INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

G.612

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

TRANSMISSION MEDIA CHARACTERISTICS

CHARACTERISTICS OF SYMMETRIC CABLE PAIRS DESIGNED FOR THE TRANSMISSION OF SYSTEMS WITH BIT RATES OF THE ORDER OF 6 TO 34 Mbit/s

ITU-T Recommendation G.612

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation G.612 was published in Fascicle III.3 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 G.612

CHARACTERISTICS OF SYMMETRIC CABLE PAIRS DESIGNED FOR THE TRANSMISSION OF SYSTEMS WITH BIT RATES OF THE ORDER OF 6 TO 34 Mbit/s

(Geneva, 1976; amended at Geneva, 1980)

1 Preamble

This Recommendation relates to symmetric pair cables which have been developed for the transmission of signals with bit rates of the order of 6 to 34 Mbit/s, but they are not ruled out for the transmission of lower or higher bit rates, subject to the use of an appropriate regeneration section; in most cases they can also be used for baseband transmission of videophone or television signals.

These cables fall into two categories, according to whether or not the cable is intended for use in both directions of transmission in the same cable.

2 Parameters to be measured

Those parameters which, for digital system transmission, have to be measured by a particular method or at frequencies different from those defined in Recommendation G.611, are: characteristic impedance, attenuation coefficient, and far-end crosstalk between pairs on the same direction of transmission. If the cable is intended for use with both directions of transmission within the same cable, it is also necessary to measure the near-end crosstalk between pairs intended for different directions of transmission.

2.1 *Characteristic impedance*

The characteristic impedance may be measured:

- either in the sinusoidal mode, when the measured pair will be terminated by an impedance constantly equal to that measured by the bridge, except when the length is sufficient for the measurement result to be independent of the termination impedance;
- or by a pulse echo meter[1)], when the impedance of the pair being measured is compensated by an adjustable balancing network graduated to show the impedance value. The pair being measured is terminated by an identical network.

2.2 *Attenuation coefficient*

The attenuation per km of the pairs is derived from that value to be obtained on an elementary cable section, allowance being made for the tolerance accepted on the length of these sections.

Note - In the case of looped measurement, a check should be carried out to ensure that the near-end crosstalk attenuation between the ends of the circuit being measured is sufficient.

2.3 *Crosstalk*

Crosstalk may be specified either in sinusoidal mode, at a frequency near the timing half-frequency of the system concerned, or in digital mode[2)] .

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1) This method is similar to the one used for coaxial pairs, but with a symmetrical measuring head and networks. The pulse duration is equal to 100 ns; the echo is not corrected.

2) An example of a digital technique is given in Supplement No. 19.

2.3.1 *Far-end crosstalk measurement*

The far-end crosstalk measurements are carried out on pairs used in the same direction of transmission at a frequency above about 100 kHz; if this frequency is not the timing half-frequency of the system, the value to be specified will be corrected to the factor 20 $\log_{10} f$ [3)].

2.3.2 *Near-end crosstalk measurements*

If it is intended to transmit in both directions on the same cable, these measurements are conducted on a prototype length, either in sinusoidal mode or digital mode, between pairs used for opposite directions of transmission.

3 Description of pairs and cables

Administrations which decide to use symmetrical pairs to transmit digital signals with a bit rate of the order of 6 to 34 Mbit/s should, wherever possible, choose one of the types of cable described in §§ 3.1 and 3.2 below.

3.1 *Cable designed for use with one cable for each direction of transmission*

3.1.1 The basic characteristics of the pairs are given in Table 1/G.612.

3.1.2 The characteristics of cables constructed with these pairs are given in Table 2/G.612.

3.2 *Cables designed for transmission in both directions in the same cable*

Tables 3/G.612 and 4/G.612 indicate the characteristics of the pairs which make up cable pairs and quad cables respectively.

All these cables consist of bundles protected by one or more copper or aluminium screens, the pairs in each bundle being used for the same direction of transmission. For this reason, near-end crosstalk values relate only to pairs in different bundles.

Note 1 - To make the presentation of Tables 3/G.612 and 4/G.612 uniform, the values of characteristic impedance are given at 1 MHz (real part of Z_1). The ratio between impedance $Z_1 = X_1 - jY_1$ at 1 MHz and impedance $Z_f = X_f - jY_f$ at f MHz is

$$X_f = X_1 - Y_1 + Y_1 / \sqrt{f} \text{ and } Y_f = Y_1 / \sqrt{f} .$$

The difference between the value of the real part of the impedance at 1 MHz and its value at 4 MHz is between 2 and 3 Ω. At 1 MHz, the imaginary part of the impedance is between 4 and 6 Ω; for frequencies above about 0.3 MHz, it varies in the inverse ratio to the square root of the frequency.

Note 2 - For the same reason as in Note 1 above, the attenuation value is given at 1 MHz. At a frequency f MHz ($f > 1$), attenuation α_f is related to attenuation α_1 at 1 MHz by the ratio $\alpha_f = \alpha_1 \sqrt{f}$.

