IEC/PAS 61156-6

Edition 1.0
2001-08

PRE-STANDARD

Symmetrical pair/quad cables for digital communications with transmission characteristics up to 600 MHz –

Work area wiring – Sectional specification

PUBLICLY AVAILABLE SPECIFICATION

INTERNATIONAL
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SYMMETRICAL PAIR/QUAD CABLES FOR DIGITAL COMMUNICATIONS WITH TRANSMISSION CHARACTERISTICS UP TO 600 MHZ –

WORK AREA WIRING – SECTIONAL SPECIFICATION

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IEC-PAS 61156-6 has been processed by subcommittee 46C, Wires and symmetric cables, of IEC technical committee 46: Cables, wires, waveguides, r.f. connectors and accessories for communication and signalling.

The text of this PAS is based on the following document:

This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document:

Draft PAS	Report on voting
46C/466/PAS	46C/475/RVD

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

SYMMETRICAL PAIR/QUAD CABLES FOR DIGITAL COMMUNICATIONS WITH TRANSMISSION CHARACTERISTICS UP TO 600 MHz –

WORK AREA WIRING – SECTIONAL SPECIFICATION

1 Scope

This sectional specification relates to IEC 61156-1: Multicore and symmetrical pair/quad cables for digital communications - Part 1: Generic specification. The cables described herein are specifically intended to construct patch, equipment, and work area cords for class D, E and F channels, as defined in ISO/IEC 11801 (2001): Information technologies - Generic cabling for customer premises cabling (see Table 1).

This sectional specification covers individually screened (STP), common screened (FTP) and unscreened (UTP) pairs or quads having a pair count of four pairs or less. The transmission characteristics of the cables are specified at 20 °C. See Annex A of IEC 61156-5 for a discussion of cable performance at temperatures higher than 20 °C.

The designation "Category 5e" is used herein to describe an enhanced Category 5 cable and is used in the same context as "Category 5" in ISO/IEC 11801 (2001). This enhanced cable is designated Category 5e to differentiate it from the Category 5 cables described in IEC 61156-2, -3, and -4. Although both Category 5 and 5e cables are characterized to 100 MHz and can in used for Class D channels, Category 5e has additional requirements, as compared to Category 5, which make it preferred for use in systems utilizing four pairs transmitting simultaneously in both directions.

Table 1

Cable Designation	Maximum Reference Frequency [MHz]	Channel Designation
Category 5e	100[1.)]	D
Category 6	250	E
Category 7	600	F
NOTE 1 Some characteristics are measured up to 125 MHz, in order to comply with IEEE's request to specify the electrical performances up to a frequency 25 % higher than the referenced frequency.		

These cables are intended for various new communication systems that are under development and which use as many as 4 pairs simultaneously. In this sense, this specification provides the cable characteristics required by system developers to evaluate new systems.

Under static conditions, the cables shall operate in the temperature range from -40 °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. Patch cables are susceptible to moisture pick-up. This in turn impacts also on the attenuation. Therefore the maximum increase in attenuation due to long term exposure to humidity is specified.

The cables covered by this sectional specification 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.

1.2 Reference documents

IEC 60189-1:1986, *Low-frequency cables and wires with PVC insulation and PVC sheath. Part 1: General test and measuring methods*

IEC 60304:1982, *Standard colours for insulation for low-frequency cables and wires*

IEC 61156-1:2000, *Multicore and symmetrical pair/quad cables for digital communications - Part 1: Generic specification*

IEC 61158-5:2000, *Digital data communications for measurement and control - Fieldbus for use in industrial control systems - Part 5: Application Layer Service definition*

ISO/IEC 11801:2001, *Information technology - Generic cabling for customer premises*

1.3 Installation considerations

See 1.3 of IEC 61156-1 (Under consideration)

2 Definitions, materials and cable construction

2.1 Definitions

See 2.1 of IEC 61156-1

2.2 Materials and cable construction

2.2.1 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 fire performance (such as burning properties, smoke generation, evolution of halogen gas etc.).

2.2.2 Cable construction

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

2.2.3 Conductor

The conductor shall consist of annealed copper.

The conductor shall be solid or stranded annealed copper conductor, in accordance with 2.2.3 of IEC 61156-1 and shall have a diameter between 0,4 to 0,65 mm. The stranded conductor should have preferably seven strands.

The conductor(s) shall be plain or tinned.

The conductor may consist of one or more elements of thin copper or copper alloy tape, which shall be applied helically over a fibrous thread (tinsel cord). In this case joints in the complete element shall not be permitted.

