TECHNICAL REPORT

IEC TR 60344

Third edition
2007-02

Calculation of d.c. resistance of plain and coated copper conductors of low-frequency cables and wires – Application guide

Reference number
IEC/TR 60344:2007(E)

Publication numbering

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE G

For price, see current catalogue

INTERNATIONAL ELECTROTECHNICAL COMMISSION

CALCULATION OF DC RESISTANCE OF PLAIN AND COATED COPPER CONDUCTORS OF LOW-FREQUENCY CABLES AND WIRES – APPLICATION GUIDE

FOREWORD

IEC 60344, which is a Technical Report, has been prepared by subcommittee 46C: Wires and symmetric cables, of IEC technical committee 46: Cables, wires, waveguides, r.f. connectors, r.f. and microwave passive components and accessories.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

This third edition cancels and replaces the second edition published in 1980 and amendment 1 (1985). This edition constitutes a technical revision.

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

– improvement of the calculation method of the resistance of copper conductors.

– the content was considered more appropriate for the publication of a Technical Report rather than a International Standard.

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

Enquiry draft	Report on voting
46C/761/DTR	46C/795A/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 publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn;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

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

CALCULATION OF DC RESISTANCE OF PLAIN AND COATED COPPER CONDUCTORS OF LOW-FREQUENCY CABLES AND WIRES – APPLICATION GUIDE

1 Scope

This Technical Report applies to low-frequency cables and wires for telecommunication and gives a general method for calculating the resistance of copper conductors.

2 General method of calculation

The maximum conductor resistance, R, at 20 °C of insulated copper conductors is equal to

$$R = R_0 \, k_1 \, k_2 \, k_3 \, k_4 \quad \Omega/\text{km}$$

where

$$R_0 = \frac{21{,}95}{nd^2}$$

n is the number of strands in the conductor (for a solid conductor n = 1);

d is the nominal diameter of the strands in the conductor, in millimetres, or, for a solid conductor, its nominal diameter;

k_1 is a factor depending on the diameter of the strands and on plain or coated conductor. Values for k_1 are given in Table 1;

k_2 is a factor depending on the type of conductor; the value is equal to

1,00 for solid conductors;

1,04 for stranded conductors;

k_3 is a twisting factor depending on conductor dimension and the way the insulated conductors are twisted together (for single wires k_3 = 1). Values for k_3 are given in Table 2;

k_4 is, for cables with more than one cabling element, a cabling factor depending on conductor size and on the way the cabling elements are assembled, or, for cables with one cabling element and for screened wires up to and including five insulated conductors, an elongation factor depending on conductor size. Values for k_4 are given in Table 3. Values of R are given in Table 4. These values are calculated with different coefficients k_1, k_2, k_3, k_4. The result of the calculations is given with six significant figures. In publications, the value chosen in this table shall be indicated with three significant figures for R below 1 000, and four significant figures from 1 000; for this the table value shall be rounded off to the nearest value.

NOTE The copper conductivity is 58 m/Ωmm².

Table 1 – Strand nominal diameter

Nominal diameter of strands in conductor mm	Values of k_1					
	Solid conductor			Stranded conductor		
	Nickel coated	Tinned	Plain or silver plated	Nickel coated	Tinned	Plain or silver plated
Over 0,05 up to and including 0,10	–	–	–	1,20	1,12	1,07
Over 0,10 up to and including 0,31	1,16	1,08	1,05	1,15	1,07	1,04
Over 0,31 up to and including 0,91	1,13	1,05	1,03	1,12	1,04	1,02
Over 0,91 up to and including 3,60	–	1,04	1,03	–	1,03	1,02

Table 2 – Twisting lay factor

Twisting lay factor	Values of k_3					
	Nominal diameter of solid conductors d mm			Nominal section of stranded conductors S mm		
	$d \geq 0,8$	$0,8 > d \geq 0,4$	$d < 0,4$	$S \geq 0,5$	$0,5 > S \geq 0,15$	$S < 0,15$
>16	1,02	1,03	1,04	1,02	1,03	1,04
≤16	1,05	1,06	1,07	1,05	1,06	1,07

NOTE The twisting lay factor is the ratio of twisting lay length to overall diameter of the twisted insulated conductors.

Table 3 – Cabling lay factor

Cabling lay factor	Values of k_4			
	Nominal diameter of solid conductors d mm		Nominal section of stranded conductors S mm	
	$d \geq 0,8$	$d < 0,8$	$S \geq 0,5$	$S < 0,5$
>16	1,02	1,03	1,02	1,03
≤16	1,05	1,06	1,05	1,06

NOTE 1 The cabling lay factor is the ratio of stranding lay to overall diameter of the assembled layer.

NOTE 2 For screened wires, k_4 is determined by reference to the value associated with a cabling lay factor greater than 16.

