IEC 61156-5

Edition 3.0 2020-04
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

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

IEC 61156-5:2020-04 RLV(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.120.20

ISBN 978-2-8322-8147-5

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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- withdrawn,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 cat7A, 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 MΩ·m~~ 5 000 MΩ · 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).

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

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.

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

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

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

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

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.

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

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

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

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	*PS NEXT*(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	*PS~~-EL FEXT~~ ACR-F*(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 *FEXT* loss is greater than 90 dB, ~~*EL FEXT*~~ *PS ACR-F* 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 ~~EL FEXT~~ ACR-F* is greater than 75 dB, the requirement shall be 75 dB.

The minimum pair-to-pair *~~EL FEXT~~ ACR-F* for any pair combination shall be at least 3 dB better than the *PS ~~EL FEXT~~ ACR-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 (*~~AFEXT~~ AACR-F*)

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

The *PS AACR-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-F*

Category	Frequency range MHz	Minimum *PS AACR-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):~~

~~The impedance measured in accordance with 6.3.10.2 or 6.3.10.3 of IEC 61156-1 shall be 100 Ω ± 5 Ω at 100 MHz. In this case, the return loss shall also be measured.~~

~~Case B (Characteristic impedance):~~

~~The impedance measured in accordance with 6.3.10.1.1 of IEC 61156-1 shall fall within the impedance template limits given in Figure 1. The relevant template limits are derived using Equation (8) and Equation (9) for the corresponding cable category, frequency range and return loss requirement given in Table 10.~~

~~Cables that meet the requirements of the template are not required to be measured for return loss; alternately cables that meet the return loss requirements given in 6.3.11 are not required to be measured for characteristic impedance.~~

~~The upper impedance limit, Zu of the template is given by Equation (8),~~

$$Zu = Z_0 \cdot \frac{(1+|\rho|)}{(1-|\rho|)} \quad (8)$$

~~The lower impedance limit, Zl of the template is given by Equation (9),~~

$$Zl = Z_0 \cdot \frac{(1-|\rho|)}{(1+|\rho|)} \quad (9)$$

~~where~~

~~Z_0 is 100 Ω;~~

~~$|\rho|$ is the reflection coefficient magnitude calculated from Equation (10),~~