2.2.4 Insulation

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

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

The insulation may be solid or cellular with or without a solid dielectric skin. The insulation shall be continuous and shall have a thickness such that the completed cable meets the specified requirements. The nominal thickness of the insulation shall be compatible with the method of conductor termination.

2.2.5 Colour code of insulation

The colour code is not specified but shall be indicated in the relevant detail specification. The colour shall be readily identifiable and shall correspond reasonably with the standard colour shown in IEC 60304.

NOTE It is acceptable to mark or stripe the "a" wire with the colour of the "b" wire to facilitate pair identification.

2.2.6 Cable element

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

2.2.7 Screening of cable element

When required the screen for the cable element shall be in accordance with 2.2.7 of IEC 61156-1.

2.2.8 Cable make-up

A cross web or any other spacer may be used to separate the cable elements. The cable elements, including cross webs or spacers, shall be assembled to form the cable core.

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

2.2.9 Screening of 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 2.2.9 of IEC 61156-1.

2.2.10 Sheath

The sheath material shall consist of a suitable thermoplastic 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.

2.2.11 Colour of Sheath

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

2.2.12 Identification

The cable shall be identified as to the manufacturer, and when required, the year of manufacture, 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 on the cable sheath. If used, such markings should be indicated in the relevant detail specification.

2.2.13 Finished Cable

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

3 Characteristics and requirements

3.1 General remarks

This clause lists the characteristics and minimum requirements of a cable complying with this specification. Test methods shall be in accordance with clause 3 of IEC 61156-1. A detail specification may be prepared to identify a specific product and its performance capabilities (see clause 4).

3.2. Electrical characteristics

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

3.2.1 Conductor resistance

When measured in accordance with 5.1 of IEC 60189-1, the maximum loop resistance shall not exceed 29,0 Ω/100 m of cable.

3.2.2 Resistance unbalance

The conductor resistance unbalance shall not exceed 2 %.

3.2.3 Dielectric strength

The test shall be performed on conductor/conductor and, where screen(s) are present, conductor/screen with 1,0 kV d.c. for one minute or, alternately, with 2,5 kV d.c. for 2 seconds. An a.c. voltage may be used. The a.c. voltage levels in these cases shall be 0,7 kV a.c. for one minute or, alternately, 1,7 kV a.c. for 2 s.

3.2.4 Insulation resistance

The test shall be performed both on:
- conductor/conductor
- conductor/screen (when present)

The minimum insulation resistance at 20 °C shall not be less than 5 000 MΩ·km.

3.2.5 Mutual capacitance

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

3.2.6 Capacitance unbalance pair to ground

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

3.2.7 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

Frequency [MHz]	Max. surface transfer impedance [mΩ / m]	
	Grade 1	Grade 2
1	10	50
10	10	100
30	30	300
100	60	1000

3.2.8 Resistance of the screen

The d.c. resistance of the individual screens or an overall screen is not specified, but may be indicated in the relevant detail specification.

3.3 Transmission characteristics

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

3.3.1 Velocity of propagation, delay and differential delay (delay skew)

3.3.1.1 Velocity of propagation

The minimum velocity of propagation for any pair within the cable is equal to or greater than 0,6 c for all frequencies between 4 MHz and the maximum referenced frequency. This value is given only for information purposes (see 3.3.1.2).

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.

3.3.1.2 Delay and differential delay (delay skew)

The delay for a specified length of cable is understood as the inverse of the velocity of propagation. The delay shall be equal to or smaller than:

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

Where f is the frequency in MHz.

Differential delay (delay skew) is the difference in delay between any two pairs.

3.3.1.3 Differential delay (delay skew)

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

3.3.1.4 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 -40 °C to +60 °C within the differential delay (delay skew) of 3.3.1.3

3.3.2 Attenuation

The maximum attenuation α of any pair in the frequency range indicated in Table 3 shall be less than or equal to the value obtained from equation (2) using the corresponding values of the constants given in Table 3. The values indicated correspond to an increase of attenuation of 20 % or 50 % with respect to the horizontal cable of the same category (see 3.3.2 of IEC 61156-5)

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

Table 3

Cable designation	Increase of attenuation [%]	Frequency Range [MHz]	Constants		
			a	b	c
Category 5e	20	4 – 125	2,360	0,028	0,120
Category 6		4 – 250	2,184	0,020	0,300
Category 7		4 – 600	2,160	0,012	0,240
Category 5e	50	4 – 125	2,866	0,033	0,300
Category 6		4 – 250	2,730	0,026	0,375
Category 7		4 – 600	2,700	0,015	0,300

For Category 5e cables, the frequency range has been extended by 25 % to 125 Hz. In this case values above 100 MHz are for information only.

