

INTERNATIONAL STANDARD



**Multicore and symmetrical pair/quad cables for digital communications –
Part 5: Symmetrical pair/quad cables with transmission characteristics
up to 1 000 MHz – Horizontal floor wiring – Sectional specification**



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IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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**Multicore and symmetrical pair/quad cables for digital communications –
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up to 1 000 MHz – Horizontal floor wiring – Sectional specification**

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CONTENTS

FOREWORD	5
1 Scope	7
2 Normative references	7
3 Terms and definitions	8
4 Installation considerations	8
4.1 General remarks	8
4.2 Bending radius of installed cable	8
4.3 Climatic conditions	8
5 Materials and cable construction	8
5.1 General remarks	9
5.2 Cable construction	9
5.2.1 Conductor	9
5.2.2 Insulation	9
5.2.3 Cable element	9
5.2.4 Cable make-up	9
5.2.5 Screening of the cable core	9
5.2.6 Sheath	9
5.2.7 Identification	10
5.2.8 Finished cable	10
6 Characteristics and requirements	10
6.1 General remarks	10
6.2 Electrical characteristics and tests	10
6.2.1 Conductor resistance	10
6.2.2 Resistance unbalance	11
6.2.3 Dielectric strength	11
6.2.4 Insulation resistance	11
6.2.5 Mutual capacitance	11
6.2.6 Capacitance unbalance	11
6.2.7 Transfer impedance	11
6.2.8 Coupling attenuation	12
6.2.9 Current-carrying capacity	13
6.3 Transmission characteristics	13
6.3.1 Velocity of propagation (phase velocity)	13
6.3.2 Phase delay and differential delay (delay skew)	13
6.3.3 Attenuation (α)	14
6.3.4 Unbalance attenuation (TCL)	15
6.3.5 Near-end crosstalk ($NEXT$)	16
6.3.6 Far-end crosstalk ($FEXT$ $ACR-F$)	16
6.3.7 Alien (exogenous) near-end crosstalk ($ANEXT$)	17
6.3.8 Alien (exogenous) far-end crosstalk ($AFEXT$ $AACR-F$)	17
6.3.9 Alien (exogenous) crosstalk of bundled cables	17
6.3.10 Impedance	17
6.3.11 Return loss (RL)	17
6.4 Mechanical and dimensional characteristics and requirements	20
6.4.1 Dimensional requirements	20
6.4.2 Elongation at break of the conductors	20

6.4.3	Tensile strength of the insulation	20
6.4.4	Elongation at break of the insulation	20
6.4.5	Adhesion of the insulation to the conductor.....	20
6.4.6	Elongation at break of the sheath	20
6.4.7	Tensile strength of the sheath.....	20
6.4.8	Crush test of the cable.....	20
6.4.9	Impact test of the cable	20
6.4.10	Bending under tension	20
6.4.11	Repeated bending of the cable	20
6.4.12	Tensile performance of the cable	20
6.4.13	Shock-test requirements of the cable	20
6.4.14	Bump-test requirements of the cable	21
6.4.15	Vibration-test requirements of the cable.....	21
6.5	Environmental characteristics	21
6.5.1	Shrinkage of insulation	21
6.5.2	Wrapping test of insulation after thermal ageing	21
6.5.3	Bending test of insulation at low temperature.....	21
6.5.4	Elongation at break of the sheath after ageing	21
6.5.5	Tensile strength of the sheath after ageing	21
6.5.6	Sheath pressure test at high temperature	21
6.5.7	Cold bend test of the cable	21
6.5.8	Heat shock test.....	21
6.5.9	Damp heat steady state	21
6.5.10	Solar radiation (UV test)	21
6.5.11	Solvents and contaminating fluids.....	22
6.5.12	Salt mist and sulphur dioxide	22
6.5.13	Water immersion	22
6.5.14	Hygroscopicity	22
6.5.15	Wicking.....	22
6.5.16	Flame propagation characteristics of a single cable	22
6.5.17	Flame propagation characteristics of bunched cables	22
6.5.18	Halogen gas evolution	22
6.5.19	Smoke generation.....	22
6.5.20	Toxic gas emission	22
6.5.21	Integrated fire test	22
7	Category 5e multipair cable	22
7.1	General.....	22
7.2	Transmission	23
8	Introduction to the blank detail specification	23
Annex A (informative) Acronyms for common cable constructions		26
Annex A (informative) Blank detail specification		26
Bibliography.....		31

