

Formulas of electrotechnic and electronic

Cross-section for **single wire round**

$$q = \frac{D^2 \cdot \pi}{4} \quad \text{or} \quad D^2 \cdot 0,7854$$

Cross-section for **bunched wire**

$$q = \frac{d^2 \cdot \pi}{4} \cdot n \quad \text{or} \quad d^2 \cdot 0,7854 \cdot n$$

Diameter for

single wires cross-section

$$D = \sqrt{\frac{q \cdot 4}{\pi}} \quad \text{or} \quad \sqrt{q \cdot 1,2732}$$

Diameter for **bunched wires**

$$D = \sqrt{1,34 \cdot n \cdot d}$$

q = cross-section (mm²)

D = conductor diameter (mm)

d = single wire diameter (mm)

n = number of wires

Conductor Resistance

$$R = \frac{1}{\kappa \cdot q} \quad \text{or} \quad \frac{\rho \cdot l}{q}$$

$$R_{\text{Loop}} = \frac{2 \cdot l}{\kappa \cdot q} \quad \text{or} \quad \frac{2 \cdot l \cdot \rho}{q}$$

R = Electrical direct-current resistant (Ohm)

R_{Loop} = Resistance of a complete circuit

q = cross-section (mm² or q mm)

κ (Kappa) = Conductivity

ρ (Rho) = Specific resistance (ρ = $\frac{1}{\kappa}$)

l = Conductor length (m)

Materials	Conductivity $\frac{\text{m}}{\Omega \cdot \text{mm}^2}$	Spec. resistance $\frac{\Omega \cdot \text{mm}^2}{\text{m}}$
Copper	58,00	0,01724
Aluminium	33,00	0,0303
Silver	62,00	0,1613
Iron	7,70	0,1299
Constantan	2,00	0,50

Serial connection

Resistance: $R = R_1 + R_2 + R_3 + \dots + R_n$

Capacitance: $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots + \frac{1}{C_n}$

Inductance: $L = L_1 + L_2 + L_3 + \dots + L_n$

Parallel connection

Resistance: $R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}}$

Capacitance: $C = C_1 + C_2 + C_3 + \dots + C_n$

Inductance: $L = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \dots + \frac{1}{L_n}}$

Equivalent resistance of 2 parallel connected resistance

$$R = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

Mutual capacity (C)

• coaxial cable $C = \frac{\xi r \cdot 10^3}{18 \cdot \ln \frac{Da}{d}} \quad (\text{nF/km})$

• parallel core $C = \frac{\xi r \cdot 10^3}{36 \cdot \ln \frac{Da}{d}} \quad (\text{nF/km})$

• shielded twisted pair

$$C_B = \frac{\xi r \cdot 10^3}{36 \ln \frac{2a}{d} \cdot \frac{(Da^2 - a^2)}{(Da^2 + a^2)}} \quad (\text{nF/km})$$

Da = Outer diameter over insulation

Ds = diameter over shield

d = diameter of conductor

a = distance – mid to mid of both conductors

ξ = dielectric constant

Ohm's Law

The current intensity (I) is proportional to voltage (U) and inversely proportional to resistance (R)

$$I = \frac{U}{R} \quad R = \frac{U}{I} \quad U = I \cdot R$$

I = current intensity (Amps – A)

R = electrical resistance (Ω)

U = electrical voltage (V)

Conductance

$$G = \frac{1}{R} \quad 1\text{S} = \frac{1}{1\Omega} \quad \text{or} \quad 1\mu\text{S} = \frac{1}{1\text{M}\Omega}$$

S (Siemens) = reciprocal value of a resistance
is used as **conductance**

1 Siemens = 1/Ohm

G = electrical conductance

Capacitance

• Single core against earth

$$C_B = \frac{\xi r \cdot 10^3}{18 \ln \frac{Da}{d}} \quad (\text{nF/km or pF/m})$$

• Unshielded symmetrical twisted pair

$$C_B = \frac{\xi r \cdot 10^3}{36 \ln \frac{2a}{d}} \quad (\text{nF/km or pF/m})$$

• Coaxial pair

$$C_B = \frac{\xi r \cdot 10^3}{18 \ln \frac{Da}{d}} \quad (\text{nF/km or pF/m})$$

• Shielded symmetrical twistet pair

$$C_B = \frac{\xi r \cdot 10^3}{36 \ln \frac{2a}{d} \cdot \frac{(Da^2 - a^2)}{(Da^2 + a^2)}} \quad (\text{nF/km or pF/m})$$

Di = outer diameter over single core (mm)

Da = outer diameter of multicores (mm))

d = conductor diameter (mm)

a = distance between two conductors –
mid to mid of both conductors

Inductance of parallel cores

at low frequencies

$$L = 0,4 \left(\ln \frac{Da}{r} + 0,25 \right) \text{ mH/km}$$

at high frequencies

$$L = 0,4 \left(\ln \frac{Da}{r} + 0 \right) \text{ mH/km}$$

Inductance of coaxial cable

at high frequencies

$$L = 0,2 \left(\ln \frac{Da}{r} + 0 \right) \text{ mH/km}$$

Da = distance between two conductors –
mid to mid of both conductors

r = radius of a conductor

ξr = dielectric constant

Impedance (Z)

$$\text{for coaxial cable} \quad Z = \frac{60}{\sqrt{\xi r}} \cdot \ln \frac{D}{d} \quad (\Omega)$$

D = diameter over insulation

d = conductor diameter

for communication cable

$$\text{at low frequencies} \quad Z = \sqrt{\frac{R}{\omega C}} \quad (\Omega) \cdot \tan \varphi = 1, \quad \varphi = 45^\circ$$

$$\text{at high frequencies} \quad Z = \sqrt{\frac{L}{C}} \quad (\Omega)$$

R = Resistance (Ω/km)

L = Inductance (mH/km)

C = Capacitance (nF/km)

ω = 2 π f

Wave length $\lambda = \frac{v}{f}$

λ = wave length

v = propagation velocity (velocity of light: 300 000 km/s)

f = frequency

units of attenuation – Neper (N), decibel (dB) and Bel (B)

1 Np = 8,686 dB

$$1 \text{ dB} = 0,1151 \text{ Np} = \frac{1}{10} \text{ Bel}$$

$$1 \text{ Bel} = 10 \text{ dB} = 1,1513 \text{ Np}$$