NOTE 1 The increase of attenuation refers to an increase of the attenuation of stranded patch cables with respect to solid horizontal cables. This increase is also referred to as “de-rating”.

NOTE 2 For channels, or for cascaded cables with differing impedance or cables with a distinct impedance roughness, the term insertion loss is used (see IEC 61156-5, Annex B). The term insertion loss refers to inserting a device under test between a generator and a load. Only if the generator, the device under test, and the load have the same impedance, are we talking strictly speaking about “attenuation”.

NOTE 3 See Annex B of IEC 61156-5 for a discussion of ILD

The values in Table 4 are for information only. Because the measurement of attenuation at 1 MHz on a length of 100 m is prone to error, these values are given in brackets for reference purposes only.

Table 4

Attenuation at 20 °C [dB / 100 m]						
Frequency [MHz]	Cable designation					
	20 % Increase of attenuation			50 % Increase of attenuation		
	Category 5e	Category 6	Category 7	Category 5e	Category 6	Category 7
1	[2,5]	[2,5]	[2,4]	[3,2]	[3,1]	[3,0]
4	4,9	4,6	4,5	6,0	5,8	5,6
10	7,8	7,2	7,0	9,5	9,0	8,8
16	9,9	9,1	8,9	12,1	11,4	11,1
20	11,1	10,2	10,0	13,5	12,8	12,4
31,25	14,1	12,9	12,5	17,1	16,1	15,6
62,5	20,4	18,6	17,9	24,8	23,3	22,3
100	26,4	23,9	22,8	32,0	29,9	28,5
125	[29,9]	26,9	25,7	[36,2]	33,8	32,1
200		34,9	33,0		43,8	41,2
250		39,6	37,2		49,7	46,5
300			41,0			51,3
600			60,1			75,1

3.3.2.1 Temperature effects

The increase in attenuation due to elevated temperature shall not be greater than 0,4 %/ °C in the frequency range from 1 MHz to 250 MHz and 0,6 % / °C for frequencies above 250 MHz for unscreened cables and 0,2 % / °C for screened cables.

The method for determining compliance with this requirement is under consideration.

3.3.2.2 Environmental effects

To simulate a long term exposure to higher humidity levels at normal operating temperatures, the cable is exposed for a short term to a higher temperature and a high humidity level, i.e. 120 hours to a temperature of 60 °C at a relative humidity of 95 % minimum.

The method for determining attenuation increase due to long term exposure to humidity and compliance with this requirement is under consideration.

3.3.3 Unbalance attenuation

The minimum unbalance attenuation near-end (Transverse conversion loss or TCL) shall be equal to or greater than the value obtained from equation (3) for the frequency ranges given in Table 5.

Unbalance attenuation near-end (TCL):

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

Table 5

Cable Category	Frequency Range for TCL [MHz]
Category 5e	1 - 100
Category 6	1 - 200
Category 7	1 - 200

NOTE Unbalance attenuation near-end (TCL) for Category 7 at frequencies greater than 200 MHz is for further study.

Equal level unbalance attenuation far-end (Equal level transverse conversion transfer loss or EL TCTL) is specified with common mode signal injection, while measuring the differential mode signal.

The minimum equal level unbalance attenuation far-end (EL TCTL) for all categories shall be equal to or greater than the value obtained from equation (4) for all frequencies in the range from 1 to 30 MHz. The formula for the EL TCTL is:

$$EL\ TCTL = 35{,}0 - 20 \times \log_{10}(f) \qquad [dB] \qquad (4)$$

For 1 to 30 MHz and for all Categories

3.3.4 Near-end cross-talk

When measured in accordance with IEC 61156-1 the worst power sum near-end cross talk, PS NEXT, of any pair in the frequency range indicated in Table 6 shall be equal to or greater than the value obtained from equation (5) using the corresponding value of PS NEXT(1) given in Table 6.

$$\text{PS NEXT}(f) = \text{PS NEXT}(1) - 15 \times \log_{10}(f) \quad [\text{dB}] \qquad (5)$$

Where:

Table 6

Cable designation	Frequency range [MHz]	PS NEXT(1) [dB]
Cat. 5e	4 – 125	62,3
Cat. 6	4 – 250	72,3
Cat. 7	4 – 600	99,4

For Category 5e cables, the frequency range has been extended by 25 % to 125 MHz. Values above 100 MHz are for information only and are given in brackets.

The values given in Table 7 are for information only. For those frequencies where the calculated value of PS NEXT is greater than 75 dB, the requirement shall be 75 dB.