$$|\rho| = 10^{-\frac{RL}{20}} \quad (10)$$

~~where RL is the return loss given in 6.3.11.~~

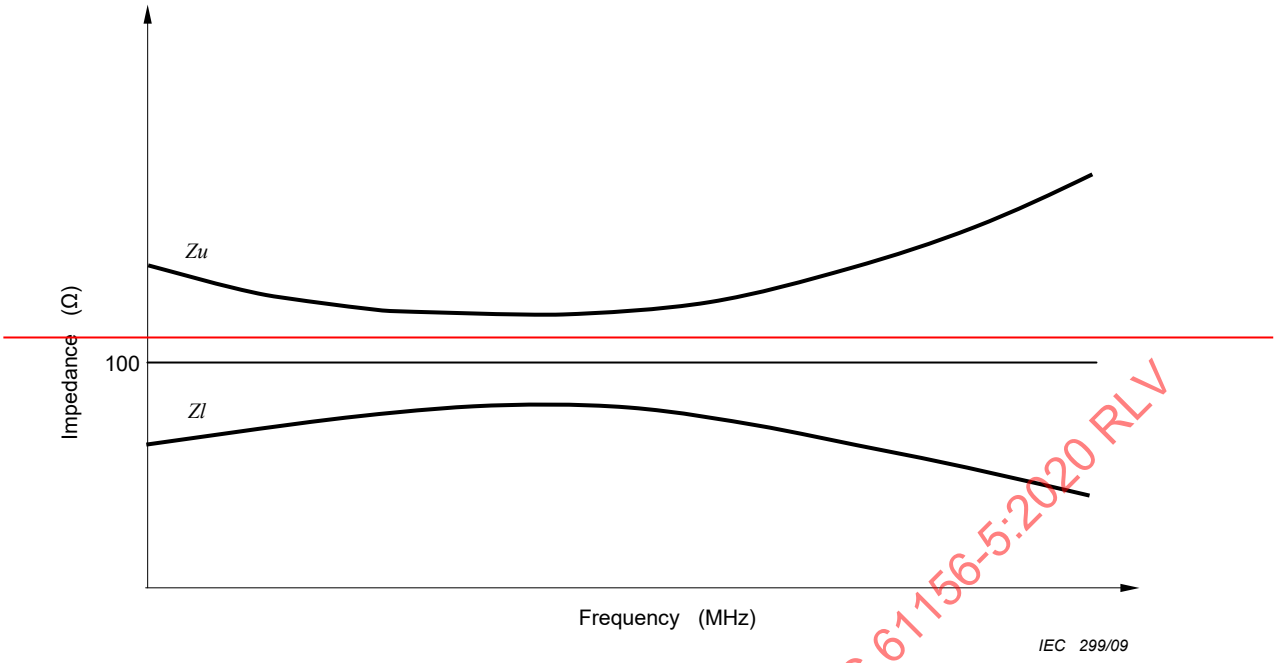

Figure 1 – Impedance template

The impedance requirement is specified as fitted or mean characteristic impedance at a certain frequency.

Further background on the measurement of fitted and mean characteristic impedance can be found in IEC TR 61156-1-2. Recommendations given in IEC TR 61156-1-2 and IEC TR 61156-1-5 for improvement of measurement uncertainty should be considered.

The impedance measured in accordance with IEC 61156-1:2007 and IEC 61156-1:2007/AMD1:2009, 6.3.10.2 or 6.3.10.3, shall be 100 Ω ± 5 Ω at 100 MHz. The return loss shall also be measured.

6.3.11 Return loss (*RL*)

The minimum return loss of any pair in the frequency range indicated in Table 10 shall not be less than the values in Table 10 for the respective categories.

Table 10 – Return loss

Cable category	Frequency range MHz	Return loss dB
All	1 to 10	$20{,}0 + 5{,}0 \cdot \times \log_{10}(f)$
All	10 to 20	25,0
Category 5e	20 to 100	$25{,}0 - 7{,}0 \cdot \times \log_{10}(f/20)$
Category 6	20 to 250	$25{,}0 - 7{,}0 \cdot \times \log_{10}(f/20)$
Category 6_A	20 to 500	$25{,}0 - 7{,}0 \cdot \times \log_{10}(f/20)$ [a]
Category 7	20 to 600	$25{,}0 - 7{,}0 \cdot \times \log_{10}(f/20)$ [a]
Category 7_A	20 to 600	$25{,}0 - 7{,}0 \cdot \times \log_{10}(f/20)$ [a]
	600 to 1 000	$17{,}3 - 10 \cdot \times \log_{10}(f/600)$

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.

[a] Calculated values below 17,3 dB revert to a 17,3 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 tensile strength of the insulation is not specified, but may be indicated 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 adhesion of the insulation to the conductor is not specified, but may be indicated 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 may be indicated in the relevant detail specification.

6.4.10 Bending under tension

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

6.4.11 Repeated bending of the cable

Not applicable.

6.4.12 Tensile performance of the cable

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

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 the 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.

6.5.2 Wrapping test of insulation after thermal ageing

Not applicable.

6.5.3 Bending test of insulation at low temperature

The bending test of the insulated conductor shall be carried out at (–20 ± 2) °C. The mandrel diameter shall be 6 mm. There shall be no cracks in the insulation.

6.5.4 Elongation at break of the sheath after ageing

The ageing regime shall be seven days at (100 ± 2) °C. The ~~tensile strength~~ elongation at break after ageing shall not be less than 50 % of the unaged value ~~and shall in no case be less than 100 %~~.