~~Figure 1 — Impedance template~~

~~Figure A.1 — Common cable construction examples~~

Table 1 – Cable categories

Table 2 – Transfer impedance

Table 3 – Coupling attenuation in dB	13
Table 4 – Attenuation equation constants	14
Table 5 – Near-end unbalance attenuation.....	15
Table 6 – Worst-pair <i>PS NEXT</i> (1) values.....	16
Table 7 – Worst-pair <i>PS-EL-FEXT ACR-F</i> (1) values	16
Table 8 – <i>PS ANEXT</i>	17
Table 9 – <i>PS AACR-F</i>	17
Table 10 – Return loss.....	19
Table A.1 – Cable construction acronyms	

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**MULTICORE AND SYMMETRICAL PAIR/QUAD CABLES
FOR DIGITAL COMMUNICATIONS –****Part 5: Symmetrical pair/quad cables with transmission
characteristics up to 1 000 MHz – Horizontal floor wiring –
Sectional specification**

FOREWORD

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International Standard IEC 61156-5 has been prepared by subcommittee 46C: Wires and symmetric cables, of IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories.

This third edition cancels and replaces the second edition published in 2009 and Amendment 1:2012. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) additional balance levels with respect to MICE implementation by certain cabling specifications;
- b) reference to current standards and technical reports with respect to measurement techniques and remote powering.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
46C/1140/FDIS	46C/1144/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

This International Standard is to be used in conjunction with IEC 61156-1:2007 and IEC 61156-1:2007/AMD1:2009.

A list of all parts in the IEC 61156 series, published under the general title *Multicore and symmetrical pair/quad cables for digital communications*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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MULTICORE AND SYMMETRICAL PAIR/QUAD CABLES FOR DIGITAL COMMUNICATIONS –

Part 5: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Horizontal floor wiring – Sectional specification

1 Scope

This part of IEC 61156 describes the cables intended primarily for horizontal floor wiring as defined in ISO/IEC 11801 (all parts).

It covers cable designs comprising individually screened, common screened and unscreened pairs or quads ~~(see Annex A)~~. The transmission characteristics and the frequency range (see Table 1) of the cables are specified at 20 °C.

Table 1 – Cable categories

Cable designation	Maximum referenced frequency MHz
Category 5e	100
Category 6	250
Category 6 _A	500
Category 7	600
Category 7 _A	1 000

These cables can be used for various communication channels which use as many as four pairs simultaneously. In this sense, this document provides the cable characteristics required by system developers to evaluate new systems.

The cables covered by this document are intended to operate with voltages and currents normally encountered in communication systems. While these cables are not intended to be used in conjunction with low impedance sources, for example the electric power supplies of public utility mains, they are intended to be used to support the delivery of low voltage ~~and~~ remote powering applications such as IEEE 802.3af (Power over Ethernet) ~~and~~ or further developments for example according to IEEE 802.3at ~~(Power over Ethernet Plus)~~ or IEEE 802.3bt. More information on the capacity to support these applications according to the installation practices are given in IEC 61156-1-4, IEC TR 61156-1-6 and ISO/IEC TS 29125.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61156-1:2007, *Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification*
IEC 61156-1:2007/AMD1:2009

~~IEC 61156-5-1, Multicore and symmetrical pair/quad cables for digital communications – Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Horizontal floor wiring – Blank detail specification~~

IEC 62153-4-3, *Metallic communication cables test methods – Part 4-3: Electromagnetic compatibility (EMC) – Surface transfer impedance – Triaxial method*

IEC 62153-4-5, *Metallic communication cables test methods – Part 4-5: Electromagnetic compatibility (EMC) – Coupling or screening attenuation – Absorbing clamp method*

IEC 62153-4-9, *Metallic communication cable test methods – Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of screened balanced cables, triaxial method*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61156-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

4 Installation considerations

4.1 General remarks

Installation considerations are defined in IEC 61156-1:2007, Clause 4.