Note 3 - The value of far-end crosstalk is reduced to a length of 1000 m by a correction of 10 $\log_{10} L$ if the cable length L being measured is different from 1000 m. The crosstalk values indicated are the minimum limit values for the specification of systems. Where either of the above conditions is not fulfilled, the values are shown between brackets.

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3) For symmetrical pair star-quad cables the correction law 20 $\log_{10} f$ is used for pairs of the same quad only up to a certain characteristic frequency, above this frequency the law 40 $\log_{10} f$ must be used.

TABLE 1/G.612

Pair characteristics	Type I cable
Diameter of conductors (mm) Average mutual capacitance of pairs (nF/km) Characteristic impedance (Ω)[a)] Attenuation coefficient at 24° C (dB/km)[a)]	0.64 24.2 178 13.5

a) The attenuation and impedance measurement frequency is 3150 kHz.

TABLE 2/G.612

	Set 1[a)]	Set 2[a)]
Nominal characteristic impedance Z_0 (Ω) (desired average at 3150 kHz)	178	
Attenuation and crosstalk		
Attenuation at 3150 kHz to 24° C (dB/km)		
pair minimum	11.8	11.8
pair maximum	14.35	14.6
Far-end crosstalk (FEXT) loss at 3150 kHz dB for a 300 m (1000 feet length)		
pair minimum power sum	37.5	39.0
minimum pair-to-pair (0.1% point)	40.5	40.5
DC resistance at 24°C (Ω /km)		
maximum conductor	56.8	
desired average	54.5	
Cable average mutual capacitance (nF/km)		
maximum	25.4	
minimum	23.0	
desired average	24.2	
r.m.s standard deviation (σ) of pairs within a cable (%)	≤ 7	
Capacitance unbalance to ground (pF/km)		
maximum pair	≤ 443	
cable average	≤ 164	
DC dielectric strength		
between conductors for ARPAP [b)] sheath	≥ 1 500 V (applied for 1 s)	
core and inner aluminium to shield	≥ 20 000 V (applied for 3 s)	
core to inner aluminium and shield	≥ 5 000 V (applied for 3 s)	

a) Two sets of values for attenuation and far-end crosstalk are given. The cable may meet either one of these sets, thus allowing a cable with lower loss to meet a less stringent crosstalk requirement.

b) Aluminium-resin-polythene-aluminium-polythene.

TABLE 3/G.612

Cable pairs

Characteristics		Cable type				
		I	II	III	IV	V
Nominal characteristic impedance Z_0 at 1 MHz (Ω)		160	160	140	120	145
far-end crosstalk (minimum values referred to 1000m) (dB)	1 MHz 4 MHz 17 MHz	43[a)]	43[a)]	40	56 44 31	64 52 40
Near-end crosstalk from 1 to 17 MHz (minimum values, dB)		119	119	98	116	125
Nominal attenuation coefficient at 1 MHz[b)] (dB/km at 10° C)		7.0	9.3	10.5	9.5	5.2
Nominal capacity (nF/km)		28.5	28.5	31.5	38	30
Diameter of conductors (mm)		0.8	0.6	0.65	0.9	1.2

a) Far-end crosstalk measurements on elementary cable sections for pairs of this type are made in the digital mode only (see Supplement No. 19). The maximum value specified is 30 mV.

b) The real values should make it possible to meet the conditions required for an elementary cable section (Type I: 56 ± 2 dB at 4.2 MHz and 10°C for 4 km; Type II: 56 ± 2 dB at 4.2 MHz and 10 °C for 3 km; Type III: below 55 dB at 3.15 MHz for 2.8 km).

TABLE 4/G.612

Quad cables

Characteristics			Cable Type I	Cable Type II
Nominal characteristic impedance Z_0 at 1 MHz (Ω)			165	120
Far-end crosstalk (minimum values referred to 1000 m) (dB)	Different quads	1 MHz		56
		4 MHz	46	44
		13 MHz	34	
		17 MHz	31	31
	Same quad	1 MHz		46
		4 MHz	(45)	34
		13 MHz	(25)}[a]	
		17 MHz	(21)	[c]
Near-end crosstalk, from 1 to 17 MHz (minimum values, dB)			125[b]	116
Nominal attenuation coefficient at 1 MHz (dB/km at 10°C)			8.8	9.5
Nominal capacity (nF/km)			28	38
Diameter of conductors (mm)			0.65	0.9

[a] For 34 Mbit/s transmission over each pair of a star quad, a balancing method is applied to the elementary cable section of 2 km by means of systematic crossings every 500 m, which improves the far-end crosstalk values by at least 15 dB. Hence the values given in this box correspond to 500 m of cable.

[b] The value must be above 130 dB in 99% of cases.

[c] The transmission of 34 Mbit/s over each pair of a star quad is studied.