6.5.5 Tensile strength of the sheath after ageing

The ageing regime shall be seven days at (100 ± 2) °C. The ~~elongation~~ tensile strength after ageing shall be not less than 70 % of the unaged value.

6.5.6 Sheath pressure test at high temperature

Not applicable.

6.5.7 Cold bend test of the cable

The bending test shall be carried out at (–20 ± 2) °C. The mandrel diameter shall be eight times the overall diameter of the cable. There shall be no cracks in the sheath.

6.5.8 Heat shock test

Not applicable.

6.5.9 Damp heat steady state

Not applicable.

6.5.10 Solar radiation (UV test)

The resistance to solar radiation is not specified but may be specified in the relevant detail specification.

6.5.11 Solvents and contaminating fluids

The resistance to solvents and contaminating fluids is not specified but may be specified in the relevant detail specification.

6.5.12 Salt mist and sulphur dioxide

Not applicable.

6.5.13 Water immersion

Not applicable.

6.5.14 Hygroscopicity

The amount of moisture gained after 3 h shall not exceed 1 % in weight.

6.5.15 Wicking

The test solution shall not wet the filter paper at the end of 6 h.

6.5.16 Flame propagation characteristics of a single cable

If required by local regulations and indicated in the relevant detail specification, the test shall be performed in accordance with IEC 61156-1.

6.5.17 Flame propagation characteristics of bunched cables

If required by local regulations and indicated in the relevant detail specification, the test shall be performed in accordance with IEC 61156-1.

6.5.18 Halogen gas evolution

If required by local regulations and indicated in the relevant detail specification, the test shall be performed in accordance with IEC 61156-1.

6.5.19 Smoke generation

If required by local regulations and indicated in the relevant detail specification, the test shall be performed in accordance with IEC 61156-1.

6.5.20 Toxic gas emission

If required by local regulations and indicated in the relevant detail specification, the test shall be performed in accordance with IEC 61156-1.

6.5.21 Integrated fire test

If required by local regulations and indicated in the relevant detail specification, the test shall be performed in accordance with IEC 61156-1.

7 Category 5e multipair cable

7.1 General

Multipair cables are cables which contain multipair units. Each unit shall contain a minimum of 4 pairs and a maximum of 25 pairs for use in the backbone cabling system. The conductors and the cable structure are defined in Clause 5. The units are assembled into binder groups of 25 pairs or part thereof following the standard colour code. The groups are identified by

distinctly coloured binders and assembled to form the core. The core shall be covered by a protective sheath. The sheath consists of an overall thermoplastic jacket and may contain an underlying metallic shield and one or more layers of dielectric material applied over the core.

7.2 Transmission

The pairs are evaluated in groups of 4 pairs each (i.e. group 1 = pairs 1 to 4, group 2 = pairs 5 to 8, group 3 = pairs 9 to 12, group 4 = pairs 13 to 16, group 5 = pairs 17 to 20, group 6 = pairs 21 to 24, etc.). Groups are comprised of consecutive pairs, marked according to the standard colour code. For 25-pair and multiples of 25-pair binder groups, the twenty-fifth pair shall satisfy all other transmission parameters when used within any 4-pair group.

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.

All pairs within a unit shall meet the requirements of 6.2, 6.3.2, 6.3.3, 6.3.4, 6.3.10 and 6.3.11. In addition, for all frequencies from 1 MHz to 100 MHz, *NEXT* loss between the twenty-fifth pair and all other pairs within the 25-pair binder group shall meet the values determined using the equation and values defined in 6.3.5.

The pair-to-pair resistance unbalance of the twenty-fifth pair shall be compatible with any of the groups.

The delay skew (differential delay) of the twenty-fifth pair shall be compatible with any of the groups.

8 Introduction to the blank detail specification

The blank detail specification for cables described in this document is ~~published as IEC 61156-5-1~~ given in Annex A and should be used to identify a specific product.