4.2 Bending radius of installed cable

The bending radius of the installed cable shall not be less than four times the outside diameter of the cable.

4.3 Climatic conditions

~~Under static conditions, the cables shall operate in the temperature range from –40 °C to +60 °C. The conductor and cable temperature dependence is specified for screened and unscreened cables and should be taken into account for the design of an actual cabling system.~~

~~Other temperature ranges may be specified in the relevant detail specification.~~

Under static conditions, the cable shall operate at least in the temperature range of the environment from –20 °C to +60 °C.

The attenuation increase due to the elevated operating temperature (temperature of the environment) is described in 6.3.3.3.

In the case of application of remote powering, the maximum temperature of the conductor shall not exceed the maximum operation temperature under static conditions in order to maintain the integrity of the dielectric material performance which is aligned to the environmental temperature range.

Extended temperature ranges are permitted and may be specified in the relevant detail specification.

5 Materials and cable construction

5.1 General remarks

The choice of materials and cable construction shall be suitable for the intended application and installation of the cable. Particular care shall be taken to meet any requirements for EMC and fire performance (such as burning properties, smoke generation, evolution of halogen gas, ~~etc.~~).

The cable construction shall be in accordance with the details and dimensions given in the relevant detail specification.

5.2 Cable construction

5.2.1 Conductor

The conductor shall be a solid annealed copper conductor, in accordance with IEC 61156-1:2007, 5.2.1 and should have a nominal diameter between 0,4 mm and 0,65 mm. A conductor diameter of up to 0,8 mm may be used.

5.2.2 Insulation

The conductor shall be insulated with a suitable material. Examples of suitable materials are:

- polyolefin;
- fluoropolymer;
- low-smoke zero-halogen thermoplastic material.

~~The diameter of the insulated conductor shall be indicated in the relevant detail specification.~~

5.2.3 Cable element

5.2.3.1 General

The cable element shall be a twisted pair or quad.

5.2.3.2 Screening of the cable element

When required, the screen for the cable element shall be in accordance with IEC 61156-1:2007, 5.2.3.2.

5.2.4 Cable make-up

A spacer may be used to separate the cable elements. The cable elements, including spacers, shall be assembled to form the cable core.

The core of the cable may be wrapped with a protective layer of non-hygroscopic and non-wicking material.

5.2.5 Screening of the cable core

When required by the relevant detail specification, a screen for the cable core shall be provided.

The screen shall be in accordance with IEC 61156-1:2007, 5.2.5.

5.2.6 Sheath

The sheath material shall consist of a suitable material.

Examples of suitable materials are:

- polyolefin;
- PVC;
- fluoropolymer;
- low-smoke zero-halogen thermoplastic material.

The sheath shall be continuous, having a thickness as uniform as possible. A non-metallic ripcord may be provided. When provided, the ripcord shall be non-hygroscopic and non-wicking.

The colour of the sheath is not specified but should be specified in the relevant detail specification.

5.2.7 Identification

Each length of cable shall be identified with the supplier's details, and when required, by means of a traceability code, using one of the following methods:

- a) appropriately coloured threads or tapes;
- b) with a printed tape;
- c) printing on the cable core wrapping;
- d) marking on the sheath.

Additional markings, such as length marking, ~~etc.~~ are permitted. If used, such markings should be indicated in the relevant detail specification.

5.2.8 Finished cable

The finished cable shall be adequately protected for storage and shipment.

6 Characteristics and requirements

6.1 General remarks

Clause 6 lists the characteristics and minimum requirements of a cable complying with this document. Test methods shall be in accordance with IEC 61156-1:2007 and IEC 61156-1:2007/AMD1:2009, Clause 6.

The tests according to 6.2 shall be carried out on a cable length of not less than 100 m, unless otherwise specified.

