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Second edition
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Multicore and symmetrical pair/quad cables for digital communications –

Part 6:
Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Work area wiring – Sectional specification

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

MULTICORE AND SYMMETRICAL PAIR/QUAD CABLES FOR DIGITAL COMMUNICATIONS –

Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Work area wiring – Sectional specification

FOREWORD

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International Standard IEC 61156-6 has been prepared by subcommittee 46C: Wires and symmetric cables, of IEC technical committee 46: Cables, wires, waveguides, r.f. connectors, r.f. and microwave passive components and accessories.

This second edition cancels and replaces the first edition published in 2002. This edition constitutes a technical revision.

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

a) new requirements for new cables $Cat6_A$, $Cat7_A$ for 10 GBase-T applications;
b) revised requirements and tests for the cables.

The text of this standard is based on the first edition and on the following documents:

FDIS	Report on voting
46C/818/FDIS	46C/826/RVD

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

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

This standard shall be read in conjunction with IEC 61156-1.

The list of all the parts of the IEC 61156 series, 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 publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn;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

A bilingual version of this publication may be issued at a later date.

MULTICORE AND SYMMETRICAL PAIR/QUAD CABLES FOR DIGITAL COMMUNICATIONS –

Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Work area wiring – Sectional specification

1 Scope

This part of IEC 61156 relates to IEC 61156-1. The cables described herein are intended for work area wiring as defined in ISO/IEC 11801.

It covers individually screened, common screened and unscreened pairs or quads. 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 reference 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 sectional specification provides the cable characteristics required by system developers to evaluate new systems.

The cables covered by this standard are intended to operate with voltages and currents normally encountered in communication systems. These cables are not intended to be used in conjunction with low impedance sources, for example, the electric power supplies of public utility mains.

2 Normative references

The following referenced documents are indispensable for the application 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 60304, *Standard colours for insulation for low-frequency cables and wires*

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

IEC 61156-6-1, *Multicore and symmetrical pair/quad cables for digital communications – Part 6-1: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Work area wiring – Blank detail specification*

ISO/IEC 11801, *Information technology – Generic cabling for customer premises*

3 Terms and definitions

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

4 Installation considerations

4.1 General

Installation considerations are defined in Clause 4 of IEC 61156-1.

4.2 Climatic conditions

Under static conditions, the cables shall operate in the temperature range from –20 °C to +60 °C. The temperature dependence of the cables is specified for screened and unscreened cables and should be taken into account for the design of an actual cabling system.

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 special requirements for EMC and fire performance (such as burning properties, smoke generation, evolution of halogen gas, etc.).

5.2 Cable construction

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

5.2.1 Conductor

The conductor shall be a solid or stranded annealed plain or tinned copper, in accordance with 5.2.1 of IEC 61156-1 and shall 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.

NOTE Refer to IEC 60304 for standard colours for insulation.

5.2.3 Cable element

5.2.3.1 General

The cable element shall be a pair or quad adequately twisted.

5.2.3.2 Screening of the cable element

When required, the screen for the cable element shall be in accordance with 5.2.3.1 of IEC 61156-1.

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 5.2.5 of IEC 61156-1.

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 it should be stated in the relevant detail specification.

5.2.7 Identification

Each length of cable shall be identified as to the manufacturer and, when required, the year of manufacture.

Additional markings, such as length marking, etc., are permitted on the cable sheath. 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

This clause lists the characteristics and minimum requirements of a cable complying with this standard. Test methods shall be in accordance with Clause 6 of IEC 61156-1.

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.

6.2.1 Conductor resistance

The maximum conductor resistance at or corrected to 20 °C shall not exceed 14,5 Ω/100 m of cable.

6.2.2 Resistance unbalance

6.2.2.1 Resistance unbalance within a pair

The conductor resistance unbalance shall not exceed 2 %.

6.2.2.2 Resistance unbalance between pairs

The pair-to-pair resistance unbalance shall not exceed 4 %.

6.2.3 Dielectric strength

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

6.2.4 Insulation resistance

The test shall be performed both on

– conductor/conductor;
– conductor/screen (when available).

The minimum insulation resistance at, or corrected to, 20 °C shall be not less than 5 000 MΩ/m.

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 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	60	1 000

6.2.8 Coupling attenuation

Three types of performance are recognized for coupling attenuation. When measured using the absorbing clamp method, the coupling attenuation in the frequency range from f = 30,0 MHz to 1 000 MHz shall be equal to, or greater than, the values indicated in Table 3.

Table 3 – Coupling attenuation

Coupling attenuation type	Frequency range MHz	Coupling attenuation dB
Type I	30-100	≥85,0
	100-1 000	≥85,0 – 20 × $\log_{10}$ (f/100)
Type II	30-100	≥55,0
	100-1 000	≥55,0 – 20 × $\log_{10}$ (f/100)
Type III	30-100	≥40,0
	100-1 000	≥40,0 – 20 × $\log_{10}$ (f/100)

6.2.9 Ampacity

Under consideration.