When completing the detail specification, the following information shall be supplied:

a) conductor size and type;
b) number of elements;
c) cable construction details;
d) category number (5e, 6, 6_A, 7, 7_A) to describe basic performance requirements;
e) nominal impedance of the cable;
f) mechanical requirements;
g) environmental requirements;
h) fire performance.

Annex A
(informative)

Acronyms for common cable constructions

The acronym structure for the cable name is defined in Table A.1.

Some common cable construction examples are given in Figure A.1.

Table A.1 – Cable construction acronyms

Acronym		
XX / ABB		
XX – Overall screen	A – Cable element screen	BB – Cable element type
U – Unscreened F – Foil screened S – Braid screened SF – Braid on foil screened	U – Unscreened F – Foil screened	TP – Twisted pair TQ – Twisted quad

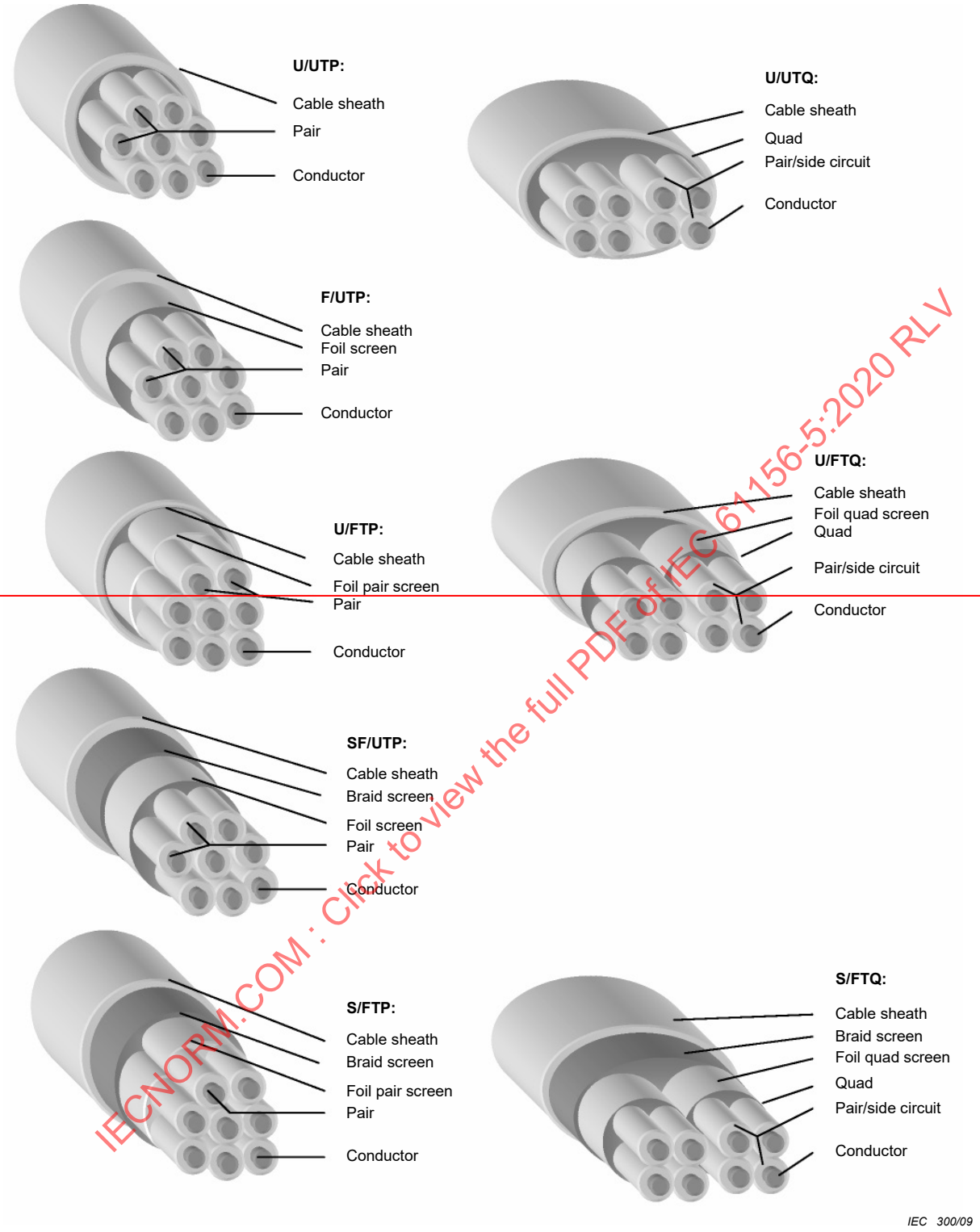

Figure A.1 – Common cable construction examples

Annex A
(informative)

Blank detail specification

The blank detail specification determines the layout and style for detail specifications describing symmetrical pair/quad cables for digital communications. Detail specifications, based on the blank detail specification, may be prepared by a national organization, a manufacturer, or a user.

This blank detail specification includes additional recommended environmental characteristics and severities, which are derived from the environmental classifications that are specified for cabling for various environments.

NOTE Environmental classifications are presented in ISO/IEC 11801-1:2017 with three levels of severity in four areas: mechanical, ingress, climatic, and electromagnetic; thus, in tabular form, they are referred to as the “MICE table”.

It is necessary to keep the transmission characteristics indicated in this sectional specification for the referenced category number, i.e. 5e, 6, 6_A, 7 or 7_A. The detail specification shall be written in accordance with the layout of the blank detail specification described here.

The numbers shown in square brackets in the following pages correspond to the following items of required information, which shall be entered in the spaces provided.

[1] Name and address of the organization that has prepared the document.