All the tests according to 6.3 shall be carried out on a cable length of 100 m, unless otherwise specified. If suitable, respective lengths correction formulas according to IEC 61156-1 shall be used. For Category 7_A, unless the test is performed with very sensitive test equipment, it is recommended to limit the cable length to 50 m for a better accuracy in high frequencies.

In case balunless measurements are made, the procedures should be as per IEC TR 61156-1-2:2009 and IEC TR 61156-1-2:2009/AMD1:2014 which covers the application of balunless measurement technology.

6.2 Electrical characteristics and tests

~~The tests shall be carried out on a cable length of not less than 100 m, unless otherwise specified.~~

~~NOTE—For cat7A₇, unless the test is performed with very sensitive test equipment, it is recommended to limit the cable length to 50 m for a better accuracy in high frequencies.~~

6.2.1 Conductor resistance

The maximum conductor resistance at or corrected to 20 °C shall not exceed 9,5 Ω for 100 m of cable.

6.2.2 Resistance unbalance

6.2.2.1 Resistance unbalance within a pair

The resistance unbalance shall not exceed 2,0 %.

6.2.2.2 Resistance unbalance between pairs

The pair-to-pair resistance unbalance shall not exceed ~~4 %~~ 5,0 %.

6.2.3 Dielectric strength

There shall be no failures when a test is performed on a conductor/conductor and, where screen(s) are present, on a conductor/screen with 1,0 kV DC for 1 min or, alternately, with 2,5 kV DC for 2 s. An AC voltage may be used. The AC voltage levels in these cases shall be 0,7 kV AC for 1 min or, alternately, 1,7 kV AC for 2 s.

6.2.4 Insulation resistance

The test shall be performed both on

- conductor/conductor;
- conductor/screen (when present).

The minimum insulation resistance at or corrected to 20 °C shall be not less than ~~5 000 M Ω ·m~~ 5 000 M Ω · km.

6.2.5 Mutual capacitance

The mutual capacitance is not specified but may be indicated in the relevant detail specification.

6.2.6 Capacitance unbalance

The maximum capacitance unbalance pair to ground shall not exceed 1 600 pF/km at a frequency of 800 Hz or 1 000 Hz.

6.2.7 Transfer impedance

For cables containing a screen or screens, two grades of performance are recognized for transfer impedance. The transfer impedance ~~measured according to IEC 62153-4-3~~ shall not exceed the values shown in Table 2 ~~at the discrete frequencies indicated~~ for each grade.

Table 2 – Transfer impedance

Frequency MHz	Maximum surface transfer impedance mΩ/m	
	Grade 1	Grade 2
1	10	50
10	10	100
30	30	200
100	100	1 000

Frequency range MHz	Maximum surface transfer impedance mΩ/m	
	Grade 1	Grade 2
1 to 10	$Z_t \leq 15 \times f^{0,176}$	$Z_t \leq 50 \times f^{0,301}$
10 to 30	$Z_t \leq 10 \times f/10$	$Z_t \leq 23,392 \times f^{0,6309}$
30 to 100	$Z_t \leq 10 \times f/10$	$Z_t \leq 2,1206 \times f^{1,3368}$

NOTE The screen longitudinal DC resistance of 30 mΩ/m or less is an indicator for fulfilling the transfer impedance requirement of Grade 2. A measurement of DC resistance cannot replace a transfer impedance measurement.

6.2.8 Coupling attenuation

~~Three~~ Four types of performance are recognized for coupling attenuation. When measured using the absorbing clamp method (IEC 62153-4-5) or the triaxial method (IEC 62153-4-9), the coupling attenuation in the frequency range from $f = 30$ MHz to 1 000 MHz shall meet the requirements indicated in Table 3. For screened cables ~~the triaxial method (IEC 62153-4-9) may also be used~~, Type II is the minimum coupling attenuation requirement.

