IEC TR 61156-1-6

Edition 1.0 2016-09

TECHNICAL REPORT

colour inside

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

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IEC TR 61156-1-6, which is a technical report, 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.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
46C/1044/DTR	46C/1051/RVC

Full information on the voting for the approval of this technical report 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.

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- withdrawn,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.

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

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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

1 Scope

This part of IEC 61156, which is a Technical Report, provides informative values for DC-resistance of typical installed cables at the time of publication to enable further analysis of cable performance mainly influenced by DC-resistance, such as thermal heating.

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

IEC 61156-5, *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 61156-6, *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 61156-9, *Multicore and symmetrical pair/quad cables for digital communications – Part 9: Cables for channels with transmission characteristics up to 2 GHz– Sectional specification*

IEC 61156-10, *Multicore and symmetrical pair/quad cables for digital communications – Part 10: Cables for cords with transmission characteristics up to 2 GHz– Sectional specification*

3 Terms and definitions

No terms and definitions are listed in this document.

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 Overview

Measurement of thermal heating /1/ or other analysis of applications such as POE /2/ or other remote powering application requires DC-resistance values reflecting the higher performance of higher categories not explicitly specified in IEC 61156-5, IEC 61156-6, IEC 61156-9 and

IEC 61156-10. This document therefore informatively provides such values for horizontal floor wiring and work area wiring taking into account different possible basic designs.

5 DC-resistance values

5.1 General

IEC 61156-5, IEC 61156-6, IEC 61156-9 and IEC 61156-10 only have a basic DC-resistance requirement each, possible to be fulfilled by cables of the lowest category. As higher categories provide a better attenuation, also the DC-resistance of such a cable is lower, even though not required, as cabling standards also do not require more severe values for higher Classes /3/.

The DC-resistance of a balanced pair is basically dependent on conductivity and diameter of the wires. During the stranding process, the wires are forced on certain trajectories that are defined by lay-lengths, diameter of insulation and the dimensions of possible fillers and foils being applied during stranding. Due to the inevitable forces needed to form the insulated wires, the diameter of the conductors is slightly reduced while being stranded. As the measurement of the resulting conductor diameter is a measurement at a discrete point and thus less representative of the entire length of the cable and, furthermore, achieving a low measurement uncertainty requires a significant technical effort, the following tables only roughly indicate the conductor diameter.

The nominal DC-resistance values given in Tables 1, 2 and 3 below are to be understood as typical values. No requirements therefore can be derived from these values. Continuous progress of technical development might result in cable designs fulfilling all current requirements of IEC 61156-5, IEC 61156-6, IEC 61156-9 or IEC 61156-10 respectively (including the request for copper conductors), but having higher DC-resistance than indicated in Tables1, 2 and 3 below. The use of cables with a lower DC-resistance than indicated is possible and might provide benefit with respect to thermal heating and possibly further performance parameters.

5.2 Values for horizontal floor wiring cables

Cables for horizontal floor wiring according to IEC 61156-5 and IEC 61156-9 have a design based on solid copper wires. Shorter lay-lengths are necessary to obtain a better crosstalk performance. As shorter lay-lengths lead to increased attenuation, such designs need a larger conductor diameter to achieve attenuation requirements. Also foils e.g. applied as pair shielding add to attenuation and accordingly high category pair-shielded cables need higher conductor diameters, too. Table 1 provides nominal values for the conductor diameter and resistance for horizontal floor wiring cables.

Table 1 – Nominal conductor-diameter (range) and conductor-resistance (typical) values for horizontal floor wiring cables

	U/UTP	F/UTP, SF/UTP	U/FTP, F/FTP, S/FTP
Category 5e	0,49 mm to 0,52 mm 9,5 Ω/100 m	0,51 mm to 0,53 mm 9,0 Ω/100 m	No typical design
Category 6	0,52 mm to 0,55 mm 9,0 Ω/10 0 m	0,53 mm to 0,55 mm 8,5 Ω/100 m	0,54 mm to 0,56 mm 8,0 Ω/100 m
Category 6A	0,54 mm to 0,56 mm 8,0 Ω/100 m	0,55 mm to 0,57 mm 7,5 Ω/100 m	0,55 mm to 0,57 mm 7,5 Ω/100 m
Category 7	No typical design	No typical design	0,55 mm to 0,57 mm 7,5 Ω/100 m
Category 7A	No typical design	No typical design	0,58 mm to 0,60 mm 6,8 Ω/100 m
Category 8.1 (ffs.)	No typical design	0,61mm to 0,64 mm 6,5 Ω/100 m (ffs.)	0,61 mm to 0,64 mm 6,5 Ω/100 m (ffs.)
Category 8.2 (ffs.)	No typical design	No typical design	0,61 mm to 0,64 mm 6,5 Ω/100 m (ffs.)