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 minimum velocity of propagation for any pair within the cable shall be not less than 0,65 × c for all frequencies between 4 MHz and the maximum referenced frequency.

NOTE The velocity of propagation, group velocity and phase velocity are approximately equal for frequencies greater than 4 MHz when measured on symmetric cables, i.e. when the cables are operated in a balanced mode.

6.3.2 Phase delay and differential delay (delay skew)

The phase delay, τ, shall not exceed the value obtained from equation (1) for all the frequencies in the referenced frequency range,

$$\tau = 534 + \frac{36}{\sqrt{f}} \quad \text{(ns/100 m)} \qquad (1)$$

where f is the frequency in MHz and τ in seconds.

6.3.2.1 Differential delay (delay skew)

When the delay is measured at (10 ± 2) °C and (40 ± 1) °C, the maximum delay skew between any two pairs at a given temperature shall be not greater than 45 ns/100 m for cat5e, cat6, cat6$_A$ cables and 25 ns/100 m for cat 7 and cat 7$_A$ cables in the frequency range from 4 MHz to the maximum referenced frequency.

6.3.2.2 Environmental effects

The differential delay (delay skew) between any two pairs due to temperature shall not vary by more than ±10 ns/100 m over the temperature range from –20 °C to +60 °C.

6.3.3 Attenuation

6.3.3.1 General figures

The maximum attenuation α of any pair in the frequency range indicated in Table 4 shall not exceed the value obtained from equation (2) using the corresponding values of the constants a, b and c given in Table 4.

$$\alpha = a \times \sqrt{f} + b \times f + \frac{c}{\sqrt{f}} \quad \text{(dB/100 m)} \qquad (2)$$

where f is the frequency in MHz.

Table 4 – Attenuation, constant values

Cable designation	Frequency range MHz	Constants		
		a	b	c
Category 5e	4-100	2,866	0,033	0,300
Category 6	4-250	2,730	0,026	0,375
Category 6$_A$	4-500	2,730	0,026	0,375
Category 7	4-600	2,700	0,015	0,300
Category 7$_A$	4-1 000	2,700	0,015	0,300

The increase in maximum attenuation requirement obtained from equation (2) due to elevated temperature shall be 0,4 %/°C, for the frequency range from 4 MHz to 250 MHz and 0,6 %/°C for frequencies above 250 MHz for unscreened cables and 0,2 %/°C for screened cables.

6.3.4 Unbalance attenuation

Two levels of performance are recognized for unbalance attenuation. The minimum near-end unbalance attenuation (transverse conversion loss or TCL) shall be not less than the value obtained from equation (3) for the frequency ranges given in Table 5.

The TCL for level 1 is obtained from equation (3) and for level 2 from equation (4)

$$TCL = 40{,}0 - 10 \times \log_{10}(f) \text{ (dB)} \qquad (3)$$

$$TCL = 50{,}0 - 10 \times \log_{10}(f) \text{ (dB)} \qquad (4)$$

Table 5 – Near-end unbalance attenuation

Cable category	Frequency range for *TCL* MHz
Category 5e	1-100
Category 6	1-250
Category 6_A	1-250
Category 7	1-250
Category 7_A	1-250

The minimum equal-level far-end unbalance attenuation (equal-level transverse conversion transfer loss or *EL TCTL*) for all categories shall be equal to, or greater than, the value obtained from equation (5) for all frequencies in the range from 1 MHz to 30 MHz.

The formula for *EL TCTL* is

$$EL\ TCTL = 35{,}0 - 20 \times \log_{10}(f) \quad \text{(dB)} \tag{5}$$

6.3.5 Near-end crosstalk (*NEXT*)

The worst-pair power-sum near-end crosstalk, *PS NEXT*, in the frequency range indicated in Table 6 shall be equal to, or greater than, the value obtained from equation (6) using the corresponding value of *PS NEXT*(1) given in Table 6.

$$PS\ NEXT(f) = PS\ NEXT(1) - 15 \times \log_{10}(f) \quad \text{(dB)} \tag{6}$$

Table 6 – Worst-pair *PS NEXT* values

Cable designation	Frequency range MHz	*PS NEXT*(1) dB
Category 5e	4-100	62,3
Category 6	4-250	72,3
Category 6_A	4-500	72,3
Category 7	4-600	99,4
Category 7_A	4-1 000	99,4

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*)

The worst-pair power-sum equal-level far-end crosstalk, *PS EL FEXT*, in the frequency range indicated in Table 8 shall be equal to, or greater than, the value obtained from equation (7) using the corresponding value of the *PS EL FEXT*(1) given in Table 7.

$$PS\ EL\ FEXT(f) = PS\ EL\ FEXT(1) - 20 \times \log_{10}(f) \quad \text{(dB for 100 m)} \tag{7}$$

Table 7 – Worst-pair *PS EL FEXT*

Cable designation	Frequency range MHz	*PS EL FEXT*(1) dB for 100 m
Category 5e	4-100	61,0
Category 6	4-250	65,0
Category 6_A	4-500	65, 0
Category 7	4-600	91,0
Category 7_A	4-1 000	91, 0
NOTE If *FEXT* loss is greater than 70 dB, *EL FEXT* loss may not be measured.		