Table 3 – Coupling attenuation in dB

Coupling attenuation type	Frequency range MHz	Coupling attenuation dB
Type I	30—100	≥ 85
	100—1 000	≥ 85—20 × log ₁₀ (f/100)
Type II	30—100	≥ 55
	100—1 000	≥ 55—20 × log ₁₀ (f/100)
Type III	30—100	≥ 40
	100—1 000	≥ 40—20 × log ₁₀ (f/100)

Coupling attenuation type	Frequency range MHz	
	30 to 100	100 to 1 000
Type I	≥ 85	≥ 85 – 20 × log ₁₀ (f/100)
Type Ib	≥ 70	≥ 70 – 20 × log ₁₀ (f/100)
Type II	≥ 55	≥ 55 – 20 × log ₁₀ (f/100)
Type III	≥ 40	≥ 40 – 20 × log ₁₀ (f/100)

6.2.9 Current-carrying capacity

The maximum current-carrying capacity is not specified but may be indicated in the relevant detail specification. Further guidance with respect to current carrying capacity is provided by ISO/IEC TS 29125 and the test method described in IEC 61156-1-4.

6.3 Transmission characteristics

~~All the tests shall be carried out on a cable length of 100 m, unless otherwise specified.~~

6.3.1 Velocity of propagation (phase velocity)

The requirement is not specified but may be indicated in the relevant detail specification.

6.3.2 Phase delay and differential delay (delay skew)

6.3.2.1 Phase delay

The phase delay, τ , shall not exceed the value obtained from Equation (1) in the frequency range from 4 MHz to the maximum referenced frequency.

$$\tau = 534 + \frac{36}{\sqrt{f}} \quad (1)$$

where

τ is the phase delay in ns/100 m;

f is the frequency expressed in MHz.

6.3.2.2 Differential delay (delay skew)

When the delay is measured at ~~(20 ± 1~~ 20 ± 3) °C, the maximum delay skew between any two pairs ~~at a given temperature~~ shall be not greater than 45 ns/100 m for Category 5e, Category 6 and Category 6_A cables and 25 ns/100 m for Category 7 and Category 7_A cables in the frequency range from 4 MHz to the maximum referenced frequency.

6.3.3 Attenuation (α)

6.3.3.1 Attenuation at 20 °C operating temperature

The maximum attenuation, α , of any pair in the frequency range indicated in Table 4 shall not exceed the value obtained from Equation (2).

$$\alpha = a \sqrt{f} + b f + \frac{c}{\sqrt{f}} \quad (2)$$

where

α is the attenuation expressed in dB/100 m;

a, b, c are constants indicated in Table 4;

f is the frequency expressed in MHz.

Table 4 – Attenuation equation constants

Cable designation	Frequency range MHz	Constants		
		a	b	c
Category 5e	1 to 100	1,967	0,023	0,100
Category 6	1 to 250	1,820	0,016 9	0,250
Category 6 _A	1 to 500	1,820	0,009 1	0,250
Category 7	1 to 600	1,800	0,010	0,200
Category 7 _A	1 to 1 000	1,800	0,005	0,250 0,240
The cable performance between 1 MHz and 4 MHz is achieved by design only and it is therefore not necessary to test for this performance below 4 MHz.				

6.3.3.2 Category 5e special consideration

The constants for Category 5e in Table 4 are based on the use of ~~patch~~ cables for work area wiring having up to a 20 % higher attenuation than the horizontal cable. When ~~patch~~ cables for work area wiring having an attenuation up to 50 % higher than the horizontal cable are used, the constants should be 1,910 8, 0,022 2 and 0,200 for a, b and c respectively.

6.3.3.3 Attenuation at elevated operating temperature

The increase ~~in~~ of the maximum attenuation ~~obtained~~ from Equation (2) due to an elevated environmental temperature above 20 °C, ~~shall be~~ is obtained by calculation as follows:

- for unscreened cables: 0,4 %/°C, for the temperature range from 20 °C to 40 °C and 0,6 %/°C for the temperature range 40 °C to 60 °C.
- for screened cables: 0,2 %/°C in the temperature range 20 °C to 60 °C.