5.3 Values for work area wiring cables

Work area wiring cables typically have designs applying stranded conductors. Nevertheless, solid conductors are an option according IEC 61156-6 and IEC 61156-10. Therefore, both cases are reflected in Table 2. The explanations with respect to the relation between cable design and attenuation made for horizontal floor wiring cable also apply to work area wiring cables.

Table 2 – Nominal conductor-diameter (range) and conductor-resistance (typical) values for work area wiring cables

	U/UTP	F/UTP, SF/UTP	U/FTP, F/FTP, S/FTP
Category 5e stranded conductor	0,45 mm to 0,48 mm 0,12 mm^2 to 0,14 mm^2 14,5 Ω/100 m	0,45 mm to 0,48 mm 0,12 mm^2 to 0,14 mm^2 14,5 Ω/100 m	No typical design
Category 5e solid conductor	0,40 mm to 0,46 mm 14,5 Ω/100 m	0,40 mm to 0,46 mm 14,5 Ω/100 m	No typical design
Category 6 stranded conductor	0,48 mm to 0,54 mm 0,13 mm^2 to 0,18 mm^2 13,5 Ω/100 m	0,48 mm to 0,54 mm 0,13 mm^2 to 0,18 mm^2 13,5 Ω/100 m	0,48 mm to 0,54 mm 0,13 mm^2 to 0,18 mm^2 13,5 Ω/100 m
Category 6 solid conductor	0,40 mm to 0,46 mm 13,5 Ω/100 m	0,40 mm to 0,46 mm 13,5 Ω/100 m	0,40 mm to 0,46 mm 13,5 Ω/100 m
Category 6_A stranded conductor	0,48 mm to 0,54 mm 0,13 mm^2 to 0,18 mm^2 13,5 Ω/100 m	0,48 mm to 0,54 mm 0,13 mm^2 to 0,18 mm^2 13,5 Ω/100 m	0,48 mm to 0,54 mm 0,13 mm^2 to 0,18 mm^2 13,5 Ω/100 m
Category 6_A solid conductor	0,40 mm to 0,46 mm 13,5 Ω/100 m	0,40 mm to 0,46 mm 13,5 Ω/100 m	0,40 mm to 0,46 mm 13,5 Ω/100 m
Category 7 stranded conductor	No typical design	No typical design	0,48 mm to 0,54 mm 0,13 mm^2 to 0,18 mm^2 13,5 Ω/100 m
Category 7 solid conductor	No typical design	No typical design	0,40 mm to 0,46 mm 13,5 Ω/100 m
Category 7_A stranded conductor	No typical design	No typical design	0,48 mm to 0,54 mm 0,13 mm^2 to 0,18 mm^2 13,5 Ω/100 m
Category 7_A solid conductor	No typical design	No typical design	0,40 mm to 0,46 mm 13,5 Ω/100 m
Category 8.1 stranded conductor (ffs.)	No typical design	0,48 mm to 0,54 mm 0,14 mm^2 to 0,18 mm^2 13,5 Ω/100 m (ffs.)	0,48 mm to 0,54 mm 0,13 mm^2 to 0,18 mm^2 13,5 Ω/100 m (ffs.)
Category 8.1 solid conductor (ffs.)	No typical design	0,40 mm to 0,46 mm 13,5 Ω/100 m (ffs.)	0,40 mm to 0,46 mm 13,5 Ω/100 m (ffs.)
Category 8.2 stranded conductor (ffs.)	No typical design	No typical design	0,48 mm to 0,54 mm 0,13 mm^2 to 0,18 mm^2 13,5 Ω/100 m (ffs.)
Category 8.2 solid conductor (ffs.)	No typical design	No typical design	0,40 mm to 0,46 mm 13,5 Ω/100 m (ffs.)