[2] IEC document number, issue number and date of issue.

[3] Address of the organization from which the document is available.

[4] Related documents.

[5] Any other reference to the cable, national reference, trade name, etc.

[6] A complete description of the cable which shall include

a) type and number of elements;

b) nominal impedance;

c) screening;

d) application;

e) category;

f) other distinguishing performance characteristics.

EXAMPLE 4-pair, unshielded twisted pair cable for use in horizontal floor wiring, having a nominal impedance of 100 Ω and meeting the transmission requirements of Category 6 and the coupling attenuation requirements of Type III.

[7] Details of the cable material and construction.

[8] Special requirements for bending radius or operating temperatures.

[9] List of cable characteristics. They are separated into electrical, transmission, mechanical and environmental characteristics.

[10] Appropriate subclause references in the sectional specification IEC 61156-5.

[11] Requirements applicable to this cable. The values entered shall meet as a minimum the requirements of the sectional specification IEC 61156-5.

[1] Prepared by:		[2] Document: Issue: Date:	
[3] Available from:		[4] Generic specification: IEC 61156-1 Sectional specification: IEC 61156-5 Blank detail specification: IEC 61156-5, Annex A	
[5] Additional references:			
[6] Cable description: a) Type and number of elements: b) Nominal impedance: c) Screening: d) Application: e) Category: f) Other distinguishing performance characteristics:			
[7] Cable construction:	IEC 61156-5 subclause		Comments
	5.2.1	Conductor description:	
	5.2.2	Insulation description: Maximum diameter: Colour code of elements:	
	5.2.3	Number of elements (pair(s)/quad(s)):	
	5.2.3.2	Screening of the cable element: Tape material Drain wire Braid wire Braid material	
	5.2.4	Cross web, spacer or protective wrapping(s):	
	5.2.5	Screen of the cable core: Tape material Minimum overlap Drain wire Braid wire Braid material	
	5.2.6	Sheath Material Nominal thickness Colour Maximum overall Diameter Marking Ripcord	
	5.2.7	Identification	
	5.2.8	Packaging of finished cable	
[8] Minimum bending radius for static bending: Minimum bending radius for dynamic bending:			