Table 4 – Solid conductor

Nominal conductor diameter mm	Coefficients				Calculated resistance Ω/km
	k_1	k_2	k_3	k_4	
0,12	1,05	1,00	1,00	1,00	1 600,52
	1,08	1,00	1,00	1,00	1 646,25
	1,16	1,00	1,00	1,00	1 768,19
0,15	1,05	1,00	1,00	1,00	1 024,33
	1,08	1,00	1,00	1,00	1 053,60
	1,16	1,00	1,00	1,00	1 131,64
0,20	1,05	1,00	1,00	1,00	576,188
	1,08	1,00	1,00	1,00	592,650
	1,16	1,00	1,00	1,00	636,550
0,25	1,05	1,00	1,00	1,00	368,760
	1,08	1,00	1,00	1,00	379,296
	1,16	1,00	1,00	1,00	407,392
0,32	1,03	1,00	1,00	1,00	220,786
	1,05	1,00	1,00	1,00	225,073
	1,13	1,00	1,00	1,00	242,222
0,40	1,03	1,00	1,00	1,00	141,303
	1,05	1,00	1,00	1,00	144,047
	1,05	1,00	1,03	1,00	148,368
	1,05	1,00	1,03	1,03	152,819
	1,13	1,00	1,00	1,00	155,022
0,50	1,03	1,00	1,00	1,00	90,434 0
	1,05	1,00	1,00	1,00	92,190 0
	1,05	1,00	1,03	1,00	94,955 7
	1,05	1,00	1,03	1,03	97,804 4
	1,13	1,00	1,00	1,00	99,214 0
0,60	1,05	1,00	1,00	1,00	64,020 8
	1,05	1,00	1,03	1,00	65,941 5
	1,05	1,00	1,03	1,03	67,9I9 7
0,80	1,05	1,00	1,00	1,00	36,011 7
	1,05	1,00	1,02	1,00	36,732 0
	1,05	1,00	1,02	1,02	37,466 6
1,00	1,04	1,00	1,00	1,00	22,828 0
	1,04	1,00	1,02	1,00	23,284 6
	1,04	1,00	1,02	1,02	23,750 3
1,4 (1,38)	1,04	1,00	1,00	1,00	11,987 0
	1,04	1,00	1,02	1,00	12,226 7
	1,04	1,00	1,02	1,02	12,471 3

Table 4 *(continued)* **– Stranded conductor**

Nominal conductor section area (number of strands × nominal diameter of strand in mm)	Coefficients				Calculated resistance
	k_1	k_2	k_3	k_4	Ohm/km
0,035 mm² (7 × 0,08)	1,07 1,12 1,20	1,04 1,04 1,04	1,00 1,00 1,00	1,00 1,00 1,00	545,222 570,700 611,464
0,055 mm² (7 × 0,10)	1,07 1,12 1,20	1,04 1,04 1,04	1,00 1,00 1,00	1,00 1,00 1,00	348,942 365,248 391,337
0,079 mm² (7 × 0,12)	1,04 1,07 1,15	1,04 1,04 1,04	1,00 1,00 1,00	1,00 1,00 1,00	235,527 242,321 260,438
0,124 mm² (7 × 0,15)	1,04 1,07 1,15	1,04 1,04 1,04	1,00 1,00 1,00	1,00 1,00 1,00	150,737 155,085 166,681
0,150 mm² (19 × 0,10)	1,07 1,12 1,20	1,04 1,04 1,04	1,00 1,00 1,00	1,00 1,00 1,00	128,558 134,565 144,177
0,210 mm² (19 × 0,12)	1,04 1,07 1,15	1,04 1,04 1,04	1,00 1,00 1,00	1,00 1,00 1,00	86,773 1 89,276 2 95,951 0
0,220 mm² (7 × 0,20)	1,04 1,07 1,07 1,07 1,15	1,04 1,04 1,04 1,04 1,04	1,00 1,00 1,03 1,03 1,03	1,00 1,00 1,00 1,03 1,00	84,789 7 87,235 6 89,852 6 92,548 2 93,757 9
0,340 mm² (7 × 0,25)	1,04 1,07 1,15	1,04 1,04 1,04	1,00 1,00 1,00	1,00 1,00 1,00	54,265 4 55,830 8 60,005 0
0,340 mm² (19 × 0,15)	1,04 1,07 1,15	1,04 1,04 1,04	1,00 1,00 1,00	1,00 1,00 1,00	55,534 8 57,136 7 61,408 7
0,500 mm² (28 × 0,15)	1,07 1,07 1,07	1,04 1,04 1,04	1,00 1,02 1,02	1,00 1,00 1,00	38,771 4 39,546 8 40,337 7
0,500 mm² (16 × 0,20)	1,07 1,07 1,07	1,04 1,04 1,04	1,00 1,02 1,02	1,00 1,00 1,02	38,165 6 38,928 9 39,707 5
0,560 mm² (7 × 0,32)	1,02 1,04 1,12	1,04 1,04 1,04	1,00 1,00 1,00	1,00 1,00 1,00	32,484 0 33,121 0 35,668 7
0,600 mm² (19 × 0,20)	1,04 1,07 1,15	1,04 1,04 1,04	1,00 1,00 1,00	1,00 1,00 1,00	31,258 3 32,139 4 34,542 4
0,750 mm² (42 × 0,15)	1,07 1,07 1,07	1,04 1,04 1,04	1,00 1,02 1,02	1,00 1,00 1,02	25,847 6 26,364 5 26,891 8
0,750 mm² (24 × 0,20)	1,07 1,07 1,07	1,04 1,04 1,04	1,00 1,02 1,02	1,00 1,00 1,02	25,443 7 25,952 6 26,471 6
1,000 mm² (32 × 0,20)	1,07 1,07 1,07	1,04 1,04 1,04	1,00 1,02 1,02	1,00 1,00 1,02	19,082 8 19,464 4 19,853 7
1,500 mm² (30 × 0,25)	1,07 1,07 1,07	1,04 1,04 1,04	1,00 1,02 1,02	1,00 1,00 1,02	13,027 2 13,287 7 13,553 5

ISBN 2-8318-8998-7

9 782831 889986

ICS 29.060.01

Typeset and printed by the IEC Central Office
GENEVA, SWITZERLAND