In the case of application of remote powering, the actual conductor temperature shall be considered to calculate the attenuation increase. If an extended environmental temperature range is specified (see 4.3) the temperature coefficients given in 6.3.3.3 might not be

applicable. The method provided in IEC 61156-1 shall be used to determine temperature coefficients in this case.

6.3.4 Unbalance attenuation (*TCL*)

~~Two~~ Four levels of performance are recognized for unbalance attenuation. The minimum near-end unbalance attenuation (transverse conversion loss or *TCL*) shall not be less than the value obtained from Equation (3) (Level 1) ~~or from Equation (4) (Level 2)~~ to Equation (6) (Level 4), for all frequencies, f , in the frequency ranges indicated in Table 5.

$$\text{Level 1:} \quad TCL = 40,0 - 10 \times \log_{10}(f) \text{ (dB)} \quad (3)$$

$$\text{Level 2:} \quad TCL = 50,0 - 10 \times \log_{10}(f) \text{ (dB)} \quad (4)$$

$$\text{Level 3:} \quad TCL = 60,0 - 10 \times \log_{10}(f) \text{ (dB)} \quad (5)$$

$$\text{Level 4:} \quad TCL = 70,0 - 10 \times \log_{10}(f) \text{ (dB)} \quad (6)$$

NOTE If the intention is to increase the frequency range of balance measurements, IEC TR 61156-1-2 provides guidance on the respective (e.g. balunless) measurement techniques.

Table 5 – Near-end unbalance attenuation

Cable category	Frequency range MHz
Category 5e	1 to 100
Category 6	1 to 250
Category 6 _A	1 to 250
Category 7	1 to 250
Category 7 _A	1 to 250

For those frequencies where the calculated value of *TCL* is greater than 50 dB, the requirement shall be 50 dB. *TCL* requirements for frequencies higher than 250 MHz may be defined in the detail specification.

The minimum equal-level far-end unbalance attenuation (equal-level transverse conversion transfer loss or *EL TCTL*) for all categories shall not be less than the value obtained from Equation (7) to Equation (9) for all frequencies, f , in the range from 1 MHz to 30 MHz.

$$\text{Level 1, Level 2} \quad EL \ TCTL = 35,0 - 20 \times \log_{10}(f) \text{ (dB)} \quad (7)$$

$$\text{Level 3} \quad EL \ TCTL = 45,0 - 20 \times \log_{10}(f) \text{ (dB)} \quad (8)$$

$$\text{Level 4} \quad EL \ TCTL = 55,0 - 20 \times \log_{10}(f) \text{ (dB)} \quad (9)$$

For those frequencies where the calculated value of *EL TCTL* is greater than 40 dB, the requirement shall be 40 dB. *EL TCTL* requirements for frequencies higher than 30 MHz may be defined in the detail specification.

6.3.5 Near-end crosstalk (*NEXT*)

The worst pair power sum near-end crosstalk, *PS NEXT*, at all frequencies, *f*, in the frequency range indicated in Table 6 shall not be less than the value obtained from Equation (10) using the corresponding value of *PS NEXT*(1) indicated in Table 6.

$$PS\ NEXT(f) = PS\ NEXT(1) - 15 \times \log_{10}(f) \text{ (dB)} \quad (10)$$

Table 6 – Worst-pair *PS NEXT*(1) values

Cable designation	Frequency range MHz	<i>PS NEXT</i> (1) dB
Category 5e	1 to 100	62,3
Category 6	1 to 250	72,3
Category 6 _A	1 to 500	72,3
Category 7	1 to 600	99,4
Category 7 _A	1 to 1 000	102,4
NOTE The cable performance between 1 MHz and 4 MHz is achieved by design only and it is therefore not necessary to test for this performance below 4 MHz.		

For those frequencies where the calculated value of *PS NEXT* is greater than 75 dB, the requirement shall be 75 dB.

The minimum pair-to-pair *NEXT* for any pair combination shall be at least 3 dB better than the *PS NEXT* for any pair.