Temperature range for installation: Operating temperature range under static conditions: C1: -10°C to +60°C C2: -25 °C to +70°C C3: -40 °C to +70°C			
[9] Characteristics	[10] IEC 61156-5 subclause	[11]	Comments
Electrical characteristics	**6.2**		
Conductor resistance	6.2.1	≤ .... Ω/km	
Resistance unbalance Resistance unbalance within a pair Resistance unbalance between pairs	6.2.2 6.2.2.1 6.2.2.2	 ≤ .... % ≤ .... %	
Dielectric strength Conductor/conductor Conductor/screen	 6.2.3 6.2.3	 ..... kV/time ..... kV/time	
Insulation resistance Conductor/conductor Conductor/screen	 6.2.4 6.2.4	 ≥ ... MΩ · km ≥ ... MΩ · km	
Mutual capacitance	6.2.5	≤ .... pF/m	
Capacitance unbalance pair to ground	6.2.6	≤ .... pF/m	
Transfer impedance	6.2.7		Cable should be according to Grade 1 or 2 if screened.
Coupling attenuation	6.2.8	.....dB Cable type.....	Cable type should be I, Ib, II or III.
Current carrying capacity	6.2.9	.....mA	Respective installation conditions shall be specified.
Transmission characteristics	**6.3**		
Velocity of propagation	6.3.1		
Delay Differential phase delay (skew)	6.3.2.1 6.3.2.2	≤ ... ns/m ≤ ... ns/m	
Attenuation General figures Environmental temperature effects	6.3.3 6.3.3.1 6.3.3.3	 ≤ ... dB/100 m ≤ ... %/°C	
Unbalance attenuation near end (TCL) Unbalance attenuation far end ($EL\ TCTL$)	6.3.4 6.3.4	≥ ... dB ≥ ... dB	Cable grade shall be identified.
Near end crosstalk	6.3.5	≥ ... dB	
Attenuation to crosstalk ratio far end	6.3.6	≥ ... dB	

Power sum alien (exogenous) near-end crosstalk	6.3.7	≥ … dB	
Power sum alien (exogenous) Attenuation to crosstalk ratio far end	6.3.8	≥ … dB	
Impedance	6.3.10		
Return loss	6.3.11	≥ … dB	
Mechanical and dimensional characteristics	**6.4**		
Dimensional requirements Insulation diameter Sheath thickness Cable diameter	6.4.1	… mm	
Elongation at break of the conductors	6.4.2	≥ … %	
Tensile strength of the insulation	6.4.3	≥ … MPa	
Elongation at break of the insulation	6.4.4	≥ … %	
Adhesion of the insulation to the conductor	6.4.5		
Elongation at break of the sheath	6.4.6	≥ … %	
Tensile strength of the sheath	6.4.7	≥ … MPa	
Crush test of the cable	6.4.8	M1: ≥45 N over 25 mm (linear) min. M2: ≥1 100 N over 150 mm (linear) min. M3: ≥2 200 N over 150 mm (linear) min.	
Impact test of the cable	6.4.9	M1: ≥1 J M2: ≥10 J M3: ≥30 J	
Bending under tension	6.4.10		
Repeated bending	6.4.11		
Tensile performance of the cable	6.4.12		
Shock test	6.4.13	Not applicable	
Bump test	6.4.14	Not applicable	
Vibration test	6.4.15	Not applicable	
Environmental characteristics	**6.5**		
Shrinkage of the insulation	6.5.1	≤… %	
Wrapping test of insulation after thermal ageing	6.5.2	Not applicable	
Bending test of insulation at low temperature	6.5.3		
Elongation at break of the sheath after ageing	6.5.4	≥ … %	