5.4 Resistance unbalance

Stranding of the elements is generally necessary in order to obtain a flexible cable. Due to the prolongation of conductors due to stranding, the resistance of a stranded wire per cable length l is higher than the resistance of a stretched out wire of the same length l. For a single stranding step, the prolongation factor r can be calculated using the diameter of the stranding trajectory D and the lay length s.

$$r(s) = \sqrt{1 + \left(\frac{\pi D}{s}\right)^2} \quad (1)$$

As the pairs of a cable for digital communications usually have a different lay length, there are generally differences in the conductor resistance between pairs. This is characterised by the resistance unbalance between pairs as defined in IEC 61156-1. Assuming that the lay length of the pairs of a cable varies in a range of $s_{max}/s_{min} = k$, the resistance unbalance between pairs to be expected can be estimated using equation (1) as follows.

$$\Delta RP = \frac{r(s_{\min}) - r(ks_{\min})}{r(s_{\min}) + r(ks_{\min})} \tag{2}$$

For certain parameters, the result of this calculation is shown as an example in Figure 1. This is considered to be an approximation of the resistance unbalance between pairs of currently existing cables in cabling. The same nominal conductor diameter is assumed for all pairs. Manufacturing variances are neglected. Therefore, the resistance unbalance of the pairs is evanescent.

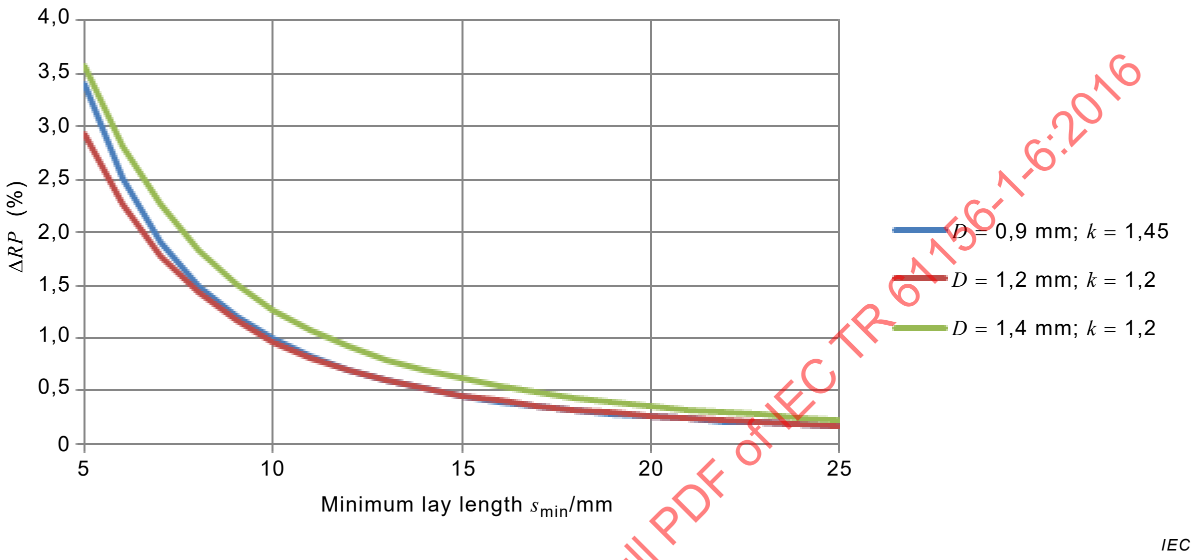

Figure 1 – Evaluation of resistance unbalance between pairs for certain stranding diameters and lay lengths ranges

In case a certain resistance unbalance within a pair ΔR is assumed for the pairs, the value of the resistance unbalance between the pairs can be influenced. In the worst case, both pairs have the maximum resistance unbalance absolute value with a different algebraic sign. This value then adds to the resistance unbalance between pairs. Figure 2 shows a similar evaluation as Figure 1 taking into account the maximum resistance unbalance of a pair according to IEC 61156-5: 2 %. The equations used are in line with the definitions in IEC 61156-1:

$$\Delta R = 100\frac{R_{\max} - R_{\min}}{R_{\max} + R_{\min}} \tag{3}$$

where

ΔR is the conductor resistance unbalance (%);