6.3.6 Far-end crosstalk (~~*FEXT*~~ *ACR-F*)

The worst-pair power-sum equal-level far-end crosstalk, *PS-~~EL-FEXT~~ ACR-F*, at all frequencies, *f*, in the frequency range indicated in Table 7 shall not be less than the value obtained from Equation (11) using the corresponding value of *PS-~~EL-FEXT~~ ACR-F* (1) given in Table 7.

$$PS\ EL\ FEXT(f) = PS\ EL\ FEXT(1) - 20 \times \log_{10}(f)$$

$$PS\ ACR - F(f) = PS\ ACR - F(1) - 20 \times \log_{10}(f) \text{ (dB)} \quad (11)$$

Table 7 – Worst-pair *PS-~~EL-FEXT~~ ACR-F* (1) values

Cable designation	Frequency range MHz	<i>PS-EL-FEXT ACR-F</i> (1) dB for 100 m
Category 5e	4 1 to 100	61,0
Category 6	4 1 to 250	65,0
Category 6 _A	4 1 to 500	65,0
Category 7	4 1 to 600	91,0
Category 7 _A	4 1 to 1 000	92,3
NOTE 1 If <i>FEXT</i> loss is greater than 90 dB, <i>EL-FEXT</i> <i>PS ACR-F</i> loss may not be calculated.		
NOTE 2 The cable performance between 1 MHz and 4 MHz is achieved by design only and it is therefore not necessary to test for this performance below 4 MHz.		

For those frequencies where the calculated value of $PS\text{-}\cancel{EL\text{-}FEXT} ACR\text{-}F$ is greater than 75 dB, the requirement shall be 75 dB.

The minimum pair-to-pair $\cancel{EL\text{-}FEXT} ACR\text{-}F$ for any pair combination shall be at least 3 dB better than the $PS\text{-}\cancel{EL\text{-}FEXT} ACR\text{-}F$ for any pair.

6.3.7 Alien (exogenous) near-end crosstalk ($ANEXT$)

Alien (exogenous) near-end crosstalk, $ANEXT$, is only a measurement consideration for Type III cables according to 6.2.8. For Type I, Type Ib and Type II screened cables as defined in Table 3, $ANEXT$ is proven by design.

The $PS ANEXT$ (power sum alien (exogenous) near-end crosstalk) of cable when tested in accordance with IEC 61156-1:2007, 6.3.7.1 shall be not less than the values obtained from Table 8.

Table 8 – $PS ANEXT$

Category	Frequency range MHz	Minimum $PS ANEXT$ dB
Category 6 _A	$1 \leq f \leq$ to 500	$92,5 - 15 \times \log_{10}(f)$
Category 7 _A	$1 \leq f \leq$ to 1 000	$107,5 - 15 \times \log_{10}(f)$
NOTE Calculated values greater than 67 dB revert to a value of 67 dB.		

6.3.8 Alien (exogenous) far-end crosstalk ($\cancel{AFEXT} AACR\text{-}F$)

Alien (exogenous) far-end crosstalk, $\cancel{AFEXT} AACR\text{-}F$, is only a measurement consideration for unscreened cables. For Type I, Type Ib and Type II screened cables as defined in Table 3, $\cancel{AFEXT} AACR\text{-}F$ is proven by design.

The $PS AACR\text{-}F$ (power-sum alien attenuation to crosstalk ratio far-end) of the cable when tested in accordance with IEC 61156-1:2007, 6.3.8, shall not be less than the values obtained from Table 9.

Table 9 – $PS AACR\text{-}F$

Category	Frequency range MHz	Minimum $PS AACR\text{-}F$ dB
Category 6 _A	$1 \leq f \leq$ to 500	$78,2 - 20 \times \log_{10}(f)$
Category 7 _A	$1 \leq f \leq$ to 1 000	$93,2 - 20 \times \log_{10}(f)$
NOTE Calculated values greater than 67 dB revert to a value of 67 dB.		

6.3.9 Alien (exogenous) crosstalk of bundled cables

The minimum requirement is not specified but should be stated in the relevant detail specification.

6.3.10 Impedance

~~The impedance requirement is specified by either case A or case B below as specified in the relevant detail specification.~~

~~Case A (Fitted or mean characteristic impedance):~~