3 kHz.

NOTE – See notes to this figure in Figure I.6.

FIGURE I.7/K.10

Longitudinal voltage of receivers and transmitters

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