Tensile strength of the sheath after ageing	6.5.5	≥ ... MPa	
Sheath pressure test at high temperature	6.5.6	Not applicable	
Cold bend test of cable	6.5.7		
Heat shock test	6.5.8	Not applicable	
Damp heat steady state	6.5.9	Not applicable	
Solar radiation	6.5.10	C1: not applicable C2, C3: under consideration	
Solvents and contaminating fluids	6.5.11		
Salt mist and sulphur dioxide tests	6.5.12	Not applicable	
Water immersion test	6.5.13	Not applicable	
Hygroscopicity	6.5.14		
Wicking	6.5.15		
Flame propagation characteristics of a single cable	6.5.16		
Flame propagation characteristics of bunched cables	6.5.17		
Halogen gas evolution	6.5.18		
Smoke generation	6.5.19		The requirement and the test method shall be specified in the detailed specification.
Toxic gas emission	6.5.20		
Integrated fire test	6.5.21		

When a characteristic applies but a specific value is not considered necessary, then NS for Not Specified should be entered at the appropriate place. When NS is used, the appropriate requirements in the specification should apply.

NOTE 1 When a characteristic is marked as not applicable, it is not required by Clauses 4 to 7 of this document but can be required in the detail specification.

NOTE 2 Ingress requirements using particles are not applicable to a cable.

NOTE 3 Electromagnetic requirements given in the MICE table of ISO/IEC 11801-1:2017 have been dealt with by using the requirements that are given for transfer impedance, screening attenuation and coupling attenuation. ESD requirements are considered not applicable.

NOTE 4 The proposed severities are taken from the MICE table of ISO/IEC 11801-1:2017. Depending on the actual need of end users, other severities can be agreed between customer and suppliers.

Bibliography

~~IEC 60304, *Standard colours for insulation for low-frequency cables and wires*~~

ISO/IEC 11801 (all parts), *Information technology – Generic cabling for customer premises*

ISO/IEC 11801-1:2017, *Information technology – Generic cabling for customer premises – Part 1: General requirements*

ISO/IEC TS 29125, *Information technology – Telecommunications cabling requirements for remote powering of terminal equipment*

IEC TR 61156-1-2:2009, *Multicore and symmetrical pair/quad cables for digital communications – Part 1-2: Electrical transmission characteristics and test methods of symmetrical pair/quad cables*
IEC TR 61156-1-2:2009/AMD1:2014

IEC 61156-1-4, *Multicore and symmetrical pair/quad cables for digital communications – Part 1-4: Assessment of conductor heating in bundled cables due to the deployment of remote powering*

IEC TR 61156-1-5, *Multicore and symmetrical pair/quad cables for digital communications – Part 1-5: Correction procedures for the measurement results of return loss and input impedance*

IEC TR 61156-1-6, *Multicore and symmetrical pair/quad cables for digital communications – Part 1-6: Nominal DC-resistance values of floor-wiring and work-area cables for digital communications*

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

IEEE 802.3, *IEEE Standard for Ethernet*

IEEE 802.3af-2003 – *IEEE Standard for Information Technology – Telecommunications and Information Exchange Between Systems – Local and Metropolitan Area Networks – Specific Requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications – Data Terminal Equipment (DTE) Power Via Media Dependent Interface (MDI)*

IEEE 802.3at-2009 – *IEEE Standard for Information technology – Local and metropolitan area networks – Specific requirements – Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements*

IEEE 802.3bt-2018 – *IEEE Standard for Ethernet Amendment 2: Physical Layer and Management Parameters for Power over Ethernet over 4 pairs*

IEC 61156-6

Edition 4.0 2020-04

INTERNATIONAL STANDARD

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

IEC 61156-6:2020-04(en)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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

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, RF connectors, RF and microwave passive components and accessories.

This fourth edition cancels and replaces the third edition published in 2010 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/1141/FDIS	46C/1145/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.

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 describes the cables intended primarily for working area wiring as defined in ISO/IEC 11801 (all parts).

It covers cable designs comprising 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 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 remote powering applications such as IEEE 802.3af (Power over Ethernet) or further developments for example according to IEEE 802.3at 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 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 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 6.3.3.2.