$R_{\max}$ is the resistance for the conductor with the higher resistance value (Ω);

$R_{\min}$ is the resistance for the conductor with the lower resistance value (Ω).

$$\Delta RP_{i,k} = 100\frac{R_{\max i}R_{\min i}(R_{\max k} + R_{\min k}) - R_{\max k}R_{\min k}(R_{\max i} + R_{\min i})}{R_{\max i}R_{\min i}(R_{\max k} + R_{\min k}) + R_{\max k}R_{\min k}(R_{\max i} + R_{\min i})} \tag{4}$$

where

$\Delta RP_{i,k}$ is the resistance unbalance between pair i and pair k (%);

$R_{\max}$ is the resistance of the wire with the higher resistance of a pair (Ω);

$R_{\min}$ is the resistance of the wire with the lower resistance of a pair (Ω);

i, k $i \neq k$, where i = 1 to n and k = 1 to n for n = number of pairs.

It is obvious that fulfilling a certain requirement for the resistance unbalance between pairs might require significantly lower values for the resistance unbalance within pairs in case very low lay lengths are used.

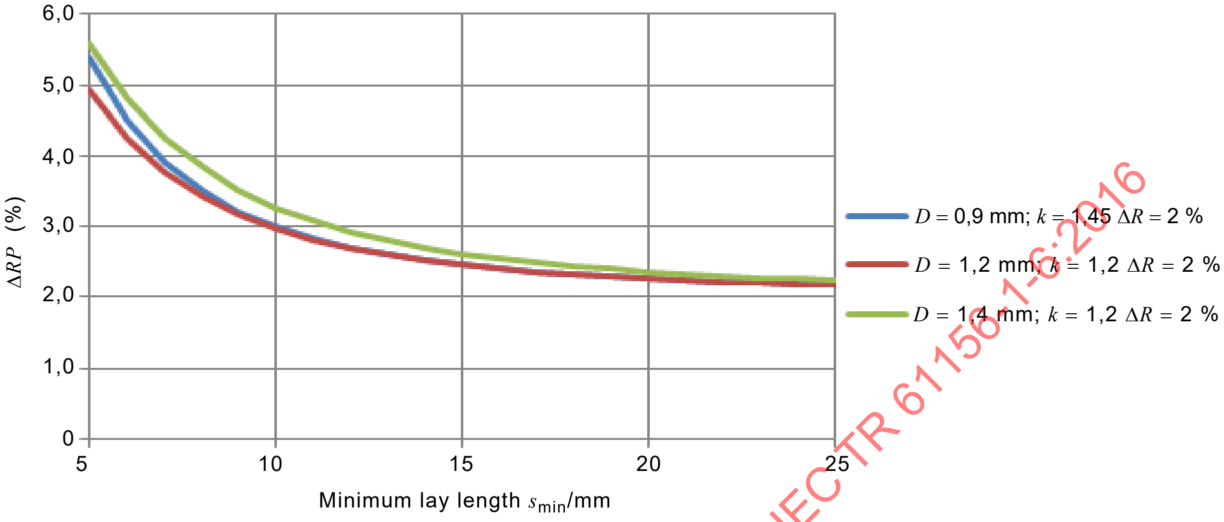

Figure 2 – Evaluation of resistance unbalance between pairs taking into account a resistance unbalance of the pairs of 2 %

As the resistance unbalance is not dependent on the absolute value of the resistance, the same resistance unbalance between pairs can be assumed for both horizontal floor wiring cables and work area wiring cables. Table 3 provides typical values for resistance unbalance between pairs for horizontal floor wiring and work area wiring cables.

Table 3 – Nominal (typical) values of resistance unbalance between pairs for horizontal floor wiring cables and work area wiring cable

	U/UTP	F/UTP, SF/UTP	U/FTP, F/FTP, S/FTP
Category 5e	1 %	1 %	No typical design
Category 6	1,5 %	1,5 %	1 %
Category 6_A	3 %	3 %	1 %
Category 7	No typical design	No typical design	1 %
Category 7_A	No typical design	No typical design	1,5 %
Category 8.1 (ffs.)	No typical design	3,5 %	2 %
Category 8.2 (ffs.)	No typical design	No typical design	2 %