Table 7

Frequency [MHz]	PS NEXT [dB for 100 m] Cable designation		
	Category 5e	Category 6	Category 7
1	62	72	75
4	53	63	75
10	47	57	75
16	44	54	75
20	43	53	75
31,25	40	50	75
62,5	35	45	72
100	32	42	69
125	[31]	41	68
200		38	65
250		[36]	63
300			62
600			58

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

3.3.5 Far-end cross talk

When measured in accordance with IEC 61156-1 the worst pair power sum equal level far-end cross talk, PS EL FEXT, of any pair in the frequency range indicated in Table 8 shall be equal to or greater than the value obtained from equation (6) using the corresponding value of the PS EL FEXT(1) given in Table 8.

$$\text{PS EL FEXT}(f) = \text{PS EL FEXT}(1) - 20 \times \log_{10}(f) \qquad [\text{dB for } 100\,\text{m}] \qquad (6)$$

Where:

Table 8

Cable designation	Frequency range [MHz]	PS EL FEXT(1) [dB / 100 m]
Cat. 5e	4 – 125	61,0
Cat. 6	4 – 250	65,0
Cat. 7	4 – 600	80,0 (f.f.s.)

Far Category 5e cables, the frequency range has been extended by 25% to 125 MHz. Values above 100 MHz are for information only and are given in brackets. The values given in Table 9 are for information only. For those frequencies where the calculated value of PS EL FEXT is greater than 75 dB, the requirement shall be 75 dB.

Table 9

Frequency (MHz)	PS EL FEXT [dB for 100 m]		
	Cable designation		
	Category 5e	Category 6	Category 7
1	61	65	75
4	49	53	68
10	41	45	60
16	37	41	56
20	35	39	54
31.25	31	35	50
62.5	25	29	44
100	21	25	40
125	19	23	38
200		19	34
250		17	32
300			30
600			24

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.

3.3.6 Characteristic impedance

3.3.6.1 Open/short circuit impedance (Input impedance)

The magnitude of the input impedance, when measured in a swept frequency mode (open- short circuit method per 3.3.6.2.2 of IEC 61156-1) over the frequency range from 4 MHz to the maximum referenced frequency shall meet the requirements given in Table 10.

Table 10

Input impedance [Ω]			
Frequency range [MHz]	Cable designation		
	Category 5e	Category 6	Category 7
4 - 100	N ± 15	N ± 15	N ± 15
100-250		N ± 22	N ± 22
200 - 600			N ± 25

N= Nominal impedance

Measurement of input impedance is not required when the mean characteristic impedance of 3.3.6.2 is measured.

3.3.6.2 Function fitted impedance / mean characteristic impedance

When measured in accordance with 3.3.6.3, 3.3.6.3/3.3.6.2.3 or 3.3.6.3/3.3.6.2.3-5 of IEC 61156-1, the mean characteristic impedance shall be within ±5 % of the requested nominal impedance at 100 MHz.

3.3.7 Return loss

When measured in accordance with 3.3.7 of IEC 61156-1, the minimum return loss of any pair in the frequency range indicated in Table 11, shall be equal to or greater than the values in Table 11 for the respective categories.

Table 11

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 - 125	$25,0 - 8,6 \times \log_{10}(f/20)$
Category 6 and Category 7	20 - 250	$25,0 - 8,6 \times \log_{10}(f/20)$
Category 7	250 - 600	$25,0 - 8,6 \times \log_{10}(f/20)$ (f.f.s.)

For Category 5e cables, the frequency range has been extended by 25 % to 125 MHz. Values above 100 MHz are for information only.

3.3.8 Screening attenuation

Two grades of performance are recognized for screening attenuation. Screening attenuation is a part of the coupling attenuation. When measured separately, using the absorbing clamp method, the screening attenuation for containing a screen in the frequency range from 30,0 MHz to the maximum referenced frequency shall be equal to or greater than the values indicated below:

For Grade 1 cables: ≥60dB
For Grade 2 cables: ≥40 dB

There are no requirements for unscreened cables.

3.3.9 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 the maximum referenced frequency shall be equal to or greater than the values indicated in Table 12.

Table 12

Coupling attenuation Type	Frequency range [MHz]	Coupling attenuation [dB]
Type I	30 - 100	≥ 85,0
	100 to the maximum referenced frequency	≥ 85,0 – 20 × $\log_{10}$ (f/100)
Type II	30 - 100	≥ 55,0
	100 to the maximum referenced frequency	≥ 55,0 – 20 × $\log_{10}$ (f/100)
Type III	30 - 100	≥ 40,0
	100 to the maximum referenced frequency	≥ 40,0 – 20 × $\log_{10}$ (f/100)

3.4 Mechanical and dimensional characteristics and requirements

3.4.1 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.

3.4.2 Elongation at break of the conductor

The minimum elongation of the conductor of the completed cable shall be 8 %.