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

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

6.3.7 Alien (exogenous) near-end crosstalk

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

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

Table 8 – *PS ANEXT*

Category	Frequency range MHz	Minimum *PS ANEXT* dB
$Cat6_A$	$1 \le f \le 500$	$92{,}5 - 15 \times \log_{10}(f)$
$Cat7_A$	$1 \le f \le 1\ 000$	$92{,}5 - 15 \times \log_{10}(f)$
NOTE Calculated values greater than 67 dB revert to a value of 67 dB.		

6.3.8 Alien (exogenous) far-end crosstalk

Alien (exogenous) far-end crosstalk is only a measurement consideration for Type III cables as defined in Table 3. For Type II and Type I screened cables, the alien (exogenous) far-end crosstalk is proven by design.

The *PS AACR-F* (power-sum alien attenuation to crosstalk ratio far-end) of cable when tested in accordance with 6.3.7.1 of IEC 61156-1 shall be not less than the values obtained from Table 9.

NOTE PS ACCR-F is equivalent to PS AELFEXT.

Table 9 – PS AELFEXT

Category	Frequency range MHz	Minimum *PS AFEXT* dB
$Cat6_A$	$1 \le f \le 500$	$78{,}2 - 20 \times \log_{10}(f)$
$Cat7_A$	$1 \le f \le 1\,000$	$78{,}2 - 20 \times \log_{10}(f)$
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 Mean characteristic impedance

The mean characteristic impedance shall be within ±5 % of the requested nominal impedance in the frequency range 1 MHz to 100 MHz.

6.3.11 Return loss (RL)

The minimum return loss of any pair in the frequency range indicated in Table 10 shall be equal to, or greater than, the values in Table 10 for the respective categories.

Table 10 – Return loss

Cable category	Frequency range MHz	Return loss dB
All	4-10	$20{,}0 + 5{,}0 \times \log_{10}(f)$
All	10-20	25,0
Category 5e	20-100	$25{,}0 - 8{,}6 \times \log_{10}(f/20)$
Category 6	20-250	$25{,}0 - 8{,}6 \times \log_{10}(f/20)$
Category 6_A	20-500	$25{,}0 - 8{,}6 \times \log_{10}(f/20)$
Category 7	20-600	$25{,}0 - 8{,}6 \times \log_{10}(f/20)$
Category 7_A	20-1 000	$25{,}0 - 8{,}6 \times \log_{10}(f/20)$
NOTE Calculated values below 15,6 dB revert to a 15,6 dB plateau.		

6.4 Mechanical and dimensional characteristics and requirements

6.4.1 Dimensional requirements

The overall diameter of insulation, the nominal thickness of the sheath and the maximum overall diameter of the sheath are not specified but shall be indicated in the relevant detail specification.

6.4.2 Elongation at break of the conductors

The minimum elongation of the conductor shall be not less than 8 %.

6.4.3 Tensile strength of the insulation

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

6.4.4 Elongation at break of the insulation

The minimum value of the elongation at break of the insulation shall be not less than 100 %.

6.4.5 Adhesion of the insulation to the conductor

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

6.4.6 Elongation at break of the sheath

The minimum value of the elongation at break of the sheath shall be not less than 100 %.

6.4.7 Tensile strength of the sheath

The minimum tensile strength of the sheath shall be not less than 9 MPa.

6.4.8 Crush test of the cable

The minimum force shall be 1 000 N.

6.4.9 Impact test of the cable

The impact resistance of the cable is not specified but shall be indicated in the relevant detail specification.

6.4.10 Bending under tension

The bending performance of the cable is not specified but may be indicated in the relevant detail specification.

6.4.11 Repeated bending of the cable

The repeated bending performance of the cable is not specified but shall be indicated in the relevant detail specification.

6.4.12 Tensile performance of the cable

The cable shall withstand 500 cycles without cracking of the insulation or sheath or loss of continuity in any metallic components.

6.4.13 Shock-test requirements of the cable

Not applicable.

6.4.14 Bump-test requirements of the cable

Not applicable.

6.4.15 Vibration-test requirements of a cable

Not applicable.

6.5 Environmental characteristics

6.5.1 Shrinkage of insulation

When tested at (100 ± 2) °C for 1 h, the shrinkage of the insulation shall not exceed 5 %. The length of the sample shall be 150 mm, and the shrink-back shall be measured as the sum from both ends.