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

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 or stranded annealed copper, 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.

5.2.3 Cable element

5.2.3.1 General

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

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 it 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:

– appropriately coloured threads or tapes,
– with a printed tape,
– printing on the cable core wrapping,
– marking on the sheath.

Additional markings, such as length marking 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 should 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

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 resistance unbalance shall not exceed 2,0 %.

6.2.2.2 Resistance unbalance between pairs

The pair-to-pair resistance unbalance shall not exceed 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, alternatively, 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, alternatively, 1,7 kV AC for 2 s.

6.2.4 Insulation resistance

The test shall be performed on

– conductor/conductor;

– conductor/screen (when present).

The minimum insulation resistance at or corrected to 20 °C shall be not less than 5 000 MΩ · 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 using the triaxial method (IEC 62153-4-3) shall not exceed the values shown in Table 2 indicated for each grade.

Table 2 – Transfer impedance

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	$Z_t \leq 10 \times f/10$	$Z_t \leq 2{,}120\,6 \times f^{1,3368}$

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

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, Type II is the minimum coupling attenuation requirement.

Table 3 – Coupling attenuation in dB

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

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 in MHz.

6.3.2.2 Differential delay (delay skew)

When measured at (20 ± 3) °C, the maximum delay skew between any two pairs shall not exceed 45 ns/100 m for Category 5e, Category 6, 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

6.3.3.1 Attenuation at 20 °C ambient 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) using the corresponding values of the constants a, b and c given in Table 4.

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

where

α is the attenuation expressed in dB/100 m;

f is the frequency in MHz.

Table 4 – Attenuation, constant values

Cable designation	Frequency range MHz	Constants		
		a	b	c
Category 5e	1 to 100	2,866 [a]	0,033 3	0,300
Category 6	1 to 250	2,730	0,026	0,375
Category 6_A	1 to 500	2,730	0,0136 5	0,375
Category 7	1 to 600	2,700	0,015	0,300
Category 7_A	1 to 1 000	2,700	0,007 5	0,360
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.				
[a] To understand the historical background: 2,866 was arrived at by 1,5 × 1,91 = 2,866 as an approximate 150 % factor to accommodate smaller conductor stranding and also ILD since 2,866/1,5 = 1,910 6 fitted the old ISO/IEC 11801 model; the actual 150 % attenuation should be a factor of 2,951.				

6.3.3.2 Attenuation at elevated operating temperature

The increase of the maximum attenuation from Equation (2) due to an elevated environmental temperature above 20°C 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 6.3.3.2 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)

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) to Equation (6) (Level 4), for all frequencies, f, in the frequency ranges indicated in Table 5.

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

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

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

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

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.

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

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

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

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, $PS\ NEXT$, in the frequency range indicated in Table 6 shall not be less than the value obtained from Equation (10) using the corresponding value of $PS\ NEXT(1)$ given 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	*PS NEXT*(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
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 Attenuation to crosstalk ratio far end (*PS ACR-F*)

The worst pair power sum attenuation to crosstalk ratio far end, $PS\ ACR\text{-}F$, in the frequency range indicated in Table 7 shall not be less than the value obtained from Equation (11) using the corresponding value of the $PS\ ACR\text{-}F(1)$ given in Table 7.

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

Table 7 – Worst pair *PS ACR-F*(1)

Cable designation	Frequency range MHz	*PS ACR-F*(1) dB
Category 5e	1 to 100	61,0
Category 6	1 to 250	65,0
Category 6_A	1 to 500	65, 0
Category 7	1 to 600	91,0
Category 7_A	1 to 1 000	91, 0
If $FEXT$ loss is greater than 70 dB, $PS\ ACR\text{-}F$ loss may not be measured. 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 $PS\ ACR\text{-}F$ is greater than 75 dB, the requirement shall be 75 dB.

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

6.3.7 Alien (exogenous) near end crosstalk

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